SCIENCE AND CULTURE

VOLUME 73 ❑ MARCH-APRIL 2007 ❑ NOS. 3–4

EDITORIAL

PHYSICS BEYOND BOUNDARIES

Physics, counting from the time of Isaac Newton (1643-1727), is now about three hundred years old. It is presently the most mature, successful and dependable of all the natural sciences. Its inherent strength is manifested not only in its own development but also in its exploration, often very successfully, of some other domains of the natural sciences. Examples of this cross-disciplinary endeavour include biophysics, astrophysics and geophysics. Intense research activity, in the first two areas, is now conducted by the physicists in their own departments and not in the biology or astronomy departments (although a few "older" departments are still named Department of Physics and Astronomy!). The research results are also published in regular physics journals. Some outstanding physicists working in these areas have been awarded Nobel prizes in physics. The same is not, however, true where the subject of geophysics is concerned. Although research in this important area has a strong physical basis, geophysicists do not work in conventional physics departments, their research papers do not appear in standard physics journals and the Nobel prize in physics has generally eluded geophysicists.

The mainstream physics research can broadly be divided into two major categories. In one category, the focus is on the basic constituents of matter and their interactions as well as dynamics. The second category deals with the collective properties of many body systems composed of an Avogardo number (~ 10^{23}) of elementary entities. The system in many cases is defined by local (in space as well as time) dynamical rules, which, combined with the couplings between the constituents, lead to "emergent" features like self-organization and "universality", independent of the microscopic details of the system. The ambit of these general physical principles has now been extended to include many-component systems associated with disciplines like sociophysics and econophysics. Since the last few years, several physics journals have started publishing research papers in econophysics and sociophysics on a regular basis. Research in biological physics is now undergoing a paradigm shift with an emphasis on quantitative and global aspects of biological phenomena. The concepts, tools and techniques of physics are now extensively used in biological research. The earlier skepticism of biologists that physicists oversimplify biological complexity is giving way to fruitful interdisciplinary collaboration. The meeting of disciplines is facilitated by a rich interplay between theory and experiments. In this special issue of *Science and Culture* on "Unconventional Applications of Physics", we bring together a few papers by experts and provide a glimpse of the current interdisciplinary research scenario.

The earlier skepticism of biologists that physicists oversimplify biological complexity is giving way to fruitful interdisciplinary collaboration. The meeting of disciplines is facilitated by a rich interplay between theory and experiments.

The paper by Anirban Chakraborti of the Benaras Hindu University, Varanasi, gives a brief introduction to classical gas-like models of markets with income or wealth distributions similar to those observed in various societies or countries. The money exchanges in a market are visualized as "elastic scattering" which conserve money. Considerations of inhomogeneous saving propensities of the agents then lead to the observed steady state distributions. This is just one example of the problems studied in econophysics. In the next paper, Kerry Emanuel of the Massachusetts Institute of Technology, Cambridge gives a simple introduction to the physics of hurricanes by drawing analogies between a hurricane and the Carnot heat engine. The paper has been reprinted with kind permission from Physics Today. A very common natural geophysical phenomenon which causes major destruction to civil life is that of earthquakes. Srutarshi Pradhan of the Norwegian University of Science and Technology, Trondheim describes some of the very recently developed physics-based models of earthquakes, apart from the classic Burridge-Knopoff stick-slip frictional model. It is interesting to see how many of these self-organised critical and fractal-overlap models can easily capture the celebrated "Gutenberg-Richter" like statistics of avalanches or "quakes". Indrani Bose of the Bose Institute, Kolkata discusses in the next paper the origin and consequences of noise associated with gene expression and how physics-based theories are providing important insight on the different aspects of noisy gene expression. In the last few years, innovative single cell and single molecule experiments have been designed to quantify noise and many of the experimental observations are consistent with theoretical predictions. Finally, Bikas K Chakrabarti of the Saha Institute of Nuclear Physics, Kolkata, discusses how the distributed nature of computations in the brains are captured in the artificial neural network models the genesis of which lies in the physics of frustrated systems. It also addresses the questions raised by the enthusiasts of "strong artificial intelligence" who claim that all of our mathematical and physical science problems can be solved by the (future) computers, which can even perhaps be conscious!

In the Opinion Section, Stephen G. Benka, the Editor-in-Chief of Physics Today highlights the fact that despite the "elegance and profundity" of physics and its undeniably vast legacy, many of its applications remain "invisible". The article is reprinted here, courtesy the Physics Today and resounded the tone for the Special Issue.

We certainly hope that the sample papers in this issue convey to the readers the creativity and excitement associated with the "unconventional applications of physics". We also hope that the readers enjoy reading the articles. ❒

Indrani Bose and
Bikas K. Chakrabarti
(Guest Editors)

Prof. Indrani Bose is currently a Professor in the Physics Department, Bose Institute, Kolkata. She graduated from Calcutta University and obtained her Ph. D. degree in Physics from the Calcutta University. Her research interests include quantum antiferromagnets and strongly correlated systems, quantum entanglement in spin systems, statistical physics and systems biology. She is a Fellow of the Indian Academy of Sciences, Bangalore and the National Academy of Sciences, Allahabad.

Prof. Bikas K. Chakrabarti is currently a Senior Professor at Saha Institute of Nuclear Physics, Kolkata. He was graduated from Calcutta University and also obtained his Ph.D. degree from Calcutta University. His areas of research interests are statistical physics, condensed matter physics and computational physics. He has been awarded *Young Scientist Award* (INSA) in the year 1984 and the *Shanti Swarup Bhatnagar Award* in 1997. He is a fellow of the Indian National Science Academy (INSA), Delhi and Indian Academy of Sciences, Bangalore.