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Prof. R. Narasimhan with Sir John Cockroft, Lady Cockroft, Homi Bhabha, M.M. Dosbhai and an engineer of a computer company, at TIFR.

Top: Prof. Yash Pal addressing the public in the Homi Bhabha Auditorium. Left-bottom: Dignitaries on stage after Prof. R. Cowsik's public lecture, and Ramanath Cowsik answering questions from the audience after the lecture.

PITFALLS IN ELEMENTARY PHYSICS – *SOME LESSONS FROM HISTORY*

by

Arvind Kumar

Homi Bhabha Centre for Science Education, TIFR, Mumbai

A public lecture on 28th Feb., 2008 in the Homi Bhabha Auditorium.

Introduction: There are two interesting observations about the errors that we all commit in elementary physics – the physics that one learns in school and junior college stages. First, many of the errors are universal (i.e. prevalent across different educational systems/countries) and robust (i.e. they persist even after much instruction). Second, the more common errors are also those which are encountered in the history of physics. In simple words, young students' conceptions are often (though not always) similar to those of scientists in the past, before the modern conceptual framework of classical physics emerged. The two observations need to be qualified a great deal, yet their significance cannot be denied. They suggest that there may be something basic to some of the common errors in elementary physics; the errors seem to be 'natural', arising from spontaneous modes of cognition of phenomena around us. But we will not go into the educational theories and viewpoints about their origin. Rather, we will simply describe a few of these 'pitfalls' on the students' road to learning elementary physics. Though we restrict ourselves to physics, many of the ideas here are relevant to science learning in general. A good example of universal misconceptions outside physics is students' notions on the Darwinian theory of natural selection for understanding the evolution of species.

Some common pitfalls in elementary mechanics:

A widely prevalent students' notion is that a force is always required to keep a body in motion; the greater the velocity and mass, the greater the force needed to keep it in motion. This notion is, no doubt, rooted in our experience of bodies coming to rest when (apparently) there is no external force acting on them.

Of course, we have all learnt that when bodies initially in motion eventually stop, they do so under the action of external forces – the frictional/viscous forces, etc. that cannot be completely eliminated in practice. Yet the fundamental insight (due to Galileo and Newton) that rest and uniform motion are equivalent is not an easy concept to internalize. This is hardly surprising, for it took two millennia to arrive at this notion beginning with Aristotle, the great Greek thinker of antiquity.

Aristotelian physics viewed all motion in terms of two categories: 'the natural movement' and the 'violent movement'. The 'natural movement' is the spontaneous motion of an object towards its 'natural place'. Aristotle regarded all (terrestrial) matter to consist of four elements: earth, water, air and fire. Each element has a tendency to reach its 'natural place' of rest: earth at bottom, then water, then air and fire at the top. [The 'natural movement' of the heavenly objects (made of a fifth element called 'ether') was circular (without a beginning or end).]

A corollary of this view was that the speed of natural motion was proportional to the amount of the dominant element. That is how Aristotle concluded that bigger stones will fall to the earth faster than smaller stones.

The other category, 'violent movement' is the motion caused by an applied force. The greater the applied force, thought Aristotle, the higher the object's speed; the higher the mass, the lower is the speed for a given force. In modern terms, Aristotle's principle of motion is Force *proportional to* mass x velocity.

Newtonian mechanics has no categories of 'natural' and 'violent' motion. It also unifies laws of terrestrial and celestial motion. Yet these major conceptual turning points are often lost on students. They continue to replay Aristotelian ideas, especially the idea about the need for an external force to keep a body in motion.

There is another common and robust misconception, one that is not quite Aristotelian. This shows up in the simplest of questions: "Describe what happens when a ball is thrown vertically upward, after it is out of touch with the hand." A typical response: "During the upward journey, there are two forces acting on the body, one due to gravity and the other, the force needed to throw it up. The second dominates in the upward journey. At the uppermost point, the initial force has spent itself out; the ball then falls freely under gravity." This 'absurd' response (from the point of view of physics) seems actually very natural. It arose in history in the Middle Ages, when people began to feel uncomfortable with the Aristotelian answer to the question "why does an arrow go so far?" For Aristotle, this was an example of 'violent movement', so something must be pushing the arrow. That 'something' was the air behind the arrow.

Jean Buridan (14^{th} century) was among those who argued against the Aristotelian view and advocated the so called 'Impetus Theory'. According to him, the arrow continues to move not because of air pushing from behind but because at the initial time it is projected it stores something called impetus. The more the impetus the farther it will go.

In this theory an object that is moved in a circle gets 'circular impetus' enabling the circular motion to continue even when there is no force. This notion was used to explain the continued rotation of a wheel after it is set in motion.

Impetus theory was a transitional stage between Aristotelian and Newtonian mechanics. Aristotle said that an external force was needed to keep a body moving (violent movement); in impetus theory a body moves by an internal force impressed in it when it is set in motion. From 'something in a body' to the Newtonian law of 'force on a body' being the explanatory agency of dynamics was a huge conceptual jump that students need to be made aware of. To get rid of impetus theory ideas, we need to stress the locality (the notion not the word) of Newton's Second Law, namely that acceleration at a point at an instant is caused by an external force at that point at that instant.

