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# ESSENT

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Society for Collaborative  
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IIT MANDI



INDIAN INSTITUTE OF TECHNOLOGY MANDI

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*“We live on an island surrounded by a sea of ignorance. As our island of knowledge grows, so does the shore of ignorance.”*

*-John A. Wheeler*

## EDITORIAL

*Amidst new waves of development, Indian Institute of Technology (IIT) Mandi is scaling new heights with its vision, “To be a leader in science and technology education, knowledge creation and innovation, in an India marching towards a just, inclusive and sustainable society”. IIT Mandi is continuously nurturing new avenues for promotion of research and innovation. It has given a launching pad to **Society for Collaborative Research and Innovation (SCRI)**, a student run society at IIT Mandi which aims at providing a collaborative platform for extensive, effective and sustainable research and innovations. **SCRI** fully realizes the importance of collaborations in research and facilitates the same. **ESSENT** is a part of this quest. It aims to provide a platform for students, researchers, academicians and others to share and exchange knowledge and ideas on research and innovation. **ESSENT** also aims at highlighting the potential areas where research and innovation in technology and social sciences can successfully intervene.*

*We are highly pleased to bring out the first issue of **ESSENT** with articles and papers contributed by students as well as by scientists and academicians. Being the first issue, we have tried to include articles from diverse fields including sciences and humanities so as to make it relevant to a wider section of readers rather than a smaller specialized one. **ESSENT** is a humble beginning and it has to go a long way.*

*In this issue, we also present an exclusive interview with Prof. Richard Ernst, 1991 Nobel laureate in Chemistry for his work on NMR spectroscopy. Prof. Ernst has given us a deep insight into his life and contributions as a scientist. We are sure this interview will act as a key in opening up and igniting a lot of minds.*

*As we intend to continue this endeavor of opening up to the world via this technical magazine in its subsequent issues, we invite you to be a part of it as a contributor, reader or a well wisher.*

*We would like to thank all our present contributors and advisors for their support. We are also highly thankful to IIT Mandi administration, especially honorable Director Prof. T. A. Gonsalves for supporting and guiding us. We look forward for your kind comments and suggestions for improving our future issues.*

*Athar Aamir Khan  
Editor*

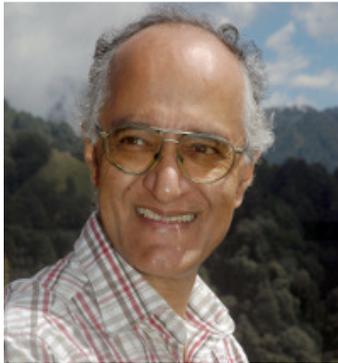
*“For a successful technology, reality must take over public relations, for Nature cannot be fooled.”*

*-Richard P. Feynman*

# Innovation for a Better

## India

**Prof. Timothy A. Gonsalves,**  
*Director,*  
*Indian Institute of Technology Mandi*



*Prof. Gonsalves did his B. Tech. at IIT-Madras, M.S. at Rice University, Houston and Ph.D. at Stanford University, California. He joined the Department of Computer Science & Engineering, IIT-Madras as an Assistant Professor in 1989 and rose to Professor and Head of the Department.*

*Prof. Gonsalves is the Cofounder of the TeNeT Group of IIT-Madras and founding Director of NMSWorks Software Ltd, n-Logue Communications Ltd and the IIT-Madras Rural Technology Business Incubator (RTBI).*

*In January 2010, Prof. Gonsalves was appointed as the first full-time Director of the Indian Institute of Technology (IIT), Mandi. His interests include design and performance of computer and telecom networks, innovative and low-cost product and technology development for Indian and international industry and fostering software development in small towns and rural areas.*

### 1 Introduction

The Internet has changed the world. In the short span (historically) of 50 years, it has transformed the way in which billions of us work, socialise, get entertainment, and conduct our personal and work lives. Even the billions who do not directly use the Internet are affected by the globalisation that the Internet has made possible. Two key factors in this remarkable transformation are the World-Wide Web (WWW) and the search engine.

The World-Wide Web was invented by Tim Berners-Lee, a scientist working in the CERN labs in Geneva [Wiki 12]. He needed to collaborate with a group of scientists in different places. Typically, they exchanged information and documents via the nascent Internet using email and FTP. This was tedious. Email requires that the author sends the document, and that the recipient saves the document. Thereafter, there are multiple copies of the document that may not be consistent with one another – when the original author changes the document, the recipient's version becomes obsolete. FTP requires the recipient to know the exact location, filename and format of each document and to have a login account in every computer.

WWW greatly simplifies this task. The documents are connected to one another via URLs (links) and accessed by a browser that finds and retrieves each document when it is required. Underlying this simple user experience is an array of technologies: electronic storage of documents, indexes and cross-references in documents, HTTP/TCP/IP, HTML, FTP, etc. Berners-Lee did not invent most of these. His contribution was to combine them in an unusual way to serve a burning need. This is *innovation* at its best.

The Internet is not the only radical change in our lives in modern India. One example: until the 1970s, the small urban middle and upper classes used shampoo, then available in bottles

costing Rs. 50 and upwards (equivalent to paying Rs. 500 or more today). The vast majority of Indians, especially those in rural areas, did not use shampoo. There were many reasons: Rs. 50 was a large investment for most Indians; the shampoo in the bottle could easily be adulterated; during use, if it spilt, several months of hair-washing could go down the drain. People preferred to buy soap or powders costing a rupee or two. The shampoo market was dominated by Hindustan Lever which was making a comfortable profit with its urban-based distributor network selling to the upper classes.

Along came CavinKare with a unique business plan [Munshi 09]. They packaged shampoo in small sealed plastic sachets, set up a large distributor network throughout the country to sell shampoo at Re 1 per sachet. Even a poor person in a remote village could now use shampoo occasionally when s/he had Re 1 to spare. As the packet was sealed, there was no question of adulteration. Their Chik shampoo sachets rapidly gained popularity among the rural people. Today, CavinKare has 25% of the shampoo market and sachets account for 70% of the shampoo market.

Again, this innovation used existing business practices and technologies. It put them together in a novel way to create and capture a vast new market. *While bottled shampoo was profitable due to high margins on small volumes, sachet shampoo was profitable despite very small profit margins because of very high volumes.*

As engineers, we dream of being responsible for the next disruptive innovation. What is innovation, why is it important to India, how can we be more innovative, can innovation be taught? These are questions that we address in the rest of this paper.

## 2 What is Innovation?

Creativity and innovation are related but distinct. *Creativity is coming up with something novel and non-obvious.* This may include a new theory to explain observed facts, writing a book or poem, composing music, and inventing technical mechanisms.

*Innovation is putting ideas to use in a novel way for the benefit of society.* Two key differences: innovation may make use of existing ideas while creativity involves new ideas. Innovation must be useful, while creativity need not result in any immediate benefit to anyone.

## 3 Why is Innovation Important?

India faces vast and seemingly insurmountable problems. These include lack of affordable housing, clean water, sanitation, basic health facilities, good schools and colleges, and many more for the majority of Indians. The 70% who live in rural India are especially badly off. While our cities score better on many of these parameters, they are bursting at the seams and affordability is a problem for the many slum dwellers.

With the advent of TV and ubiquitous telecommunications, the poor are no longer willing to accept their lot as “fate”. Thwarted aspirations often lead to social unrest and violence. Besides, a country cannot claim to be a mature democracy unless there is a measure of equality in the quality of life of its citizens.

India is a country of contrasts. Consider per capita income [WorldBank 12]. The family income of the top 250 million people is about Rs. 19 lakhs/year<sup>1</sup>. This is quite generous by any standards. The middle 500 million people have a family income of about Rs. 6

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<sup>1</sup> Considering an exchange rate of Rs. 50 per \$1 and a family size of 5. The figures quoted are averages. Within each group there is obviously a range of income.

lakhs/year. This enables a comfortable middle-class lifestyle. However, at the bottom of the pyramid we have 125 million people who subsist on Rs. 75 per day which is at best adequate for the bare necessities of existence.

To address these inequalities, large-scale redistribution of income is not politically feasible. Bringing the poor up to middle-class standards requires growth in national income. Much of this increase in national income will be absorbed by the well-off. Hence, to achieve decent living standards for all in a few years requires continuing growth at a high rate of 10% per annum or more. Of course, growth must be tempered by measures to ensure a reasonable degree of equality.

India's remarkable growth over the past 2-3 decades has been driven primarily by manufacturing and services. These can result in only a linear rate of growth. If the investment in a factory is doubled, it typically results in double the output. Likewise, if an IT company increases its workforce by 50%, its revenues increase by about 50% also. In fact, this has been largely how our successful IT companies – Infosys, Wipro, IBM and others – have achieved their spectacular growth. They have each increased their headcount from a few thousand to 1-2 lakhs.

Product design and innovation promises much higher growth rates. For example, the Google search engine patent was based mainly on the work on 2 graduate students done over a few years. It has earned over \$330m (Rs. 1,600 crores) in royalties for Stanford University [Chao 06]. Another example: for every cellphone sold in India, an amount of between 2-15% of the price is paid as royalty to the developers of various parts of the cellphone [Jhun 11]. These designers did their work a few years ago, and now collect huge amounts of royalties every year with practically no effort. Most of this royalty flows outside India, though this is changing gradually.

Innovation is needed for another reason. A modern lifestyle consumes a lot of irreplaceable natural resources and generates considerable pollution. The ratio of per-capita consumption of resources of the average Indian to that of the average person in the US is about 1:20. Comparing rural India to urban India, again the ratio is about 1:20. If India's 1.25 billion people consume resources at the rate of the 100 million affluent urban Indians, or the 250 million affluent in the US, there will be an environmental disaster. As a democracy, we cannot prevent rural India from developing. *Innovative solutions that are environmentally sustainable are crucial for India's development.*

#### 4 The Roads to Innovation

Is innovativeness innate, or can it be cultivated? Research and experience indicate that there are factors that encourage innovation. We first give a very simplified view of how the human brain works. Next, we describe some of the factors favouring innovation.

##### 4.1 The Human Cognitive Process

The human brain has a memory consisting billions of neurons. Each neuron can hold a fact or other piece of knowledge. An idea occurs when a number of these facts are connected together. Connections occur when neurons emit signals that flow to other neurons through synapses. There is some randomness in the paths taken by the signals. Thus, with a given set of facts, different networks of neurons, i.e. different ideas, may emerge. Ideas may emerge from a combination of apparently unrelated facts (serendipity). The firing of neurons occurs both when we are awake and when we are asleep.

##### 4.2 Factors Favouring Innovation

This view of the human brain appears to suggest a simple recipe to foster innovation: fill your brain with facts, train your neurons to fire, and be prepared to recognize which patterns are useful ones.

Can innovation be fostered so simply? We examine this question in more detail below. This draws heavily on the excellent book by Steve Johnson [Johnson 10]. Johnson describes 7 factors, devoting one chapter to each. We classify these factors into three: those that depend on the *domain* of the problem, those that are the influence of the *external* world, and those that are *internal* to the innovator.

#### 4.2.1 Domain Factors

**The Adjacent Possible:** The essence of engineering is building on the work of others. The vast majority of innovations require a set of pre-conditions to be successful. Innovation is the art of having the right idea in the right time and place. Consider the invention of the World-wide Web (WWW) by Tim Berners-Lee in CERN, Geneva in 1989. This was based on several ingredients: a large corpus of digital documents; a ubiquitous, reliable network with many users; indexing and cross-referencing used in printed books coupled with hypertext for including these in digital documents; standard encoding of digital text (ASCII); and standard protocols for transfer of files across a network (FTP). In addition, Berners-Lee had the problem of collaborating with scientific colleagues in geographically remote labs. Combining these ideas, Berners-Lee invented HTML, HTTP and WWW to solve the problem of accessing the corpus of documents produced by members of his distributed team.

Suppose Berners-Lee had conceived the idea of WWW in 1979? At that time: networks were fragmented and had few users; diverse encoding formats were used for digital documents; many operating systems had incompatible file formats and even incompatible names for file. WWW in 1979 might have run on a few computers, but most people would have continued to rely on printed documents. WWW in 1979 would have flopped. Successful innovation is usually an incremental advance on existing technologies. Radically new *creative* ideas are

rarely converted immediately into useful innovations.

**Exaptation:** Coined by Stephen Jay Gould and Elisabeth Vrba in 1971, *exaptation* refers to something designed for one purpose but used for another quite unrelated purpose [Gould 82]. Eg. Gutenberg used the screw press for printing text on paper. This was a mature technology used for wine-making in the Rhineland.

A contemporary example is the SMS. This was originally invented as a convenient way for operators to download short service messages to subscribers, using some unused “free” bandwidth during a cellphone voice call. SMS has now become an important means of communication between subscribers, for advertisement, etc. It is a revenue-earner, in some cases earning more revenue for the operator than voice calls.

#### 4.2.2 External Factors

**Networking:** In 2008, Geoffrey West and his team at the Sante Fe Institute studied the quantity of infrastructure in different cities across the world. They found that the infrastructure needs of a city grow much more slowly than the population. The growth was found to be proportional to the population raised to the power  $-1/4$ . I.e., a city 10 times larger requires only 1.77 times increase in roads, a city with 1,000 times the population requires only about 5.6 times the roads. However, when they considered innovation, they found that while a power law holds, the exponent is positive. Thus, a city that has *10 times larger population is 17 times more innovative*.

Why does this happen? Interaction with others in formal and informal settings has two effects. One, when we expose our ideas or the problems we are working on, the questions and comments by others may lead us to rethink our solutions. Second, when we are exposed to the

ideas of others, even in very different areas, this may give us new insights into our own problems. Networking is much more powerful when the people in the network are passionate and creative. Thus certain areas have been extremely innovative – Silicon Valley encompassing Berkeley, San Francisco, San Jose and many cities within a span of 100 km, and Route 128 in a radius of 50 km around Boston and Cambridge are two renowned hotbeds of innovation. Other large metropolitan areas have not been so successful, such as Pittsburgh despite the presence in it of the world-renowned Carnegie Mellon University.

Table 1: Hypothetical rate of innovations in 3 Indian cities

City	Mandi	Chandigarh	Delhi
Population	0.5 lakhs	10 lakhs	110 lakhs
Innovation rate	1	42	847

Table 1 gives hypothetical rates of innovation in 3 Indian cities, based on West's findings. Do we conclude that we need to live in a large metropolitan area to be innovative? This would be bad news for IIT Mandi! Fortunately, telecommunications and the Internet have greatly reduced the barriers to communication in today's world. Skype, Facebook, email, WWW and inexpensive POTS (plain old telephone service) reaching almost everywhere have made it possible to build up networks of people with whom one exchanges ideas regardless of distance. Note that the choice of people in your network is important. Johnson writes: *“This is not the wisdom of the crowd, but the wisdom of someone in the crowd. It’s not that the network itself is smart; it is that the individuals get smarter because they are connected to the network.”*

#### 4.2.3 Internal Factors

**Serendipity:** Sometimes, when trying to solve a difficult problem we reach a dead-end,

unable to make progress. Suddenly, out of the blue, while we are engaged in something quite different, the solution emerges. This is *serendipity*.

The classic example is the discovery of the ring structure of benzene by the German chemist Kekulé von Stradonitz in 1865. He had been struggling with this question since 1855. One day, while daydreaming in his living room before a crackling fire, he had a vision in the flames of Ouroboros, the mythical Greek serpent that eats its own tail. This gave him the insight that benzene consists of a ring of 6 carbon atoms, opening up the field of organic chemistry that has profoundly changed human existence through a myriad of useful compounds.

**Slow Hunch:** An idea does not always get developed into an innovation by working on it over a short time. The idea may be ahead of its time such as the hypothetical example of WWW in 1979. At the time we have the idea, we may lack knowledge or experiences necessary to convert it into something useful. After the idea remains in the back of our mind perhaps for years, we may realise that its time has come and we are able to work it out to its full potential. The seed germinates slowly then when conditions are right, suddenly sprouts and grows rapidly into an innovation.

During his boyhood, the 18th century scientist Joseph Priestley liked to trap spiders in glass jars. He had a hunch that there was some deeper reason why they perished if the jar was sealed. Twenty years later, this hunch resurfaced when he devised an experiment with a sprig of mint in a jar that showed that plants produce oxygen.

**Note:** Johnson's book elaborates on these factors leading to innovation. [Johnson 10] He covers two more factors, *platforms* and *error* that we classify as domain and internal factors respectively.

## 5 Cultivating Innovation

The first step towards having innovative ideas is to fill your brain with as many facts as possible. To this end, read widely within your discipline and interests and even outside these. Apart from the courses in your discipline, take some courses that are quite unrelated to your future profession. You never know when these will become useful, perhaps many years down the road. Academic institutions give you the opportunity to attend seminars on a variety of topics. Again, make it a point to attend seemingly “irrelevant” seminars. While reading and attending seminars, think about what you read and hear, make notes on what you have learnt. This effort “cements” the facts into your neurons, triggers neurons to fire and helps result in useful new ideas.

Last but not least, exploit the power of networking. Develop a network of thoughtful, intelligent people with whom you can interact in person, by email, by social networking. Some of these may be in your current core interest area, many should be in diverse fields. Bounce your ideas off them, listen and comment on their ideas however fanciful and unrelated to your core interests. Miller describes innovation conversations as an important part of the innovation process [Miller 07].

## 6 The Final Word

India is a country with vast problems, arguably the most fertile place in the world for a budding young engineer or scientist looking for challenges. Innovation is the key to the well-being for all India's citizenry through equitable, sustainable growth. Innovation can be cultivated by any bright young engineer. While solving key problems of the nation, you

will achieve immense self-satisfaction, probably great financial rewards and possibly widespread fame. The exhortation of John F. Kennedy “Ask not what your country can do for you, ask what you can do for your country” is not a call to sacrifice and suffering, but an invitation to a rich professional career!

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## References

- 1) [Chao 06] Linda Chao, "Licensing to Companies in Asia: The Stanford Model", Oct-2006  
<http://asia.stanford.edu/events/fall06/slides/061026-chao.pdf>.
- 2) [Gould 82] Stephen J. Gould & Elisabeth S. Vrba, “Exaptation – A Missing Term in the Science of Form”, *Paleobiology* 8, Jan. 1982, pp. 4-15.
- 3) [Johnson 10] Steven Johnson, *Where Good Ideas Come From: the natural history of innovation*, Penguin, 2010.
- 4) [Jhun 11] Ashok Jhunjhunwala, Personal communication, Apr. 2011.
- 5) [Miller 07] William C. Miller, *The Innovation Process*, IEEE-USA eBook, 2007.
- 6) [Munshi 09] Porus Munshi, *Making Breakthrough Innovation Happen: How 11 Indians Pulled off the Impossible*, HarperCollins, 2009.
- 7) [Wiki 12] “Tim Berners-Lee”, [https://en.wikipedia.org/wiki/Tim\\_berners-lee](https://en.wikipedia.org/wiki/Tim_berners-lee), visited 13/10/12.
- 8) [WorldBank 12] “World Bank Indicators - - India -- Income distribution – 2012”, <http://data.worldbank.org/indicator/SI.DS.T.05TH.20/countries>.

## Research, Innovation and IIT Mandi

**Prof. Subrata Ray,**  
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School of Engineering, IIT Mandi



*Prof. Ray is an eminent researcher and academician. He has extensive experience in administration of academic institutions in various capacities including Dean Administration and Dean Sponsored Research at IIT Roorkee, Chairman GATE and Head Department of Metallurgical and Materials Engineering, at erstwhile University of Roorkee. He has also held visiting appointments in the University of Wisconsin – Milwaukee, USA, Institut National Polytechnique de Grenoble, France and Technical University, Berlin, Germany.*

*Prof. Ray has research interests in Materials development with special emphasis on cast metal matrix composites (MMC). He has many pioneering contributions in cast MMC including introduction of stir-casting and addition of surface active elements for which he held the second patent in the world in this area.*

*Prof. Ray has published more than 200 technical papers, mostly in International journals and handbooks including those of ASM and ASLE. For his research contributions, Professor Ray has received MRSI Annual Medal and Khosla Research Medal. He is a fellow of the National Academy of Sciences, India and Indian National Academy of Engineering.*

IIT Mandi is the first Himalayan IIT, being set-up for embedding excellence in research and innovation in the tranquil environment of education at Kamand in Himachal Pradesh. A new institute has always an advantage that it is not burdened by history since the history is yet to be created. The history of IIT Mandi is going to be product of our actions – mistakes and achievements. Many of us have grown up in institutions where time has taken its toll by compromising into many norms and traditions, which are not in the best interest of nurturing academic excellence. Many of the practices, which we take for granted, should not be adopted blindly before ensuring that these practices will genuinely contribute to our goal of attaining excellence. In addition, each of us in the community consisting of teachers, students and employees carrying out administration and supporting services, should also guard against narrow interests, which may jeopardize the future of the institute. Any of the actions should be discussed widely so that there is no adverse impact of it on our goal of creating global excellence, which is not easy to attain as evident from the fact that none of our institutes has figured in the first 200 institutes in the global QS ranking in the current year. We must not despair but work resolutely with care so that all our practices including those related to the academic processes must be jointly examined and bench marked against the best practices available globally. In the brief span of this article, the process of research and innovation is examined from historical perspective so as to help evolve better practices eventually.

### 1. Research and Scientific Knowledge

Human beings are surrounded by the world outside and each is experiencing the surrounding through sense organs, sending signals to the brain for internalising the experience to develop a perception of the world around. The signal processing is done in the internal world of the experiencing individual, involving his thoughts, dreams and other mental processes, which may result in either similar or different individual perception under identical

circumstances. When the same circumstances leads to identical experience (there may be training required sometimes for such experiencing) irrespective of the individual involved, leading to the same perception, such perception qualifies as scientific knowledge. The starting point of a scientific knowledge is an experience or experiment, which may also be controlled experience, simulated sometimes inside the laboratory. This conception of scientific knowledge rooted in experience evolved over time. Towards the end of the sixteenth century, it was Galileo, who established experiment as the foundation of scientific knowledge. This profound contribution has been acknowledged by Max Born [1] in his Nobel lecture in these words - "The scientific attitude and the methods of experimental and theoretical research have been the same through the centuries since Galileo and will remain so." Before Galileo, since the days of Plato and Aristotle, experience or experiment was considered superficial and reason alone, in their opinion, has the capability of penetrating deep into the mystery of nature. Experience was considered superficial and unreliable since it involves individual perception. In those days, both science and philosophy were together in the domain of natural philosophy. Aristotle propounded the sciences of astronomy and mechanics presumably on the basis of reason alone. Interestingly, Aristotelian sciences had a long run and dominated life till sixteenth century, strengthened by their adoption in the theology of Judaism, Islam and Christianity. There is no better example of how could application of reason alone may mislead science into fiction and reliable science could only emerge from experiment, to be followed thereafter by reasoning (theory). The predictions of theory need to be checked by experiments so that theory may not stray into unreality.

Since the days of Galileo we gather knowledge about nature by first carrying out experiment several times and arrive at a perception by application of inductive logic. Suppose we want to understand interaction between like charges.

We may do it by noting the outcome of unit positive charge being brought near another positively charged species of known amount of charge. They repel each other and the repulsive force is more when the distance between these charges becomes smaller. The experiments may be conducted to measure the repulsive force for several predetermined distances. Similar experiments may be carried out for the negative charges as well for different distances. The experiments may be repeated several times to check reproducibility of the results. After perusing the outcome of repulsive force in all the experiments, we apply inductive logic (do not confuse it with the principle of induction in mathematics) to arrive at the general conclusion from the results of particular experiments - "like charges repel each other". The forces of repulsion measured at several distances will allow one to apply deductive logic (mathematics) to evolve Coulomb law for electrostatic repulsion, which may be employed in the analysis of numerous circumstances where it has relevance and the outcome may again be experimentally verified. This is how experiment and theory (reason) are intertwined in scientific research.

Research to gather knowledge about the world around started from the dawn of human settlement when we learnt to use stones as tools and to light fire. Thereafter, we learnt to break and grind stones to make sharp tools and eventually discovered animal husbandry and agriculture to secure supply of food. Nobody knows the names of these discoverers but the impact of their discoveries on our civilization is no less compared to those of the great scientists of present times. In science we generally have short memory of the contribution of individual scientists and so, it is often said that there is depreciation of history in science. What is important is the knowledge and the individuals contributing to it are secondary. The ancient discoveries mentioned earlier made profound changes in the quality of life, paving the way for many ancient civilizations including those at Mesopotamia, Indus Valley, China and Greece,

to name a few. Each of these civilizations made significant progress in knowledge through research. Mesopotamia is known for its innovation of ploughing leading to surplus of grains which possibly inspired them to invent boats for commerce. Indus valley civilization is marked by their excellent knowledge of planning the habitats. There is evidence of commerce between Mesopotamia and Indus valley civilization made possible by navigation in the sea along the coast. Sailing across the ocean became increasingly important with progress of time as commerce developed between Asia and the Arabic world on the one hand and Arabic world and the Europe on the other. Maritime activities were guided by the position of celestial bodies and there was need for reliable astronomical chart, which led to the development of astronomy in the early days. India in the Vedic ages collected enormous data on the movement of celestial bodies as it was important for their religious rites. Geometry emerged in Egyptian civilization to facilitate reallocation of land after flooding by the river Nile and it was developed further in Greece and also in India due to its importance in the Vedic rituals. The world also owes it to India for the development of decimal system and the profound concepts of zero and infinity. Without these contributions the modern science could not have emerged because of inability to handle large numbers, which was limited in Greek and Roman civilizations. Significant amount of knowledge had been lost because of limiting it within a restricted group, often within a family and also, due to absence of facilities for proper documentation and transmission. The printing technology developed by Chinese civilization and its diffusion to Europe, made it possible for printing scientific knowledge for circulation so that it could be shared and jointly pursued, leading to the scientific revolution in Europe in the sixteenth and seventeenth century. Thus, research is a cooperative enterprise across civilizations in different geographical regions, culminating in knowledge which is the joint legacy of the entire mankind.

Earlier there were no textbooks giving a consolidated account of the status of knowledge in an area. The natural philosophers or scientists often wrote books to highlight their contribution and establish the current status of knowledge in an area as Ptolemy did it in the book titled 'Almagest', Newton in 'Principia' and 'Optika', Franklin in 'Electricity', Lavoisier in 'Chemistry' and Lyell in 'Geology'. Around these books, a consistent framework for scientific thought, including law, theory, application and instrumentation together, emerged and this framework, called a paradigm, provided the basis for further scientific research. Different areas of science were established as physics, chemistry, Geology, Electrical science etc., having their distinct paradigms, which, according to Kuhn [2], should satisfy the following two characteristics:

- (i) The paradigm should have an enduring group of scientists accepting it
- (ii) Following the paradigm, the scientists should be able to resolve all kinds of problems within its framework

Now-a-days the current paradigm in an area is given in textbooks, which are used to train the students to become scientists to carry out research in future as a member of the scientific community, which shares the same paradigm committing to the same rules and standards for scientific practice. Paradigm does not allow free flight of thoughts and it restricts the vision within the inflexible box of the current paradigm, in which the nature has to fit. Normally, the scientists devote their entire career in fitting the different problems of nature within the paradigm. What are the different kinds of experimental research normally undertaken? Generally, the research investigations have one of these three aims – (i) to Increase accuracy and scope of the most revealing facts within the paradigm, (ii) to verify the predictions of the theory evolving in a paradigm and (iii) to apply the paradigm to residual problems yet to be solved. The theoretical investigations, in addition to what is

aimed at experimental research, try to predict facts, which are of intrinsic value. Only those problems, which can be solved under a paradigm, are only accepted as scientific by the community while encouraging the members to find the solution. Individual scientists are happy to solve such problems that no one has ever solved or solved so well. This type of research has been called 'normal research' by Kuhn [2] and most of the scientists devote their entire life to it. Normal research continues till one encounter accumulating facts exposing the inadequacy of a paradigm, which comes increasingly under attack. If you read history of science you will know the anomalous results accumulated at the turn to twentieth century and these results could not be explained by Newtonian mechanics. In those days, there were intense debates which marked the transition from Newtonian Mechanics to Quantum mechanics. Similar debates ensued before the emergence of Maxwell's electromagnetic theory and of statistical Mechanics. Kuhn [2] comments that "discovery commences with awareness of anomaly – the recognition that nature has somehow violated the paradigm induced expectation that govern normal science. Novelty emerges only with difficulty, manifested by resistance, against a background provided by expectation". It is not easy for shifting from the existing paradigm to a new paradigm. There is a stiff resistance from the scientists following the existing paradigm because of extravagance involved in retooling, similar to that happens in manufacturing. Retooling here means that all the scientists needed to be retrained in the new paradigm. Extreme efforts are made to avoid retooling and somehow explain the anomaly within the existing paradigm. If there is no way of reconciling the anomalous results in the existing paradigm only then the scientists develop new theory to explain the anomaly. There is a paradigm shift and knowledge progresses.

The account of progress of science through paradigm shift may have been correct before the time of Galileo. In modern science, the

paradigms rest on the bed rock of experimental results and so, there is an element of truth in it. The Newton's theory of gravitation has not been abandoned as it has been realized that it gives the same results under low gravity as the theory of Einstein, which is more exact but complex. In situation of high gravity, Newtonian mechanics will give wrong results and so, Einstein's theory is required. Similarly, the Quantum mechanics for sub-microscopic particles has correspondence with Newtonian mechanics valid for macroscopic bodies. So, new paradigms, which are more general and often more complex, extend the boundaries taking care of inadequacies arising in existing paradigm, which are relatively simpler but lacks in consideration. This paradigm still could be employed under certain circumstances. Thus, we still study Newtonian mechanics along with quantum mechanics and theory of relativity of Einstein.

## 2. Innovation

Innovation is neither invention nor discovery. One discovers the laws to solve mystery of nature and invents new ways of achieving something. Innovation is taking an idea through to result in a product or practice in real life. What is required to succeed in innovation? In the words of French author Portnoff [3], it requires 'intuition of a poet with strong technical background combined with the skill of engineer who can put the idea into practice, and that of entrepreneur who can turn it into a viable business.'

