Challenges and recent advances in mathematical sciences*

The Department of Mathematics at IIT Kharagpur organized an international conference and an international symposium to commemorate the World Mathematical Year 2001 (as declared by the International Mathematical Union) and the Golden Jubilee of Indian Institute of Technology, Kharagpur.

The Symposium on *Challenges in Mathematical Sciences for the New Millennium* held on 21 December consisted of 7 invited lectures by renowned mathematicians from all over the globe and was dedicated to Srinivasa Ramanujan, a great mathematician of the millennium. The other technical programmes included invited lectures and contributed papers in three parallel sessions. There were mainly five categories of abstracts, which were organized as (numbers within braces indicate number of papers under each category): (i) Applied Mathematics (60), (ii) Pure Mathematics (48), (iii) Statistics and Operations Research (21), (iv) Computing Science and Information Technology (40), and (v) Applications to Engineering, Physical, Biological and Medical Sciences (36). Selected important papers of the Symposium and the Conference were published in two books by Narosa Publishing House, New Delhi. These are: (1) *Applicable Mathematics, its Perspectives and Challenges*, J. C. Misra (ed.), and (2) *Recent Trends in Mathematical Sciences*, J. C. Misra and S. B. Sinha (eds). Some of the highlights of the Symposium and different technical sessions of the Conference follow.

Symposium: A. M. Hinz (Germany) discussed some open problems and new tasks in applied mathematics. He mentioned that application-oriented mathematics is now facing a wealth of new areas of research. It was pointed out that a new branch like *Experimental Mathematics* is evolving due to availability of high-speed computers. He discussed two unsettled problems of mathematics. The first problem, which belongs to mathematical physics, was concerned with Jorgen's conjecture on self-adjointness of Schrödinger operators. The second problem, from discrete mathematics, was the problem of 'Tower of Hanoi with four pegs'. In this connection he added that the new challenges for applied mathematics cannot only be displayed by unsettled problems of the past, but are also characterized by a considerable extension of tasks. Hinz mentioned that the practical problems of classical fields of application of mathematics like physics, chemistry, engineering, biology, medicine, banking and many recent industrial areas have to be understood and turned into mathematical questions. He concluded his lecture with a couple of missions and visions for mathematics in the future.

Andrea De Gaetano (Italy) discussed the emerging trends and challenging tasks in Biomathematics which are evolving fast due to cheap computing power and societal issues, i.e. biological, ethical and environmental. The awareness of surroundings demands the feasible modelling and computational solutions within short time frames. Theoretical development, which is needed, would lead Mathematical Sciences to profit from these new challenges in Biomathematics. He stressed that the communication gap must be eliminated among the professionals from mathematical and biological sciences in order to tackle the challenges efficiently in this area.

S. Dasgupta (INSA and ISI, Kolkata) discussed Lorenz curves and Gini index in the context of measuring income inequity in a given population and for different populations. He pointed out some problems of defining a poor population on a universal basis and stressed upon several commodities or variables such as income, education level, monthly consumption, land holding. A brief mention of the economic theory advocated by Indian Nobel Laureate Amartya Sen was also made by him. Some new concepts such as Gini correlation ratio and Gini regression index were explained by him in order to assess the degree of monotone dependence amongst random variables.

T. B. Moodie (Canada) presented a model for the complex dynamics of sedimenting and non-eroding particle-driven flows; he also discussed the velocity shear in particle-driven gravity currents. W. Schneider (Vienna) gave an exposition of some peculiarities of boundary-layer flows over horizontal, heated or cooled plates for large Reynolds and Grashofs numbers.

Tuong Ton-That (USA) considered four unsolved mathematical problems of the 19th century, viz. (a) The Riemann Hypothesis, (b) The Poincare Conjecture, (c) The N-body Problem and (d) The Hilbert's Fourteenth Problem. He said that in spite of many advances made in the last century, these problems still remain essentially open. According to him, even pursuing some of these potential problems may open up altogether different fields of research and completely new sets of theories, even if one is unable to solve the original problem completely. He detailed his experiences while trying to solve the Hilbert's Fourteenth Problem and discussed some important results in that context.

Eugene Eberbach (Canada) presented some challenges facing computer science in the 21st century. He discussed some problems facing computer technology, architecture, distributed and parallel computing, programming paradigms, computational models and complexity, model of uncertainty and artificial intelligence.