Early theories of vision and children's ideas on light:

Early Greeks had conflicting models of vision. The so called *Extramission theory* was advocated by the Pythagoreans: The eye emits out something in the act of perception. (Plato had a more sophisticated version of this view.) The *Intromission theory* due to Epicurus held that objects emit ‘particles’ that have the same appearance as objects – and thus cause perception. Aristotle opposed the Extramission theory. But for a while Extramission Theory seemed to have an upper hand mainly due to Euclid’s book on optics. Euclid’s argument:

To see a needle, you must see it directly, else you cannot see it. You must actively send rays from the eye; in the alternative (intromission) picture, the needle is sending rays all the time, then you should be able to see it as long as your eyes are open, whether or not you are looking at it directly.

This argument in its different versions held sway for centuries. The unresolved issue in extramission was whether the eye is sending a finite number of rays or the visual cone is completely filled with light from the eye. Meanwhile, Europe entered its Dark Age, Optics became a forte of Arabian science and the debate continued. Simple but brilliant arguments were made advocating one or the other model of vision.

For example, al-Kindi (9th century AD) argued against intromission saying that intromission is fine for hearing since the ear is not movable but has a shape to receive sound. By contrast the eye is movable directing itself to the object to be seen. On the other hand, Avicenna (986–1037 AD) criticized extramission theory saying it would imply that two or more people with weak vision standing close would improve vision of each! But it was Alhazen who took the key step forward: Rather than thinking that the entire object sends out tiny copies of itself, Alhazen said that each point or small region of the object radiates in all directions. But Alhazen could not satisfactorily deal with the problem that each point of the eye would receive a jumble of rays from all points of the object. It remained for Kepler to give the modern view. Using the knowledge of eye anatomy at the time, Kepler correctly argued that the diverging rays from a point on the object striking different parts on the eye get refracted by the eye lens at a single point on the retina at the back of the eye. This resolved Alhazen’s difficulty.

With this background of centuries of debates, it is no wonder that children’s spontaneous ideas of light and vision are far from the correct model. An early systematic study of this topic was carried out by Jayashree Ramadas and Rosalind Driver.

How do we see objects? Interestingly, children ‘explain’ vision differently depending on whether the object is self-luminous or not. We see the former since light comes out from it. For non-luminous objects, vision is explained by giving the eye an active role. Light comes out of the eye to see the objects! If you ask a child to draw a free drawing of how she thinks she sees say a book on a table, chances are that the figure will show rays coming out of the eye, striking the book and going off in other directions. The child’s model is not very different from the extramission model that dominated early history.

Older students too are not free from similar errors. Even college students sometimes use words like ‘image’, ‘reflection’, ‘shadow’ indistinguishably. There are deep-seated confusions regarding image formation by mirrors and lenses, location of images, real and virtual images, etc. Some of these are revealed vividly in a number of beautiful investigations by Goldberg and McDermott. To quote just one interesting misconception:

The diagnostic apparatus consists of an optical bench, a luminous filament of an unfrosted bulb, a converging lens and a translucent screen. Students see an inverted image on the screen, which they know is real since it is captured on a screen. Students are asked whether there would be an image if the screen were removed. This question leaves most students puzzled, perhaps because they cannot reconcile to an image ‘suspended in air’, as it were, without some surface, a screen.

Next, can they see the image without the screen, they are asked. Many think it is possible if you keep your eye at the position of the screen! Clearly, they think the image becomes real only if there is something to hold the image!

At this point, the investigator asks students to view from the side facing the lens and at a certain distance away from the original position of the screen, students are able to see the inverted image. The observation surprises many students, but they still cannot grant the existence of an aerial image; many think that the image they are seeing is ‘at or in the lens’.

We thus see that elementary optics is another important domain where misconceptions abound, perhaps because we seem to take the difficult notions of vision, image formation, etc. (that took centuries to get clear about) as easy or obvious and do not pay attention to the spontaneous errors of children. Further, the ray diagrams, even if correctly drawn, are a source of several misconceptions.

Galilean Relativity: Galilean Relativity (the relativity principle of Newtonian mechanics) is often regarded as a simple topic, based on common sense. A detailed study carried out at HBCSE some years ago, however, revealed a large number of misconceptions about this basic topic, even among good physics undergraduates. We quote just two examples:

Consider the frame of reference associated with a rotating turntable. What are the forces on a coin on the turntable co-rotating with it? This question would usually evoke a correct response:
The forces on the coin are its weight and normal reaction of the turntable and the friction and centrifugal force. Each pair of forces adds up to zero, since the coin is stationary relative to the turntable. (For the same reason there is no Coriolis force.)

What are the forces on a coin lying on the ground outside the turntable, relative to the non-inertial rotating frame of the turntable? The correct answer is that there are both centrifugal and Coriolis forces on the coin outside, resulting in a net radially inward force. The weight of the coin and the normal reaction of the ground, of course, cancel out.