Scientific knowledge by itself may not benefit the society directly in improving the quality of life of its citizens. Why should the society pay for it if it is merely for the platonic purpose of revealing the mystery of nature? The expensive instrumental infrastructure as required for present day research (to confirm one may visit the research laboratories being set-up at IIT Mandi) requires considerable funding by the government on behalf of society. The profession of engineering has evolved to exploit scientific knowledge by innovative application to develop

technologies and products for use by the society. It does not mean that innovation always follows scientific knowledge. There are instances in the history of technology where innovation takes place before the governing scientific knowledge could evolve. Steam engine started working much before thermodynamics was formulated. Also, one may remember that it does not require a trained scientists or researcher for carrying out innovation. The common people often conceive innovative products like 'jugad' vehicles serving on the roads of North India. The walkman was invented by Akio Morita, the famous head of Sony and he persisted with it against the advice of the experts. The chip card was conceived by a journalist before it was taken up by the banking industry. There are large numbers of such examples.

Engineering proficiency is an important component of innovation. Thus, an engineer armed with the knowledge of science, including technical science, has a distinctive advantage as the innovative ideas often emerges from creative applications of scientific knowledge and extend benefit to the society. Today the distinction between the professions in science and engineering are getting increasingly blurred and there is strong cross current from one to the other. Many scientists are innovating products and are opening companies to market it successfully. However, there remains an interesting difference between the profession of the engineers and the scientists. Scientists are never called upon to speculate where there is gap in knowledge. But engineers are often required to do it. If a civil engineer has to construct a bridge over a river, he may ask for past water level data to design the height of the bridge from the river below but it is often not available. He will not be allowed a few years to collect the data and then design it. He has to use his speculative judgment, often from the data of possibly other similar rivers in the region, if available, to design and construct the bridge, only to find that it has been washed away next year and everybody is baying for his blood. This is a professional hazard an engineer has to

navigate because he often operates in a knowledge gap for the need of the society. He must develop the necessary social understanding and skill from the study of social sciences and ethics so that he may negotiate such hazards. Many students undergoing engineering education now-a-days believe that the study of courses on sciences and social sciences in their curriculum are sheer wastage of time. It is high time for the students to start pondering over the skills they need to work as an engineer and change their attitude towards these courses away from the core of their engineering expertise.

Engineers innovate to find real life ideas, which may often involve expertise from different areas of engineering. It has been observed that better innovation is done in a team. The team should comprise of members having as diverse background as available in persons of different region, culture and nationalities. Generally people from different backgrounds bring different ideas, approaches and perspectives on the table while evolving an idea, enhancing the capability of the team. Therefore, an engineer must be trained to work in a group. An understanding of human psychology and group dynamics is essential in an engineer for him to perform in a group or to lead it.

The engineering scenario has undergone a fundamental change. Earlier, in a manufacturing company, the life time of a product was very long and domestic market would eventually saturate in that time, leading to search for market abroad. The competition for market between industrialized nations was so fierce that it led to world wars. This danger has now receded because of an interesting change in strategy. One is competing with one's own product by innovating every few years the next generation product, which integrates more functions with better technology at lower cost. The earlier generation product thus becomes obsolete before its lifetime has exhausted. There is no market saturation. But the cost of this strategy is faster depletion limited material resources of nature while generating huge

amount of (often toxic) waste. If one follows the product evolution of mobiles, tv, computers and other consumer products, the strategy and its adverse impact become immediately apparent. An engineer to-day will have to serve and survive in this industrial environment by his ability to innovate.

It is not only important to innovate but one has to innovate the right product at the right moment. The failure to adapt to emerging digital technology brought Xerox to the brink of bankruptcy in 2000 and Polaroid became bankrupt in 2001. Kodak, Fuji, Nikon, Canon and Minolta sank billions in developing 'Advance Photo System' (APS), which combines electronics with traditional film when digital photography was about to emerge. If you have not seen rightly through your crystal ball, you waste precious resources and time for wrong innovation endangering the future of your company.

### **3. Ambience for Research and Innovation and IIT Mandi**

IIT Mandi is a new IIT and it has to develop appropriate ambience for research and Innovation. The faculty and students are coming from different parts of the country fully aware of the challenges facing our society. To meet these challenges, we have to bring upon all the scientific and technical knowledge at our command to chalk out a strategy. IIT Mandi offers pristine natural ambience of the Himalayan environment, which has inspired profound thoughts of Indian sages in the area of philosophy. Will we succeed in getting similar inspirations for science and technology? It appears that if we could combine this natural ambience with appropriate ambience for interaction to promote group activities, we will succeed in attaining excellence in research and innovation. Traditionally, we have created departments in the institutions of learning and with time, the departments have evolved into world of their own with rigid barriers preventing interaction with outside. Personal competition and rivalry within a department has become so

acute as to create further barrier between individuals. Two persons of the same department working in the same research area are not even aware of each other's work and so, their mutual references are rare in their publications. There is hardly any new idea emerging from Indian soil and we are busy in pursuing incremental research over the ideas generated elsewhere. It is therefore not surprising that even the best institutions attracting the best students from the country are hardly able to make international grade. This situation is inevitable unless we learn to interact amongst ourselves across the narrow barriers of the departments and contribute to generating new ideas. Now, the stress has shifted to interdisciplinary research where ideas are shared between widely different areas. For example, mathematics could borrow ideas from biology leading to evolution of neural network or genetic algorithm used widely for solving complex engineering problems. IIT Mandi has organised broad schools in order to bring together people of diverse background within and across schools. But to promote sincere interaction amongst them requires establishing a strong tradition of ethics to govern it. There should be trust that everybody will be legitimately credited and nobody will attempt to deprive others of their legitimate credits. To establish ethical tradition, we have to be uncompromising in condemning any deviation amongst us even if it may not concern us directly. However, this condemnation is for correction. We must learn appropriate soft skills to handle it pleasantly so that it may not lead to enmity, which will adversely affect the ambience.

The students are important resources for novel ideas in research and innovation as their mind has not yet been confined in the standard box of a paradigm. We must encourage and inspire the students at different levels to participate in the current research and innovation undertaken by the faculty. Our students have a dream of making their millions with innovative ideas and

this provides a strong motivation to get trained in this area and this training is critical for their professional success as emphasized earlier. In India, we do not get much of opportunity of doing things with hand and so, we lack the skill of implementing ideas. This weakness has to be overcome. IIT Mandi is encouraging the students to generate innovative ideas and then, implement them through design practicum and other similar courses. Our curriculum should be so designed that there is adequate scope for the students to get involved in research and innovation. Those interested to participate in these activities even outside the ambit of curriculum, must have adequate opportunity to do so. I wish if the students could have access to a small workshop outside academic hours so that their ideas generated outside curriculum, may find expression into prototypes.

#### 4. Concluding Remarks

In the present article, the nature of research and innovation has been highlighted with special emphasis on the necessity of wider interaction and the importance of working in a group. To establish tradition of strong ethical standards is essential for creating appropriate ambience for group work, which makes evolution of worthwhile ideas possible. In my opinion, the success of IIT Mandi depends critically on our ability to create healthy interactive environment and there is no reason for us to fail if we join efforts sincerely to achieve this goal..

#### References:

- 1) Born M., 1956, Physics of My Generation, Pergamon Press, p.7
- 2) Kuhn T., 1962, The structure of Scientific Revolution, University of Chicago Press, p.23-43.
- 3) Portnoff Andre-Yves, 2003, Pathways to Innovation (Translation by Ann Johnson), Futuribles, p.21

# INTERVIEW

With

Nobel laureate

**Professor Richard R. Ernst**



*Prof. Richard Robert Ernst (born August 14, 1933) is a Swiss physical chemist and Nobel Laureate.*

*Born in Winterthur, Switzerland, Prof. Ernst was awarded the Nobel Prize in Chemistry in 1991 for his contributions towards the development of Fourier Transform nuclear magnetic resonance spectroscopy while at Varian Associates, Palo Alto and the subsequent development of multi-dimensional NMR techniques. These underpin applications of NMR both to chemistry (NMR spectroscopy) and to medicine (MRI). He also received the Louisa Gross Horwitz Prize in 1991.*

*Prof. Ernst has been a great inspiration to large number of scientists and researchers all across the world.*

*By Athar Aamir Khan*

It has been a great pleasure for us to be able to interact with Prof. Richard Ernst. He gave us a deep insight into his life and his contributions as a scientist. Here are the replies of Prof. Ernst to the questions we asked.

**How did the fascination for chemistry come in your life?**

My life, so far, was full of chemical excitements, and I can confirm: A chemist remains a chemist for his lifetime!

I have been telling my life story already hundred times, but its accidental beginning still fascinates me : A curious, 12 years old boy discovering in 1945 in the attic of his house in Winterthur, Switzerland, chemicals collected by an uncle, Karl Ernst, who died in 1923, and whom he obviously never met. The chemicals were originally used for developing photo plates. In the hands of an adventurous boy, their mixing often led to unexpected reactions and explosions that stimulated his desire to lift all chemical mysteries. - Our house, built in 1898 by my grandfather, Walter Ernst, was originally enlightened by city-gas illumination. The original tubing still existed in my time, 1945. So it was easy to attach a Bunsen burner for converting a storage room in the basement into a veritable chemistry lab. Running water was a bit more difficult to come by. But the abandoned tiny photographic darkroom, used by my deceased uncle, still survived after more than twenty years, and served as my source for tap water. - Our house was from the basement to its attic an inexhaustible treasury house, an environment in which one would wish all young people to grow up. How could they miss in such a paradise the chance of becoming explorers or, in the best case, experimental chemists? And it worked, unintentionally, in my case to all extents and I became a passionate spare-time chemist, of course without anticipating ever receiving great science prizes for my curiosity.

Later, while working at ETH Zürich, I had no longer a need for a "hobby-chemistry lab". Not much remained of it, except for some pre-1923

bottles that moved 1977 with us to our newly built home again in Winterthur. At that time, I did not plan for another hobby chemistry lab. Chemistry had long before turned into my “earnest” profession. My other passions, emerging besides chemistry, playing the cello, and much later collecting Tibetan painting art did not require chemical facilities. The passions were rather complementary to my “professional” activities, each with its own personal relevance and fascination, as I will explain briefly in the following.

Playing music fascinated me already very early in my youth, much before my interest for chemistry emerged from the mentioned discovery in the attic. I was born as an introverted person with difficulties to establish verbal human contacts. Music became a way to live out my inhibited emotions. Fortunately, I grew up in the midst of a spectacular musical atmosphere; our old house stood just 100 meters from the home of the legendary music patron of Winterthur, Werner Reinhart. Many world-famous musicians were guests in his hospitable house just across the street from ours, and some of them were composing immortal music for him and for the Winterthur symphony orchestra in which he occasionally played the basset horn and the bass clarinet. Among them were Igor Stravinsky, Anton Webern, Paul Hindemith, Arthur Honegger, Frank Martin, Adolf Busch, and Othmar Schoeck. Inspired by these musical heroes, whom I often met at the frequently closed railroad gate when going to school, I started to play the cello and to compose music myself. Most of it has never been performed nor deserves a performance. But looking back, the creativity of composing music was for me similarly satisfactory as writing a scientific manuscript in my later years.

Music developed for me into a most relevant societal link, also towards my wife Magdalena as her love for music exceeds the one for chemistry. Actually, we met for the very first time at a private musical party; she played the violin and I the cello, and it seemed to

harmonize. - My attraction to music possesses also historical aspects. The Musikkollegium Winterthur is an ancient institution, dating back to 1629. From its beginning, gifted members of the family Ernst were actively taking part in musical performances. My musical interests developed, so to say, by default and were relevant for my participation in local social activities. They allowed me to interact also with my "non-chemical" fellow-citizens. I still remember how some passengers in the commuter train wrinkled their noses and even opened the windows near to me, during my returning in the evening to Winterthur after having spent 8-10 hours in a smelly chemistry lab at ETH Zürich! This revealed to me how much chemistry was disliked by my philistine compatriots!

My relation to Tibetan and Central Asian painting art has a more direct chemical relevance. The fascination for Asian art developed accidentally during a touristic journey through Asia, and particularly Nepal, in 1968, while returning to Switzerland after having spent four and a half professional years at Varian Associates in Palo Alto, California. At Varian, I was successful by introducing the Fourier transform concept that increased the sensitivity by several orders of magnitude [4]. It gave NMR a major push and finally led to my “little Prize” received in Stockholm in December 1991. In order to keep this short essay in bounds, I refrain from a discussion of my research work in NMR spectroscopy.

My unexpected encounter with Tibetan Buddhist art in Nepal was indeed “love on the first sight”. I was immediately fascinated by the bold colorfulness of the paintings and the skillful drawing of great details. This art has, at the same time, the qualities of naive children’s art and of most sophisticated and expressive mediaeval European art. It is art conceived and executed by “unspoiled” pure minds that have not yet learned to depict pseudo-feelings of a decadent and money-minded Western “high” society. Although Tibetan art from beyond the

Himalayas is reflecting a culture shockingly alien to ours, the colorful paintings allow for a direct non-verbal access, revealing an enormously rich world. It was for me a true discovery opening the door to a marvelous spiritual and artistic domain. I felt like “profane chemist” having gotten access to a spiritual paradise, to the “Pure Land” or Sukhavati, using a Sanskrit Buddhist term.

No, I did not convert into a Buddhist, nor am I particularly religiously inclined; but this experience widened my perception for spiritual concepts and for non-verbal expressions of eternal truths. While we chemists are using chemical formulas for representing structures and chemical reaction pathways, in the spiritual context, metaphors, symbols, and rituals have equal importance to express abstract philosophical concepts independently of a particular language, and become universally understandable. I was struck by a wealth of similarities and correspondences between Eastern and Western philosophies and religions. Having once become acquainted with one particular language or philosophy, one may comprehend others without much difficulty; they all emerge from similar human minds and use related symbols or metaphors.

Since 1968, Magdalena and I have established in our home a sizeable collection of ancient Tibetan and Central Asian, mostly Buddhist, paintings from the 12<sup>th</sup> to the 19<sup>th</sup> century. Today, they decorate virtually all the available walls. My curiosity was stimulated as much as by my first encounter with chemistry in the attic of our old house in 1945. I was inspired to acquaint myself with the complexity of Central Asian history that evolved during the past 1000 years; I had to learn about the depth of Buddhist philosophy and symbolism in order to comprehend the secret messages of the beautiful paintings; and I got insight into the Tibetan life style that is depicted in all details within the religious and historical pictures. All aspects of the Tibetan daily life are intimately related to the Buddhist view of life and tradition. This

renders these paintings invaluable sources on Tibetan culture and philosophy in the past and present.

Technically speaking, the paintings are skillful products of “applied chemistry”, of “Angewandte Chemie”. Here, the relation between chemistry and painting art is becoming obvious and highly relevant for art conservation. In the course of maintaining our precious collection of Central Asian paintings, I started to realize that art conservation is one of the most demanding scientific occupations conceivable. The range of relevant scientific aspects is breathtaking, from knowledge of the painting materials: support, grounding of the support (the so-called gesso), to the traditional binders and to a wide variety of natural and synthetic pigments. The application of quite delicate natural pigments requires a lot of skill and experience, and chemical knowledge is indeed indispensable.

After my compulsory professional retirement in 1998, I set out to properly equip a small “art conservation laboratory” within our private home, converting a hobby crafting room into a tiny specialized analytical spectroscopy and restoration lab. I needed to add facilities for the chemical, microscopic, and spectroscopic analysis of the paintings, for the cleaning of the painting surface from centuries of surface soiling, for retouching minor damages of the pigment layer, and for repairs of the Chinese silk framing of the paintings. Each step comprises of highly delicate and demanding aspects that can be handled only by experienced experts, who themselves are often coming to their own limits of skill and expertise.

Before attempting to consolidate or restore damaged details within a precious ancient painting, it is necessary to learn as much as possible on the chemical aspects of the painting materials that have been applied by the ancient artists. Obviously, of primary interest are the painting pigments. My first acquired optical tool was a Stereomicroscope Zeiss Stemi SV11 with objectives, polarizer and photographic

equipment. The microscope was mounted on a sufficiently large and stable mobile gantry to cover paintings up to 2 m<sup>2</sup>. A stereo microscope is indispensable for the study of pigment layers and for the restoration of minor damages by a very fine brush and a tungsten needle.

Initially, I applied my practical chemical knowledge in wet chemistry, remaining from my first semester chemistry lab course, to identify under a Zeiss Axiolab microscope some of the pigments. In many cases, it was sufficient to identify a characteristic metal ion that uniquely identified, together with its color, the inorganic natural or synthetic pigment. In the case of blue pigments, for example, the presence of copper verified azurite, iron led to Prussian blue, and aluminum to ultramarine or natural lapis lazuli. However, the application of my first-semester chemistry was invasive and required appreciable amounts of sample to be taken crudely from the painting. Performing characteristic color reactions under a stereo microscope reduces the need for large samples; but in the case of the extremely fine Tibetan and Mongolian paintings, where a painted eye might consist just of a single grain of pigment, the limits of tolerable sampling are rapidly approached.

My respect for the integrity of ancient paintings forced me to switch as soon as possible to non-invasive modes of spectroscopy without any need of sample-taking. Not all kinds of spectroscopy are applicable for non-invasively examining painting art. For example, my beloved NMR, is often unsuited because paintings are too bulky for fitting into a narrow-gap NMR spectrometer; and NMR techniques are frequently not sensitive enough for examining the thin layers of pigments applied by the artist.

The most ideal known analytical technique for pigment studies is Raman spectroscopy. Molecular vibrations are excited by a laser beam and the specific emission lines are observed. Raman is non-destructive, if used with some care not to burn holes into the canvas by

excessive laser power, and it is truly a molecular analysis technique, measuring indirectly the vibration frequencies of molecules or of crystalline material. Raman spectroscopy can also be implemented on relatively small space, becoming the method of choice for the narrow analytical laboratory in my private home. It was not too difficult to adapt a commercial Raman microscope to the study of quite large scroll paintings. The Bruker-Optics SENTERRA Raman microscope was mounted on a sufficiently spacious gantry to accommodate paintings up to one square meter or more. Any desired spot could then be reached by the microscope objective under computer control. Sometimes, it is not even necessary to unframe a painting as the Raman measurement is also possible through a painting's mineral cover glass, but not through Plexiglas.

### **What has been the biggest influence and motivation in your life that finally culminated into a Nobel Prize?**

My biggest motivation was to do good and well respected work, so that I could become a respected citizen, overcoming my inferiority complex.

### **What do you think is involved in being a great scientist?**

I do not think that "great" is the proper term. I think it is sufficient to perform adequately and as well as ever possible. Properties such as honesty, helpfulness, and compassion are of great importance.

### **NMR inarguably as a very powerful tool for determining molecular structure has revolutionised chemistry. At the beginning did you have the idea that it would become such a powerful tool? Can you briefly describe what brought you to work in the field of NMR spectroscopy?**

I did not choose NMR myself, I was pushed into it by my supervisor, and I liked it. I did not

think that NMR was the greatest technique, but I was assigned to this project and I wanted to do my work as well as ever possible.

**Can you shortly tell us about your contributions to NMR spectroscopy that culminated in the award of a Nobel Prize?**

I very simply introduced the Fourier transformation in order to implement parallel data processing and increasing the sensitivity by orders of magnitude, a very simple trick!

**What do you feel about the current public understanding of NMR Spectroscopy?**

It is of great advantage that NMR has with MRI a highly successful clinical application. Therefore, people know about it. They hardly know the analytical chemical features.

**What is your take on the quality and quantity of ongoing research?**

The present research front is very wide and a lot of good work is being done in various fields, especially in the biologically and medically relevant aspects.

**How important do you think Nobel Prize has been in your life?**

The Nobel Prize gave me a voice with which I can address virtually all communities and people are normally attentive. Without a Nobel prize, they would either stay away or sleep!

**You have been very concerned about the university systems. What do you think are the major current drawbacks and possible ways to reform?**

To be specific, I do not think India has a good university atmosphere. Too much is just learned by heart without much creativity and originality. In the West, the situation is better, but could still be improved: more personal involvement, more creativity, and out of the way thinking.

**As a path-breaker in science what advice do you have for the researchers and students who are reading this interview?**

Honesty is the greatest property. Be self-critical, never believe what you have done and check it over and over again. Be cooperative with your colleagues; help them rather than stealing ideas.



# Thermo-physical modeling of Laser-Therapy for Cancer

**Dr. Niraj Sinha**, Assistant Professor,  
School of Engineering, IIT Mandi.



*Dr. Sinha has received his PhD from University of Waterloo and has worked as post doctoral fellow at Massachusetts Institute of Technology.*

*His research interests are in the areas of manufacturing, materials science, nanotechnology and bioengineering.*

and

**Dr. Ankit Bansal**, Assistant Professor  
School of Engineering, IIT Mandi



*Dr. Bansal has received his PhD in Mechanical Engineering from the Pennsylvania State University.*

*Dr. Bansal specializes in radiative heat transfer and spectral modeling of radiative properties in thermal plasma. He is currently involved in Stochastic modeling of infectious disease and radiative heat transfer for applications related to cancer treatment.*

Cancer is the most common malignancy with over 10.9 million people diagnosed each year worldwide. Approximately 60% of cancer patients go through radiation therapy as a means of the treatment. If the radiation is delivered from outside the body, photon energies of several million electron volts are needed to reach deep-seated tumours. Use of high intensity doses may damage healthy tissues laterally. Delivering radiation dose only to cancerous cells is a great challenge in the radiation therapy. An ideal strategy for improvement of radiotherapeutic efficacy against human cancer is to effectively deliver radiosensitizer to target tumour cells, causing preferentially increased tumour cytotoxicity, while simultaneously protecting normal tissues and organs. It has been found that the dose delivered to a tumour during photon-based radiation therapy can be enhanced by loading high atomic number (Z) materials into the tumour. To this end, radiosensitization using gold nanoparticles (AuNPs) seems a very promising approach for radiotherapy as they are biologically inert and because nanoparticles (NPs) can more easily penetrate the tumour vasculature.

## Heat Transfer in Biological Tissue with External Irradiation

In radiotherapy, tissue or tumour cells are irradiated with a collimated or converging radiation source. The radiation source can be either collimated or focusing. The collimated radiation beam requires high power and long exposure time to sufficiently achieve the desired effect. This leads to significant heat diffusion which will damage the surrounding healthy tissue. In contrast, the converging beam could penetrate a greater depth and significantly increase the incident power at the target, avoiding undesirable reactions in the surrounding healthy tissues. Nanoparticles attached to the tissue cells absorb the radiation energy and gets heated. Long laser pulses—with pulse duration exceeding the thermal relaxation time—cause heating of the surrounding medium along with the nanoparticles, as heat diffuses across the particle boundary. On the other hand,

if the pulse duration of the radiation source is short, the radiation

energy can be confined within the particle for some duration of time, which may cause rapid heating of particles and melting and evaporation of the particle material. As a consequence, this will lessen thermal damage to the surrounding healthy tissues. Introduction of ultrafast pulsed lasers into radiotherapy have significantly improved the damage localization over continuous wave and general pulsed lasers. There are five types of laser-tissue interaction mechanisms, which are summarized below [1-3]:

1. Photochemical Interactions: Radiation can induce chemical effects and reactions within macromolecules or biological tissue. These interactions take place at low power density ( $1 \text{ W/cm}^2$ ) and long exposure time ranging from seconds to continuous wave.

2. Photothermal Interactions: Radiation energy is absorbed by a chromophore (a light-absorbing molecule) and converted into thermal energy, which can cause a range of thermal effects from temperature change, tissue coagulation to vaporization.

3. Photoablation Interactions: This interaction is caused by the absorption of high-energy ultraviolet (UV) radiation. The high-energy UV radiation results in the dissociation of the molecular bonds. This phenomenon is followed by a rapid expansion of the irradiated volume and ejection of the tissue debris from the surface.

4. Plasma-Induced Ablation: In this type of interaction, a free electron is accelerated by the intense electric field of radiation beam. The accelerated electron collides with a molecule and frees another electron, initiating a chain of reactions of similar collisions to form plasma.

5. Photodisruption: A number of mechanical effects, such as bubble formation, cavitation and

shock wave generation accompanied with plasma-induced ablation.

For a laser-tissue thermal interaction, the increase of local temperature due to the laser irradiation is the most significant measure. In clinical laser therapies, accurate prediction of temperature distributions and heat transfer rates in biological tissues is very crucial [4]. The thermal impact on tissue changes drastically when temperature exceeds  $43^\circ\text{C}$ ; with the rate of cell kill increasing by a factor of two for every  $1^\circ\text{C}$  increase, and decreases by a factor of 4-6 for every  $1^\circ\text{C}$  drops below  $43^\circ\text{C}$  [4]. It has also been noticed that tumour cells are more sensitive to temperature increase than normal tissues. The temperature rise in biological tissues under radiotherapy primarily depends on radiation source such as power density, pulse duration, spot size and repetition rate. It also strongly depends on the optical, thermal and physiological properties of the biological tissues.

Biological tissues contain dispersed cells separated by voids, perfused with blood from arteries and capillaries. The main mechanisms of energy transport in biological tissues are thermal conduction across the tissue and convection due to blood perfusion. The energy transport in a biological system is usually expressed by the bioheat equation developed by Pennes[5] through a series of experiments measuring temperatures of human forearms. Thus, as the blood leaves the control volume it carries away energy, and hence acts as an energy sink in hyperthermia treatment. For short duration radiation pulses, the influence of convection due to blood perfusion plays a minor role and can be neglected. A complete model of heat transfer in a biological tissue with nanoparticles must address the interaction of laser radiation with the particles: heating, melting, and heat removed from the particle by heat conduction and thermal radiation. In ultrafast radiative heat transfer (where the pulse

duration of the laser is very small, of the order of the characteristic radiation propagation time in the medium), transient radiative heat transfer must be taken into account. The simulation of the transient radiation transport process necessary to analyze the short pulse laser propagation through tissue medium is more complicated than the traditional steady-state analysis. The hyperbolic wave nature of the equation coupled with the in-scattering integral term makes the radiative transport equation (RTE) an integro-differential equation and, thus, extremely difficult to solve accurately and time efficiently.

Optical properties of the particles required in the solution of the RTE are obtained from Mie's theory [6]. The radiative heat transfer equation can be solved for general geometries using a number of approximate methods, such as the discrete ordinate method (DOM), the spherical harmonics ( $P_n$ ) method, and the statistical Monte-Carlo method. Since biological tissues are generally highly scattering against laser irradiation, a two-dimensional (2-D) transient analysis is more appropriate to accurately capture the propagation of a short pulse beam in multi-dimensional geometries.

Between two successive radiation pulses, diffusion of thermal waves through conduction across the tissue is required. This is modelled through transient Fourier conduction model. The traditional Fourier heat conduction is described by a parabolic diffusion equation which has an infinite speed of thermal propagation, indicating

that a local change of temperature and/or heat generation causes an instantaneous perturbation in the entire temperature field. However, for ultra-short duration heat pulses heat wave theory is more appropriate to use.

### References:

- 1) Jian, J. and Zhixiong, G., "Thermal Interaction of Short-Pulsed Laser Focused Beams with Skin Tissues," *Physics in Medicine and Biology*, Vol. 54, 2009, pp. 4225–4241.
- 2) Huang-Wen, H. and Chihng-Tsung, L., "Review: Therapeutical Applications of Heat in Cancer Therapy," *Journal of Medical and Biological Engineering*, Vol. 32, 2012, pp. 1–11.
- 3) M., N., *Laser-tissue interactions: Fundamentals and Applications*, Springer Verlag, 2003.
- 4) S. W., J., H., L., and W. R., C., "Temperature control in deep tumor treatment," *SPIE*, 2003, pp. 210–216.
- 5) H. H., P., "Analysis of tissue and arterial blood temperatures in the resting human forearm," *J. Appl. Physiol.*, Vol. 1, 1948, pp. 93–122.
- 6) Stephan, L. and Mostafa, E. A., "Shape and size dependence of radiative, nonradiative and photothermal properties of gold nanocrystals," *Int. Reviews in Physical Chemistry*, Vol. 19, 2000, pp. 409–453.
- 7) Z., G., J., A., B. A., G., and S., K., "Monte Carlo simulation and experiments of pulsed radiative transfer," *Journal of Quantitative Spectroscopy and Radiative Transfer*, Vol. 73, 2002, pp. 159–168.

# Piezoelectric Properties of Diphasic Ferroelectric PZT–PVDF and PZT–PMMA Composites

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## Abstract

Ferroelectric ceramic-polymer composites are of special interest in transducer/sensor applications because of their several advantages over pure ferroelectric ceramics. The composites have improved mechanical properties, low density and better durability. In this work, the piezoelectric properties of PZT-Polymer composites of 0-3 connectivity, prepared by hot-press technique are presented, wherein a ferroelectric polymer PVDF and a non-ferroelectric polymer PMMA were used as matrices. The density, piezoelectric strain coefficient  $d_{33}$ , piezoelectric voltage coefficient  $g_{33}$ , dielectric constant  $k$  and microhardness of the two types of composites measured as a function of volume fraction of PZT in the polymers indicate that the PZT–PVDF composites exhibit better piezoelectric sensitivity than PZT–PMMA composites, which could be attributed to the ferroelectric nature of the polymer PVDF.

## 1. Introduction

The best known material for piezoelectric applications is the ferroelectric ceramic lead zirconate titanate (PZT). PZT has high piezoelectric parameters, making it an extremely sensitive sensor/actuator material. But it has the disadvantage of being highly dense and brittle. To get a less dense and more compliant ferroelectric material, composites of PZT and polymers have been proposed and widely studied [1-3]. The properties of the composites can be tailored by changing the connectivity of the phases and the volume fraction of the ceramic in the composite. Of the ten different connectivity patterns [1], 0-3 connectivity is the simplest and easily achievable.