Y. C. Tay (Singapore) talked on the challenges which are likely to be faced by scientific community in the field of Computing Science and Information Technology in future years. He stressed that the Internet, is going to pose a challenge and pointed out that similar networks have already suffered several disruptions caused due to hardware failures, misbehaving routers and virus invasions; the Internet may suffer a congestion collapse. He warned that till today, there is no mathematical model for predicting the behaviour of the Internet; no model to show how the number of hosts, the network topology, the protocol specifications, the traffic interactions, etc. affect its behaviour; no model to guide the engineering community in designing its hardware and

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software architecture; no model to predict how it might become unstable. Therefore, he invited the mathematicians to start work in order to formulate a model which can help analyse, understand and control its behaviour.

Enrique G. Reyes (USA) addressed some aspects of the modern geometrical study of different equations where formal differential geometry, moving frame techniques and integrable systems play an important role. T. T. That (USA) discussed some important theorems in Lie algebras and presented some generalized theorems in lie groups and lie algebras. B. P. Sinha (IIT, Kharagpur) presented an overview on high performance computing system. A. Sengupta (IIT, Kanpur) introduced a new mathematical approach to the understanding of chaos with the help of graphical convergence of a set of functions to a *maximally ill-posed problem*. He explained this concept to give a physical understanding of the nature of chaos and also to suggest a plausible explanation to the question of why a natural system tends to be chaotic.

Detailed algorithmic studies were presented by S. K. Dey (USA) to modify Perturbed Functional Iterations (PFI) and to make it suitable in a distributed computing environment. He also discussed the applications of the algorithm to large scale tridiagonal nonlinear systems which are frequently found in flow models. In another lecture, S. K. Dey presented in an interesting way the mathematical modelling of mind in mediation. Through mathematical modelling he showed that meditation could lead mind to a state where stress is absolutely zero. B. R. Sutherland (Canada) discussed the reflections and stability of large amplitude at which internal waves were in uniform shear and derived an analytic theory for predicting the amplitude for transmission through a reflecting level should occur. H. Taniguchi (Japan) put forward proofs of the existence of the d-embedding of an affine space into a projective space. R. Saigal (USA) presented a saddle point algorithm for solving Semi-Definite Programming (SDP) problems. D. K. Bhattacharya (Kolkata) discussed some aspects of mathematical modelling of mercury poisoning and optimal therapeutic dose to control the effect of various diseases. He considered a mathematical model giving the growth equations of the fish and the fisherman and determined the optimal therapeutic dose from a control theoretic standpoint. S. K. Sen (IISc, Bangalore) discussed the accuracy of numerical solutions of linear differential equations and presented the inconsistency index and error bounds while obtaining numerical solutions of linear differential equations with the help of linear programming techniques.

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Storm–substorm relationship*

The conference on storm–substorm relationship was sponsored by The American Geophysical Union (AGU) and co-sponsored by many Indian and international organizations. About 100 scientists working in the field of geomagnetism, aeronomy, space physics, plasma physics and solar-terrestrial physics participated in this Conference. There were 44 foreign delegates from USA, Japan, Germany, China, Indonesia, Poland, Russia, Finland, United Kingdom and Sweden.

In his inaugural address, V. S. Ramamurthy (DST) emphasized the need for global cooperation and collaboration toward predictions of geomagnetic storms and substorms resulting from solar disturbances. As one becomes increasingly dependent on the space-related technologies, awareness about the adverse effects of geomagnetic storms on the technological systems both in space and on earth has become an important issue. He urged the international space and earth scientific community to undertake collaborative projects to study the delicate balance between life on earth and forces of nature.

Geomagnetic storms are phenomena occurring in space, high in the upper atmosphere as opposed to the well-known thunderstorms that occur in the lower atmosphere. Eruptive processes, like coronal mass ejections (CMEs) and solar flares, occurring on the Sun can distort the earth's magnetosphere and cause geomagnetic storms. The magnetosphere is formed by the interaction of the solar wind, an ionized gas consisting essentially of electrons and protons, and the geomagnetic field. Substorms are a process during which a significant amount of energy stored in the Earth's magnetotail is released primarily into the polar ionosphere and into the inner magnetosphere. This release of energy is known to occur in the form of plasma kinetic energy in an explosive manner. Broadly speaking, large perturbations of the Earth's space environment can be called geomagnetic or space storms.

The scientific program of the conference was organized into 10 oral sessions and 2 poster sessions and one panel discussion session. There were no parallel sessions. Various topics concerning storm–substorm relationships, such as interplanetary drivers, modelling the magnetosphere, plasma processes in the magnetosphere–ionosphere system related to storms and substorms, the response of the ionosphere and the atmosphere to geomagnetic storms and substorms, and prediction techniques for space weather were discussed extensively during these sessions.

*Indian Institute of Geomagnetism, Mumbai hosted an International Chapman Conference on 'Storm–Substorm Relationship' at Holiday Resort of Fariyas Hotel, Lonavala, from 12 to 16 March 2001.