However, a typical response would be that relative to the turntable's frame, there are no pseudo-forces on the coin on the ground since it is 'outside' the turntable. The rotating frame in this view is thus being localized by the spatial extension of the associated object – a flawed but very common conception.

The second example relates to how students transform distance, time and velocity from one frame to another. Most students transform velocity correctly. But if we think they would 'obviously' respect the intuitive 'time invariance' of Galilean relativity, we would be surprised. Consider the question:

There is a 10 m long tube along the length of a tram moving uniformly with speed 10 m/s. A ball is rolled down the tube from one end to the other with a speed of 1 m/s relative to the tram. For an observer on the ground, what is the distance traveled by the ball and how much time does it take?

Many students would correctly add velocities (10+1= 11 m/s), take the distance to be equal to the length of the tube (supposed 'length invariance'), divide it by speed to get the answer 10/11 s, and fail to be surprised by it. The wide frequency of such responses shows that for physics undergraduates, invariance of time interval (of Galilean Relativity) is not as obvious as we might think. They can abandon it for the more (visually) appealing 'distance invariance', even when the concerned events are not simultaneous.

Some general sources of misconceptions: The misconceptions are very domain specific. Still, there may be some general sources of common errors in physics. We list a few. First, the erroneous conceptions may have a functional need! In our daily life, we need to push, throw and catch objects; deal with hot and cold sources and, in the modern environment, deal with electrical gadgets, and so on. We need some intuitive theory of the behaviour of objects to carry on with our daily life. 'Folk physics' may thus be a necessity as much as folk psychology! Second, a major source of error particularly in school science is language. The connotations of ordinary language can wrongly transfer to the technical language of science. Another interesting source of error is anthropomorphism. This shows up, for example, in students' equating physical description to viewing, equating 'forces' to the forces 'felt' by a human, etc. Lastly, young students are greatly attracted by causal (time-dependent) rather than 'principle-based' explanations that do not explicitly invoke time. Yet their causal thinking could well be teleological. Most students do not appreciate that 'final causality', so much a part of daily life and language, has no place in science.

To conclude, learning and teaching of elementary physics can improve if we increase our awareness of the common spontaneous modes of reasoning in physics. In this task, the history of science could play a useful role in anticipating and addressing the common errors.

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Swarna Kanti Ghosh: *Fellow of the National Academy of Sciences, India.*

P.N. Pandita: *Fellow of Indian National Science Academy.*

Welcome to our New Patron and Director, TIFR.

Prof. Mustansir Barma took over as the Director, TIFR in November 2007. He is a theoretical physicist working in the area of statistical physics. His research interests include non-equilibrium statistical mechanics, phase transitions, and disordered systems. In recent years, he has worked on deposition-evaporation dynamics of extended objects, driven systems with quenched disorder, and large scale clustering in passive scalar problems.

Prof. Barma did his undergraduate work at St. Xavier's College, Mumbai and his Ph. D. at the State University of New York at Stony Brook. After postdoctoral work at Michigan State University, he joined TIFR in 1976, and has been there since, except for extended visits to Cornell University and the University of Oxford. He has received several honours and awards, and is a fellow of the national academies of science in India, and the Academy of Sciences for the Developing World (TWAS). Between 2002 and 2005, he served as Chairman of the C3 commission on statistical physics of the International Union of Pure and Applied Physics.

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Journey from Quarks to Cosmos and Back

by

Ramanath Cowsik

Physics Department & McDonnell Center for the Space Sciences, Washington University, St. Louis, Missouri

JRD Tata Memorial Lecture, Homi Bhabha Auditorium, 29th July 2008

JRD Tata was a pioneer, a perfectionist, a patron, a patriot and above all, a man of wit and wisdom of immeasurable vastness and depth. In Homi Jehangir Bhabha, Jeh recognized a precocious genius, wisdom beyond his years, a renaissance figure ready to devote his life to building the scientific prowess of India and pave the way for its technological growth. I have been infinitely blessed to have had the opportunity to work in TIFR for 41 years. It is indeed a great honor to deliver the JRD Tata Memorial Lecture, and a great pleasure to have been invited to do so by my friends, colleagues and the fellow alumni.

In the year 1939, when Dr. Homi Jehangir Bhabha was back in India from Cambridge to spend a holiday with his family, the Second World War broke out, preventing him to return to England and Europe, where many professorships awaited him. Despite several more lucrative offers from universities in India, he decided to join as a Reader the department of physics of the Indian Institute of Science, where C. V. Raman was a professor. The physics department was an exciting place with great intellectual fervor, but could not expand amidst the competing effects of several other departments on the limited funds and facilities that were available. His association with Raman and others had kindled in Bhabha a strong nationalistic spirit, and he clearly saw a great future for science in India. Accordingly, on August 19, 1943, he wrote a letter to JRD Tata, stating "the lack of proper conditions and intelligent financial support hampers the development of science in India at a pace which the talent in the country would warrant." JRD wrote back – "from what you say in your letter, it is evident that there is scope for rendering valuable service to the country and the cause of scientific research in India." He then strongly supported Bhabha in founding the Tata Institute of Fundamental Research, initially in Bangalore, and soon to a more permanent location at the Kenilworth in Bombay.