The parameters of interest in the application of these materials as transducers are the piezoelectric strain coefficient ( $d$ ), piezoelectric voltage coefficient ( $g$ ), piezoelectric constants ( $e$  and  $h$ ), electromechanical coupling factor, density and mechanical parameters such as compliance constant and mechanical strength. The  $d$  and  $g$  coefficients measure the

performance of piezoelectric sensors in the receiver mode whereas the  $e$  and  $h$  coefficients are used to express the ability of the piezoelectric actuators in the transmitting mode. The piezoelectric constants  $d$ ,  $g$ ,  $e$  and  $h$  are tensors of rank 3. They are defined by as below [3],

$$d_{ij} = \left( \frac{dD_i}{dT_j} \right)_E = \left( \frac{dS_j}{dE_i} \right)_T$$

$$g_{ij} = \left( \frac{dE_i}{dT_j} \right)_D = \left( \frac{dS_j}{dD_i} \right)_T$$

$$e_{ij} = \left( \frac{dD_i}{dS_j} \right)_E = - \left( \frac{dT_j}{dE_i} \right)_S$$

$$h_{ij} = - \left( \frac{dE_i}{dS_j} \right)_D = - \left( \frac{dT_j}{dD_i} \right)_S$$

Here  $i = 1,2,3$  and  $j = 1, 2, 3, 4, 5,6$ .  $T_j$  is the stress (tensor of rank 2 expressed in matrix notation),  $S_j$  is the strain (tensor of rank 2 expressed in matrix notation),  $E_i$  is the electric field (vector) and  $D_i$  is the electric displacement (vector). In this work, the piezoelectric parameters  $d_{33}$ ,  $g_{33}$ , dielectric constant  $k$ , and microhardness are studied as a function of volume fraction of PZT in the polymers PVDF and PMMA. Here 3 refers to the poling direction. The parameters  $d_{33}$  and  $g_{33}$  are denoted by  $d$  and  $g$  in the rest of the text.

In this work, a ferroelectric polymer, polyvinylidene fluoride (PVDF) and a non-ferroelectric polymer, polymethyl methacrylate (PMMA) were used along with PZT to prepare composites of 0-3 connectivity and their piezoelectric properties were studied.

## 2. Experimental Methods

The PZT powder was purchased from American Piezoceramics. The polymers PVDF and PMMA were from Aldrich chemicals. The

composites were prepared by hot-press technique described in literature [4]. The solvent used was dimethyl formamide (DMF) for PZT–PVDF composite and acetone for PZT–PMMA composites. Samples of specific dimensions were obtained by applying a pressure of  $115 \times 10^6 \text{ Nm}^{-2}$ . The samples were electroded on both the faces using conductive silver epoxy (Chemtronics USA). The electroded samples were poled at  $3.5 \times 10^6 \text{ Vm}^{-1}$  for one hour at  $120^\circ\text{C}$  for PZT–PVDF composites and at  $90^\circ\text{C}$  for PZT- PMMA composites, depending on the melting point of the respective polymer. For poling, the sample was kept immersed in silicone oil bath to ensure uniform heating and to avoid arcing. It is to be mentioned that the samples suffered electrical breakdown frequently and several experiments need to be performed.

Volume fraction of PZT in the polymer (%)	Density values of PZT–PVDF composites ( $10^4 \text{ Kg m}^{-3}$ )		Density values of PZT–PMMA composites ( $10^4 \text{ Kg m}^{-3}$ )	
	Theoretical	Experimental	Theoretical	Experimental
10	2.37	2.03	1.84	1.78
20	2.96	2.59	2.49	2.36
30	3.56	3.04	3.14	2.92
40	4.15	3.47	3.79	3.59
50	4.74	4.26	4.45	4.18

Table 1. Comparison of the theoretical and experimental density values of PZT–PVDF and PZT–PMMA composites

The density of the composite samples was determined by knowing the mass and volume. The mass of the samples was measured using a digital balance of 0.1 mg resolution and the volume was determined from the dimensions. The dielectric constant of the samples, at a fixed frequency of 1 KHz, was measured using a Piezometer (Take Control Piezometer System PM35) in mode C. The piezoelectric strain coefficient ( $d$ ) of the composite samples was measured using the Piezometer System in mode D. The frequency of the dynamic force was fixed at 103 Hz. The microhardness of the composite samples were measured using

Mitituo Micro Vickers Hardness Tester at a load of  $25 \times 10^{-3}$  Kg.

### 3. Results and Discussion

The theoretical density values of the composites are calculated using the rule of mixtures:

$$\rho_c = \rho_1(1 - \phi) + \rho_2\phi$$

where  $\rho_c$  is the density of the composite,  $\rho_1$  is the density of the matrix (polymer) and  $\rho_2$  is the density of the ceramic (PZT) and  $\phi$  is the volume fraction of PZT in the polymer. The experimentally determined density values are compared with the theoretical values (obtained from literature) for all the composites and are tabulated in Table 1. For PZT–PVDF composites the experimental density values are in the range of 86% to 90% of the theoretical values while for PZT–PMMA composites they are in the range of 91% to 98% of the theoretical values. This can be attributed to the better compaction of the PZT–PMMA composites than the PZT–PVDF composites. The variation of the dielectric constant as a function of PZT volume fraction for the two types of composites is presented in Figure 1. The dielectric constant of PZT–PVDF composites is higher than that of PZT–PMMA composites, since the dielectric constant of PVDF is higher than that of PMMA

The variation of piezoelectric strain coefficient,  $d$  for the PZT–PVDF and PZT–PMMA composites as a function of volume fraction of PZT is shown in Figure 2. The  $d$  values of PZT–PVDF composites are significantly higher than those of PZT–PMMA composites, which could be attributed to the ferroelectric nature of the polymer PVDF.

The piezoelectric voltage coefficient,  $g$  is related to the piezoelectric strain coefficient,  $d$  by the following relation [5], where  $k_0$  is the permittivity of free space ( $8.854 \times 10^{-12}$  F m<sup>-1</sup>).

$$g = \frac{d}{k_0 k}$$

The variation of  $g$  as a

function of volume fraction of PZT in the polymers is shown in the Figure 3.

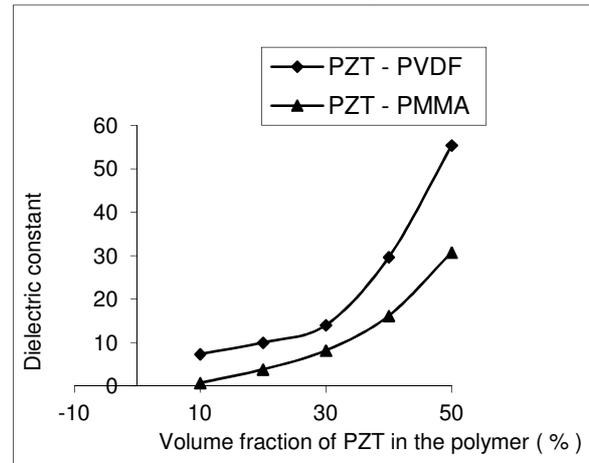


Figure 1. Dielectric constant ( $k$ ) as a function of volume fraction of PZT in the polymer

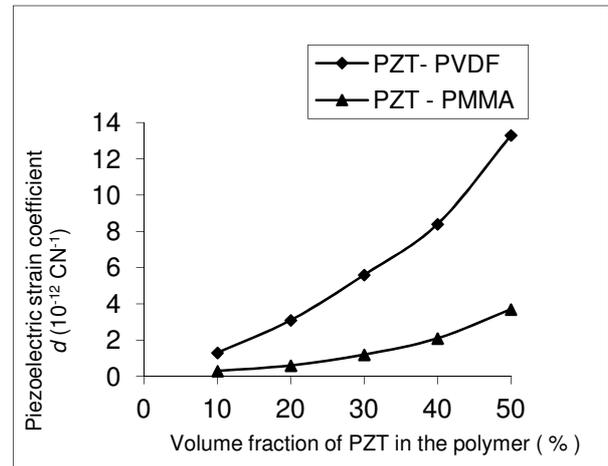
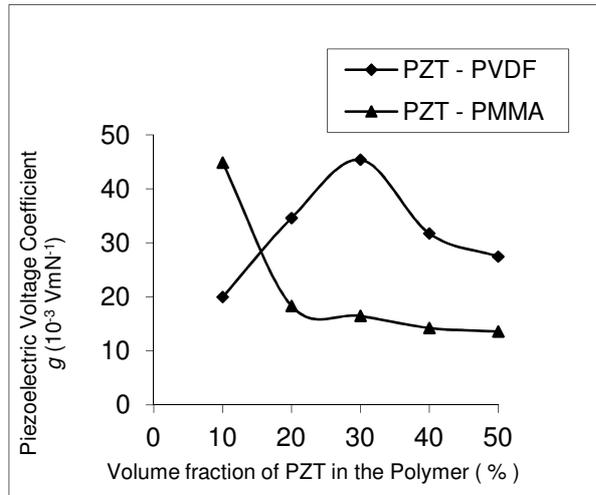


Figure 2. Piezoelectric strain coefficient ( $d$ ) as a function of volume fraction of PZT in the polymer

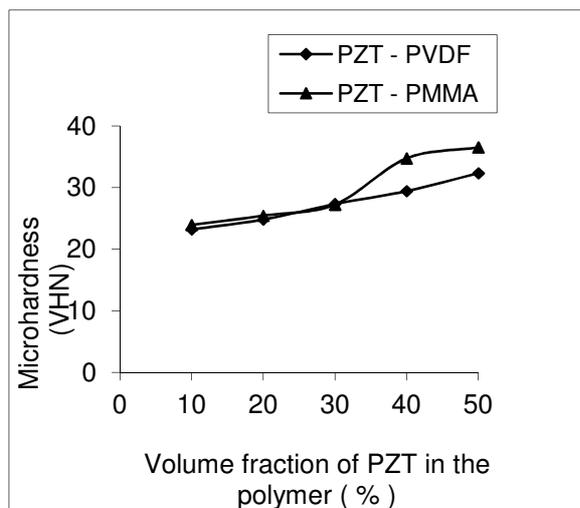
Since  $g$  is the ratio of  $d$  and  $k$ , the variation of  $g$  depends on the variation of the two parameters ( $d$  and  $k$ ). For PZT–PVDF composites  $d$  increases steadily with increasing volume fractions, whereas the dielectric constant has a steep increase beyond 30% volume fraction, which leads to a peak value of  $g$  at 30%. For PZT–PMMA composites the variation of  $d$  with volume fraction is insignificant at low volume fractions (up to 20%) whereas the dielectric constant shows a steady increase with volume fraction up to 50% volume fraction. This results in a sharp decrease in  $g$  for the composite at a volume fraction of 20%. Beyond 20% both  $d$

and  $k$  vary almost linearly and so  $g$  remains almost constant in this range.



**Figure 3.** Piezoelectric voltage coefficient ( $g$ ) as a function of volume fraction of PZT in the polymer

The microhardness values of the two types of composites as a function of volume fraction is shown in Figure 4. The microhardness of the two composites are nearly equal up to 30% volume fraction of PZT. Beyond 30% the microhardness of PZT-PMMA composites is about 15% higher than that of PZT-PVDF composites. This is attributed to the better compaction of PZT-PMMA composites compared to PZT-PVDF composites at higher volume fractions, which is evident from the density values.



**Figure 4.** Microhardness as a function of volume fraction of PZT in the polymer

## Conclusion

The results show that the piezoelectric parameters  $d$  and  $g$  are reasonably higher for PZT-PVDF composites than those for PZT-PMMA composites for volume fractions greater than 20%. These high values are mainly attributed to the ferroelectric nature of the polymer PVDF. The polymer PVDF is more compliant than PMMA and hence PZT-PVDF composites have better mechanical stability than PZT-PMMA composites. These results reveal that PZT-PVDF composites are more suitable for transducer applications than PZT-PMMA composites. However, PZT-PMMA composites do exhibit reasonable piezoelectric and mechanical properties. Since the polymer PVDF is relatively expensive, replacement of PVDF with PMMA would result in more cost-effective transducer material with some compromises in piezoelectric and mechanical properties.

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## References

- 1) R. E. Newnham (1978), *Mater. Res. Bull.*, 13, 525.
- 2) T. R. Shrout et al. (1979), *Mater. Res. Bull.*, 14, 1553.
- 3) T. Furukawa, K. Ishida, E. Fukada (1979), *Japan. J. Appl. Phys.*, 50, 4904.
- 4) E. Venkatragavaraj, B. Satish, P. R. Vinod, M. S. Vijaya (2001), *J. Phys. D: Appl. Phys.*, 34, 487.
- 5) K. Uchino (2000), *Ferroelectric Devices*, Marcel Dekker.

# Material Selection for Engineering Design

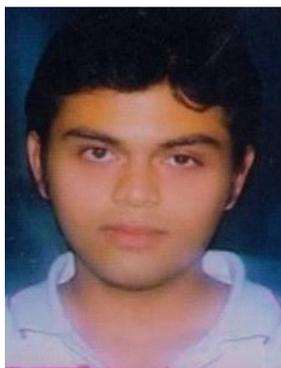
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Materials play an important role in engineering design. Engineer needs to find materials with specific properties, which can be used to achieve the required system performance and/or other requirements. To this end, the design task is often focused on comparing the properties of a finite set of materials and selecting the best. It is important to note that more than 160,000 useful materials including metallic alloys, nonmetallic engineering materials such as plastics, ceramics and glasses, composite materials, and semiconductors are exist. This large number of materials and enormous number of manufacturing processes available to the engineers, coupled with the complex relationships between different selection parameters, often make the selection of materials for a given component a difficult task. In selecting materials, engineers have to take into account a large number of properties. These material properties include mechanical properties (Young's modulus, strength, yield stress, elasticity, fatigue, creep resistance, ductility, hardness and toughness), physical properties (crystal structure, density, melting point, vapor pressure, viscosity, porosity, permeability, reflectivity, transparency, optical properties, dimensional stability), magnetic properties, electrical (resistivity, permittivity, dielectric strength), thermal and radiation (specific heat, conductivity, expansively, diffusivity, transmissivity, reflectivity, emissivity), surface (texture, corrosivity, wear resist), manufacturing properties (machinability, formability, weld ability, cast ability, heat treatability, etc.), material cost, reliability, durability, recycle ability, material impact on environment, performance characteristics, availability, fashion, market trends, cultural aspects, aesthetics, etc. Beside these aspects, recently user-interaction aspects such as appearance, perceptions and emotions are considered in material selection.

Fig. 1 shows systematic approach for material selection. It is clear that material selection is a decision that has to be made based on several considerations. Such a decision making process

can be classified and solved by Multiple Criteria Decision Making (MCDM) technique. MCDM techniques have been used for decision making since a long time but found their way to material selection only recently. MCDM techniques may be further divided into two techniques namely Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM). Various material selection methodologies are shown in Fig. 2. MODM techniques rely on the functional interdependency between the various attributes associated with the material and based on design constraints. These functional requirements are then used to formulate figures of merits (FOMs) based on one or more goals of the design that the designer wants to achieve or maximize, it can be minimum weight, highest strength or lowest cost. Thus, these FOMs provide a scale of comparison for various material candidates. Alternatives with higher value of FOMs are preferred. Pioneer work in this field has been done by M. F. Ashby. Ashby divided performance index  $P$  of any engineering component as  $P = f(F,G,M)$ , where 'f' denotes function of functional (F), geometric (G) and materials (M) parameters, respectively. These parameters are independent of each other and their collective output determines the overall performance of the component [1].

MADM technique on the other hand relies on predetermined mathematical models to rank and compare the materials based on their attributes [3-5]. Some of these techniques are data driven while others are method driven. Numerous MADM methods have been reported and found to be promising for the purpose of material selection [2]. However, as is with any method, every selection and ranking technique has its own shortcomings and drawbacks. Ashby technique is an efficient method and directly correlates the effect of various physical parameters on the overall performance of a device

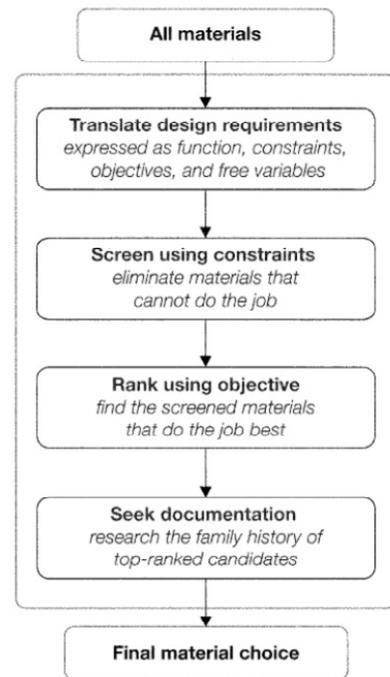


Fig. 1: Material selection strategy [1]

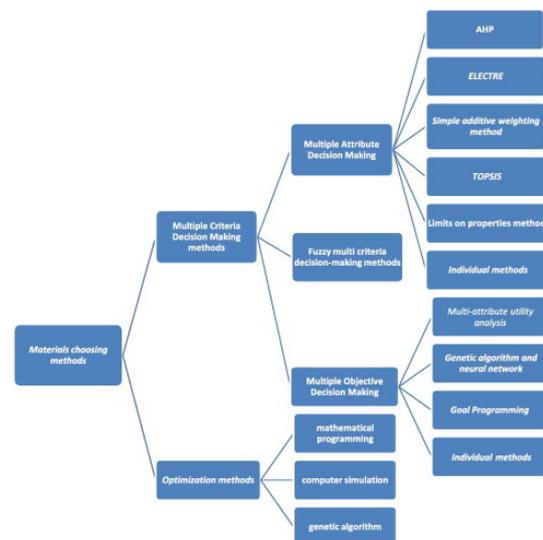


Fig.2: Material selection methods [2]

However, the formulation of indices can be a cumbersome and difficult task based on the fact that each application is inherently different from another application and also, exact functional relation between the parameters must be known and require expert decision. The constraints imposed on different category of similar components could be different and hence different indices are supposed to be used in it. Also, Ashby approach requires the component to be approximated to a near simple object for which a standard index may either be present or

may be developed (for example a beam or a plate) which may not completely justify the working or loading conditions of that particular component under given application. Nevertheless, it is a highly reliable technique and its results are highly accurate. However, MADM techniques can be used without prior knowledge of physical relations of materials properties for their specific application. It offers the following advantages when used: a) it can be used to evaluate the ranks of alternatives regardless of the number of attributes associated with it, b) the technique can be applied regardless of the interdependence of the attributes, c) no functional relationship needs to be established or used, d) the user may apply weights as necessary to priorities different attributes as per the given design constraints, d) due to the normalization the result may be obtained regardless of the different units of the attributes, e) these are relatively simple and fast, and f) subjective attributes can also be considered using fuzzy techniques. However material selection requires more sophisticated methods since materials properties vary with fabrication methods and scale of study.

Several thriving attempts have been made by the researchers to apply MCDM techniques in material selection for various devices (piezoelectric, pyroelectric, magnetic, semiconductor and dielectric devices). Attempts have also been made to see the effectiveness of various MCDM techniques for a given study when used independently [4] and in conjunction with each other [6]. Also, It is observed that the

two branches of MCDM i.e. MADM and MODM can be clubbed together to solve problems that otherwise pose complexity in nature [3]. Despite the large number of MCDM and other material selection methods available, no technique can be considered the most appropriate or universal in nature. Therefore it is necessary to understand the techniques in order to make a choice on which is most appropriate. However, multiple attribute decision making approaches have immense potential to improve the performance of material selection. The authors are currently trying to develop an error free algorithm that would be the first step towards a universally acceptable selection procedure while the ultimate aim is to develop an algorithm that can be easily automated and integrated with the existing Computer Aided Engineering (CAE) softwares available.

#### References:

- 1) Ashby, M.F. (2011). *Materials Selection in Mechanical Design*. 4th ed, Elsevier.
- 2) Jahan, A., Ismail, M.Y., Sapuan, S.M. and Mustapha, F., *Materials and Design*, **31**, 696(2009).
- 3) Chauhan A. and Vaish R., *Materials and Design*, **41** 177 (2012).
- 4) Chauhan A. and Vaish R., *Materials and Design*, **36**, 1 (2012).
- 5) Chauhan A. and Vaish R., *Materials and Design*, **44** 240 (2013).
- 6) Chauhan A. and Vaish R., *Advanced Science, Engineering and Medicine*, **5** 149 (2013).

# Alleviating Wait-and-See Behavior for Climate Change through Computer Simulation Tools

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Despite strong scientific consensus about the causes and risks of climate change, the general public exhibits a complacent attitude towards actions benefiting Earth's climate (Dutt, 2011; Dutt & Gonzalez, 2012; Sterman, 2008; Weber, 2006). For example, based upon evidence from recent surveys of people's beliefs and policy preferences, a large majority would likely advocate wait-and-see preferences: They would like to delay significant actions to reduce greenhouse gas emissions until impacts have been more convincingly demonstrated (Dutt & Gonzalez, 2012).

There are several real-world instances that show widespread wait-and-see preferences for climate change mitigation actions. In a recent U.S. survey, for example, 60% of participants chose either the option "until we are sure that global warming is really a problem, we should not take any steps that would have economic costs," or the option "its effects will be gradual, so we can deal with the problem gradually" (Dutt, 2011). Such wait-and-see preferences are also prevalent among policymakers: "Slow the growth of greenhouse gas emissions (GHGs), and as the science justifies stop, and then reverse that growth" (G.W. Bush, 2/14/02). Thus, George Bush believed that climate mitigation actions could be taken at a slow pace until science confirmed climate change as a real problem. Similarly, Tony Abbott, opposition frontbencher and a senior member of the Liberal Party of Australia in response to a news-poll recently commented, "The government should not be rushing headlong into any premature trading scheme [for policies that mitigate climate change]" (Conway, 2009, para. 2).

Wait-and-see preferences for climate change seem prevalent among climate scientists as well. For example, Fred Singer, professor emeritus environment sciences, University of Virginia, recently expressed a strong wait-and-see view by commenting that, "human activities are not influencing the global climate in a perceptible way. Climate will continue to change, as it always has in the past, warming and cooling on

different time scales and for different reasons, regardless of any human action” (Singer, 2009, p. 1). In this regard, climate initiatives like the Kyoto Protocol and Clear Skies, which have promised to mitigate climate change, have indirectly expressed support for wait-and-see preferences: The Kyoto Protocol’s proposed reductions in emissions fall short of the proposed targets and Clear Skies’ initiative promotes even further

greenhouse gas emissions growth (Sterman & Booth Sweeney, 2007).

One could argue that wait-and-see preferences would work well in simple engineering systems with short delays between the detection of a problem and the implementation of corrective actions. For example, one can afford to wait-and-see when boiling beans until steam builds up and the cooker whistles because there is a short delay between the whistle and removing the cooker from the flame (Dutt & Gonzalez, 2012). Unfortunately, for a complex system like Earth’s climate, the delays between the decision to mitigate emissions and the corresponding changes in atmospheric GHG concentrations are much longer. Due to these long feedback delays, wait-and-see preferences would become problematic. That is because, even if mitigation actions are taken, atmospheric CO<sub>2</sub> accumulation would continue to rise until emissions fell below the absorptions rates. Average atmospheric temperature would then peak, and consequences such as rising sea levels and thermal expansion would continue. Therefore, wait-and-see preferences are likely to cause abrupt, persistent, and costly regime changes on Earth in the future (Dutt, 2011).

Through a number of laboratory studies involving common people, I have shown that people’s wait-and-see preferences for climate change are related to their reliance on certain heuristic and biases. Here, people exhibiting wait-and-see preferences for climate change seem to rely on two particular heuristics: correlation thinking and mass balance violation. For climate, relying on the correlation heuristic means wrongly inferring that an accumulation (CO<sub>2</sub> concentration) follows the same trajectory

as the inflow (CO<sub>2</sub> emissions); hence, people think that stabilizing emissions would rapidly stabilize the concentration, and emissions cuts would quickly reduce the concentration and damages from climate change. Consequently, people who rely on this heuristic would demonstrate wait-and-see preferences because they would significantly underestimate the delay between

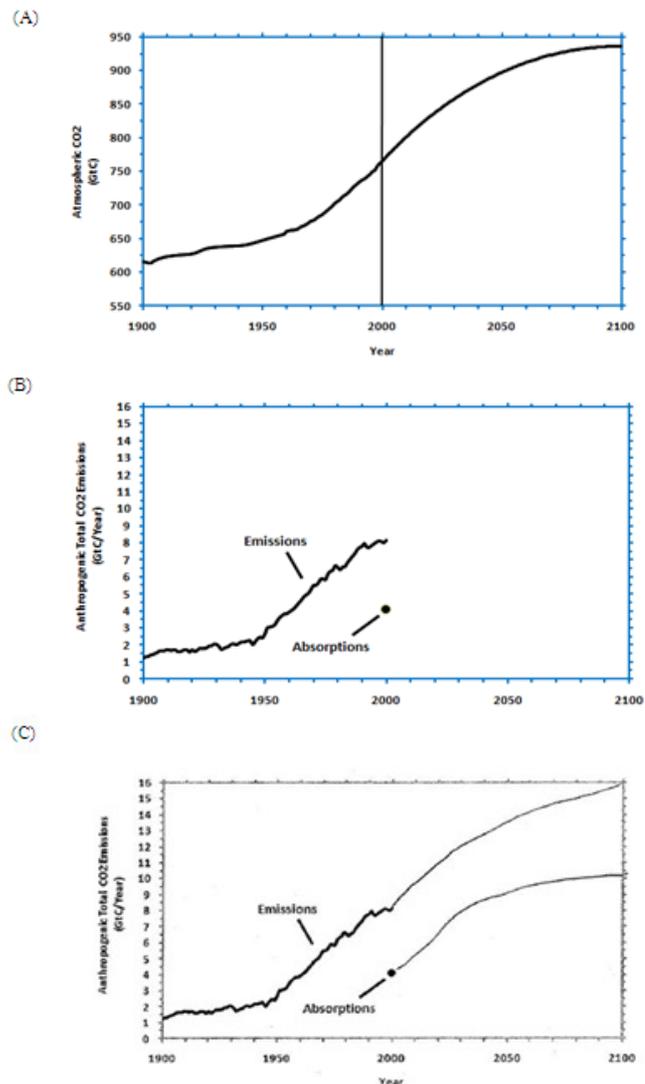


Figure 1. The climate Stabilization (CS) Task. (A) Participants are given CO<sub>2</sub> concentration stabilization scenario, and (B) they are required to sketch the CO<sub>2</sub> emissions and absorptions corresponding to the scenario. (C) A typical response showing reliance on the correlation heuristic (emissions similar in shape to CO<sub>2</sub> concentration) and mass balance violation (emissions > absorptions in 2100, i.e., when CO<sub>2</sub> concentration stabilizes).

reductions in CO<sub>2</sub> emissions and in the CO<sub>2</sub> concentration. Thus, they would underestimate

the magnitude of emission reductions needed to stabilize the concentration (Dutt, 2011).

It has also been shown that people’s wait-and-see preferences for climate change mitigation actions are related to mass balance violation, whereby people incorrectly infer that atmospheric CO<sub>2</sub> concentration can be stabilized even when emissions exceeds absorptions. Mass balance violation leads to wait-and-see preferences because people think the current state of the climate system, where emissions are about double that of absorptions, would not pose a problem to future stabilization (Dutt, 2011).

Figure 1 shows the experimental task (called the “climate stabilization” (CS) task) that has been classically used to evaluate participants’ reliance on correlation heuristic and mass balance violation. In the CS task, participants are asked to sketch CO<sub>2</sub> emissions and absorptions that would stabilize the CO<sub>2</sub> concentration according to a given scenario by the year 2100 (given in Figure 1a). Participants are given the concentration’s starting value in the year 2000 (Figure 1b), and its historic trends and emissions between the years 1900 and 2000 (emissions being twice the absorptions in 2000). Participants are asked to sketch the CO<sub>2</sub> emissions and absorptions shapes that would correspond to the projected scenario of CO<sub>2</sub> concentration between 2001 and 2100. Dutt and Gonzalez (2012) report that about 82% of participants at Carnegie Mellon

University (about 50% of whom had backgrounds in science, technology, engineering, and management (STEM), and a majority of the rest in economics) sketched emissions that were positively correlated with the concentration. Figure 1c, shows an example of a participant that relied on the correlation heuristic, whereby she inferred that the shapes of the CO<sub>2</sub> emissions and concentration should look alike. Moreover, 80% of participants showed mass balance violation in their responses either by failing to keep emissions greater than absorption before the concentration stabilized in the year 2100; or by failing to make emissions equal to absorption when the concentration reached 2100 (Figure1c). Given this widespread reliance on correlation heuristic and mass balance violation, researchers at Columbia University have suggested that experiencing the adverse consequences of climate change in simulation-based tools is likely to improve people’s understandings of the climate system (Weber, 2006). Recent studies have validated this claim and shown that indeed these simulation-based tools that depict the dynamics of CO<sub>2</sub> concentrations, emissions, and

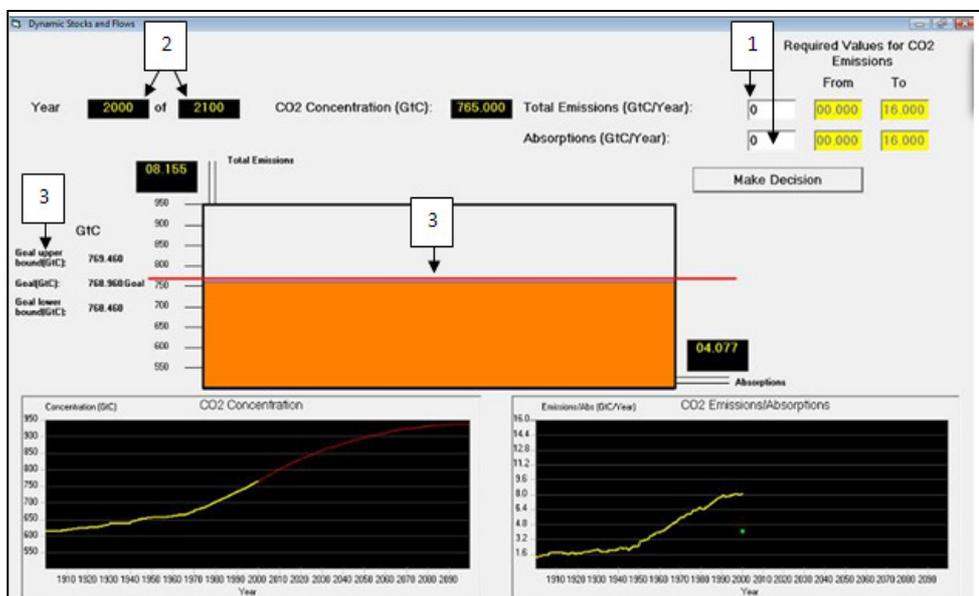


Figure 2. The Dynamic Climate Change Simulator (DCCS) microworld. The simulation is a dynamic replica of the CS task. (1) Participants set yearly CO<sub>2</sub> emissions and absorptions and press Make Decision button. (2) The system now moves forward a certain number of years. (3) Participants need to maintain their CO<sub>2</sub> concentration at the red goal line in the tank (which represents the atmosphere) and follow the CO<sub>2</sub> concentration trajectory shown in the bottom left panel.

University (about 50% of whom had

absorptions help people to correct their reliance on heuristics about Earth’s climate (Dutt, 2011;

Dutt & Gonzalez, 2011; Dutt & Gonzalez, 2012). Results from using a simulation-based tool called the Dynamic Climate Change Simulator (DCCS) have been particularly noteworthy. DCCS (see Figure 2) provides repeated feedback on the changes in the CO<sub>2</sub> concentration each year as a result of CO<sub>2</sub> emission and absorption policies set by participants, allowing participants to observe the results of their decisions as they try to control the CO<sub>2</sub> concentration to a goal (Dutt & Gonzalez, 2012). One main and consistent result is that acquiring experiential feedback in the DCCS helps to reduce participants' misconceptions about the way the climate system works.

Experiential feedback in DCCS enables participants to test several hypotheses they might have about how CO<sub>2</sub> emission and absorption processes affect the CO<sub>2</sub> concentration. It is likely that the ability to test several hypotheses repeatedly about the cause-and-effect relationship in DCCS enables them to understand that the concentration increases when CO<sub>2</sub> emissions are greater than absorptions, decreases when emissions are less than absorptions, and stabilizes at a particular value when emissions equal absorptions. Therefore, it seems that the experience gained in DCCS is likely to enable participants to decrease their reliance on the correlation heuristic and mass balance violation. This expectation has indeed been found to be true. For example, in the CMU study described above, participants who interacted with DCCS before encountering the CS task reduced their reliance on correlation heuristic (60%) and mass balance violation (57%) (Dutt, 2011).

The above explanations about feedback in DCCS are supported by similar findings for other dynamic tasks. For example, researchers at George Mason University have suggested that participants can get increasingly accurate answers in simple dynamic tasks with even just "correct/incorrect" feedback given for repeated attempts. In the first attempt, only 15% of their

participants answered the accumulation question correct, but 80% of the participants were able to solve the problem correctly by the seventh attempt (Cronin, Gonzalez, & Serman, 2009).

In summary, in this article, I have proposed the use of computer-simulation tools (like DCCS) for alleviating people's heuristics and biases for our climate system. One could make of such tools for education purposes in schools and colleges, as well as an effective computational aid during policymaking for climate change. Future research would benefit by investigating the unique features of these simulation tools that make them as effective climate models and pedagogic approaches to science, mathematics, and engineering teaching. Also, future research would benefit by investigating the connection between public's reliance on heuristics for our climate system and their socio-demographics factors (e.g., gender, age, income, citizenship, educational level, race or ethnicity, political party identification, and political ideology). Furthermore, it would be interesting to investigate whether the influence of socio-demographic factors on heuristic reliance is moderated by people's interaction with DCCS-like simulation tools.

There is substantial scientific evidence that climate change would occur with catastrophic consequences in the near future if we continue on a path of increasing greenhouse gas emissions (IPCC, 2007a). The 1992 Rio Declaration on Environment and Development (UNCED, 1993, Article 15) gave the world the "precautionary principle" for resolving the climate change problem: "a lack of full scientific certainty should not be used to justify postponing cost-effective measures in the face of threat of serious or irreversible harm." From a public-policy perspective, given the uncertainties present in the probability, timing, and costs of future climate consequences, many people advocate that we should follow a precautionary approach to climate change and that policies should be such that they cause people to act on climate change rather than

exhibit wait-and-see preferences (Spratt & Sutton, 2008). Therefore, we need to be on the lookout for interventions that enable people to improve their understanding of Earth's climate and its processes, enable them to reduce their wait-and-see preferences, and enable them to make decisions that benefit the environment. Given the fact that we need a strong public support for any mitigation actions against climate change, climate experts and policymakers should understand and pay close attention to the underlying mental models, preexistent knowledge, and needs of common people (Morgan et al., 2002). According to Morgan et al. (2002), simply asking climate experts what to do for the climate and then passing their view onto lay people generally results in lay people missing the point and becoming confused, disinterested, and even annoyed. Here again, the use of simulation tools like DCCS is likely to help improve lay people's understanding of the cause-and-effect relationships that govern Earth's climate and help them alleviate their widespread reliance on heuristics.

#### References

- 1) Conway, D. (2009). *Wait-and-see on climate change: Abbott*. Retrieved November 15, 2009, from The Age Newspaper Web site: <http://news.theage.com.au/breaking-news-national/wait-and-see-on-climate-change-abbott-20090728-dztr.html>.
- 2) Cronin, M., & Gonzalez, C., & Sterman, J. D. (2009). Why don't well-educated adults understand accumulation? A challenge to researchers, educators and citizens. *Organizational Behavior and Human Decision Processes*, 108(1), 116-130.
- 3) Dutt, V. (2011). *Why do we want to defer actions on climate change? A psychological perspective* (Doctoral dissertation). Carnegie Mellon University. Pittsburgh, PA, USA.
- 4) Dutt, V., & Gonzalez, C. (2012). Decisions from experience reduces misconceptions about climate change. *Journal of Environment Psychology*, 32(1), 19-29. doi: 10.1016/j.jenvp.2011.10.003
- 5) Dutt, V., & Gonzalez, C. (2011). Human Control of Climate. *Climatic Change*, 111(3-4), 497-518. doi: 10.1007/s10584-011-0202-x
- 6) IPCC. (2007a). Climate Change 2007: Synthesis Report. In R.K. Pachauri & A. Reisinger (Eds.), *Contribution of Working Groups I, II and III to the Fourth Assessment*
- 7) Morgan, M. G., Fischhoff, B., Bostrom, A., & Atman, C. (2002). *Risk communication: A mental models approach*. New York: Cambridge University Press.
- 8) Singer, S. F. (2009, September 1). CLIMATE CHANGE natural and unstoppable. *FC EDGE*, p. 1.
- 9) Spratt, D., & Sutton, P. (2008). *Climate Code Red: The case for Emergency Action*. Carlton, North: Australia.
- 10) Sterman, J.D. (2008). Risk Communication on Climate: Mental Models and Mass Balance. *Science*, 322, 532-533.
- 11) Sterman, J. D., & Booth Sweeney, L. (2007). Understanding public complacency about climate change: Adults' mental models of climate change violate conservation of matter. *Climatic Change*, 80(3-4), 213-238.
- 12) Weber, E. U. (2006). Experience-Based and Description-Based Perceptions of Long-Term Risk: Why Global Warming Does Not Scare Us (Yet). *Climatic Change*, 77(1-2), 103-120.

# Brinkmanship in India-Pakistan Conflicts: A Game Theory Approach

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## I. Introduction

Can the insights from game theory be applied to Indo-Pakistan situations? There is a large variety of games that we play in daily life knowingly or unknowingly. Some games on chance e.g. Snakes and Ladders. Others rely on Strategy – e.g. Chess. In some games chance and strategy both play a role. Game theory is a discipline in Operational Research which tries to model human interaction as a game. The games are analyzed to elicit a deeper understanding of human behavior. Game theory has been extensively used in corporate world, in politics etc to understand the strategy of the opponent and to sharpen one's own moves. Game theory has been widely used to model the nuclear deterrence between USA and USSR in the days of cold war. In the aftermath of the Cuban nuclear crisis in 1962 when USA and USSR came to the brink of a nuclear war before USSR backed out, game theory was used to understand brinkmanship, escalation and crisis stability [1].

India and Pakistan have fought several wars and have lived through the era of cooperation (though limited) and cold peace (since Mumbai attacks) [2]. They have been unable to make a transition to the era of cooperation and durable peace. What explains the durability of India Pakistan tensions? India-Pakistan relations have been studied extensively by analysts from politico-military, economic, social points of view. Can game theory bring fresh insights to the understanding of Indo-Pak relations? Game-theoretic exercises, applied to India-Pak situations can supplement even strengthen traditional; analysis. Game theory can be particularly helpful in understanding how the two countries can get out of the low paying unhelpful situations. Game theory can also throw light on crisis escalation and crisis stability. It is also possible to apply game theory to understand nuclear thresholds of the two countries.

## II. Game with No Threat

**Prisoner’s dilemma** is a game in which two players try to maximize their own benefits. The benefits, called pay-offs in game theory parlance, are such that the two players end up in a state where they choose not negotiation over negotiation on an issue (say Siachen glacier). This state of play is called *Nash Equilibrium*, named after mathematician John Nash. Consider the following pay off matrix modeling the behavior of India and Pakistan [3]. Both players have two strategies to choose from, either negotiate or not negotiate. The pay-off matrix is at Table 1.

		Pakistan	
		Negotiate	Not Negotiate
India	Negotiate	2, 2	0, 3
	Not Negotiate	3, 0	1, 1

↓
↓  
Pareto-optimal solution
Nash Equilibrium

Table1. Payoff matrix

Table 1 assumes that if both countries compromise on a given issue and choose to ‘Negotiate’, each will have a payoff of 2. On the other hand, if both choose the strategy ‘Not Negotiate’, the standoff continues and each would get a lesser payoff of 1. However, if only India were to compromise and adopt the strategy ‘Negotiate’ while Pakistan adopts the ‘Not Negotiate’ strategy, India loses by getting a payoff of 0, whereas Pakistan will get some incentive (payoff 3). Similarly, if only Pakistan were to compromise its stance and India were to defect, India gets a payoff of 3.

Now, if Pakistan chooses to “negotiate”, India has two choices - either negotiate or not negotiate. If it chooses to negotiate, it will get a benefit of 2, but if it chooses not to negotiate it will get a benefit of 3. Thus it will choose the strategy of not negotiating. What if Pakistan chooses not to negotiate? India’s benefit will be 0 if it chooses to negotiate. Its benefit will be 1

if it chooses not to negotiate. Clearly it will choose not to negotiate. Thus, in this special game, India has a dominant strategy of not negotiating irrespective of the strategy chosen by Pakistan.

Likewise the game is structured in such a way that Pakistan also has the dominant strategy of not negotiating. Therefore they will eventually end up in a situation where both choose Not Negotiate strategy and get a payoff of (1,1). Thus, when both countries choose the dominant strategy ‘Not Negotiate’ as the best option, the negotiations collapse. The dominant strategy (‘Not Negotiate, Not Negotiate’) is then a *Nash Equilibrium*. Note that if both had chosen strategy (Negotiate, Negotiate) they would have gained a better pay off of (2, 2). Why did they not choose this strategy? Because, either player then had the temptation of moving on to a situation of not negotiating where its pay off would be even higher (3) in the hope that the opponent will continue to negotiate. In such a situation the one who negotiates gets a pay of only 0 while the one who did not negotiate got a pay off of 3. Thus, both players will end up not negotiating and settle for lower pay offs of (1, 1) rather than risk being caught in any other situation where their pay offs may be higher but the chances of cheating by the other player could not be ruled out. Such situation is known as prisoner’s dilemma.

Hence, India and Pakistan are for the moment stuck in a low pay-off *Nash Equilibrium*, whereas the obvious choice should be to move to *Pareto-optimal* solution. Neither side is able to make the transition because of the hardened position each has acquired over time, which prevents appropriate compromises. The hardline domestic constituencies, which see any concession as a defeat, prevent the two sides from making a compromise. Therefore, in India-Pakistan situations, the low paying ‘*Nash Equilibrium*’ is preferred by the players over the more rational ‘*Pareto-optimal*’ solution. In order to make the transition to *Pareto-optimal*,

India and Pakistan will need to break away from traditional thinking of making no concessions.

It is worth mentioning here that the strategy choices and the associated payoffs shown in Table 1 are only assumptions, there can be more alternatives, as well as several variations on each. However it is noticed that as far as we stick to the logic of the game, rather than payoffs, we are sure to get the same equilibrium of the problem.

### III. Game with Threat

In response to frequent terrorist attacks, it is necessary for India to take an appropriate action. In this context, game theory can help in assessing India and Pakistan probabilistic reaction in order to move away from *Nash equilibrium*. Game theory throws light on crisis stability [4,5]. When can a crisis be stabilized and when does it spin out of control? The key insight here is that whenever a threat or a promise of reward is given, it should be credible. Empty threats or rhetoric can lead to crisis escalation. Another insight is that one should be clear about the points of no return. The crisis can escalate if repeated threats push the opponent to a point where he does not care whether the threat will be implemented or not. Whenever a threat is issued, an escape route should also be provided. Game theory shows that sometimes threats can bring about stability while in other cases, beyond a threshold, threats can prove to be destabilizing. The key is to find that threshold. This will depend upon the payoff structures and probabilities assigned to the likelihood of strategies which an opponent will adopt. Thus, perception about how the opponent will react becomes important in deciding own strategies.

Now the problem is formulated using brinkmanship game theory model. Brinkmanship is a form of diplomatic maneuver generally used in international politics which seeks threat as a strategic move in a situation where one state is willing and able to push a highly dangerous situation to the limit and not

tolerate it any further. India's probabilistic approach in order to expect positive solution using brinkmanship model is estimated.

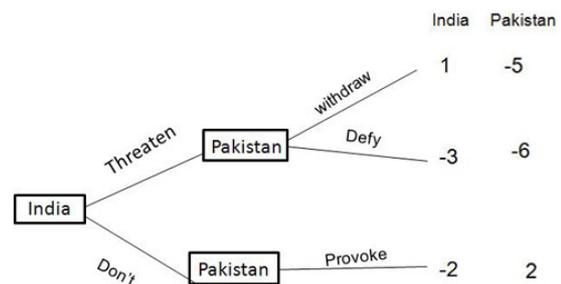


Fig. 1 The simple threat model with Pakistan

Suppose that India takes a first move and issue a threat against Pakistan. In this case Pakistan can either withdraw or defy as shown in Fig.1. It shows a tree diagram of the payoff structure of the two countries in various situations. Withdrawal is a substantial minus for the Pakistan and a reaffirmation of India's military superiority; so the payoffs are 1 for the India and -6 for the Pakistan. If Pakistan retaliates, it will be a situation of war. In this case payoffs are negative for both, so -3 and -5 are assigned for the India and Pakistan, respectively. It assumes more loss for Pakistan because India is more powerful in terms of weapons designs and technology. However, if India chooses to do nothing, Pakistan will continue to provoke India by various means like terrorist attacks, in this case the payoffs are -2 for the India and 2 for the Pakistan. This is because there is always some loss for India as a result provocation and a gain for Pakistan. India will be successful in claiming brinkmanship if all the payoffs are known as it is assumed in Fig. 1. However in reality, one country is not sure about payoffs structure of the other country. In such situations probabilities of the possible outcomes can be estimated. For example it is assumed that Pakistan would be hard-line (prone to defy) or soft-line (prone to withdraw). Hence in order to consider the twofold risks, a more complex tree structure is assumed in Fig.2. The game starts with two cases, when Pakistan can be hard-line or soft in the face of a threat from India. The case shown in Fig. 1 is of Pakistan being soft-line. In this

case, if faced with the India threat, the Pakistan gets -5 for withdrawal and -6 by defy; so Pakistan prefers to withdraw. However in the alternate scenario when Pakistan is hard-line, the payoffs are opposite of what they were before. Therefore, suppose along the upper branch (Fig.2), the hard-line Pakistan will defy India's threat with probability  $p$  and, along the lower branch the soft Pakistan will withdraw in the face of the threat with probability  $1-p$  as shown in Fig.2.

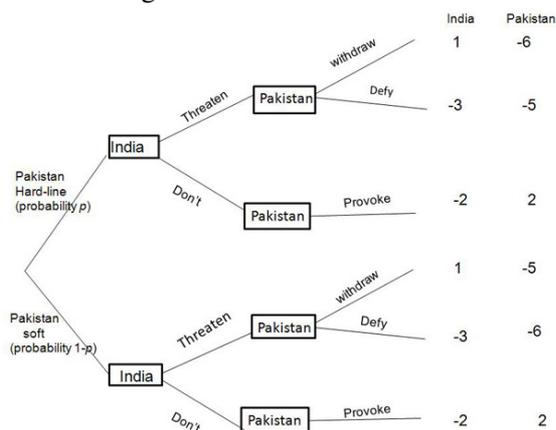


Fig.2 The Brinkmanship model of the crises.

Therefore India can look ahead and find that, if she issues the threat, the payoffs would be -3 with probability  $p$  in case of Pakistan's retaliation and 1 with probability  $(1-p)$  in case of withdrawal. The expected payoffs from making the threat therefore is

$$= -3p + (1-p)$$

$$= -4p + 1$$

On the other hand if the India decides not to threaten, her expected payoff is -2. Hence, for the India, making the threat is useful only if  $-4p + 1 > -2$  or  $p < 0.75$ . In this situation, India's threat will be beneficial only when  $p < 0.75$  otherwise it is too risky for India to make the threat. Here probability  $p$  is known as pure threat. Now we introduce probabilistic threat as  $q$ . It consists of fixing a probability such that if the Pakistan defy war will occur with that probability. Whereas  $1-q$  indicates that the India will give up on the threat. If Pakistan defy, for the India, the outcome is -3 with the probability  $q$  and -2 with  $(1-q)$ ; so the expected value is

$$-3q - 2(1-q) = -3q - 2 + 2q$$

$$= -q - 2$$

For the Pakistan, the expected payoff depends on whether hard or soft. If hard-line, Pakistan will get -5 from the war which happens with probability  $q$ , and 2 if India decides to do nothing with probability  $(1-q)$ . The expected payoff for Pakistan is

$$-5q + 2(1-q) = -7q + 2$$

Which is better than -6 for all values of  $q \in [0, 1]$ . Therefore the hard-line Pakistan will always defy the threat. Similarly it can be shown that the expected payoff for soft Pakistan would be  $-6q + 2(1-q) = -8q + 2$ , if defy the threat. It would get -5 in case of withdrawal. In this case withdrawal is better if  $-5 > -8q + 2$  or  $q > 0.875$ .

Thus India's brinkmanship must contain 87.5% probability of war, otherwise it will not deter Pakistan even if they are soft. This value of  $q$  is called effective condition. For further insight, we can formulate  $q$  as a function of  $p$ . If the India makes a threat, there is a probability of  $p$  that the Pakistan is hard and will defy the threat and the India gets a payoff of  $[-(q+2)]$ . With probability of  $1-p$ , the India meets a soft Pakistan, which is assumed to withdraw to the threat giving a payoff of 1. Therefore, the expected payoff to the India from deployment of probabilistic threat is  $-p(q+2) + 1 \cdot (1-p)$ . Threat would be effective for India when  $-p(q+2) + 1 \cdot (1-p) > -2$  (payoff for India in the absence of threat) or  $q < [(3-3p)/p]$ . This upper limit on  $q$  is called acceptability condition. It interprets that if  $q$  is greater than  $[(3-3p)/p]$ , India is better off not to threaten Pakistan. It is clear now that for the successful threat  $q$  should lie between  $[0.875, (3-3p)/p]$  i.e.  $0.875 < q < (3-3p)/p$ . The values associated with  $p$ , at  $q=1$  and  $q=0.875$  are called lower bound ( $p_L$ ) and upper bound ( $p_U$ ), respectively. In our case, the values for  $p_L$  and  $p_U$  are 0.75 and 0.774, respectively.

Hence, in Fig. 3, the horizontal axis is the probability,  $p$  that the Pakistan is hard line, and vertical axis is the probability,  $q$ , that war will occur if they defy the India treat. The horizontal line  $q=0.875$  gives the lower limit of the effectiveness condition; the threat should be

such that it associated  $(p,q)$  combination is above this line if it is to work even against the soft type Pakistan. The upper limit of the this curve if it is to be tolerable to the India. The region where both effective and acceptability conditions hold is shown in Fig. 3 (hatched).

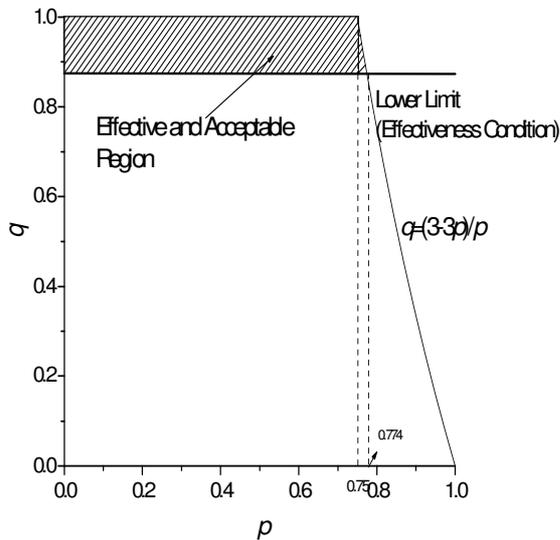


Fig. 3: Conditions of successful brinkmanship

**IV. Conclusions**

India and Pakistan are for the moment stuck in a low pay-off *Nash Equilibrium*. Neither side is able to make the transition because of the hardline domestic constituencies, which see any concession as a defeat, prevent the two sides from making a compromise. In any negotiation

acceptability condition, the curve  $q=(3-2p)/(2p+1)$  is the threat such that  $(p, q)$  is below

we have to adopt somewhat reciprocal approach irrespective of harder stands at domestic level. The kind of analysis presented here with the help of game theory put forward a rational way of negotiation which can advance a new era of cooperation in the subcontinent. This will give us some options for going ahead in breaching the deadlock so to say which is mathematically sustainable. While most of us feel that we know what is holding us from arriving at optimal solutions, the facts when presented in terms of numbers as has been done here brings the reality more starkly than otherwise.

**References:**

- 1) T. G. Allison (1969), Conceptual Models and the Cuban Missile Crisis. *The American Political Science Review*, 63:3, 689-718.
- 2) S. Ganguly (1999), The Crisis in Kashmir: Portents of War, Hopes of Peace. Woodrow Wilson Center Press.
- 3) Sarita Azad and Arvind Gupta (2011), India Pakistan Game Theoretic Interplay, IDSA views.
- 4) Avinash K. Dixit and, Susan Skeath (2004): Games of Strategy. W.W. Norton & Company, New York.
- 5) Navin A. Bapat (2010), A Game Theoretic Analysis of the Afghan Surge. *Foreign Policy Analysis* 6, 217-236.

# Cloud computing for Academic Libraries

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## Abstract

Cloud computing offers organizations new cost-effective ways to use web services for their computing needs, including software applications, data storage, cloud development platforms, and processing power. This article defines cloud computing and shows how it is different from other types of computing. It also discusses how cloud computing solutions could be beneficial to libraries with some live examples.

## Introduction

Cloud computing represents one of the most important technology trends of our time. Every day we make use of computing and information resources through a web browser powered by some distant and diffuse infrastructure. In more recent months and years cloud computing has entered the library technology sphere. Cloud computing brings the opportunity for libraries to shift away from the need to own and operate their own servers to power their core automation applications and through web-based services.

“Cloud computing” is not a precise term, with various definitions given; some examples:

According to Wikipedia: “Cloud computing is internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid.”

VMware, a company involved in providing software and services, offers a more business-oriented definition: “Cloud computing is a new approach that reduces IT complexity by leveraging the efficient polling of on-demand, self-managed virtual infrastructure, consumed as a service.”

The term ‘cloud’ is used to indicate the whole of computing services accessible via the Internet. It is an all-encompassing description of the complex internet connected networks that exist in datacenters all over the world that power services and applications behind the scenes. The term “cloud computing” is used quite freely, tagged to almost any type of virtualized

computing environment or any arrangement where the library relies on a remote hosting environment for a major automation component. Cloud computing is not an all-or-nothing proposition. A library can continue to manage some parts of its computing operation on locally managed servers as it makes selective use of cloud services.

The following is a list of three main types of services that can be offered by the cloud<sup>1</sup>:

**Infrastructure as a Service (IaaS):** Product offered via this mode includes the remote delivery (through the Internet) of a full computer infrastructure (e.g., virtual computers, servers, storage devices, etc.). Amazons' EC2, Eucalyptus, Go Grid, Right Scale and Linode are examples of IaaS.

**Platform as a Service (PaaS):** PaaS puts in a nutshell a layer of software and provides it a service that can be used to build higher level services. Platform as a Service provides a full or partial application development environment that users can access and utilize online, even in collaboration with others. Examples are Mosso, Heroku, GoogleApp engine, Engine Yard, and Force.com.

**Software as a Service (SaaS):** This model of computing provides access to all features and functionality of an application without having to be involved in the technical details of how it is hosted. In its pure form, users access the application through a web browser, with all the data involved stored on the provider's servers.

### How cloud computing help?

The cloud is an ever evolving and changing computing paradigm. With cloud computing, hardware and functionality traditionally installed and run in a local environment is now performed on the network, in the Internet cloud. In essence, the Internet cloud becomes the development platform and the operating system to which programmers write reusable, constantly updated software components that are delivered over the network and that can be

embedded or loosely coupled with other web applications. Libraries have been using some cloud computing services for over a decade. Online databases are accessed as cloud applications. Large union catalogs can also be defined as cloud applications. However, a look outside libraries is warranted to better understand the value proposition of cloud computing.<sup>2</sup>

### Impact of cloud computing on Academic Libraries

The Introduction of the Internet to libraries was part of a significant shift from in-house focused service to online provided service. While libraries have historically turned to large capital investment for their IT resources, they have adopted online and subscription based models for a number of other services, including resource management, patron-driven acquisition, and resource aggregation services. Given the success of these services, libraries are positioned to view the subscription focus of cloud based IT in a positive light. By itself, subscription models are not entirely representative of the cloud computing service platform, but the concepts of capital-based purchases and just-in-case resource models that libraries rejected when they began utilizing subscription-based services are in line with cloud computing goals.<sup>3</sup>

### Power a static Library Website from the cloud

A library's website is one of the most visible and critical components of its technical infrastructure. It's essential for it to be fast, reliable, and flexible. Operating a website using cloud infrastructure can deliver these qualities without the overhead involved in maintaining a local server in the library.

There are many options available in the way that a library can operate its website. The possibilities are almost endless, but a few of the alternatives include the following<sup>4</sup>:

- House a local server in the library. Common environments include Windows Server operating system using the built-in Internet Information Server, Linux, or Unix using the Apache web server.
- Use a collocated server. The library-owned server is housed in a data center of the higher-level organization.
- Use a fully outsourced hosting service, an external firm takes full responsibility for the hosting of the site. These arrangements may also include services related to the graphical design, layout, and navigation.
- Enter a specialized web-hosting arrangement based on a specific content management system such as Drupal. The hosting site maintains an instance of Drupal for the library along with the appropriate server infrastructure. The hosting site maintains an instance of Drupal for the library along with the appropriate server infrastructure. The hosting arrangement may include services such as the initial Drupal layout, development of custom themes, and integration of any Drupal modules needed.
- Choose a cloud-based infrastructure in which the library manages the design and content of the site.

### **Some live examples where Libraries are adopting Cloud Computing**

#### **OCLC**

OCLC Online Computer Library Center is a nonprofit, membership, computer library service and research organization dedicated to the public purposes of furthering access to the world's information. In a sense OCLC has been functioning as a cloud computing vendor. They provide cataloguing tools over the Internet and allow member institution to draw on their centralized data store. This centralized database allows for the sharing of catalog records

between libraries and greatly reduces the time spent in cataloging incoming material.<sup>5</sup>

#### **Library Thing**

Library Thing combines aspects of social networking and cloud computing. Tim Spalding is the originator of this site. Library Thing offers services which are just like social networking site, authorizes people to contribute information and suggestion about books and allows them to interconnect globally to share interests. This site also contributes web services for libraries after paying a nominal fee it allows libraries to draw on the vast database of recommendation and other users available in Library Thing.<sup>5</sup>

#### **Amazon and Google**

These are among the leading enterprises also providing solutions for libraries by having partnerships with library automation vendors. Amazon has been developing for years a large web services architecture and they now offer hosting services for data which are priced at gigabytes-month and CPU hour rates. We basically pay what we actually use. Google for years is working for the dissemination of information also taking interest in library solutions, going to implement "APP Engine" which provides a hosted service for application within their server farms and on massive and highly redundant storage system. IBM are showing curiosity in the world and has begun developing an infrastructure known by the name 'Blue Cloud'.<sup>5</sup>

#### **Reed Elsevier**

Reed Elsevier is a service provider for scientific information. It is capitalizing on the cloud computing model. There is the possibility to place monographic and article content or even technical manuals so that technician and other medical personnel can get assistance exactly when they need it. This utilizes the cloud computing model in the way that computers and other devices used in the medical profession can be tied into the data and application provided by Elsevier from anywhere.<sup>5</sup>

### Kindle and Mobile Me services

In the electronic book arena Amazon is providing some reading services with Kindle. If one has wireless connection, he can purchase and read a rapidly growing list of books and periodicals from the Kindle no matter what the location is. "MobileMe" service is being provided by Apple computing. The concept is distributed calendaring and messaging no matter what device you are using. Modifications made via one device are instantly reflected on all of the devices and computers that are tied into "Mobile Me". This has many applications in the library world for e.g. with the library acting as the gatekeepers, institutions could provide mobile access to say, a list of articles to their students simply by selecting them and giving them a code which would bring up the lists of articles from a vendors' cloud. The same cloud works for preprint archives, data archives and digital object repositories.<sup>5</sup>

### Koha (Open Source Library Management Software) and the Cloud

Running on a cloud of any sort, public or private, Koha is an ideal application. Number of factors need to be considered when deciding whether to invest in an internal infrastructure to implement a private cloud or to outsource all of those details and go with a public cloud as the hosting platform for Koha. The public cloud becomes a very cost-effective alternative, and given the nature and purpose of Koha as because a significant number of libraries do not own or maintain enterprise class data centers. Koha 1.0 was released in January 2000 as open source to the world and the Horowhenua Library Trust was the first library to go live on a completely cloud. With Koha, Libraries get the added benefit of using an open source application with a vibrant developer community behind it. When deciding which cloud-based hosting option (private or public servers) is best for a library it is important to remember to weigh all the options and consider the skills of the library staff.