The theme of today's lecture is closely connected with Bhabha's pioneering studies on the 'penetrating component of cosmic rays.' In a sequence of papers which appeared in rapid succession from 1935 to 1938, Bhabha substantiated the thesis that the penetrating component of cosmic rays is composed of charged particles with a mass intermediate between the electrons and the protons. In today's parlance, these particles are called muons; thus Bhabha may justifiably be credited with the identification of the second generation of elementary particles. This pioneering work of Bhabha illustrates the intimate interconnection that exists between the cosmos at large and the nature and subtle properties of the elementary particles – the building blocks of the physical Universe. Such interconnections were actively exploited in the twentieth century to gain insight not only into the nature and dynamics of the large-scale systems in the Universe, but also into the very nature of elementary particles and fields comprising these systems. Today we understand all of fundamental physics in terms of three generations of quarks and leptons and a set of bosons mediating the interactions amongst them – all enjoying a beautiful symmetry described by the "Standard Model" of particle physics.

We now know that there are four basic interactions electromagnetic, weak, strong and gravitational, responsible for the wide variety of phenomena that we observe in nature and in the laboratory, such as the lightning, radioactive decay, the compact and strong binding of protons and neutrons inside the atomic nucleus, and the motion of planets around the sun and the sun in the Milky Way Galaxy. The electromagnetic and weak interactions have been unified as the low energy manifestations of the 'electroweak' interaction. This when grouped with strong interactions with their own symmetries leads to the 'standard model' of particle physics. Such a unified model exploits the symmetries that exist amongst these interactions to provide a compact description of the outcome of a variety of experiments and observations, and indeed occasionally make predictions of the outcome of new experiments. Just as in the case of electroweak unification, it is conjectured that at sufficiently high energies these interactions become more symmetric and it is only in the relatively low energy domain that the symmetry is broken, leading to the apparent diversity of phenomena. The current research in fundamental physics is focused on the study of possible symmetries that unify all these forces at very high energies, predict their low energy consequences, and test these predictions. The testing ground for these new theories, which strive toward a grand unification of all the forces are particle accelerators operating at increasingly higher energies, as one can well imagine, and surprisingly, also the wider

Universe of stars, galaxies and intergalactic radiations as revealed by astronomy. Thus the paradigm adopted by Bhabha, of comparing theoretical predictions (in his case relativistic quantum mechanics applied to electromagnetic interactions) with observations of diverse phenomena in nature to elicit finer aspects of elementary particles and their interactions, is playing a central role in testing and indeed suggesting possible extensions of the standard model. Notice that the 'standard model' does not include gravitation whose nature is described by an equally elegant theory – 'General Relativity' – as formulated by Einstein. Each of these two theories has been impeccable in its success, as decades of ingenious and assiduous experimentation has not revealed a single piece of evidence that contradicts the theory. There are glimpses, for example suggested by the finite rest mass of the neutrinos, of more beautiful theories beyond the standard model, but the unification of particle physics and gravitation remains the holy grail of theoretical physics.

General Relativity – the relativistic theory of gravitation provides the framework for describing the large-scale behavior of the Universe. For example the expansion of the Universe discovered by Hubble in the 1920s by measuring the linear increase of the redshifts of spectral lines with the distance of the emitting galaxies, fits in naturally with the predictions of General Relativity. The discovery by Penzias and Wilson in 1965 of the microwave background that pervades the whole Universe at a temperature of 2.7K clearly provides evidence for an evolutionary cosmology: The Universe began with a big-bang, a near singularity in space time, with extremely high temperatures and density. As the Universe expanded and cooled the various features of the present-day Universe became manifest. As we review these observations we find that a combination of General Relativity and the standard model can account for most of the observed features. However there does remain a set of observations which indicates very clearly the need for new physics beyond the 'Standard Model.'

Astronomical spectroscopy has shown that the mass of the visible Universe is dominated by ~73% hydrogen, ~25% helium, and about a couple of percent of heavier nuclei. In the high temperature phase of the early Universe, i.e., when T > > 1 MeV, baryonic matter would have been in the form of neutrons and protons in almost equal numbers. There was of course an intense background of electrons and positrons, neutrinos and antineutrinos and radiation, as described by the Fermi-Dirac and Bose-Einstein functions corresponding to those temperatures. Some of the neutrons and protons could coalesce into deuterons and thence to helium nuclei only after some three minutes, when expansion had cooled the temperature of the Universe down below a billion degrees (0.1 MeV). This primordial nucleosynthetic process correctly yields the right abundance of helium. Moreover, a small amount of deuterons are left over and the measurement of their fraction of ~3 x 10^{-5} fixes the fraction of all baryons to photons in the Universe to be ~6 x 10^{-10}, indicating thereby that just baryonic matter is inadequate to yield a spatially flat critical Universe. The small fraction of heavier elements like C, N, O, Si and Fe that we see were synthesized in the very recent Universe in stars, and disbursed in the interstellar medium by stellar winds and supernova explosions. The formation of stars had, of course, to await the formation of galaxies, which required an essential new ingredient in the Universe.