### Conclusion

Libraries have the opportunity to improve their services and relevance in today's information society. Cloud computing is one avenue for this move into the future. It can bring several benefits for libraries and give them a different future.

Cloud computing helps libraries shift away from owning and operating local servers to web based services. It saves library time and money by enabling convenient, on-demand network access to resources like servers and applications. Libraries that take advantage of the cloud have fewer IT headaches because data centres provide continuous updates and mobility that standard computing cannot easily provide which means less time and energy spent on software, and more time and energy to devote to the library's day to day mission and services. The cloud computing will encourage libraries and their users to participate in a network and community of libraries by enabling them to reuse information and socialize around information. It can also create a powerful, unified presence for libraries on the web and give users a local, group and global reach.

### References:

- 1) Sultan, Nabil (2010): Cloud computing for education: A new dawn? International Journal of Information Management, 30, p. 109-116
- 2) Goldner, Matt (2010): Winds of change: libraries and cloud computing. OCLC report, 2010
- 3) Corrado, E. M. and Moulaison, H L (2011). Getting started with cloud computing. Facet publishing: London. p. 1-214
- 4) Breeding, M (2012): Cloud computing for Libraries. Facet Publishing: London, p. 1-121
- 5) Fox, Robert (2009): Library in the clouds. OCLC Systems & Services, Vol. 25 (3) p. 156 - 161
- 6) Khan, Shazia [et al.] (2011): Cloud computing an emerging technology: changing ways of libraries collaboration. International Research, Vol 1 (2), p. 151-159.

# An Overview of the Higher Order Compact (HOC) Scheme and Its Application to Rotatory Oscillating Cylinder

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## Abstract

In this article, we present a higher order compact finite difference scheme for the stream-function vorticity formulation of two dimensional (2D) Navier-Stokes equations. A compact finite difference scheme is one which utilises grid points located only adjacent to the node about which the differences are taken. In addition if the scheme has an order of accuracy greater than two, it is termed as a higher order compact (HOC) method. In this paper, we discuss the higher order compact scheme and its recent advances. We also discuss its new application to flow past a rotationally oscillating cylinder.

## Introduction:

Computational Fluid Dynamics, known today as CFD, is defined as the set of methodologies that enable the computer to provide us with a numerical simulation of fluid flows. This indicates that we use the computer to solve numerically the laws that govern the movement of fluids, in or around a material system, where its geometry is also modeled on a computer. This can be controverted to an experimental investigation, characterised by a material model or prototype of the system such as an aircraft or car model in a wind tunnel, or when measuring the flow properties in a prototype of an engine. This is also adverting to the fact that we can visualize the whole system and its behaviour, through computer visualization tools, with amazing levels of realism, as we certainly have experienced through the powerful computer games or movie animations that provide a fascinating level of high-fidelity rendering. Hence a complete system, such as car, an airplane, a block of buildings, etc. can be seen on a computer, before any part is ever constructed. Most physical systems can be described in terms of mathematical models that include convective and diffusive transport of some variables. These models consist of governing equations in the form of ordinary and partial differential equations. As a great number of such model equations like Navier-Stokes (N-S) equations do not possess analytical solutions, one has to resort to numerical methods.

Amongst the most popular methods that have been used quite frequently in CFD is the finite difference method. Here the basic methodology involves discretizing the problem domain by setting up a grid and then approximating the derivatives appearing in the governing equations by difference quotients at each grid point. Such approximation yields a system of algebraic equations which can then be solved with some matrix algorithm. Over the years, the second order central difference schemes, because of their easy and straight-forwardness in application, have for quite some time been a popular choice for discrete approximation of partial differential equations. Such methods are known to yield quite good results on reasonable meshes if the solution is well behaved. But for certain problems such as convection dominated flows; the solution may exhibit oscillatory behaviour if the mesh is not sufficiently refined. However mesh refinement inevitably brings in additional points into the system resulting in an increased system size and consequently more memory and CPU time are required to solve such problems on a computer. Again discretisation on a non-compact stencil increases the band width of the coefficient matrix. These ultimately result in increased arithmetic operations. Thus neither a lower order accurate method on a fine mesh nor a higher order accurate one on a non-compact stencil would be computationally cost effective. Therefore there is a need for the development of schemes which are higher order accurate and also compact at the same time.

#### **Higher Order Compact (HOC) Scheme:**

Of late, the Higher Order Compact (HOC) finite difference schemes came up for the computation of incompressible viscous flows to overcome the above mentioned problems of a second order schemes. There exist several mechanisms through which finite difference schemes can achieve higher-order compactness. One of them is based on Taylor series expansion. Kalita et al. [1] first developed this type of HOC scheme on rectangular non-uniform grids for the steady 2D convection–diffusion equation with variable

coefficients without any transformation. It was based on the Taylor series expansion of a continuous function at a particular point for two different step lengths and approximation of the derivatives appearing in the 2D convection–diffusion equation on a non-uniform stencil. The original PDE was then used again to replace the derivative terms appearing in the finite difference approximations, resulting in a higher order scheme on a compact stencil of nine points. Later on Ray and Kalita [2] developed a transformation-free HOC scheme for steady-state convection diffusion problems on non-uniform polar grids and then extended that idea for time dependent cases [3]. The higher order accuracy of the HOC methods combined with the compactness of the difference stencils yield highly accurate numerical solutions on relatively coarser grids in various real life problems.

#### **Applications of HOC scheme till date:**

Viscous flow past a bluff body has long been appreciated owing mainly to its theoretical and practical implications. Vorticity is generated close to the surface because of the no slip boundary conditions. The coupling between the unsteady wakes of body surface with their motion is important in structural, offshore and thermal power engineering applications. As an application, this has to be taken care of while using a drill with some flammable fluid say in an oil well. The drill bit usually cylindrical in shape is subjected to inline, cross flow rotations or oscillations which is the case of flow past a cylinder. The cylinder motion appears to trigger a distinctive vortex shedding pattern which together with the wake structure gives rise to enhanced unsteadiness, pressure fluctuations, structural vibrations and noise in addition to increased heat and mass transfer. This also produces a change in the phase of vortex induced forces on the body, and can affect the sign of mechanical energy transfer between the moving body and the flow. Attempts to find ways to control or lessen the unfavourable behaviour associated with the formation and shedding of the vortices remains to be one of the most intriguing problems in computational fluid

dynamics. Since most of the bluff bodies used in engineering and other applications are circular cylinders, they warranted this in-depth treatment.

**Application of HOC scheme to Rotationally Oscillating circular Cylinder:**

Recent works done by Kalita and Ray [3] and Ray [4] have already ascertained the accuracy and reliability of the HOC scheme to characterize the diagnostics of flows behind a stationary and a rotating cylinder. Excellent qualitative and quantitative agreements are found in each case. Our approach is an extension of above scheme to rotational oscillations.

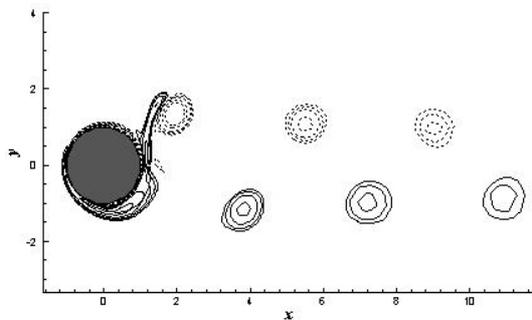


Fig 1(a): Vorticity contours for  $\alpha_m = 2.0$ ,  $S_f = 0.2$  and  $Re = 200$  where dashed and solid lines represent negative and positive vortices respectively.

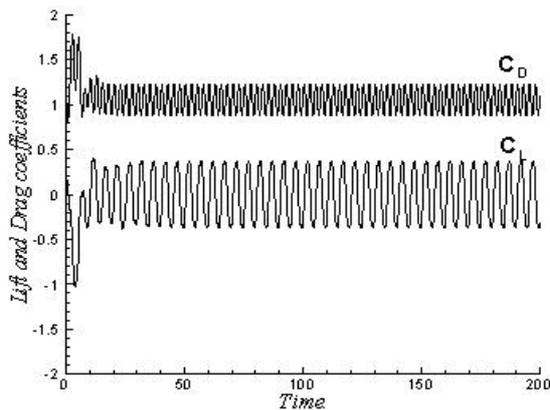


Fig 1(b): Lift and Drag coefficients

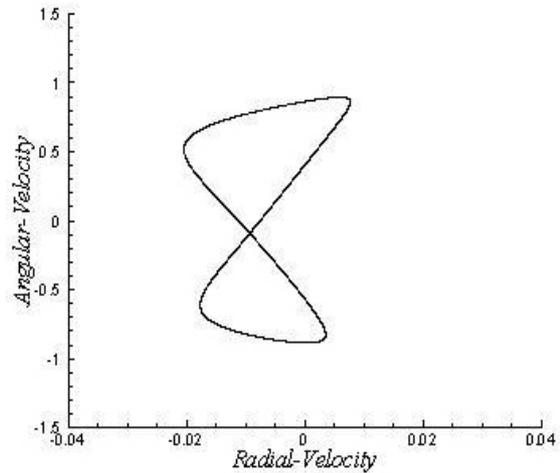


Fig 1(c): Phase Diagram

The oscillatory rotation of the cylinder introduces the boundary conditions in terms of non-dimensional speed  $\alpha$ , which can be denoted by  $\alpha = \alpha_m \sin 2\pi S_f t$ , where  $S_f$  is the forced oscillation frequency,  $\alpha_m$  is the dimensionless peak rotation rate and  $t$  is the non-dimensional time. Fig: 1(a) depicts the instantaneous vorticity contours plotted by using our scheme in a fixed frame at a low Reynolds number  $Re = 200$  after few complete oscillations. Positive and negative vortices are seen shed from both sides of the cylinder forming a vortex street. Another unavoidable consequence of an object moving through a fluid is the parallel and perpendicular force acting on a body specified as Drag and Lift forces respectively. Sinusoidal variation of lift and drag coefficient curves in Fig: 1(b) at almost fixed amplitude shows that vortices shed from both sides of the cylinder are almost of same size and strength. Phase diagram in Fig: 1(c) also predicts the periodic nature of the vortex shedding.

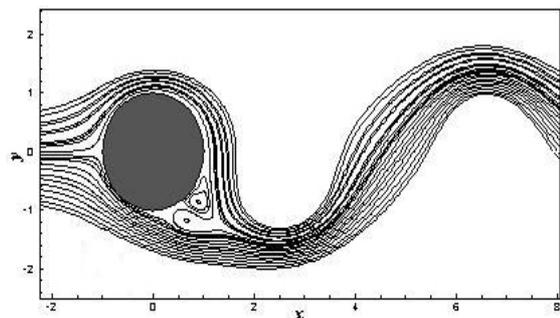


Fig 3(a): Streamlines for  $Re = 500$  by the present scheme.

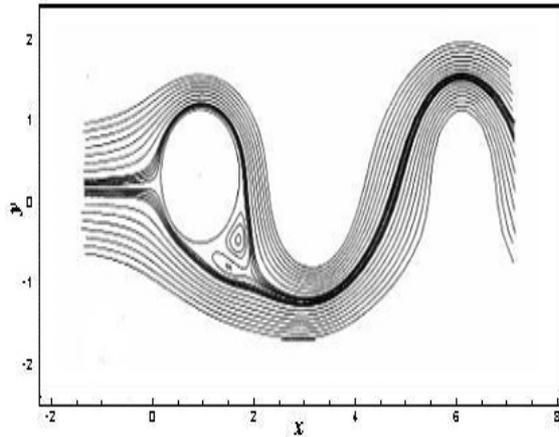


Fig 3(b): Streamlines for  $Re = 500$  from Dennis et al. [5].

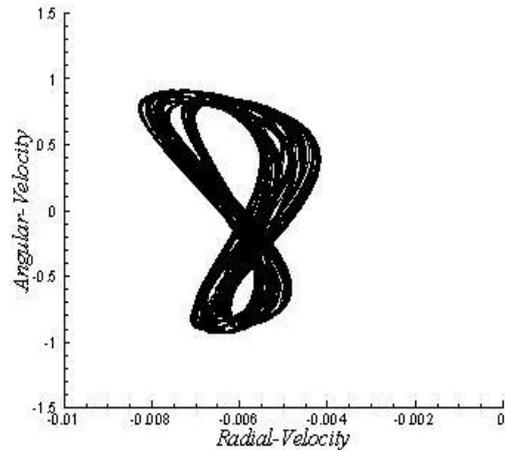


Fig 4(c): Phase Diagram

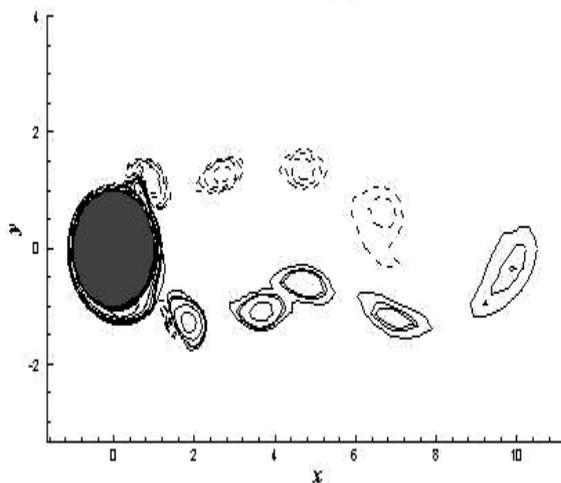


Fig 4(a): Vorticity contours for  $\alpha_m = 2.0$ ,  $Sf = 0.4$  and  $Re = 200$  where dashed and solid lines represent negative and positive vortices respectively.

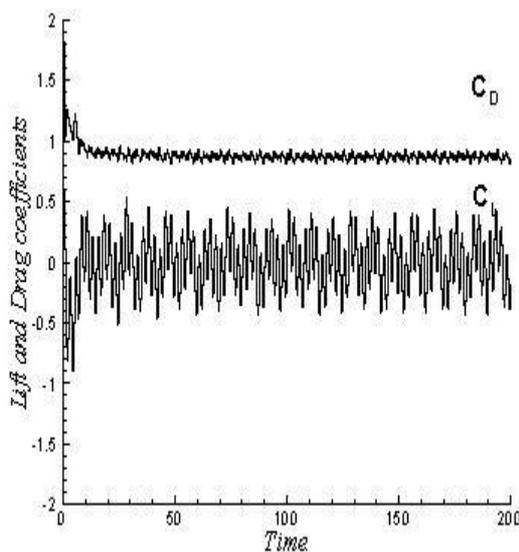


Fig 4(b): Lift and Drag coefficients

Our scheme also very accurately captures the complex flow phenomena for  $Re$  as high as 500. Fig: 3(a) shows an excellent qualitative agreement on streamlines with the numerical result of Dennis et al. [5] in Fig: 3(b). On the other hand, fig: 4(a) clearly depicts the vorticity contours at a particular instant when forcing frequency increases to 0.4 for  $Re = 200$ . A closer inspection of Fig: 4(b) discloses that there are two frequency peaks in the lift curves and both are of different amplitude. Near periodicity of velocity end point diagram in Fig: 4(c) further implies that size and strength of vortices appears uneven.

**Conclusion:**

We have discussed the higher order compact scheme and its application to flow past a rotationally oscillating cylinder. The present scheme has proven to be useful to characterize the diagnostics of two dimensional flows behind a rotationally oscillating cylinder accurately. Further there is a huge possibility to develop and implement the HOC scheme to solve the real three dimensional problems. We can extend our approach for the 2D interface problems with the possibility of using it to tackle flows in random geometries governed by Navier-Stokes equations and moving interface problems. But the potential still remains to explore many more areas and the flood gates can open up even further.

**References:**

- 1) Kalita JC, Dalal DC. and Dass AK., 2002, A transformation free HOC scheme for steady state convection diffusion on non-uniform grids, *Int. J. Numer. Methods Fluids* 44, 33-53.
- 2) Ray RK. and Kalita JC., 2010, A transformation-free HOC scheme for impulsively started circular cylinder. *J. Comput. Phys.* 228, 5207-5236
- 4) Ray R.K., 2011, A transformation free HOC scheme for incompressible viscous flow past a rotating and translating circular cylinder, *J. Sci. Comput.* 46, 265-293.
- incompressible viscous flows on non-uniform polar grids. *Int. J. Numer. Methods Fluids*, 683-708.
- 3) Kalita JC, Ray RK. , 2009, A transformation-free HOC scheme for incompressible viscous flows past an
- 5) Dennis S.C.R.,Nguyen P. and Kocabiyik Serpil, 2000, The flow induced by a rotationally oscillating and translating circular cylinder , *J. Fluid Mech.* 407, 123-144.

## American Dream vs. Melting Pot: Afro- Trinidadians in the US

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Trinidadians of African descent constitute one of the largest Caribbean immigrant groups in the United States. Despite being a foreign immigrant population, many Afro-Trinidadians encounter racial prejudice and discrimination similar to their African American counterparts. However, the Afro-Trinidadian response to the racial structure in the U.S. is markedly different from that of African Americans. Various factors such as the racial framework of Trinidad and the migrants' desire for social mobility help us understand their distinct response. As outsiders, Afro-Trinidadians, adopt various strategies to improve their life chances in the United States. Because of their status as blacks, Afro-Trinidadians, are expected to assimilate into the black subculture. However, because of the negative perceptions of black society, assimilation into African American subculture poses the risk of downward social mobility. The threat of downward assimilation impels many Afro-Trinidadians to become consciously isolated from African American society, and by extension, from the wider American social system<sup>2</sup>. Because of their overriding desire to achieve social mobility, Afro-Trinidadians consciously maintain their ethnic distinctiveness and refuse to assimilate into North American culture. Thus for West Indian immigrants of African origin in the United States, the notion of the "American dream" is, in practice, incompatible with the idea of the "melting pot".

### Encounters with U.S. Racism

A majority of Afro-Trinidadian immigrants report being shocked by the pervasiveness and extent of racial discrimination when they arrive in the United States. Despite certain similarities, the racial and ethnic structure of Trinidadian society contrasts greatly with the North American social setting. The most obvious difference lies in the fact that, whereas, the racial framework of American society is

<sup>2</sup> I use the terms "America", "North America" and "United States" interchangeably throughout the essay.

dichotomous, i.e. black versus white race relations, Trinidadian society exhibits a more complex racial hierarchy. Of course, this is not to deny the existence of Asians or Hispanics in the U.S., who are not phenotypically, black or white. However it can be argued that the major race relations question in the U.S. is *recognized* to be the conflict between blacks and whites. In contrast, in Trinidad, the *recognized* racial conflict is the one that exists between Afro- and Indo-Trinidadians. Despite the existence of racial tensions in Trinidad, however, the absence of a majority white population renders race relations in the region qualitatively different from the kind prevalent in the United States.

The differential experience of first-generation Afro-Trinidadian immigrants also lends them a racial and cultural perspective distinct from that of American-born blacks. For instance, in Reuel Roger's study of Afro-Caribbean immigrants, the majority of interviewees attributed success in the area of occupation to hard work and did not perceive racism as an all-pervading obstacle to social mobility. In contrast, African American interviewees exhibited a much higher degree of racial consciousness (Foner 2001: 178).

As immigrants, Afro-Trinidadians, also act from a different set of aspirations and expectations than African Americans. Waters writes that, "the achievement ideology of the West Indians prepares them to battle to succeed in the United States" (Waters, 159). Indeed, many researchers have argued that because immigrants are a self-selected group, they possess a higher degree of motivation and drive for social mobility than African Americans do (Butcher, 267). By adopting various strategies, Afro-Trinidadians aim to improve their life chances and to achieve social mobility in the racially structured American society that they encounter.

### Collective Strategies

Collective methods for ameliorating life conditions of Afro-Trinidadians in the U.S. consist mainly of establishing social networks

based on kinship ties with other Afro-Trinidadian immigrants. Christine Ho's study of Afro-Trinidadians in Los Angeles is particularly illuminative in understanding the role of kinship networks in the lives of these immigrants. Ho found that relatives fulfilled important instrumental functions for Afro-Trinidadians in the U.S. In material terms; family members often assisted newly arrived immigrants with financial support and in finding jobs. In many cases, Afro-Trinidadians come to the U.S. through the sponsorship of a relative who already lives here. Indeed, many researchers characterize Afro-Trinidadian migration to North America as "chain migration" where immigrants follow their family members into the United States. In fact, from the outset, family members provide material support for immigrants.

Social networks also lend Afro-Trinidadian immigrants a certain degree of psychological support. Vilna Bashi refers to the mechanism of "psychological insulation" that kinship networks provide immigrants against the racism in the wider society. (Cordero-Guzman, 229).

Among Afro-Trinidadian immigrants, women, in particular, actively participate in maintaining kinship networks both within the United States and between the U.S. and Trinidad. Caribbean women immigrants differ from other immigrant women in the sense that many of them enter the U.S. as "principal aliens" and as such, are responsible for providing for their families. Christine Ho points out that "this fact contradicts the popular assumption that immigrants are men and dependents are women and children" (Ho, 1993: 33). Christine Ho's findings reveal that women rather than men are more prone to keeping in touch with relatives in Trinidad. Ho points to a "system of reciprocity" whereby Afro-Trinidadian women immigrants send remittances to family members in Trinidad, while relatives in Trinidad help out with raising their children. She writes that, "almost twice as many women (54%) as men (26%) in the sample send remittances to mothers, aunts and

grandmothers in Trinidad every few months, 17% sending them to people “minding” children” (Ho, 1993: 35). In fact, child minding plays a cohesive role even in social networks of Trinidadians within the United States. Christine Ho, for instance, found that Afro-Trinidadian women in Los Angeles did not send their children to day care centers when they were at work, but to grandmothers or in-laws who lived “a couple of blocks away” (Ho, 1991: 95). Women also maintain a greater degree of regular contact than men do with family members through telephone conversations (Ho, 1993: 35). Women, therefore, play crucial roles in maintaining kinship ties and social network groups both within the U.S. and transnationally.

### **Transnational Ties**

While women facilitate connections in unique ways through customs such as “child minding”, Afro-Trinidadians—male and female—also employ other devices to maintain and strengthen ties with their homeland. Traveling periodically to Trinidad constitutes a particularly effective way of preserving relations with family members at home. Christine Ho notes that, “in spite of the high cost of round-trip airfare from Los Angeles to Trinidad and Tobago, 100 percent of the Afro-Trinidadian sample periodically visit their homeland on vacation” (Ho, 1991: 122). Maintaining transnational contact is important in practical terms, in case, an individual should decide to take the “exit option” and return to Trinidad. Preserving a Caribbean identity also benefits immigrants psychologically since it reaffirms for them their status as foreigners and helps them find an ““out” to experiencing racism” (Waters, 93). Participation in the annual Carnival provides an important expression of the immigrants’ transnational identity whether it is at the yearly festival in Brooklyn or traveling back home to Trinidad to participate in the real thing. Thus Afro-Trinidadians consciously maintain both *psychological* and *actual* contact with their social networks in their homeland. At the same time, however, the Afro-Trinidadian

immigrants’ desire to build and preserve social connections exclusively with fellow Afro-Trinidadians, and to achieve social mobility, isolates them from both the African American subculture and the wider American society.

### **Rejection of African American Subculture**

One of the strategies Afro-Trinidadians adopt in order to fulfill their ambitions as immigrants in the United States is to distance themselves from the African American subculture. The obvious reason for the lack of attraction that African American subculture holds for Afro-Trinidadians consists of the fact that black Americans comprise one of the most disadvantaged groups in American society. Afro-Trinidadians’ fear of jeopardizing their social positions leads them to maintain their cultural identities as distinct from those of African Americans. This is reflected in the patterns of residential segregation practiced by West Indians in America. Pointing to the importance of both race and ethnicity in determining the “residential patterns” of West Indians, Kyle Crowder writes that, “presumably on the basis of race, West Indians are denied access to Anglo-residential areas.... On the other hand, the fact that West Indians are not fully integrated into African American residential communities seems to indicate that West Indian ethnicity plays a role as well” (Crowder, 95). The self-segregation that West Indians practice provides them with twin benefits—not only does it help to distinguish them from African Americans, but it also helps them avoid relegation to areas of “concentrated poverty, physical decay, and social degradation” (Crowder, 86). Indeed, studies indicate that West Indians seem particularly preoccupied with avoiding the social ills that they perceive to be largely prevalent in black neighborhoods. Mary Waters, for instance, quotes one of her interviewees, who, comments that African Americans are “in too much drugs, on the streets, doing wrong things. Getting into trouble.... We [West Indians] try hard to work. But I feel the majority of them they depend on someone to give them a hand out all the time”

(Waters, 65-6). Indeed, the notion that African Americans are lazy seems to be a widely held belief among West Indian immigrants in North America. Milton Vickerman's study of Jamaican immigrants suggests similar findings. For instance, he reports that one of his interviewees remarked that, "I would say...that they [African Americans] are lazy and we from the West Indies work very hard" (Vickerman, 143). In some cases such negative perceptions of African Americans leads certain West Indian immigrants to view themselves as being superior to American born blacks (Foner 1987: 208). Deprecatory attitudes such as those delineated above, inevitably lead to greater tensions between African Americans and West Indian immigrants and further widen the gap between the two groups.

Afro-Trinidadians also employ devices such as language skills and a British accent to deliberately differentiate themselves from African Americans and to increase their chances for social mobility. White Americans, because they place a higher value on a British accent, also view Afro-Trinidadians in a favorable light. Mary Waters records that one of her white respondents in a study observed that, "they [West Indians] are educated. They have high values for education. A lot of times their accent is more British than American. It's sort of somehow people with a British accent; you always think that they are really intelligent no matter what they say" (Foner 2001: 214). An accent distinct from that of an African American also provides an advantage to West Indians in the job market. Vilna Bashi Bobb and Averil Clarke suggest that, there is also the role of what we call "the foreign marker", that is, an accent that may lead whites—especially those employers and providers of goods with whom the network has negotiated special status for its members—to treat West Indians better than American blacks (Foner 2001: 231). Similarly, Kasinitz points out that West Indians' ability to enter the low wage sector in New York is improved by "a mastery of the English language...that is superior to many native

graduates of the New York public school system" (qt. In Palmer, 32). Language and accent, thus, provide added ways for Afro-Trinidadians to distance themselves from American blacks. In this case, the favorable white response to West Indian accent also legitimizes and rewards the gulf between African immigrants and native blacks.

### **Conclusion: Social Mobility vs. Assimilation**

As immigrants into the United States, Afro-Trinidadians possess an achievement-oriented mindset. For both male and female Afro-Trinidadians, social mobility in the United States remains an overwhelmingly important goal (Ho, 1991: 59). Indeed, like other immigrant groups in U.S. history, West Indians of African descent consciously attempt to realize the "American dream" of personal achievement and material success through a variety of individual and collective strategies. Because of their pre-migratory experience of living in a multicultural society, Afro-Trinidadian immigrants comprehend the existence of racial stratification and tensions. But, due to the particular nature of Trinidadian society, these immigrants do not enter the United States with a developed sense of racism as it is practiced in the US<sup>3</sup>. However as Vilna Bashi pointed out to in a telephonic interview, "once the initial shock of encountering racism is over, the Caribbean immigrants understand the whole racial structure. They realize that the whites are at the top of the social hierarchy followed by Asians and Hispanics. They understand that blacks are at the bottom of the structure" (Personal Interview, 2002).

<sup>3</sup> It is interesting to note that as Afro-Trinidadians achieve social mobility and become middle class they become more perceptive of racism in the United States. This arises from their realization that unlike in the West Indies, status and wealth do not affect their *racial* standing in the United States. For instance, Nancy Foner, in her study of Jamaican immigrants comes to the conclusion that, "at home [in Jamaica]...Mr. E. had a good job as a policeman and he was a respected man in his community. In New York, as a black man, he is a member of a definite minority. Education, income and culture, do not, as in Jamaica, partially "erase" one's blackness" (Foner, 1987: 203).

They consequently also realize that membership of the most stigmatized group in U.S. society i.e. African American society, will prove to be an obstacle in the path of social mobility. Hence, many Afro-Trinidadians deliberately dissociate themselves from black American culture. However, their rejection of African American culture results in their isolation from the wider American social structure. This arises as a consequence of the lack of “an undifferentiated monolithic American structure” and the prevalent social expectation that “if these immigrants assimilate, they assimilate not just as Americans but as black Americans” (Waters, 1995). As a result, Afro-Trinidadians try to maintain and reaffirm their ethnic distinctiveness—through national and transnational ethnic social networks—to differentiate themselves from African American subculture, and, by extension, the larger American social structure. These immigrants thus reject the idea of assimilation and refuse to be a part of the American “melting pot”, making social mobility and assimilation into the American culture incompatible goals for Afro-Trinidadians within the existing framework of North American society.

#### References:

- 1) Bashi, Vilna and McDaniel, Antonio. “A Theory of Immigration and Racial Stratification” *Journal of Black Studies* 27 (1997): 668-682
- 2) Birbalsingh, Frank ed., *Indenture & Exile: the Indo-Caribbean Experience*. Toronto: TSAR, 1989.
- 3) Butcher, Kristin F. “Black Immigrants in the United States: A Comparison with Native Blacks and Other Immigrants” *Industrial and Labor Relations Review* 47 (1994) 265-284.
- 4) Cordero-Guzman, Hector R. et al Eds. *Migration, Transnationalization and Race in a Changing New York*. Philadelphia: Temple, 2001
- 5) Crowder, Kyle D. “Residential Segregation of West Indians in the New York/ New Jersey Metropolitan Area: the Roles of Race and Ethnicity” *International Migration Review* 33 (1999) 79-113.
- 6) Foner, Nancy ed., *Islands in the City: West Indian Migration to New York*. Berkeley: California, 2001.
- 7) Foner, Nancy ed., *New Immigrants in New York*. New York: Columbia, 1987.
- 8) Henry, Keith S. “Language, Culture, and Society in the Commonwealth Caribbean” *Journal of Black Studies* 7 (1976): 79-94
- 9) Ho, Christine G. T. “The Internalization of Kinship and the Feminization of Caribbean Migration: the Case of Afro-Trinidadian Immigrants in Los Angeles” *Human Organization* 52 (1993) 32-40.
- 10) Ho, Christine, *Salt-Water Trinities: Afro-Trinidadian Immigrant Networks and Non-Assimilation in Los Angeles*. New York: AMS, 1991.
- 11) Ho, Christine G. T., “Post Industrialism and the Social Organization of Afro-Trinidadian Immigrants in Los Angeles” *ISSR Working Papers* 2 (1986).
- 12) Kasinitz, Philip, *Caribbean New York: Black Immigrants and the Politics of Race*. Ithaca: Cornell, 1992.
- 13) Lowenthal, David. “Black Power in the Caribbean Context” *Economic Geography* 48 (1972) 116-134.
- 14) Palmer, Ransford W. *Pilgrims from the Sun: West Indian Migration to America*. New York: Twayne, 1995.
- 15) Ryan, Selwyn D. *Pathways to Power: Indians and the Politics of National Unity in Trinidad and Tobago*. Trinidad: ISER, 1996
- 16) Vickerman, Milton. *Crosscurrents: West Indian Immigrants and Race*. New York: Oxford, 1999
- 17) Waters, Mary C. *Black Identities: West Indian Immigrant Dreams and American Realities*. Cambridge: Harvard, 1999.

## Nineteenth Century European Studies on South Asian Buddhism

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The study of Buddhism is as old as Buddhism itself. But its modern study is only about two centuries old. It began in Europe in the early nineteenth century following the establishment of colonial rule in India, Sri Lanka, and other Asian countries. Until then, studies were limited to various aspects of philosophy, metaphysics, religion, language, logic and so on. There was also emphasis on the history of monastic establishments and the myths and legends associated with them. But modern studies added a number of new dimensions to them. They focused on the historical, cultural and sociological aspects of Buddhism. Economic and political histories were also taken up for research. These modern studies raised questions related to caste, class, oppression and resistance, patronage, proselytization, role of women, canon formation, art and architecture, literature and many other issues. As a result, new light was thrown not only on the social and cultural dimensions of Buddhism, but also on religious processes and practices in general. By the end of the nineteenth century, the western academia was thrown open to a whole new discourse on religion. In this paper we will examine the contribution of European scholars to the study of South Asian Buddhism during the nineteenth century.<sup>1</sup>

### **The Role of Asiatic Society**

The interest in Buddhism, which developed in modern Europe in the nineteenth century, was closely related to the new interest about eastern civilization in England, France, Germany and Denmark. This interest sprang from two sources, viz. the scientific temper of the Enlightenment and the administrative requirements of colonial rule. William Jones, who was the chief judge of the Calcutta High Court, established the Asiatic Society in 1784 to carry out research on ancient Indian history, society, culture and religion. Jones was himself deeply interested in customs, traditions and literature of ancient India. He translated Kalidasa's famous play *Sakuntala* into English, which became widely popular in Europe. The

famous German philosopher Hegel hailed it as one of the greatest masterpieces of literature. Jones also translated the *Bhagavadgita* into English. The initiatives taken by him generated new interest about Indian history, society, customs and traditions, which were essential for carrying out the colonial administration smoothly.

The most significant and lasting contribution of Jones was towards the study of languages. Jones realized that Sanskrit contained a number of words and expressions, which are similar to Greek and Latin. He was of course not the first to recognize this similarity, but he carried out sustained research into the subject and popularized it across Europe through his writings. This led to the origin of a new academic discipline called Comparative Philology. After this momentous discovery by Jones, many intellectuals in Europe began to feel that they shared their cultural origins with the Aryans of India. They began to look towards the East, in order to trace their own origins and identity. This gave rise to a new approach towards the East, which is popularly known as Orientalism. The theory of common origin was further strengthened in the mid nineteenth century when Charles Darwin developed the model of biological evolution and origin of species. Buddhism evolved into a modern scientific discipline in this context and offered a new direction to the academic discourse on religion in Europe. In other words, modern Buddhist studies were the outcome of a quest for the common origin, essence and destiny of humankind. It arose from a determination to discover the ultimate universal source of human joy, happiness, sorrow and suffering, which was also believed to be the real source of human culture and civilization. This makes it clear beyond any shade of doubt that the history of modern Buddhist studies is deeply indebted to Orientalism and the Enlightenment and is one of their direct outcomes. Any assessment of European research on Buddhism during the nineteenth century has to bear this connection in mind.<sup>2</sup>

## Early Scholarship

The enthusiasm for Asian languages, which developed as a result of Comparative Philology, generated interest towards many ancient languages. Pali was one of them. As early as 1821, a Danish scholar called Rasmus K. Rask arrived in Sri Lanka for studying Pali. He also learnt Sinhalese and collected a large number of palm leaf manuscripts from Sri Lanka. By this time many scholars had begun to show interest in Pali. Benjamin Clough studied Pali grammar in 1824. Two years later in 1826, Eugene Burnouf and Christian Lassen published an important work on Pali in French. This was *Essai Sur Le Pali*. Burnouf was a great scholar. He was not only a master of Pali but also a competent authority in Sanskrit. He translated various sections from Buddhist texts like *Divyavadana*, *Vajrasuchi* and *Karandavyuha*. In 1852, he published *Le Lotus de la bonne loi*, a French translation of *Saddharmapundarika*. Earlier in 1844, he had written *Introduction a l'Historie du Bouddhisme Indien* in French. This was the first history of Buddhism to be written in a European language. Burnouf also introduced the *Lankavatara sutra* and *Prajnaparamitasutra* to the western readers by writing scholarly essays about them.

Meanwhile, George Turner published an English translation of the first thirty-eight chapters of the Sri Lankan Pali chronicle *Mahavamsa*. In the introduction to this work, Turner made an attempt to give an over view of Pali literature. This exposed the English-speaking world to the Pali world of letters for the first time. Niels Ludvig Westergaard and F. Spiegel carried forward the efforts made by Turner with great zeal. J. Lewis and Brian Houghton Hodgson were other early enthusiasts. Hodgson collected a large number of manuscripts from Nepal between 1821 and 1841. These have been preserved in various libraries in Europe and India.

Studies on Buddhism in South Asia received some important fillips due to the researches

carried out in Chinese and Tibetan sources. C.J. Newman brought out a study on Chinese pilgrims of India in 1833. Three years later, in 1836, A. Remusat published a translation of Fa Hsien's travel account. The Mongol text of Kashyapa Matanga's *sutra* was translated into French in 1848 by Evariste Regis Huc and Joseph Gabet. St. Juliens' translation of Hiuen Tsang's *Si Yu Ki* appeared in 1853. By 1859, the Chinese version of the *Avadanas* had also been brought to light. On the Tibetan frontier, some work had already begun in the early eighteenth century. A Capuchin missionary called Francesco Orazio Della Perna stayed in Lhasa for sixteen years between 1716 and 1732 where he produced a Tibetan Dictionary. He also translated Tson-kha-pa's *Lam-rim-chen-mo* and *Patimokkha*. Ippolito Desideri was another missionary who lived in Lhasa from 1717 to 1721. He was a Jesuit, and wrote a book on Tibetan manners and religious customs in 1729. But these were only stray accounts. In 1827, Burnouf wrote an essay on Tibetan literature. He mentioned the Tanjur and Kanjur collection in this essay. These collections were being systematically studied at that time by the Hungarian philologist Alexander Csomo de Koros. He wrote several articles on Tibetan Buddhism during this period. In 1834, he published the monumental Tibetan-English Dictionary during his stay at the Zangla Monastery in Zanskar. This enriched the study of Tibetan Buddhism, which in turn threw fresh light on Indian Buddhism and Indo-Tibetan relationships. With the publication of J.J. Schmidt's index on the Kanjur manuscript collection, the study of Tibetan Buddhism came of age.

### Consolidation of Buddhist Studies

The initiatives taken by these early scholars lead to the development of Buddhist Studies as a fruitful and intellectually stimulating academic discipline. Gradually, more and more young researchers were drawn towards academic Buddhism. They carried out systematic studies of Pali, Sanskrit, Tibetan and Chinese languages. Grammar, syntax, etymology,

morphology and phonology in these languages were taken up for scholarly analysis. Works on grammar were published. Dictionaries were compiled. A number of them were also translated into English, French, German and other European languages. All these facilitated the growth of modern Buddhist studies in the nineteenth century.

In 1855, Vincent Fausboll translated the *Dhammapada* into Latin. This was a novel experiment. Five years later, in 1860, it was translated from Latin to German. Fausboll also brought out a critical edition of the *Suttanipata* in 1885 and an English translation of it earlier in 1881. Another major achievement of Fausboll was the publication of the *Jataka* stories. He oversaw translation of these stories by a handful of scholars and started bringing them out in 1877. By 1897, all *Jataka* stories had been translated in six volumes. These volumes remain the most authentic source for studying the *Jatakas*.

The study of Pali was experiencing several difficulties in the nineteenth century due to the non-availability of a standard dictionary of the language. There was great demand for one such dictionary. R.C. Childers fulfilled this demand when he published the Pali-English Dictionary in 1875. This has continued to be a widely consulted dictionary even to this day.

Scholars of Buddhism in the latter half of the nineteenth century were far more studious and enterprising than their predecessors. They picked up voluminous works for editing and translation. They also produced manuals and handbooks on different aspects of Buddhism. V. Trencker translated the *Milindapanha* in 1880. Trenckner was a Danish scholar. His Dutch counterpart Hendrik Kern came out with a translation of *Saddharmapundarika* in 1884. Earlier, in 1881, Kern had published an edition of Aryasura's Sanskrit *Jatakamala*. His landmark publication was the *Manual of Indian Buddhism*. This appeared in 1896. This was published in the *Grundris der Indo-Arischen Philology and Altertumskunde* or the Encyclopedia of Indo-Aryan Philology and

Research. This manual contained a brief but systematic and exhaustive overview of Indian Buddhism. Kern continued his work well into the early twentieth century. In 1901, he published the first volume of the *Historie du Buddhism Dans l'Inde*. The second volume appeared in 1903. These volumes contained an elaborate history of the life of Buddha, his philosophy and religious order. It also gave an in-depth account of the Buddhist councils, schisms and different schools of thought.

An able contemporary of Kern was the German scholar Hermann Oldenberg. He was one of the greatest orientalist of the nineteenth century. His scholarship was not restricted to Buddhist literature alone. He was equally at ease with Vedic sources. His work on the *Rigveda* is considered a masterpiece. It is consulted by scholars on Vedic religion and society even today.

Oldenberg published the translation of several Pali Buddhist texts. Between 1879 and 1883, he brought out the *Vinaya Pitaka*. He also worked on the *Chullavagga*, *Mahavagga* and *Patimokkha* between 1881 and 1885. In 1883, he published *Theragatha* and *Therigatha*. The critical edition and translation of *Dipavamsa* appeared in 1897. Apart from these primary sources, Oldenberg also wrote *The Buddha*, which was a widely read and admired biography of the master. This was translated into English in 1882 by Hoey.

Between 1879 and 1885, three major events took place in Europe, which changed the destiny of Buddhist studies. The first event was the launching of the *Sacred Books of the East* series in 1879 by Friedrich Max Muller. A large number of religious texts of various religions was published in this series between 1879 and 1897. Altogether, fifty volumes of the *Sacred Books* series came out during these eighteen years. Ten of them contained Buddhist literature. Vol. 10 was the first in the series to handle Buddhist texts. It consisted of the *Dhammapada* and *Suttanipata*, translated by Max Muller and Fausboll respectively. Vol. 11

contained several *suttas* like *Mahaparinibbanasutta*, *Dhammachakkapavattanasutta*, *Mahasudassanasutta* etc., translated by T.W. Rhys Davids. Vol. 13 was reserved for selection from *Patimokkha* and *Mahavagga* of the *Vinaya Pitaka*. In Volume 17, Rhys Davids and Oldenberg translated *Chullavagga* and *Mahavagga*. Vol. 19 and 20 were published in 1883. The former was a translation of substantial portion from the *Buddhacharita* of *Asvaghosha* from the Chinese version by Samuel Beal. The latter contained translations of the remaining portion of *Vinaya Pitaka* and *Chullavagga* by Rhys Davids and Oldenberg. The *Saddharma Pundarika* was translated by Kern in Vol. 21 in 1884. Vol. 35 and 36 were devoted to *Milindapanha*, which Rhys Davids translated. They appeared in 1890 and 1894 respectively. The last one in the series to deal with Buddhism was Vol. 49, which came out in 1894. It contained the texts from various Mahayana texts, like *Asvaghosha's Buddhacharita*, *Sukhavativyuha* and *Prajnaparamitasutra*. Edward B. Cowell, Max Muller and J. Takakusu translated these works. The *Sacred Books* series become the most important source in Europe for the study of Asian religions in general and Buddhism in particular. For nearly half a century, Buddhist scholars from the west depended on this series for most of their general research.

The second event was the establishment of the Pali Text Society in London in 1881. This was the brainchild of T.W. Rhys Davids, who can really be regarded as the greatest nineteenth century European expert on Buddhism. His contributions to the growth and discussion of modern Buddhist studies are second to none.

Rhys Davids learnt Pali from Sri Lanka after joining the Ceylon Civil Service in 1864. After returning to England in 1872, he began the study of Buddhism in association with Childers, Kern, Max Muller, Oldenberg, Fausboll and others. In 1878, he published a scholarly book called *Buddhism*. In the following year, 1879, he

translated the *Nidanakatha* into English. He also translated the *Vinaya Pitaka* in association with Oldenberg for the *Sacred Books* series. The *Milindapanha* in the *Sacred Books* series was translated by him. Rhys David also edited the *Dhatuvamsa* and *Abhidhammatthasangraha*, both in 1884. His edition of the *Digha Nikaya* was an outstanding piece of scholarship, which can still be emulated. His notes and introduction to this work show his deep understanding of Buddhist religion and philosophy. *Digha Nikaya* appeared in three volumes in 1889, 1903 and 1910.

The establishment of the Pali text Society was announced by Rhys Davids during his Hibbert lectures in America in 1881. He declared that “The sacred books of the early Buddhists have preserved to us the sole record of the only religious movement in the world’s history which bears any close resemblance to Christianity, and it is not too much to say that the publication of this unique literature will be no less important for the study of history and especially of religious history than the publication the Vedas has already been”. With this lofty ideal in mind, Rhys Davids launched the Pali Text Society. Within a short period, the society published a number of valuable Buddhist texts. The *Samyutta Nikaya* was published in five volumes between 1884 and 1898. It was edited by Leon Feer. The *Anguttara Nikaya* appeared in five volumes between 1885 and 1900. The first two volumes were edited by R. Morris, the remaining three by E. Hardy. Rhys Davids edition of *Digha Nikaya* came out in three volumes in 1889, 1903 and 1910. J.E. Carpenter collaborated with him in this project. *Majjhima Nikaya* was published in three volumes between 1888 and 1902. The first volume was edited by V. Trenckner, while R. Chalmers brought out the remaining two volumes. Fauboll’s edition of *Jatakas* and Oldenburg’s *Theragatha* and *Therigatha* were also published by the Pali Text Society. Other noteworthy publications of the society in the nineteenth century include E. Hardy’s edition of *Petavatthu* commentary in 1894, Burnouf’s *Suttanipata* in 1885, Cowell’s

*Jataka* stories in six volumes between 1895 and 1907, Edward Muller’s *Dhammasangani* in 1885, A.C Taylor’s *Kathavatthu* in two volumes between 1894 and 1897 etc. The role played by the Pali Text Society in strengthening Buddhist studies in Europe can therefore hardly be overstated.

The third event occurred in 1885. This was the publication of Edwin Arnold’s famous poem *Light of Asia*. This poem was an exciting lyrical biography of the Buddha. Arnold made good use of myths and legends from the ancient Indian cosmology in crafting a stimulating literary masterpiece. *Light of Asia* became an instant hit in Great Britain. Thousands of copies were sold and several editions came out within a few years. It was also translated into a number of European languages. With the publication of *Light of Asia*, the destiny of Buddhist studies in Europe changed once and for all. Before the appearance of *Light of Asia*, Buddhism was of interest only to the intellectual and scholastic classes and those who were attracted by the “mysteries” of the East. Now it started gaining popularity among the common people. More and more ordinary men and women become curious about the Buddha and his religion. As a result, many publishers in Europe began to bring out cheap biographies of the Buddha and handbooks on Buddhism. Arnold’s poem may be regarded as a work which brought forth the democratization of interest in Buddhism. Buddhism began to appear in a big way on the frontiers of popular culture in Europe.<sup>3</sup>

### Assessment

At the end of this survey, an important question arises. What was the real nature of Europe’s nineteenth century interest in Indian Buddhist literature? An answer to this question has already been suggested above. Nineteenth century Europe was interested in exploring their own cultural and historical roots after Jones brought the similarities between Indian and European languages to light. In other words, European scholars were concerned with their own antiquity and identity, which offered the

meta-rationale for all the genuine interest which they displayed in Buddhism, Hinduism and other cultural and religious traditions of Asia. This European attitude towards the East, and the discourses generated by it, has since been famously theorized by Edward Said in his *Orientalism*.<sup>4</sup>

Any quest for antiquity and cultural identity will naturally be concerned with the originality and authenticity of the sources. This is very clearly reflected in nineteenth century European engagements with Buddhist literature too. The genuineness of texts was a major source of concern. Is a particular saying or sermon attributed to the Buddha really that of the Buddha? Or is it a later day interpolation? Does the meaning of a word or expression in Pali or Sanskrit remain faithful to its etymological origins? What is the real nature of change, which occurs when a Sanskrit word is transformed into Pali? What was the real intention of the author or compiler of a text when a particular word, phrase, sentence, or stanza was used? Such questions remained the prime concern of scholars from Burnouf to Rhys Davids. This necessitated the production of critical editions of Pali and Sanskrit texts. These editions contained extensive notes on various aspects of the texts. Such notes were expected to authenticate the genuineness and expose interpolations in both canonical and non-canonical literature. In other words, origin and authenticity are the two major concerns, which we can identify as animating nineteenth century European scholarship on Buddhist literature. This is not at all surprising; after all Europe was deeply concerned with its own historical and cultural roots, which it wanted to unearth in authentic ways.<sup>5</sup>

This attitude continued well into the early twentieth century. Scholars like C.A.F Rhys Davids (wife of T.W. Rhys David), Jean Przyluski, Th. Stcherbatsky, Sylvain Levi, E. Obermiller, I.B. Horner, J.E. Carpenter, Karl Seidenstucker, Lord Chalmers, F.L. Wood Ward and many others continued to carry out research from within the nineteenth century paradigm of

origin and authenticity. Orientalist discourse pervaded most studies carried out under this paradigm. This paradigm came into disuse only after the fascination for historical and cultural origins paved way for the discourse on racism and pure blood, leading to the advent of Fascism in Italy and Nazism in Germany, and culminating in the holocaust.

#### References:

- 1) According to some scholars, Buddhism was not a religion in the sense in which it is understood today. It came to be represented as a religion only in the nineteenth century as a result of academic, administrative and popular British interest in it. This argument is developed in Almond, Philip C. 1988. *The British Discovery of Buddhism*. New York and Cambridge: Cambridge University Press.
- 2) A textbook history of the Asiatic Society is found in Mitra, S.K. 1974. *The Asiatic Society*. Calcutta: The Asiatic Society.
- 3) A history of academic interest in Buddhism is contained in Bhattacharya, N.N. 1981. *History of Researches on India Buddhism*. New Delhi: Munshiram Manoharlal. A brief outline can be found in the first chapter of Bhattacharya, N.N. 1993. *Buddhism in the History of Indian Ideas*. New Delhi: Manohar.
- 4) Said, Edward W. 1978. *Orientalism*. New York: Pantheon Books.
- 5) It has also been argued that the translations of Indian texts carried out in the colonial era were part of deploying knowledge for exercising power over the colonized subjects. See Niranjana, Tejaswini. 1992. *Siting Translation: History, Post-Structuralism, and the Colonial Context*. Berkeley: University of California Press.

## An Overview of Mathematics and Astronomy in India (1300-1800 CE)

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For much of the twentieth century, it was believed that mathematics and astronomy in India ceased to make progress after the twelfth century and that Bhaskara II, the author of *Lilavati*, *Bijaganita* and *Siddhanta Siromani*, was the last great Indian mathematician and astronomer. All works, which appeared after Bhaskara II, were thought to be mere commentaries on earlier works, having no original contributions to make. This was at times associated with the parallel belief that Muslim rulers turned a blind eye to the growth of science and technology, and hardly ever patronized the production of knowledge. In putting forth these arguments, it was conveniently forgotten that these disciplines registered no progress worth the name during the five odd centuries between the *Vedanga Jyotisa* (ca. 200-100 BCE) and the Bakhshali manuscripts (ca. 300-400 CE), or that after Aryabhata I, Varahamihira, Bhaskara I and Brahmagupta (all between 475-600 CE), there is nearly two and a half centuries of silence before we meet the next prominent mathematicians, Mahavira and Sankaranarayana (both ca. 850 CE).

The situation is different today. The belief that no significant mathematical treatise appeared in India after the twelfth century has been called into question, most notably by George Gheverghese Joseph.<sup>1</sup> Joseph notes that “the period between the fourteenth and seventeenth centuries marked a high point in the indigenous development of astronomy and mathematics”.<sup>2</sup> But this he believes is a phenomenon restricted only to Kerala; “the picture about the rest of India is somewhat patchy”.<sup>3</sup> What we see in Kerala constitutes, according to Joseph, a Kerala School of Mathematics.<sup>4</sup>

We come across as many as eleven leading mathematicians in Kerala between the fourteenth and the nineteenth century.<sup>5</sup> The last of them was Sankaravarman (nineteenth century), who hailed from a princely family in northern Malabar. His immediate predecessor was Pudumana Somayaji (eighteenth century),

who came from Trissur. The rest of them were part of a scholarly pedigree, which commenced with Madhavan of Sangamagrama (Irinjalakkuda). The others in this tradition were Vadasseri Paramesvaran, Damodaran, Nilakantha Somayaji, Jyeshthadevan, Chitrabhanu, Achyutappisharadi, Sankaravariyar and Mahishamangalam Narayanan. Achyutappisharadi and Sankaravariyar belonged to families traditionally associated with temple services. Sankaravarman, as we have just noted, was from a royal line. The other eight were all Namboodiri Brahmanas.

Based on this fact – that most Kerala mathematicians were Namboodiris – and on the assumption that the rest of India did not witness a similar scholarly efflorescence in the disciplines during the period, Joseph makes an attempt to account for the “unique” phenomenon in Kerala. It is well known that only the eldest son in a Namboodiri family was permitted by tradition to contract regular marriage with Namboodiri women. The other sons practiced *sambandham*, a non-marital relationship with women from other upper castes, particularly from among the Nayars.

The system of primogeniture kept the eldest son of the Nambuthiri family busy looking after the property and community affairs while his younger brothers lived unencumbered lives with plenty of leisure time. Lacking in social status and power on par with the eldest brother, the younger sons needed to attain social respectability through other means. Scholarship, both secular and religious, was one way available to them to make a mark. We therefore formulate the hypothesis that many of the well-known mathematicians/astronomers of the Kerala School may have emerged from among this unencumbered section of the Nambuthiris.<sup>6</sup>

The other factors said to have been responsible for the rise of the Kerala School of Mathematics were i) the need to maintain systematic accounts of land transactions in which Namboodiris were often involved, and ii) the dissemination of calendric knowledge in the wake of agrarian expansion, which necessitated a good understanding of seasonal forecasts.<sup>7</sup>

This is a functionalist explanation. It is also excessively instrumentalist in its reasoning. Sporadic individual acts can – and at times must – be explained in instrumentalist terms. On the other hand, historical processes and phenomena spreading over several centuries need to be understood at a processual level.

The so-called Kerala School of Mathematics begins with Madhavan, who lived in the later half of the fourteenth century and the early decades of the fifteenth. Two of his works survive, *Venvaroha* and *Sphutachandrapti*. Both were attempts to refine Vararuchi’s *chandravakya* system of calculating the moon’s position. His fame, however, rests on the infinite series he developed for circular and trigonometric functions. Works containing his thesis on the infinite series have not survived. We learn about them only from the accounts of his successors, especially from Nilakantha Somayaji and Jyeshthadevan.

Madhavan’s disciple, Vadasseri Paramesvaran, was a prolific writer. He produced *Suryasiddhantavivarana*, a gloss on the *Suryasiddhanta*, and a number of other commentaries, like *Bhatadipika* on Aryabhata’s *Aryabhatiya*, the *Laghubhaskariyavyakhya* on Bhaskara I’s *Laghubhaskariya*, the *Kramadipika* and the *Siddhantadipika*, both on Bhaskara I’s *Mahabhaskariya*, and the *Laghumanasavyakhya* on Manjula’s *Laghumanasa*. The other glosses he wrote were on Govinda’s *Muhurtaratna* and Bhaskara II’s *Lilavati*. His independent works were *Goladipika*, *Drigganita*, *Grahanamandana* and *Vakyakarana*. These works dealt with planetary

motions and their calculation. The method of observation developed in the *Drigganita* became a strong benchmark against which subsequent advancements in astronomy were made in Kerala.

Paramesvaran had two illustrious students, Damodaran and Nilakantha Somayaji. Information about the former's original contribution to mathematics is limited. A son of Paramesvaran, his renown rests on the fact that he was a much sought-after teacher. Among his disciples were Nilakantha Somayaji, Jyeshthadevan and Sankaravariyar. Nilakantha Somayaji was also a great teacher and had among his students Chitrabhanu, Jyeshthadevan and Sankaravariyar.

Nilakantha Somayaji wrote the *Tantrasangraha* in which he developed Paramesvaran's *drigganita* system. In this work, he proposed revisions to the equation on the centre of Mercury and Venus, anticipating Kepler by almost a century and a half. The other works of Nilakantha Somayaji were *Golasara* and commentaries on *Aryabhatiya*, *Chandravakyaganita* and *Siddhantadarpana*. In the commentary on *Aryabhatiya*, he came up with a computational model of planetary motion for all planets except Uranus, Neptune and Pluto (which were then unknown). This model excelled the one proposed by Tycho Brahe in many ways.

The *drigganita* system assumed new dimensions when Chitrabhanu used it to propose astronomical calculations in his *Karanamrita*, written in 1530. The *panchangam* (calendar) used in Kerala today is based on this work. Another work of Chitrabhanu's was *Ekavimsatiprasnottara*. His disciple Sankaravariyar, who also studied under Nilakantha Somayaji, wrote three commentaries on the latter's *Tantrasangraha*, viz., *Yuktidipika*, *Kriyakalapa* and *Laghuvivritti*. The *Karanasara* and the *Karanasarakriyakramam*, a commentary on the former, were two other works of Sankaravariyar's. His magnum opus

was *Kriyakarmakari*, an ambitious commentary on the *Lilavati*. He left it incomplete. It was completed in 1556 by Mahishamangalam Narayanan, a disciple of Chitrabhanu.

The most important mathematician from Kerala after Nilakantha Somayaji was Jyeshthadevan. His *Yuktibhasha* offered an excellent exposition of Madhavan's infinite series and presented justifications and proofs for a number of formulations in the *Tantrasangraha*. The work was completed in 1530. Jyeshthadevan is also said to have written *Drikkarana*, which has not come down to us.

Jyeshthadevan was the teacher of Achyutappisharadi, who wrote works like *Sphutanirnaya*, *Rasigolasphutiti*, *Uparagakriyakrama*, *Horasarochhaya* and *Jatakabharanapaddhati*. In the *Sphutanirnaya*, he proposed that calculation of the moon's longitude had to take into account its motion along the orbit, which deviates from the ecliptic by a small measure. This observation was made at a time when Tycho Brahe, his contemporary, was carrying out similar corrections with respect to planets known at that time. We now call this the reduction to the ecliptic.

Nearly a century and a half later, Pudumana Somayaji produced his *Karanapaddhati* (1732), which was deeply indebted to previous works from Kerala, particularly Jyeshthadevan's *Yuktibhasha*. But he restricted the use of the *drigganita* method only to the prediction of eclipses. In other aspects, he followed the *parahita* method. The *Karanapaddhati* was widely commented upon and soon became an influential text. Its popularity was not restricted to Kerala. It was widely studied in other parts of South India. Somayaji also wrote *Venvarohashtaka* and *Nyayaratna*.<sup>8</sup>

Now, was this spectre unique to Kerala, as Joseph would have us believe? Not really. The study of stars and numbers passed through a similar intellectual ferment in many other regions of the subcontinent. In the later half of

the fourteenth century, Mahendra Suri studied astronomy from Persian works and wrote the *Yantraraja*. He was a recipient of Firuz Shah Tughlak's patronage. Mahendra belonged to Bhrigupura and studied under Madana Suri. His disciple Malayendu Suri commented on the *Yantraraja* in his *Yantrarajatika*. Firuz Shah was himself a mathematician and astronomer of some standing and evinced keen interest in the disciplines. In his court lived Narayana Pandita, who wrote *Ganitakaumudi* and *Bijaganitavatamsa*, dealing with arithmetic and algebra respectively. Narayana made substantial contributions to the study of magic squares, differential calculus and what is now called Pell's equation, which was earlier studied by Brahmagupta and Bhaskara II. Narayana was the first to develop the method of prime factorizing which involves the differences of squares, three centuries before Fermat formulated it in Europe.