The first clues as to the existence of such an ingredient came from the observations of the dynamics of galaxies in clusters, and of stars within galaxies, first by Zwicky and by Rubin respectively, and made precise by later observations. Their observations indicated that the motions of galaxies in clusters and the speeds of stars in circular motions about the galactic center were so rapid that there was the need for some unseen mass to provide the requisite gravitational binding force in these systems. When extensive search for this unseen mass was underway, Cowsik and McClelland made the suggestion that this unseen matter was truly invisible, as the constituent particles had only weak interactions and will not emit or scatter light. Specific realization of this idea came from the considerations of hypothetical particles, more massive than several GeV, by Lee and Weinberg. Such massive neutrino-like particles find no description within the 'standard model' but may be incorporated into the extensions thereof. Such particles are produced in great abundance in the very early Universe when T > > 10 GeV and the fraction that survives annihilation until the present epoch contributes about six times as much to the Universal density as normal matter, and constitutes the invisible gravitating halos around galactic systems, which we call 'dark matter'.

The idea of weakly interacting dark matter is crucial to our understanding of the formation of galaxies and the extremely low level of anisotropy observed in the universal microwave background. Primordial quantum fluctuations impose a scale-free spectrum of density fluctuations on dark matter at various length scales and these grow as the Universe expands and cools down. In contrast the normal matter, which stays ionized until the Universe expands to about one thousandth the present-day size, stays coupled to radiation whose pressure prevents it from clumping. Only subsequently, i.e. after a redshift z ~ 1000, does the visible matter fall slowly into the potential wells of the dark matter condensates. The small level of anisotropy induced by these processes on the microwave background has been observed and lends further support to the afore noted cosmological scenario. Through these studies we understand that halos of dark matter are generic to galactic systems.

Recent attempts to improve the redshift-distance or equivalently redshift-luminosity relationship discovered by Hubble, using better standard candles such as the supernovae of type Ia, led to an astounding discovery – the Universe is in a state of accelerated expansion in the present epoch. Such an expansion is only possible if the Universe today contains about 72% of its energy density generated by quantum fluctuations of some unknown field, christened "dark-energy". Alternatively, the accelerating expansion could be accounted for by a constant term in Einstein's field equations, called the Λ term, which has the same effect as the 'dark energy'. This form of energy density does not decrease as the Universe expands, quite unlike that due to matter and radiation. Thus in future epoch 'dark energy' will become even more dominant as the Universe continues to suffer accelerated expansion.

Just like dark matter, 'dark energy' also provides hints as to the structure of theories beyond the standard model. Indeed the very presence of normal matter in the Universe places very specific requirements on the theories. A straightforward calculation of the evolution of matter (and antimatter) in a baryon-symmetric Universe, shows that even though their densities were high in the hot, early phases of the Universe: matter and antimatter annihilate each other as the Universe evolves, and we are left with less than one billionth of normal matter that is observed. The requirements for generating adequate matter in the Universe by the particle theories was pointed out in a prescient paper by Sakhorov in 1967: We need three features: a) violation of baryon number conservation, b) violation of particle-antiparticle symmetry called CP, and c) evolution of baryon number density away from thermodynamic equilibrium in the very early Universe; each of these require extensions of the Standard Model. Finally, the very isotropy of the microwave background poses a challenge. In an expanding Universe, radiation coming from regions more than a degree apart have never been in causal contact. Despite this, the microwave radiations coming from widely separated directions, indeed, even from opposite directions, have identical temperatures ~2.7° K. To accommodate this observation a concept called 'inflation' has been evoked. Exotic fields soon after the big-bang forced the Universe into a phase of accelerated expansion, so that a small causally connected region expanded to yield the isotropic, homogeneous and flat Universe today.

Thus we see that every major observation in the Universe is begging for an extension of the Standard Model and the quark-cosmos interconnections are driving the current research in fundamental physics and cosmology. Many of these problems are formidable, and amongst them the direct detection of weakly interacting dark matter particles in the laboratory is perhaps the most accessible and amenable to imminent exploitation. It may not be out of place to end with an optimistic note that Tata Institute of Fundamental Research with its prowess both in the theoretical and experimental aspects of the problem is well suited to take the leading role in this effort and make pioneering contributions.

Homi Bhabha Birth Centenary Commemoration Committee has been set up by the Director, TIFR to plan and celebrate the events starting from Oct. 30th 2008 to Oct. 30th 2010. TAA Secretary, Prof. A.K. Grover is the Convenor and may be contacted for programs and suggestions.

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Subhash G. Lokhre *lokhre@yahoo.com*	358
Gopalkrishna G. Nadkarni *ggnadkarni@yahoo.com*	355
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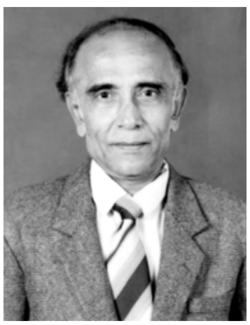
Remembering K.V. Ramanathan (1926 - 2007)

We are very sad to announce the passing away of Sh. K.V. Ramanathan on 8th March, 2007. He was well known for his pioneering work to establish in India, a viable research and development effort in the area of semi-conductor electronics. A biographical sketch has been presented by Prof. Balu Venkataraman and published in the Current Science, Vol. 92, No. 11, 10 June 2007.
http://www.ias.ac.in/currsci/jun102007/1637.pdf

Remembering Prof. P.K. Maitra (1932 - 2007)



We are very sad to announce the passing away of Prof. P.K. Maitra - a pioneer in the field of yeast biochemical genetics, in a Kolkata nursing home on 4th Sept. 2007. A biographical sketch has been presented by Pratima Sinha and Anindya Sinha and published in the Current Science, Vol. 93, No.7, 10 October 2007.
http://www.ias.ac.in/currsci/oct102007/1017.pdf

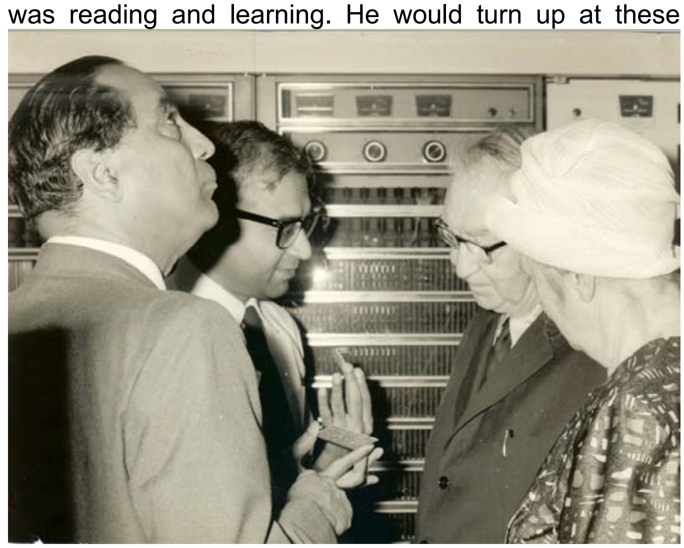
Remembering Prof. R. Narasimhan (1926 – 2007)

Professor Rangaswamy Narasimhan, RN, as he was known to many, passed away a few days before Teachers' Day, 5th Sept., 2007. He was my teacher, mentor, guide, and the person who set me on my career path. He was an enigmatic person, with strong beliefs, strong work ethic, principled in everything he did, and above all a true scholar, an outstanding academic to the core. There are many who have known him longer, and many who can chronicle his career and achievements much better than I. I will only reminisce about him as a human being who shaped many of my thoughts, and forged several attitudes that I hold even today.

The first time I saw RN was at the Annual CSI Convention held at IIT Kanpur in December 1967, forty years ago. I had just learnt programming and he gave a keynote speech on AI. It was heady. That he was a scholar was amply evident. I learnt about his seminal work on syntactic approaches to pattern recognition, particularly in the area of image processing. I also learnt about the first computer built in India, TIFRAC, under his leadership. All this was from prattle amongst my seniors. He seemed truly a *Bhishma Pitamah* of Computing Research in India! We were dazzled.

Over the next two years he visited IIT Kanpur for various reasons. His talks were always inspirational. At the end of my Master's programme, I was at cross-roads. Should I walk the treaded path of doctoral work in the west, or, dare I hope that I could go to TIFR! I consider it extremely fortunate that I was at TIFR from 1970 to 1978. It was a huge learning experience. There was a fantastic library, tremendous ambience and a mentor of the first water as they say in the form of RN. They were extremely happy years. I grew under his watchful and keen eye, despite the fact that I was not into AI, which was the theme that governed his interests after 1966. That he had done work in modeling Algol, on a Theory of Computation modeled on abstract von Neumann machines rather than Turing Machines, was all old hat. Engineering did not grip him as much (I think his interest in Engineering waned after TIFRAC and attempts to build a scientific viewpoint for software and computing based on contemporary technology, which were big influences that drew me towards him), but he always heard me out, was extremely quick in grasping the essence of technical issues unfolding in the practice of computing. He was always very articulate, precise with big and complicated words, and had a wealth of knowledge at his command. He had a lovely personal library, was fond of books and classical music, and art (I like to think that he was particularly fond of Impressionists, such as Degas). Though he had a stern external façade, he had a delightful sense of humour – very British!

I remember giving lectures at TIFR about the things I was reading and learning. He would turn up at these



lectures (on structured programming, programming language interpreters and things of that kind) and soon I would feel his penetrating gaze burrow deep in the middle of my back and I would start becoming incoherent. For here was a person who didn't need all the facile explanations forming in my head, but I felt compelled to think that I needed something to interest him too. He was not at all disruptive during such talks. Yet, I think my lecturing quality improved when I consciously tried to ignore his presence in the room! Another incredible fact was his grace and readiness in accepting a critique of his work, no matter from whom it came.