Firuz Shah's predecessor Muhammad Tughlak also evinced keen interest in mathematics and astronomy. Thakkura Pheru wrote the *Ganitasarakaumudi* while in Muhammad's service.

A strong pedigree of mathematicians and astronomers arose in Maharashtra in the sixteenth century and extended well into the late seventeenth century. It commenced with Ganesa Daivajna of Nandigrama, a coastal village near Mumbai. He wrote the *Buddhivilasini*, a gloss on the *Lilavati*. His *Grahalaghava* was an immensely popular work on astronomy. Other works of his include *Siddhantasiromanivyakhya*, *Brihattithichintamani* and *Laghutithichintamani*. The grating method (gelosia method) of multiplication was developed by him. He also substituted complex trigonometric calculations with simpler arithmetic formulations. Ganesa seems to have learnt mathematics and astronomy from his father Kesava, and in all likelihood trained Lakshmidasa and Nrisimha, his cousin and nephew respectively. He also taught Divakara

Daivajna from a village on the Godavari, which bore the sobriquet of Golagrama. Divakara's sons Kesava and Visvanatha wrote glosses on a number of works. Visvanatha's commentaries included those on *Grahalaghava*, *Suryasiddhanta*, *Tithipatra*, *Siddhantasiromani* and *Karanakutuhala*. Three other sons of his, Vishnu, Krishna and Mallari, were also renowned astronomers of their times. Vishnu was the author of the *Saurapakshaganita*, while Mallari commented on the *Grahalaghava* in his *Siddhantarahasya*. Krishna's son Nrisimha studied under Mallari and Vishnu, and went on to write the *Saurabhashya*, a commentary on the *Suryasiddhanta*, and the *Vasnavarttika* on the *Siddhantasiromani*. He trained four of his sons, Divakara, Kamalakara, Gopinatha and Ranganatha. Kamalakara studied Arabic and Persian sources and was acquainted with Euclid's *Elements*. Written in 1658, his *Siddhantattvaviveka* shows his familiarity with Euclid. Kamalakara excelled in trigonometry and made interesting formulations in it. His brother Ranganatha was the author of two major works, the *Laghubhangivibhangi* and the *Siddhantachudamani*, a gloss on the *Suryasiddhanta*. He also wrote the *Mitabhashini* on the *Lilavati*.

The influence of Ganesa's pedigree was not restricted to Maharashtra alone. Nrisimha spent many years of his life in Varanasi, where he might have engaged himself in teaching and observation. Vishnu trained Krishna Daivajna and Ranganatha, brothers who hailed from Elachpur near Dewas in Madhya Pradesh. Krishna went on to serve the Mughal ruler Jahangir who evinced deep interest in astronomy. He commented on the *Bijaganita* in his *Navankura* and on the *Lilavati* in his *Kalpalatavatara*. His brother Ranganatha produced *Gudharthaprakasika*, a gloss on the *Suryasiddhanta*. Ranganatha's son Munisvara was a leading astronomer of the seventeenth century. He wrote *Patisara* and *Siddhantasarvabhauma*. The *Marichi*, a gloss on the *Siddhantasiromani*, is another work of

Munisvara's. The *Nisrishtharthaduti* was his commentary on the *Lilavati*.

We know of at least one other pedigree from sixteenth century Maharashtra. It belonged to Parthapura on the Godavari in the Vidarbha region. The first known name in this pedigree is that of Naganatha, of whom we do not have any historical information. His son Jnanaraja was the author of *Siddhantasundara*, an extensive treatise on astronomy. His son Suryadasa wrote *Ganitamritakupaka* and *Suryaprakasa*, glosses respectively on the *Lilavati* and the *Bijaganita*. His disciple Dhundiraja was an accomplished astronomer of his times.

It is not easy to discuss the situation in other parts of India due to a paucity of adequate sources. But the evidence on hand suggests that mathematics and astronomy were taught and learnt in many regions. In Madhya Pradesh, we know of Gangadhara, who composed an astronomical treatise called *Chandramana* in the early half of the fifteenth century (1434). In the later half of the century (1478), Makaranda, an astronomer from Varanasi, wrote the *Tithipatra*, which was based on the *Suryasiddhanta*. Earlier in the century, another Gangadhara produced a gloss on the *Lilavati*. He came from Gujarat. His brother Vishnu was the author of *Ganitasara*, which was deeply indebted to Sridhara. In 1639, Nityananda wrote the *Siddhantaraja*.

Unlike Kerala, many of the works, which appeared in Maharashtra and Madhya Pradesh, lend themselves to overt influence of Persian and Arabic sources. This at times led to major controversies. Kamalakara, who as we have seen, was familiar with Persian and Arabic works and the *Elements*, was highly critical of Bhaskara II's formulations on astronomy. This in turn invited the wrath of Munisvara. Ranganatha (Kamalakara's brother and not Munisvara's father) defended Kamalakara in his *Laghubhangivibhangi*, where he argued that the methods adopted by Munisvara were flawed.

Knowledge of Persian and Arabic sources and their dissemination was not dependent on patronage from Muslim rulers. This is best borne out by Kamalakara's work. Nevertheless, we need not gainsay that such patronage at times facilitated the exchange of knowledge to a considerable extent. Faizi translated the *Lilavati* into Persian in 1587 at the instance of Akbar. The *Bijaganita* was rendered into Persian in 1634 by Ataullah Rashidi at the court of Shah Jahan. In the fourteenth century, Firuz Shah had the *Brihatsamhita* of Varahamihira translated into Persian. The thirteenth century Arabic works of Nasiruddin at Tusi, like *Kitab Zij Ilkani* and *Tahrir Uklidas* were in wide circulation in India. *Tahrir Uklidas* was a translation of the *Elements*, which was rendered into Persian more than once. Based on one such Persian translation, Jagannatha rendered the *Elements* into Sanskrit under the title, *Rekhaganita* in 1718.

Jagannatha was in the court of Savai Jai Singh II, who built the city of Jaipur in the early eighteenth century. He had a deep understanding of Indian and Arabic astronomy and had studied the works of Jamshed Kashi, at Tusi, Said al Gurgani and Mirza Ulugh Beg. He also mastered Ptolemy's *Almagest* of which he produced a Sanskrit translation entitled *Siddhantasamrat* in 1732. He was also apparently familiar with the logarithms of Napier. Jagannatha was also drawn towards contemporary European astronomy, and studied among other things Flamsteed's *Historia Coelestis Britannica* and la Hire's *Tabula Astronomicae*. He set up observatories for Jai Singh at several places like Jaipur, Mathura, Delhi, Varanasi and Ujjain. The observations made in these places were carefully recorded in the *Zij Muhammad Shahi*.

Interest in astronomy and mathematics declined considerably after the late eighteenth century. But it did not cease altogether. Sankaravarman in Kerala wrote *Sadratnamala* in 1823. In this terse encyclopedic work, he calculated the value of  $\pi$  to seventeen places with precision. Ten

years later in 1833, Ghulam Hussain Jaunpuri produced the *Jam e Bahadur Khani*, which dealt among other things with the question of trisecting the angle. At about the same time, Yogadhyana Mishra of Calcutta translated parts of an English work into Sanskrit, Hutton's *Euclidean Geometry*. In 1869, Samanta Chandrasekhara of Odisha produced his *Siddhantadarpana* after nine long years of efforts. In this work, he produced a model of planetary motion comparable to the one put forward by Nilakantha Somayaji in Kerala.<sup>9</sup>

The progress of mathematics and astronomy in India after Bhaskara II was not as disheartening as earlier believed, if our overview is any indication. Nor was the brighter side of the developments due only to the works produced in Kerala. Ingenious contributions were made by several mathematicians and astronomers from outside Kerala, like Narayana Pandita, Ganesa, Kamalakara, Munisvara and Samanta Chandrasekhara. The findings of the Kerala theorists were also not unique in any ways, as it were, although methods like *drigganita* adopted by them were not known to have replicated elsewhere in an identical form. To argue, therefore, that a School of Mathematics existed in Kerala is to make too tall a claim. The study of the Kerala phenomenon will be more fruitful when carried out in context of the larger historical and academic developments, which were unfurling in the rest of India, and by placing them in relation to the emerging realms of knowledge production in Europe and the Arabic and Persian worlds.<sup>10</sup>

## References

- 1) George Gheverghese Joseph, *The Crest of the Peacock: Non-European Roots of Mathematics*, third edition, Princeton University Press, Princeton & Oxford, 2011, pp. 418-449; idem., *A Passage to Infinity: Medieval Indian Mathematics from Kerala and Its Impact*, Sage, New Delhi, 2009; idem. (ed), *Kerala Mathematics: Its History and Possible Transmission to Europe*, B.R. Publishing Corporation, Delhi, 2009.
- 2) Idem., *A Passage to Infinity*, p. 67.
- 3) Ibid.
- 4) See Ibid., p. 158, where Joseph takes a passing note of a handful of non-Kerala works. The expression Kerala School figured earlier in K.V. Sarma, *A History of the Kerala School of Hindu Astronomy*, Vishveshvaranand Institute, Hoshiarpur, 1972.
- 5) There were a number of other lesser ones too, of whom we do not have adequate knowledge.
- 6) Ibid., p. 4
- 7) Ibid., p. 5-6.
- 8) On the "Kerala School", see K.V. Sarma, *A History of the Kerala School of Hindu Astronomy*; Joseph, *The Crest of the Peacock*, pp. 418-449; idem., *A Passage to Infinity*; and idem., *Kerala Mathematics*.
- 9) For a history of mathematics in India, see Bibhutibhusan Datta and Avadhesh Narayan Singh, *History of Hindu Mathematics*, 2 Vols, Motilal Banarsidass, Lahore, 1935 and 1938; A. K. Bag, *Mathematics in Ancient and Medieval India*, Chaukhamba Orientalia, Varanasi, 1979; G.R. Kaye, *Indian Mathematics*, Thaker, Spink and Co., Calcutta and Simla, 1915; and D.M. Bose, S.N. Sen and B.V. Subbarayappa (eds), *A Concise History of Science in India*, second edition, (With Addenda by B.V. Subbarayappa), Universities Press, Hyderabad, 2009, pp. 65-268.
- 10) For an interesting historical perspective, see Sanjay Subrahmanyam, 'Connected Histories: Notes Towards a Reconfiguration of Early Modern Eurasia', *Modern Asian Review*, Vol. 31, No. 3, pp. 735-762.

# The Incidence of Poverty and Inequality in Rural India – Study of Himachal Pradesh

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## Abstract

This study examines the incidence of poverty and inequality in Himachal Pradesh based on the first hand information. The issues of poverty and inequality are examined in a multidimensional perspective. This study shows that there is poverty as well as inequality prevalent in the study area and the inequality of income is higher among all households as compare to poor households. This study also indicates that the income of the poorest among the poor is very low mainly due to their small size of holding, lack of regular farm and non-farm employment and higher level of dependency. There is a need for greater and more effective fiscal intervention for poverty reduction and employment generation.

## Introduction

However during last few decades, several significant changes have been taken place in the poverty scenario due to Government programme & policies to empower the poor, continuous affords of voluntary organizations and civil society groups etc. They lobby for more resources for the poor, make poor aware about their rights and entitlements and mobilize the poor for collective action to promote their own development and to counter their oppressors. All these efforts have positive impact but are not trustful enough to put the poor in development orbit. Generally there are two broad concepts of poverty: relative and absolute poverty. Relative poverty arises entirely as a consequence of an unequal distribution of income irrespective of what the income level or the corresponding state of deprivation of the people of the bottom end of the income scale might be. Absolute poverty on the other hand expresses a collective view on deprivation in its somewhat physical manifestation. Therefore, relative poverty is measured in terms of inequality in the distribution of income and absolute poverty depends on an exogenously determined standard or poverty line, which represents a socially acceptable minimum level of living. In the present study relative poverty or income inequality with the help of ‘positive approach’

has been worked out because absolute measure may tell us something important about the condition of a society at a particular point of time and over a stretch of time. But it has no argument against those measures to say that they tell us little about inequality or about relative deprivation, it is not designed to tell us about them. But on the other hand relative measure tells us about inequality or the deprivation among the poor and also tells how wide is the gap between the income of the 'poor' and the income of those who are 'not poor'. Relative poverty or income inequality has been worked out with the help of 'positive approach' by adopting Head Count Ratio, Lorenz curve and Gini-coefficient.

A number of studies revealed that the extent of poverty is higher in rural areas than in urban areas. A study by Minhas (1970) revealed that the extent of rural poverty was very high during 1956-57 i.e. 65 percent and this has been reduced to 56.6 percent during 1967-68. Ojha (1970) findings revealed that 51.8 percent of rural population was below poverty line during 1960-63 at calorie norm of 2250 per capita per day. Bardhan (1970) estimated that 38 percent during 1960-61 and 54 percent of the rural population was below poverty line during 1968-69. Dandekar and Rath (1971) by applying the minimum calories norm of 2250 per capita per day consumption expenditure during 1960-61, concluded that about 40 percent rural and 50 percent urban population falls below the poverty line. Hashim and Padam Singh (1986) studied the extent of rural poverty during 1960-61 to 1983-84. Their findings revealed that 55.50 percent of rural population was below poverty line during 1960-61 and 44.98 percent were below poverty line during 1970-71. This figure came to 40.40 percent during 1983-84. According to the Planning Commission of India the extent of poverty in rural India was 28.2 percent during 1989-90. Krishna (2003) found that a number of households had climbed out of poverty in the past 25 years. Simultaneously, however, a large number of previously non-poor households had also fallen into poverty,

resulting in a rather small net improvement in the poverty situation in this area, since the reasons for people overcoming poverty are quite distinct from the reasons why they succumb to it. Dev and Mahajan (2003) observed that employment growth recorded a drastic decline during 1993-94 to 1999-2000 as compared to the period of 1983-84 to 1993-94. Bhalla and Hazall (2003) on the basis of NSS data found that there were 3.98 million unemployed in India in 1973-74 and their number had increased to 7.49 million by 1993-94 and to as much as 9.15 million by 1999-2000. In the meantime the incidence of unemployment had increased from 1.64 percent in 1973-74 to 1.96 percent in 1993-94 and to 2.25 percent in 1999-2000. S. Mahendru et al.(2007) and Himanshu (2007 ) by using the NNS data concluded almost same that in spite of higher overall growth, the extent of decline in poverty in the post reform period (1993-2005) has not been higher than in the pre-reform period (1983-1993) ,further they concluded that the inequality has increased significantly in the post reform period and seems to have slowed down the rate of poverty reduction but the extent of decline in 1995-05 seems to have been higher than in 1993-2000 in spite of slower growth in agriculture in the latter years. Datta (2008) worked out that the estimate of Head count ratio of poverty for 2005-06 to 2004-05, the decline in the Head count ratio between two years is 1.4 to 1.6 percent due to higher rate of economic growth rate accompanied by the impressive growth in the agriculture sector while the trend rate of decline between 1993-94 and 2004-05was 0.8 percent. Martin (2008) in his article discussed that in 2005, 40 percent of India's population lived below poverty line whose consumption is less than \$1.25 a day, while 25 years earlier 60 percent of India's population lived below the same real line. This is clear progress. India's long term pace of poverty reduction by this measure is no more than average for the developing world excluding China. Himanshu (2010) studied that estimates of the incidence of rural poverty show a head count ratio of 41.8 percent for 2004-05 as against the official

estimate of 28.3 percent. The estimates reveal much larger rural-urban differences but less concentration of either rural or urban poverty in few states. In Himachal Pradesh 34.1 percent of population was living below the poverty line. According to the study conducted by the federation of Chambers of Commerce and Industry in 1972. The extent of rural poverty in Himachal Pradesh on the basis of the value of poverty index for 1972-73 and 1973-74 has been calculated equal to 31.53 percent and 47.01 percent respectively (Sharma, 1982). Thakur (1985) concluded that on the basis of the value of poverty index the percentage of poor has been worked out 71.06, 50.65 and 26.34 percent on the marginal, small and medium size of holdings respectively. Ramna et al. (2008) worked out that the Percentage of poor on the marginal, small, medium and all holdings together are 43.46, 29.89, 20.17 and 33.53 percent respectively.

### **Data Source & Methodology**

This study has been conducted in Himachal Pradesh which has different cropping pattern due to varying altitude. Therefore on the basis of altitude the cultivated land in the State has been categorized into three zones; (a) low-hill zone ranging between 1200- 3000 feet, (b) mid- hill zone from 3000-5000 feet and (c) high- hill zone of 5000 feet and above. In the low- hill zone, the main agricultural products are food grain, i.e., wheat, maize, paddy, pulses, sugarcane, oilseeds etc., whereas due to suitable topography and climatic conditions, the high-hill zone of the state is widely known for horticultural products, viz., apple, seed potato, apricot, grapes, ginger, dry fruits etc. The agricultural activities in the mid-hill zone bear similarity in some areas to that of low-hill zone while in other areas to high- hill zone. Therefore present study is conducted in the mid- hill zone of the State, so the topography, climatic conditions, access to resources as well as cropping, income, consumption and

employment pattern in the study area bear similarity to some areas of low- hill zone while, other areas to high- hill zone of the state. A sample of 200 households consisting of 90 marginal size of holding having land <1 hectare, 70 small size of holding having land 1-2 hectares and 40 medium size of holding having land above 2 hectares have been selected with the help of multistage random sampling. The required information has been collected from the sample households with the help of pre-tested schedule during 2008-09. After tabulating the data in homogenous categories and working out the averages and percentages, the following methods are applied with a view to find out the magnitude of poverty/ inequality. In the present study 'poverty line' has been determined on the basis of the value of minimum nutritional requirements, i.e. 2400 calories per consumer unit per day as has been suggested by the Government of India, Planning Commission and Indian Council of Medical Research. Once the poverty line is determined, the second step is that of determining an 'Index of Poverty'. The value of minimum per consumer unit per day consumption basket (i.e. both out of home grown stock as well as out of purchases) has been calculated by multiplying quantities of different food items by their respective actual retail prices prevailing in the sample area during the period of investigation i.e. 2008-09. The total number of males, females and children of varying age have been converted into 'Standard Consumer Units' or 'adult male value' by applying the scale of coefficient suggested by the Indian Council of Medical Research, e.g. a family consisting of father, mother and three children aged 10, 8, 6 years has an 'adult male value' or consumption units of 4.9 (i.e. 1.6+1.2+0.8+0.7+0.6). In order to work out the value of 'poverty line' allowances have also been made to the minimum non-food requirements by working out the ratio of total non-food expenditure to the total food expenditure for each holding group.

## Results & Discussion

The extent of relative poverty and inequality in the study area has been measured with the help of Head Count Ratio and Gini-coefficient as follows:

### Head Count Ratio

Let  $n$  denote the total number of people in the community and  $q^*$  the number of people below the poverty line. The 'Head Count Ratio' ( $H_p$ ) is then:

$$H_p = q^* / n$$

$q^* = 234.6$ ,  $n = 1448.5$ . Therefore:  $H_p = 234.6 / 1448.5 = 16.19$  percent

The percentage of poor comes out to 16.19 percent on the basis of 'Head Count Ratio'. But as a measure of poverty head count method is considered insensitive to the extent of aggregate shortfall in income from the poverty line as well as to the distribution of income amongst the poor.

### The Lorenz Curve and Gini-Coefficient

Table- I (page 75) shows the Distribution of monthly income among the sample households. To find out the extent of income inequality in the Lorenz curve technique the size of items and the frequencies are both cumulated and taking the total as 100, than percentages are calculated for the various cumulated values.

Their percentages are plotted on a graph paper. If there were proportionately equal distribution of the frequencies over various values of a variant, the points would lie in a straight line. This line is called 'line of equal distribution'. If the distribution of items is not proportionately equal, it indicates variability and the curve would be away from the line of equal distribution. The farther the curve is from this line the greater is the variability in the series. A higher Lorenz curve implies more social welfare for the same total of income. The cumulated

percentages of income and population of sample households when plotted on a graph paper and the resultant shape of the Lorenz Curve (see diagram -1) clearly indicates that the bottom 32.83 percent of the population is sharing about 11.26 percent of the total income at the one end and at the other end 46.76 percent of the total income is shared by the 70.04 percent of the population.

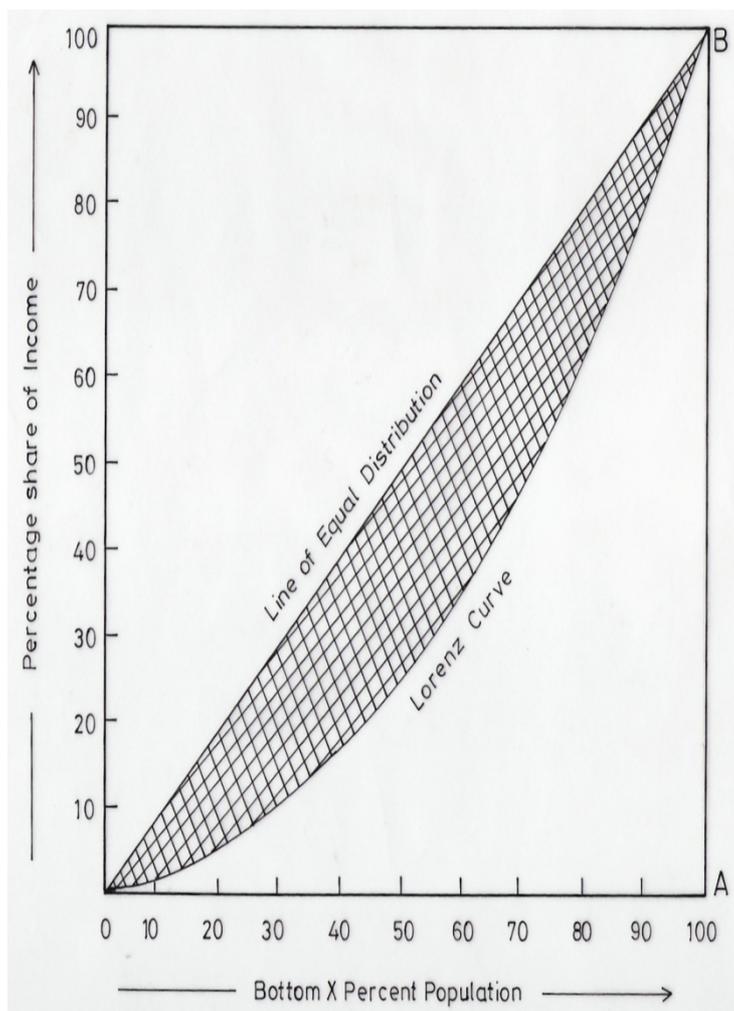


Diagram -1

### Lorenz Curve of the Income Distribution of All Households

The income of the poorest among the poor is very low due to their small size of holdings and lack of regular non-farm employment opportunities

**Table- I**

**Distribution of monthly income among the sample households**

Income Classes (Rs.)	Monthly Household Income (Rs.)	Cumulated Income (Rs.)	Cumulated Percentage	No. of Persons	Cumulated Number	Cumulated Percentage
0-200	4791.67	4791.67	0.26	35.6	35.6	2.46
200-300	20815.84	25607.51	1.41	83.3	118.9	8.2
300-400	41050.56	66658.07	3.67	115.7	234.6	16.2
400-500	30030.4	96688.47	5.33	66.9	301.5	20.81
500-600	22612.5	119301.0	6.57	40.8	342.3	23.63
600-700	25602.3	144903.3	7.98	39.5	381.8	26.36
700-800	59476.17	204379.4	11.26	93.8	475.6	32.83
800-900	68541.6	272921.0	15.04	80.0	555.6	38.36
900-1000	43591.65	316512.7	17.44	45.1	600.7	41.47
1000-1100	66368.33	382881	21.09	63.8	664.5	45.88
1100-1200	122532.5	505413.5	27.85	106.3	770.8	53.21
1200-1300	76299.16	581712.7	32.05	61.3	832.1	57.45
1300-1400	89337.5	671050.2	36.97	64.5	896.6	61.9
1400-1500	82726.66	753776.8	41.53	57.1	953.7	65.84
1500-1600	94931.25	848708.1	46.76	60.8	1014.5	70.04
1600-1700	84218.33	932926.4	51.4	51.5	1066.0	73.59
1700-2000	128045.0	1060971	58.45	106.0	1172.0	80.91
2000-3000	470286.6	1531258	84.36	198.3	1370.3	94.6
3000-above	283790	1815048	100.0	78.2	1448.5	100.0

**The value of Gini – coefficient of the income distribution among all households has been calculated as follows:**

Let Z be the mean income, Yi be the income of the i<sup>th</sup> person when income arranged in ascending order, so that Yi ≤ Yi +1 for all i and n be the total number of people in the community.

$$G(y) = 1 + \frac{1}{n} - \frac{2}{n^2} \sum_{i=1}^n (n+1-i)Y_i, \text{ where}$$

G(y) = Gini-coefficient of the income distribution of all households, n= population size (1448.5), z= mean income (1303.80),  $\sum_{i=1}^n (n+1-i)Y_i = 863760661$ , thus

$$G(Y) = 1 + \frac{1}{1448.5} - \frac{2}{(1448.5)^2} \times 863760661 = 36.92\%$$

**The value of Gini-coefficient of the income distribution among the poor has been calculated as follows:**

$$G(y) = 1 + \frac{1}{q} - \frac{2}{q^2} \sum_{i=1}^q (q+1-i)Y_i$$

G(y) = Gini-coefficient of the income distribution of poor households, q = number of poor below the poverty line (234.6), z = mean income of the poor (Rs. 284.13),  $\sum_{i=1}^q (q+1-i)Y_i = 6294820$  Thus

$$G(Y) = 1 + \frac{1}{234.6} - \frac{2}{(234.6)^2} \times 6294820$$

$$= 19.92\%$$

The value of the Gini-coefficient of the income distribution of all household (i.e., 0.3691) if compared to the value of Gini-coefficient of the income distribution among the poor (i.e., 0.1992) clearly indicates that the inequality of income is higher in the former case as compared to the later because in the former case comparatively the value of Gini-coefficient is higher which shows relatively more skewed income distribution. The income of the poorest among the poor is low due to their small size of holding, higher the dependency ratio and lack of regular non-form employment opportunities.

**The value of Gini-coefficient for the consumer expenditure distribution on food items by all households has been worked out as follows:**

$$G(c) = 1 + \frac{1}{n} - \frac{2}{n^2 z} \sum_{i=1}^n (n+1-i)ci$$

G(c) = Gini-coefficient of the consumer expenditure on food items by all households

n= total consumer units (1448.5), z= mean consumption expenditure (394.94)

ci= consumer expenditure on food items by the ith consumer unit ,  $\sum_{i=1}^n (n+1-i)ci = 337679020$  ,

Thus

$$G(c) = 1 + \frac{1}{1448.5} - \frac{2}{(1448.5)^2} \times 337679020$$

$$= 18.57\%$$

**The value of Gini-coefficient for the consumer expenditure distribution on food items by poor households has been worked out as follows:**

$$G(c) = 1 + \frac{1}{q} - \frac{2}{q^2 z} \sum_{i=1}^q (q+1-i)ci$$

G(c) = Gini-coefficient of the consumer expenditure on food items by poor households

q= number of poor consumer units (666.2), z = mean consumption of the poor (281.83)

ci = consumer expenditure on food items by the i<sup>th</sup> poor consumer unit,  $\sum_{i=1}^q (q+1-i)ci = 54508260$  , thus

$$G(c) = 1 + \frac{1}{666.2} - \frac{2}{(666.2)^2} (54508260)$$

$$= 12.99\%$$

The value of Gini-coefficient of the consumer expenditure on food items of all households (i.e. 0.1857) if compared to the value of Gini-coefficient of the income distribution among the poor (i.e. 0.1299) also clearly shows that the inequality of consumer expenditure on food items is higher in the former case as capered to the later. But when the value of Gini-coefficient of income distribution (among all and poor also) is compared to the value of Gini-coefficient of the consumer expenditure on food items (by all and poor households), it shows that the value of Gini-coefficient is higher in the former case as compared to the later mainly due to the reason that food being the bare necessity of life, requires a minimum amount of income to be spent on it.

**Distribution of monthly consumer expenditure on food and non-food items**

The percentage expenditure on food and non-food items shows that the poor households spend most of their income on food items and a very little is left for meeting out the non-food requirements where as the ‘not poor’ household spend comparatively less on food items and proportionately higher amount on non-food items.

**The value of Gini-coefficient for the distribution of consumer expenditure on food & non-food items by all households has been calculated as follows:**

$$G(c) = 1 + \frac{1}{n} - \frac{2}{n^2 z} \sum_{i=1}^n (n+1-i)ci$$

Where

G(c) = Gini- coefficient of the consumer expenditure on food and non-food items by all households

n= total consumer units (1448.5), z= mean consumer expenditure on food and non-food items by all households (526.43), ci= consumer expenditure on food and non-food items by the i<sup>th</sup> consumer units,  $\sum_{i=1}^n (n + 1 - i)ci = 442943840$ ,

thus

$$G(c) = 1 + \frac{1}{1448.5} - \frac{2}{(1448.5)^2} \frac{442943840}{526.43}$$

$$= 19.87\%$$

**The value of Gini-coefficient for the distribution of consumer expenditure on food & non-food items by poor households has been calculated as follows:**

$$G(c) = 1 + \frac{1}{q} - \frac{2}{q^2 z} \sum_{i=1}^q (q + 1 - i)ci$$

G(c) = Gini- coefficient of the consumer expenditure on food and non-food items by poor households

q = number of poor consumer units (461.9), z = mean consumer expenditure of poor households (326.66),  $\sum_{i=1}^q (q + 1 - i)ci = 31142028$

$$G(c) = 1 + \frac{1}{461.9} - \frac{2}{(461.9)^2} \frac{31142028}{326.66}$$

$$1.0022 - 0.8937 = 0.10852$$

$$= 10.85\%$$

The value of Gini-coefficient for consumer expenditure on food and non-food items by all households has been worked out to be 0.1987 which is higher to the value of Gini-coefficient of the consumer expenditure by all households on food items (i.e. 0.1857). Thus, the values of Gini- coefficient in both the cases further support the hypothesis that, as the income of the people increases percentage expenditure on non-food items increases proportionately at a higher

rate as compared to the percentage expenditure on food items. That is why in the present study too, the degree of inequality in the consumer expenditure is higher when the food and non-food items have been taken together than the degree of inequality when consumer expenditure on food items alone has been taken into consideration Gini-coefficient is more opaque since it measures the distance between the diagonal “line of equal distribution” and the Lorenz Curve. Unlike in Lorenz comparisons, the Gini-coefficient comparisons are always conclusive, since one real number must be greater than, equal to or less than another. The result of poverty based on these measures provides a scope for policy being concerned with the relatively richer among the poor, ignoring the poorest among the poor.