I remember RN as being terse in his communication, not at all loquacious. Terse, but spot on and precise, yet, he was encouraging and demanding at the same time. He expected us to excel; in fact nothing short of excellence would be acceptable to him of himself too. He mentored by example, in his integrity, in personal conduct, and the standards that he set for himself. My colleague Sudhir Mudur remarked that he brought the same attitude to administrative matters as well, whether it was the setting up of NCS(DC)T or in TIFR. Yet, after I had moved out of TIFR, and after he retired from it, I remember having discussions with him for hours on end. We probably spoke more in one of those sessions than through my tenure at TIFR! As he grew older, company mattered.

As an academic, RN did not impose his interests on others. In fact he expected all his senior colleagues to form their own research interests and pursue them vigorously, for, as he remarked once to me, “it is your professional career!”. I had expected him to set me tough goals, but he expected me to scrutinize my goals, put them through the wringer, dry clean them, and stand up for myself. I confess that I was perplexed by his attitude; after all, I was the student and he my teacher. I realize now that that self grilling initiated by him has stood by me through my professional career.

RN was deeply concerned about professional and societal matters. He was the Founder President of the Computer Society of India, and Chairman of Computer Maintenance Corporation, a Public Sector Undertaking which he helped set up, which came about because computer manufacturers were unwilling to grow the base in India and interested only in leasing refurbished machines and maintaining them – the TIFR experience in building TIFRAC and maintaining a CDC machine that was purchased outright in Homi Bhabha’s times was an indicator that self sufficiency was possible.

RN was very generous with his help. He recommended me for a UNDP Fellowship in Europe in 1973. The time I spent in Europe clarified to me the foundations of programming and software that I had intuitively come to accept. I can trace most the contributions throughout my career that I value to reinforcement of my understanding that I gained during that visit.

A man is known by the company he keeps. His mind is known through the inspiring teachers who have contributed to its maturing and growth. I am most humbly grateful to have had RN as my teacher, and to have walked with him some distance in my academic journey. I would like to be like him in so many ways.

-- Kesav V. Nori, Ex-President, TAA (TCS, Hyderabad)

Remembering Dr. Karamjeet Arya (1945 - 2008)

Dr. Karamjeet Arya was a close friend and a professional colleague. I had the rare honor of sharing a considerable part of my life journey with him. We both came from Punjab and shared the Punjabi language. For our young lives, I followed him. He preceded me at the Punjabi University Patiala Physics department in the M. Sc. program, where I often heard from my teachers how bright and diligent a student he was. Then we were together at the TIFR from 1971–76 and later at the Max Planck Institute for Solid State Physics in Stuttgart Germany from 1979–81. Finally, I got him to follow me, when totally by chance, I moved to San Jose, California in 1984 and he joined the Physics faculty at San Jose State University four years later. My friend and I shared the Silicon Valley until 2008, when a rare cancer of the brain took him away.

(Karamjeet Arya with his son-in-law Vivek Arora, daughter Ranju and wife Sunita Arya)

As physicists we shared many scientific interests, but what set Karamjeet apart was his unique charm, friendliness, and welcoming personality. If you ever visited the Arya home, you were family. He would make time to pick you up from the airport, sit and chat with you, and show you around the town. He would insist on you staying at home instead of a hotel, and all meals were taken care of. When I joined TIFR in Bombay in 1971, the TIFR hostel was not yet ready. Karamjeet offered to share his room in the Old Yacht Club hostel near the Taj Hotel. Later when I arrived in Germany; he helped me get settled.

His personality was shaped and strengthened by his upbringing. He grew up in a Punjabi village near Barnala in a family of modest means. He worked hard to excel at school and later made it to the highest institutions of learning in India, Europe, and the United States. His research was his passion. Even though San Jose State University is largely a teaching institution, he continued his research work, collaborating with scientists at UC Berkeley, Lawrence Livermore Lab and Sandia labs in New Mexico.

His successes and living in the west didn't impact his humility, character or his charming Punjabi accent. He didn't care about fancy cars or a large home as most everyone does in the USA. Instead, he lived a disciplined life and used his savings to help his siblings and their families back home. He was generous offering financial help to his friends in need. A donation from him helped getting the TIFR alumni magazine started.

In his free time he loved gardening in his backyard. Occasionally he played chess. He had a spiritual side too. I frequently met him and his wife Mrs.Sunita Arya at the Sikh Gurudwara San Jose. Besides, he was very fond of the food served in the *langar.*

Dr. Arya has left behind a beautiful family and a large group of friends, who are thankful for having had him in their lives. His wife is a teacher in a local elementary school and also volunteers her time at the Sunday School in the *Gurudwara.* His daughter Ranju is a successful electrical engineer. Her husband Mr. Vivek Arora is also an engineer and has very fond memories of Dr. Karamjeet Arya, whom he proudly calls "dad".

Dr. Karamjeet Arya passed away at young age, but he lived his life fully and made every moment of it worth its while.

-- Gurinder Pal Singh *(TIFR Alumnus)*
San Jose Research Center,
Hitachi Global Storage Technologies, CA, USA.