**Concluding Remarks**

The consumption pattern in rural area varies from place to place and from one region to other therefore present study is based on the day to day information on consumption expenditure throughout the full agricultural year. Further the results of the present study clearly indicate that there exist a lot of variations in the poverty and income inequality among the sample households. Income inequality is higher among all households as compared to poor households and the income of the poorest among the poor is very low mainly due to their small size of holding, higher level of dependency and lack of regular farm and non-farm employment. In the study area there is a great scope for providing income and employment generating opportunities by developing horticultural activities, development of cottage and small scale industries, art and craft industries such as wool based industries, bamboo based industries, leather processing units, rope making, saw mills etc. But it is also observed that economic growth by itself does not lead to the containment of poverty. Along with economic growth some favorable legal and political institutions are needed for the containment and reduction of poverty.

## References

- 1) Anirudh Krishna (2003), "Falling into Poverty: Other Side of Poverty Reduction", **Economic and Political Weekly**, Delhi, pp.533-541.
- 2) Bardhan, P. K (1970), "On the Minimum Level of Living and the Rural Poor", **Indian Economic Review**.
- 3) Beteille Andre (2003), "Poverty and Inequality" **Economic and Political Weekly**, Vol. XXXVIII, No. 42, Delhi, pp. 1455 -1463.
- 4) Bhalla, G. S. and Hazell Peter (2003), "Rural, Employment and Poverty: Strategies to Eliminate Rural Poverty Within a Generation", **Economic and Political Weekly**, Delhi, pp. 3473-3484.
- 5) Bhatt, I.Z. "Inequality and Poverty in Rural India", Poverty and Income Distribution in India, edited by T.N. Srinivasan and P.K. Bardhan, Statistical Publishing Society, Calcutta, 1974, pp. 291-336.
- 6) Dandekar, V. M. and Rath, Nilkantha (1971): **Poverty in India**, Indian School of Political Economy, p.8.
- 7) Datta, K. L. (2008), "An Estimate of Poverty Reduction between 2004-05 and 2005-06," **Economic and Political Weekly**, Delhi, Vol., XLIII, No. 43, 2008, PP. 61-67.
- 8) Department of Economic and Social Affairs, **Poverty, Unemployment and Development Policy: A Case Study of Selected Issues with Reference to Kerala**, (United Nations, New Yourk, 1975), p.7.
- 9) Dev, Mahendra S. and Mahajan Vijay (2003), "Employment and Unemployment", **Economic and Political Weekly**, March 22-29, pp.1252-1261.
- 10) Directorate of Economics and Statistics, **Symposium on Social and Economic Problems of Hilly Areas**, Simla, 1974, pp. 91 and 96.
- 11) Gopalan, C., Ramashastri, B. V. and Balasubramaniam, S.C. (1980), **The Nutritive Value of Indian Foods**, Indian Council of Medical Research, Hyderabad, p.10.
- 12) Government of India, **Draft Fifth Five Year Plan 1978-83**, Vol-II, Planning Commission, New Delhi, 1978, P.36.
- 13) Government of India, Planning Commission, **Draft Eighth Five Year Plan 1992-97**, New Delhi, 1992.
- 14) Government of India, Planning Commission, **Draft Seventh Five Year Plan 1985-90**, New Delhi, 1990.
- 15) Government of India, **Tenth Five-Year Plan, 2002-07**, Planning Commission, New Delhi, 2002.
- 16) Himanshu (2007), "Recent Trends in Poverty and Inequality: Some Preliminary Results," **Economic and Political Weekly**, Delhi, Vol., XLII, No. 6, Feb.10, 2007, PP. 497-507.
- 17) Himanshu (2008), "What are These New Poverty Estimates and What Do They Imply?" **Economic and Political Weekly**, Delhi, Vol., XLII, No. 43, 2008, PP.38-43.
- 18) Himanshu (2010),"Towards New Poverty Lines for India," **Economic and Political Weekly**, Delhi, Vol., XLV, No. 1, 2010, PP.38-48.
- 19) Kumar, Sanjay and Sharma, N. K. (2001), "Labour force and Employment scenario: Where do the Projections and Realities Lead To?", **Labour & Development**, Vol. 7, No. 2, pp. 37-51. Mahendradev,S. and Ravi, C. (2007), "Poverty and Inequality: All India and States, 1983-2005," **Economic and Political Weekly**, Delhi, Vol., XLII, No. 6, Feb.10, 2007, PP. 509-521.
- 20) Martin Ravallion (2008), "Global Perspective on Poverty in India", **Economic and Political Weekly**, Delhi, Vol., XLII, No. 43, Oct..25, 2008, PP. 31-37.
- 21) Mahendra, S. Dev and Mahajan, Vijay (2003), "Employment and Unemployment", **Economic and Political Weekly**, Delhi, pp.1252-1261.
- 22) Minhas, B. S. (1970), "Rural Poverty, Land Redistribution and Development", **Indian Economic Review**, Vol.V, No.1, April, reprinted in Sankhya, Series C, Vol. 36, 1974, pp.252-263 also see in B.S. Minhas: Planning and the Poor, S. Chand & Co., 1974, Chapter II, pp. 63-101.
- 23) Ojha, P. D. (1970), **A Configuration of Indian Poverty: Inequality and Levels of Living**, Reserve bank of India Bulletin, January.
- 24) Orshansky, M. (1965), **Counting the poor Another Look at The Poverty Profile**,

- Social Security bulletin, 28, quoted in A.B. Atkinson: *The Economics of Inequality*, Oxford University Press, 1975.
- 25) Ramna and Sikander Kumar (2008), "Measurement of Poverty and Income Inequality in the Mid-Hill Zone Agrarian Economy of Himachal Pradesh- Normative and Positive Approach," **Indian Journal of Economics**, Allahabad, Vol. LXXXVIII, No. 351, April 2008, PP. 611-632.
- 26) Rowntree B.S., *Poverty- A study of life*, Macmillan, 1922, quoted in A.B. Atkinson, *The Economics of Inequality*, p.126.
- 27) Sastry, S.A.R. and Suryanarayan, T. (1981), **Optimum Diet and Poverty Line, in Employment, Poverty and Public Policy**, (ed.) Sardar Patel Institute of Economic and Social Research, Allied Publishers, New Delhi, pp. 97-116.
- 28) Sen, Amartya K. (1974), "Poverty, Inequality and Unemployment" **Economic and Political Weekly**, Special Number, 1973, reprinted in *Poverty and Income Distribution in India* edited by Bardhan and Srinivasan, Statistical Publishing Society Calcutta, 1974, pp. 67-83.
- 29) Sen, Amartya K. (1976), "Poverty: An Ordinal Approach to Measurement", **Econometrica**, Vol. 44, No. 2, March, pp.219-230.
- 30) Sen, Amartya Kumar (1981), **Poverty and Famines; an Essay on Entitlement and Deprivation**, Oxford University Press, Walton Street, Oxford, 1981, pp. 186- 189.
- 31) Sharma, K. C. (1994), **Poverty, Unemployment and Inequalities in Tribal India: With Special Reference to Himachal Pradesh**, Reliance Publishing House, New Delhi, pp. 151-247.
- 32) Sharma, L. R. (1982), "Poverty and Inequality in the Rural Sector of Himachal Pradesh" **Economic Affairs**, Vol.27, No.7-9, Calcutta.
- 33) Sharma, Shiv Dyal (1997), **Dimensions and Dynamics of Poverty in India**, Mohit Publications, New Delhi, pp.168-193.
- 34) Singh, S. R. (1986), "How to Improve Rural Scenario Faster?" **Yojna**, New Delhi.
- 35) Thakur, Dalip S. (1985), "Measurement of Inequality and Poverty in the Hilly Agrarian Economy of Himachal Pradesh A Positive Approach", **Arth-Yikas**, January-December, 1985, pp. 78-102.
- 36) Thakur, Dalip S. (1985), **Poverty, Inequality and Unemployment in Rural India: Some Conceptual and Methodological Issues in Measurement**, B.R. Publishing Corporation, New Delhi, pp. 173-257.

# “Kamand” Campus & Its Surrounding Environs: A Brief Sojourn

Dr. Rinki Sarkar,



*Dr. Sarkar is an independent researcher based in Delhi. Over the last decade or so, she has been essentially engaged in conducting field oriented research studies on the impact of development and change, conservation issues and the role of institutional governance in ecologically fragile belts of the Middle Himalayas of Himachal and Uttarakhand. Though she is trained as an economist her research studies have evolved to assume an interdisciplinary focus in response to the needs of an interconnected ecosystem that coexists in close proximity to expanding human habitations.*

I

My first exposure to the serene natural surroundings of the ‘Kamand’ campus left me spell-bound and awe-stricken as my reflective thoughts instinctively swayed towards Rabindranath Tagore’s alternate perspectives on education. His essay titled *My School*, which formed a part of our school curriculum, had left behind a deep impression on my mind. Even during those formative years, I felt I could empathise with his overt critique of conventional teaching systems that were regimental and detached, leaving behind little room for arousing curiosity levels of evolving young minds. That was decades ago. While I pondered over his experiential learning methods under a well-canopied ‘peepal’ tree, the penetrating rays of sunlight on the North campus site caught my attention. There was a sense of satiation. What better way to pay homage to a living legend and a great visionary on his 150<sup>th</sup> birth anniversary, I thought.

Part of a global network of pioneering educators, Tagore envisioned an education system deeply rooted in one’s immediate surroundings. Besides serving as a live field laboratory for learning and experimentation, the overall environ was truly iconic and an essential element triggering his principles and beliefs such as “freedom” to learn and the necessity for an intimate relationship with one’s cultural and natural environment, the virtues of “aesthetic” development in addition to the rigours of intellectual growth and the efficacy of “openness” in education above petty vanities. In course of an accidental rural tenure during the late 19<sup>th</sup> century, his exposure to and deep concern for the acute material and cultural poverty that plagued villages led to the establishment of a small school in a poor rural hinterland of West Bengal which later developed into a university. A rural reconstruction centre was an integral part of this institutional framework to groom the locals to tread on participatory and inclusive paths of development. Tagore devoted nearly forty years in nurturing these institutions that were deeply

rooted in his alternate paradigms of education and his genuine concerns for rural reconstruction. Ruminating over Tagore's ideals, I could already envisage a whole gamut of potential opportunities that a premier educational institution of higher learning could exploit by locating in 'Kamand' and the beneficial social externalities which could emanate from this educational entity for the surrounding vicinity.

## II

The upcoming IIT campus, located in the rural confines of *Sadar* administrative block is around thirteen kilometres away from the hustle and bustle of Mandi town. For accessing the campus site, one has to embark on 'major district road' 23 from Mandi town which meanders along semi-urban settlements gathering altitude. Thereafter it converges on to predominantly rural surroundings. The campus is enclosed by a cluster of villages of the *Kamand* and *Namlay* panchayats and is perched above the confluence of the *Uhl* River and *Kataula ki khad*, a major mountain stream which emanates from the *Parashar* catchment. The north and the south segments of the campus are separated by a mixed forest that hosts a multiplicity of trees and shrubs such as '*biul*', '*shatoot*', '*chir*' '*simbal*', '*drek*', '*phagda*', '*pipal*', '*kashmal*', '*khatantola*' as well as '*timber*', all very crucial for catering to local livelihood needs of '*datun*' for oral health, firewood, fodder, fibre, furniture and fencing. Some tree species or tree parts form an integral part of religious rituals of the region.

During the last monsoon season, I had accidentally ventured into this region in course of my journey from Mandi to Kullu. The incessant rain and the precariously rising water levels of the *Beas* river at *Pandoh* left me no choice but to abandon National Highway 21 for a detour along MDR 23. At that time there was nothing much that struck me except for the resonating symphony of *cicadas* as we drove along *ban-oak* and *deodhar* forests. The overcast sky and impending nightfall had blurred my vision. All that mattered was the

urgency of reaching my final destination. I moved along in haste, oblivious of the rich historical and socio-cultural context and the natural endowments embedded in this belt.



Fig 1: Rural confines of 'Kamand campus':  
A typical hamlet surrounded by terraced fields in proximity to forests

It was simply an unusual stroke of luck that brought me back to this region, the following winter. My mission was to specifically unravel some of these multifarious regional dimensions. I spent a few fulfilling days in the hospitable company of articulate local inhabitants, sharing their hearths and their homes, listening with rapt attention to passionate accounts of their folklore, rituals as well as nuances of day to day existence. I realised that the region is steeped in myths and historicity while livelihood has always been intricately linked to the surrounding environment.

## III

Kamand campus essentially lies in the hinterland of Mandi town, traditionally known as *Uttarsal*. *Sal* in local dialect stands for serpent. Folklore has it that '*Uttarsal*' was the domain of a giant serpent and its length was as long as the boundary of the territory it commanded and demarcated from the neighbouring belts of *Snor* and *Drang*. Other local yarns ascribe the origin of the name *Uttarsal* to the encircling mountain ridges that resemble a giant serpent. In the Himalayas,

frequent references to serpents or *nagas* in folk narratives is linked to the indigenous cult of nature worship often ascribed to the fear of the unknown attributable to human existence amidst extreme mountain environments. Therefore, the earliest deities in the region were believed to be nature deities like serpents, tree spirits, mountain spirits, forest spirits and the like that need to be revered and propitiated in the hope of averting vagaries of weather, destructive natural calamities or the outbreak of fatal illnesses.

The early history of *Uttarsal* is obscure and mostly unfolded through local legends. There are meagre records pertaining to the prehistoric times in the Himalayas. These abound in ethnographies of gods but not of the mountain people. Field-work based local discourse reaffirmed these imaginings. It is believed that *Uttarsal* was infested by invincible demons or *asuras* who tormented the region through their destructive means. They were constantly at war with the gods and goddesses who ultimately overpowered them and wiped them off from the face of the universe, symbolising the victory of 'good' over 'evil'. During this period, hermits or *rishis* worked in tandem to pacify the demons for ushering in peace through their superior powers of penance and meditation. These pious *rishis* were later deified and worshipped by local people. The *Parashar rishi* temple in *Uttarsal* is an outcome of these developments.

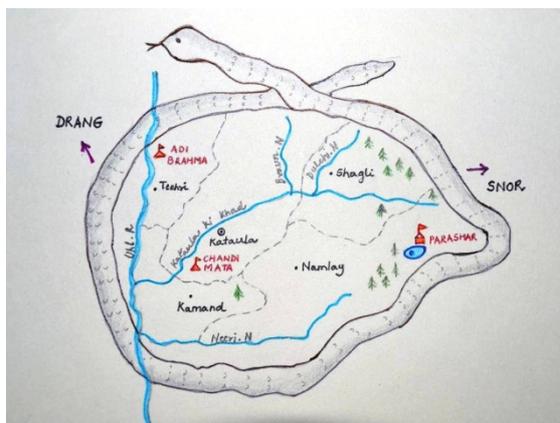


Fig2: An iconographic depiction of 'Uttarsal' as per folklore documented in the field

As per Hindu epic references and monastic records, the earliest human habitations in the

Himalayas could date back to the 2<sup>nd</sup> century B.C. This era and thereafter is primarily characterised by an influx of settlers who fled to the mountains for escaping powerful dynastic empire consolidations in the plains. Much later, these tribes were subjugated by Hindu *rajput* immigrants, who sought refuge in these highlands in the wake of gruesome religious persecution. By the 16<sup>th</sup> century they became the overpowering majority. During this period, various belts of Mandi including *Uttarsal* exhibited a fragmented political landscape consisting of dispersed rural habitations under the rule of petty chieftains known as *ranas* or *thakurais*. These inhospitable and infertile belts were futile sites for major conquests. Further, the isolating tendencies of the natural environment obstructed the indigenous rulers from expanding their localised kingdoms. Therefore, the reign of petty chieftains continued over centuries and the consolidation of dispersed political entities took a very long time. The genesis of this movement was initiated by errant generations of the *Sen* Dynasty who originally hailed from *Nadia* in West Bengal with monarchic ambitions in the hills. A protracted struggle ensued for suppressing the local feudatories. Political restructuring reached its peak during the sixteenth and the seventeenth century and was finally completed under *Ajber Sen*. He set up his capital at Mandi town. Thereafter, the hinterlands became the main source of resource expropriation that continued even after the advent of the British. While the royalty focused on means of filling the State coffers, the British focused on massive amounts of timber extraction for catering to their imperial needs of shipbuilding, railways and the setting up of strategic hill towns.

#### IV

While the political landscape of Mandi underwent progressive transformation, day to day existence for the local peasantry followed a fairly unchanging trajectory over this period. Field interactions revealed that in *Uttarsal*, the locals led a frugal existence subservient to

nature and its endowments. Livelihood strategies and forms of social organisation exhibited a high degree of interdependence and great ingenuity in design targeted at optimizing efficient use of limited resources. The high uncertainty of mountain ecosystems induced a diversified approach to production options for minimizing risks. Therefore, locals relied on agriculture as well as livestock rearing to cater to their subsistence needs. A multiplicity of summer and winter crops were cultivated depending on climate and altitudinal variation. Besides yielding milk and milk products the livestock ensured a steady supply of organic manure vital for raising the inherently low fertility levels of the soil prone to erosion due to sloped nature of the terrain. Water and forest resources were judiciously tapped for a variety of purposes. For instance, the downstream flow of mountain streams was channelized as a source of energy to fuel water mills or *gharats* for grinding grains and millets to flour. Based on the principle of energy generation by movement of turbines these water mills are truly a remarkable illustration of indigenous technology prevalent since ancient times. Forests were entirely relied on for firewood, fodder and timber. Leaf litter collected from the forests served as cattle bedding. When mixed with cattle litter, the compound was converted into high quality manure that was spread on fields for raising productivity levels.

Like subsistence oriented livelihood activities, even the village morphology and the manner in which homesteads were designed displayed a high degree of environmental determinism. Village sites were invariably adjacent to forests which provided important resources for basic needs. The best quality of land was allocated for terraced agriculture fields while compact hamlets were built on worthless spots. Each dwelling unit was meticulously designed and constructed with locally available materials to cater to a multiplicity of diurnal and seasonal subsistence activities. Principles of space dynamics and building methodology resulted from a systematic understanding of natural light

availability, constraints imposed by inclement weather and the possibilities of natural disasters in a region prone to seismic shocks.

The difficult nature of the terrain, extremities of weather and labour resource constraints necessitated a high degree of cooperation for engagement in a host of livelihood linked activities both within a household and across households in the village. What emerged was a less fragmented social structure as compared to settlements in the plains. In *Uttarsal*, the locals vividly narrated how the social practice of *jwar* or mutual assistance across households was prevalent for easing a host of activities requiring investment of intensive labour and physical toil. *Shramdan* or voluntary labour was a periodic feature in order to maintain or create village level infrastructure. These activities were managed by village councils under the surveillance of the local deity. Fear of religious spirits known to cause harm in case of noncompliance ensured successful outcomes of collective action in numerous spheres of social engagement.

Religion has always been a significant institution of local governance for regulating mountain societies of this region. Every deity had its own realm of influence within which communities evolved as a cohesive unit forming strong ties amongst themselves and the divine entity in particular. In *Uttarsal*, a three tier system of religious order was prevalent for nurturing these bonds. At the apex was the shrine of *Parasher rishi*. Next in order of importance were regional deities such as *Chandi mata* of Kataula village representing the *shakti* cult as well as the creator god '*Adi Brahma*'s' temple in 'Teehri' village. At the bottom most rung of the religious hierarchy, every village had its own local deity which served as an icon by which a village community was often identified and revered.

Religious fairs and festivals were an important element of highland existence for the peasant communities. Music and dance were an integral part of such festivities. Village festivals around

religious shrines were intricately associated with the agrarian life of the local inhabitants.



Fig 3: Religion: An important institution of local governance:

The pagoda style 'Adi Brahma' temple adjacent to a sacred deodar tree.

Tehri village, Uttarsal

Besides the customary rituals and religious practices that needed to be meticulously performed during these religious ceremonies, these periodic festivities served as an outlet for social exchange and rejuvenation that was necessary to overcome the humdrumness of physically exhausting daily chores and routine tasks necessary for survival amidst undulating terrain, extremities of climate and the unpredictability of weather conditions.

## V

The post independence era has been essentially characterised by transformation and change. Infrastructure development through creation of community development blocks and implementation of rural development programs, land reforms and improvements in market access through better road connectivity are significant factors that have triggered the process of change. These developments have

essentially fuelled transition from a subsistence based economy to one largely geared for the market resulting in growing levels of economic prosperity for the local inhabitants. During the last 25 years, the intensity and pace of change has heightened in *Uttarsal*. Crop shifts towards vegetable cultivation for the market in place of traditional grains and millet is now an all pervasive phenomena. Sale of milk and milk products is being pursued by most villages of the belt for supplementing income from agriculture. The strategic road connectivity profile of the region has been an important factor triggering these developments as it permits easy access to the urban wholesale markets of Kullu as well as Mandi towns. Locals have diversified their economic activities to include non-farm avenues of employment such as engagement in petty retail trade and transport activities. Some household members, particularly young lads, leave the region seasonally to earn income from casual employment by engaging in the flourishing tourism industry of Kullu and Manali. Similarly, a large fraction of the youth migrates seasonally to prosperous apple belts of Shimla and Kinnaur where they assist in packing and grading operations for a living.

While there has been an apparent rise in the economic well being of the local inhabitants, changes in other spheres of human development have been less dramatic. There is close to 100% enrolment in primary education. But the drop-out rate after completion of 12<sup>th</sup> grade is very high for both genders. The *gujjar* population in *Uttarsal* continues to have very low levels of literacy despite close urban links and exposure. Though it was not possible to decipher the untoward effects of transformation and change on other indices of human development such as health and the overall environment, as part of the present field research endeavour, some undesirable trends were evident. Mounting opportunities for income generation within the region has led to 'introvert' patterns of development resulting in rising demographic pressure on the natural resource base. For

instance, energy requirements for cooking and heating during winter continue to be largely dependent on firewood from forests. Despite better road access and distribution mechanisms, only 15% of the households have LPG ownership because of lack of affordability. Even those who own cylinders conserve the resource as it is expensive. Rising numbers have aggravated the problem leading to unsustainable pressure on forest resources. Lopping for firewood could have dire consequences for the standing tree-stock in the forests and the ecosystem these nurture.

In the socio-cultural realm, perhaps tradition continues to have a predominant sway over people's lives in comparison to modernity. But the scales seem to be tilting towards the other extreme, undermining local art forms, indigenous technology and architecture, diet and dialect, thereby endangering the cultural identity of these highland inhabitants. Field impressions revealed that urbanity and urban sensibilities have started permeating various spheres of local existence. The development of 'Kamand' campus in the heart of *Uttarsal* is unlikely to be a benign stimulus amidst an already buoyant scenario of transition and change. Perceptions of change have already permeated the mindset of the local community. Oral testimonies gathered in course of field studies reiterated economic gains that would be forthcoming due to the coming up of the campus. The locals however could not envisage any kind of beneficial social externalities that could potentially emanate from an educational institute of premier learning. They felt that the campus would survive as an 'encapsulated' entity.

## VI

My brief sojourn opened up a myriad of experiential avenues for comprehending a region and its historical context, its socio-cultural attributes, its natural resource endowments and its changing socio-ecological profile. In course of my field studies in Himachal and my periodic visits and re-visits, I

have been deeply concerned about the unplanned and haphazard nature of land use changes that are occurring because of expanding highways, hydro-electric projects, emerging towns and a host of educational institutions. While these ventures are an outcome of the need to cater to regional or national development goals, the effects on the social and natural environments has not always been desirable. This is of particular relevance for a mountain State that is ecologically fragile and is inhabited by human populations steeped in tradition wherein lifestyles continue to be intricately associated with the natural resource base. These land use changes have also started threatening and fragmenting wild life flora and fauna habitat some of which are endemic. While development cannot be shunned away, the process can be guided and directed to cause minimum damage to the environment. By unravelling a rich socio-ecological context, I do hope that my report will facilitate the ex-ante planning of better long term outcomes as regards the upcoming 'Kamand' campus and thereby set a new precedent for sustainable land use changes in the State.

I am extremely grateful to IIT Mandi for hosting me in course of my field studies. This report is dedicated to the faculty, students and staff of the Institute. A special note of thanks goes out to 'Ankit'. In response to my excited and gesticulated verbal 'first' accounts of *Uttarsal*, he suggested that I should write.

## References:

- 1) Berremen, G.D. (1963): '*People and Cultures of the Himalayas*', Asian Survey, Vol.3, No.6, June.
- 2) Berremen, G.D. (1999): '*Hindus of the Himalayas*', Oxford University Press, N.Delhi.
- 3) Census of India (1991): '*District Census Handbook: Mandi*'
- 4) Epstein, T.S., Suryanarayana, A.P. & Thimmegowda, T. (2002): '*Village Voices*.

- 5) *Forty Years of Rural Transformation in South India*, Sage publications, N.Delhi
- 6) Fisher, J.F. (1985): *The Historical Development of Himalayan Anthropology*, Mountain Research and Development, Vol. 5, No.1, Februar
- 7) Guillet, D. (1983): *Towards a Cultural Ecology of Mountains: The Central Andes and the Himalayas compared* Current Anthropology, Vol.24, No.5, December.
- 8) O'Connell, K. M. (2003): *Rabindranath Tagore on Education* The Encyclopaedia of Informal Education, <http://www.infed.org/thinkers/tagore.htm>
- 9) Sarkar, R (2010): *Rural Accessibility & Development: Sustainability Concerns in an Ecologically Fragile Mountain Belt*, Economic & Political Weekly, Special Article, Vol. XLV, No. 21, pp. 63-71, May 22.
- 10) Singh, C (1999): *Natural Premises. Ecology and Peasant Life in the Western Himalaya 1800-1950*, Oxford University Press, N.Delhi
- 11) Singh, M.G. (1999): *Wooden Temples of Himachal Pradesh*, Indus Publishing Company, N. Delhi

# BOOK REVISITED

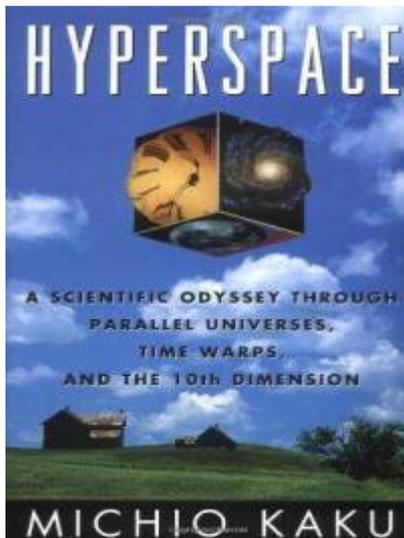
## HYPERSPACE

### A SCIENTIFIC ODYSSEY THROUGH PARALLEL UNIVERSES, TIME WARPS AND THE 10th DIMENSION

**Author: Kaku, Michio**

First published in the year 1994  
 Publisher: Oxford University Press  
 (OUP)

**Review by: Hrudaya Ranjan Sahoo,**  
*Mr. Sahoo is a first year B-Tech student of  
 IIT Mandi.*



The book titled “HYPERSPACE: A Scientific Odyssey through Parallel Universes, Time Warps and The Tenth Dimension” is written by MICHIO KAKU, an internationally acclaimed physicist & one of the co-founders of string field theory. This book was first published in the year 1994 by Oxford University Press (OUP).

This book explores the belief that dimensions exist beyond the commonly accepted ones of space and time, i.e., it explores the “Theory of Hyperspace”. Scientifically the Hyperspace theory goes by the names of Kaluza-Klein theory & Super-gravity theory and its most advanced

formulation is called SUPERSTRING THEORY which predicts that the total number of dimensions is 10. Throughout the book, Michio Kaku has tried to emphasize the fact that the universe may exist in more than 4 dimensions, which defies our common sense. In fact, he goes on to write that “if appearance and essence was the same thing, then there would be no need for science”.

To explain the lay audience about the fascinating properties of hyperspace, Kaku has developed four fundamental themes that run through this book like a thread which divides the book into four parts. In PART 1, Kaku explains how laws of nature become simpler in higher dimensions. He explains the importance of field theory, how mathematicians like Riemann shaped the future of physics, the way people in lower dimensions, if they existed, would perceive things in higher dimensions and how light can be viewed as vibrations in the fifth dimension. In PART 2, he discusses about the fundamental theories that led to the formulation of superstring theory, about the importance of Kaluza-Klein theory & Riemann’s Metric Tensor, superstrings, existence of God and the Big-Bang theory. In PART 3, he explores the possibility of existence of multiple universes and the interconnection between them & about different aspects of time. In PART 4, he explores the possibilities of harnessing the power of Hyperspace Theory, if it proves to be correct. So, throughout the book Kaku tries to encourage “scientific revolutions”. He says that “scientific revolution almost by definition, defy, common sense”. He explains about the purpose of science which is “to peel back the layer of appearance of objects to reveal their underlying nature”. So he encourages the people to look at the bigger picture while solving the scientific puzzle. As this book encourages unique ideas & provides a fascinating reading, it is recommended for one and all.

# CARTOONS

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*“The Journey of thousand miles,  
begins with a single step”*

*-Lao Tzu*