Remembering Prof. R.P. Sharma (1925 – 2008)

Prof. R.P. Sharma passed away on the 7th September, 2008 after a prolonged period of ill health following a series of strokes. Born on the 17th November, 1925, Prof. Sharma had a long standing association with TIFR. Prof. Sharma worked at Royal Institute of Science (Nagpur) from 1948-56, where he came in contact with Late Prof. B.V. Thosar. His research activities at TIFR started while he was a lecturer at MahaKoshal Mahavidyalaya, Jabalpur (1957-59). He was strongly motivated and completed his Ph.D. at TIFR taking leave from his teaching duties. Subsequently, he joined the Nuclear Spectroscopy group of TIFR. His early work was to investigate nuclear deformation effects on internal conversion process via measurement of X-ray yields and conversion coefficients. He got his Ph.D. in 1964 from Bombay University for thesis entitled "Investigations of some Nuclear Energy Levels, Internal Conversion Coefficients and Shapes of β spectra."

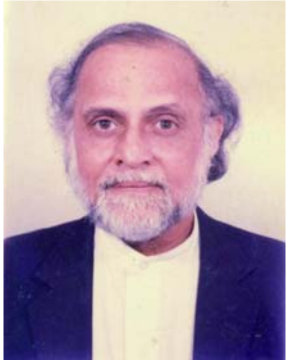
Prof. Sharma was instrumental in building the 400 kV accelerator for ion implantation in early 1974. All the crucial parts of this machine, like ion source, magnet etc., were developed in-house by him and Prof. K.G. Prasad. Only the accelerating column was imported from Danfysik, Denmark. This machine was extensively used not only for ion beam modification of materials but it also facilitated programs to investigate ion-solid collisions, spectroscopic study of ions, beam foil spectroscopy and served as a major research facility for over three decades. His pioneering work to study magnetic defects in materials using channeling techniques deserves a mention. He pursued this vigorously at Van de Graff accelerator and later at University of Maryland, where he continued to work for nearly two decade even after his retirement.

Prof. Sharma was one of the pioneering members of the Pelletron project at TIFR. His experience with building 400 kV accelerator was very valuable for this project. His enthusiasm and untiring efforts towards timely completion of this National Accelerator Facility were remarkable. This facility has been a backbone of nuclear physics research activities for the past twenty years (1988-2008). Late Prof. M.B. Kurup was one of his students. He had extensive collaborations with many universities. Prof. Sharma is survived by his wife and two sons.

(With contributions from Vandana Nanal, P. N. Tandon and other Alumni)

Remembering Prof. S.V. Damle (1936 – 2008)

Prof. Shashikant Vinayak Damle (b: Feb 2, 1936) joined the 3rd batch of the BARC training school after his M.Sc. from Ruparel College, Mumbai in 1959. He moved to TIFR in 1960 to work in the High Altitude Studies group and was involved in the study of the composition of primary Cosmic Rays using balloon borne instruments. He later moved to Infrared Astronomy in the mid seventies, and further to X-ray and Gamma-ray Astronomy. Prof. Damle was an established experimental scientist who worked with a variety of detectors like plastic scintillators, gas Cerenkov counters and spark chamber-emulsion magnet spectrographs. He completed his PhD in 1968 under the guidance of Prof. M. G. K. Menon on Primary Cosmic Ray Composition.



Shashi Damle spent 2 years at the University of New Hampshire where he collaborated with Prof. Webber to measure the charge and isotope composition of light elements (Li, Be and B) in Cosmic Rays. On his return from abroad, he committed himself to develop infrastructure at TIFR for high quality experiments. He was a part of the study group which initiated the large steerable radio telescope at Ootacamund; he was the lead person to develop the neutron and gamma ray detector for the first Indian scientific satellite Aryabhata, and also lead the collaborative experiment between TIFR and University of Calgary for a decade. He played a major role in the development of the National Balloon Facility at Hyderabad and took several new initiatives like the introduction of high speed telemetry, beacon communication for safety etc.

Shashi Damle initiated a collaborative program with the then Soviet Union, and started a balloon borne gamma-ray experiment, Natalya, leading to an Indo-Soviet Gamma ray Satellite experiment under the Integrated Long term Program (ILTP) in 1987. The gamma ray experiment – GRISP, jointly developed by TIFR and several Soviet Institutes lead by Moscow Engineering & Physics Institute was planned for a possible launch in 1992. However, due to unfavorable political situation in the Soviet Union and the consequent breaking of the union, this project was delayed and Shashi Damle will not be with us to witness the launch of this satellite early next year, with a new name `Coronas-Photon'.

Prof. Damle served on several committees of the institute and took a keen interest in strengthening the technical capabilities of TIFR and for that he initiated the ASET colloquium series. He was the recipient of the Vasvik Research Award for the ``Development of scientific balloon for carrying heavy telemetry instruments to stratospheric altitudes'' in 1994. He was a member of the Maharashtra Academy of Sciences. He breathed his last on 29th Nov., 2008.

-- A.R. Rao & R.K. Manchanda, TIFR, Mumbai

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Notices sent to a large number of email addresses have started bouncing so please inform other alumni as well.

Compiled, edited and produced by K.P. Singh. Photographs are by the photography section of TIFR. The views expressed here are those of the respective authors only.