Report of the C3 Commission of Statistical Physics for 2002 – 2005
Cape Town, South Africa (October 24 – 28, 2005)

The general aims of the Commission on Statistical Physics (C3) are:
To promote the exchange of information and views among the members of the international scientific community in the general field of Statistical Physics including:

a) statistical and thermodynamic methods concerning the static and dynamic properties of mesoscopic and macroscopic states of matter;
b) applications of statistical physics to related fields such as non-linear dynamics, turbulence, chemical kinetics, polymers, colloids, liquid crystals, non-crystalline solids, heterogeneous media, neural networks and computational physics.

To recommend for Union sponsorship international conferences which qualify for support under Union regulations.

To select winners of the Boltzmann medal.

1. ACTIVITIES

The C3 Commission sponsored and helped to organize the academic programme of STATPHYS 22, the 22nd IUPAP International Conference on Statistical Physics held in Bangalore, India, during July 4 – 9, 2004. The conference drew about 600 participants from 47 countries from all over the world. The conference was held in an academic setting, at the National Science Seminar Complex, on the campus of the Indian Institute of Science, Bangalore.

The academic programme of the conference consisted of 2 Boltzmann Award Lectures and 9 plenary talks (of 45 minutes each), 54 invited talks (of 30 minutes each), 170 oral contributed talks (of 15 minutes each) and poster contributions which were presented in poster sessions held over 4 days. Invited and oral talks were held in four parallel sessions. Designated areas provided for discussions facilitated interactions between participants. Further, easy and free access to e-mail and internet facilities was available to all participants, and all registered participants were given free lunch and dinner.

STATPHYS 22 covered major topics of current interest in Statistical Physics including:

(1) Rigorous results and exact solutions; general aspects of statistical physics; thermodynamics
(2) Phase transitions and critical phenomena (equilibrium and nonequilibrium)
(3) Nonequilibrium processes (transport theory, relaxation phenomena, random processes)
(4) Pattern formation in systems out of equilibrium (growth processes, fracture, hydrodynamic instabilities, chemical reactions, granular flows, etc.)
(5) Dynamical systems and turbulence
(6) Liquid matter (atomic, molecular and ionic fluids, freezing; metastable liquids; granular matter)
(7) Soft condensed matter (colloids, polymers, liquid crystals, microemulsions, foams, membranes, etc.)
(8) Interfacial phenomena and wetting; surface effects and confined systems
(9) Quantum-mechanical problems (quantum phase transitions; strongly correlated fermions; Bose-Einstein condensation; mesoscopic quantum phenomena, etc.)

(10) Disordered systems (random lattices, spin glasses, glass transition, localization, etc.)
(11) Biologically motivated problems (protein-folding models, dynamics at the scale of the cell; biological networks, evolution models, etc.)
(12) Other applications of statistical physics (networks, traffic flows, algorithmic problems, econophysics, astrophysical applications, etc.).

A highlight of the conference was the Boltzmann Session, which was chaired by Prof. Benjamin Widom. At this session, individual Boltzmann Medals were awarded to Prof. E.G.D. Cohen of Rockefeller University and Prof. H.E. Stanley of Boston University. Prof. Cohen was cited for his "fundamental contributions to nonequilibrium statistical mechanics, including the development of a theory of transport phenomena in dense gases, and the characterization of measures and fluctuations in nonequilibrium stationary states", and Prof. Stanley for his "influential contributions to several areas of statistical physics, including the theory of phase transitions and critical phenomena in spin systems and the percolation problem, and the application of these ideas to interpret the anomalous properties of liquid water."

The overall programme was of a high scientific standard, reflecting the organizational efforts of the International Advisory Committee, the Steering Committee and the C3 Commission, and the high standard of research in the subject. A notable feature was the breadth of the topics covered, drawn from physics, chemistry, biology and beyond. The meeting highlighted the strong and deep connections between seemingly disparate problems, connections which provide a measure of unity in the diversity.

The plenary and invited talks focused on important recent developments in diverse areas. The plenary talks consisted of lectures on Scaling limit of 2-d critical systems (W. Werner), Fluctuations and large deviations in nonequilibrium systems (B. Derrida), Sheared solid materials (A. Onuki), Fluids near structured walls (A.O. Parry), Critical Casimir forces (S. Balibar), Glass transition in simple liquids (C. Dasgupta), Dynamics in soft and granular systems (T.C. Lubensky), Active processes in living cells (F. Julicher), and Statistical mechanics of complex networks (A-L. Barabasi). Further significant developments in each area were covered in the invited talks . Besides, many exciting new results were reported in the oral and poster presentations.

Twelve smaller, satellite meetings were held in the weeks just before and after STATPHYS 22. These meetings dealt with various subjects, including quantum systems, nonlinear dynamics, pattern formation, nonequilibrium statistical physics, complex fluids, disordered systems and glass physics. They were spread across several countries in Asia, namely, India, Singapore, China, Taiwan, Korea, Japan and Iran. These more focused meetings provided a double benefit to participants who had travelled large distances to India to attend STATPHYS 22.

The proceedings of STATPHYS 22 have been published in Pramana - Journal of Physics (Vol. 64) in May and June 2005 and have also appeared separately in hard-bound book form as well as on CD. The meeting of the C3 Commission was held during STATPHYS 22. The 23rd International Conference on Statistical Physics, STATPHYS 23, will be held in Genova, Italy, in July 2007.

2. NEW DEVELOPMENTS

Research in statistical physics continues at a rapid pace, and the past three years have seen the continued growth of journals such as Physical Review E, the Journal of Statistical Physics and Physica A, besides the launching of a new electronic journal, the Journal of Statistical Mechanics: theory and experiment (JStat).

Important progress has been made in the areas of Rigorous results and exact solutions (the Schramm-Loewner evolution description of critical two-dimensional systems), Phase transitions (condensation transitions in nonequilibrium systems), Pattern formation (structure formation in granular media), Liquids (droplet dynamics on substrates; ion solvation at interfaces), Soft condensed matter physics (polymer conformations and confinement; colloidal interactions), Quantum systems (Bose-Einstein condensation and BCS pairing in ultra cold atoms; signatures of a supersolid phase), Disordered systems (aging in glasses; ordering in vector spin glasses), Biologically motivated problems (Folding problems; fusing membranes;single-molecule fluctuations).

There has been significant theoretical and experimental progress in characterizing nonequilibrium steady states — an important development since nonequilibrium phenomena are ubiquitous in statistical physics. On the theoretical side, there has been considerable analytic progress in understanding nonequilibrium phase transitions, and the scaling properties of fluctuations and large deviations in driven systems with strongly interacting components. There is close interaction between experiment and theory in several areas, such as the formation of structures and the jamming transition in granular media, and the study of scaling and intermittency in turbulence. In these studies and many others, an increasingly substantial role is played by computational and simulational methods. A significant growing trend, which has intensified over the past three years and fits within the general ambit of nonequilibrium systems, is the interaction of statistical physics with biology. Examples include the use of information networks to understand communication in biological systems, the study of cooperative effects in collections of self-propelled particles and the nature of fluctuations in a single biomolecule. Finally, statistical physics techniques are finding significant applications in computer science, a recent example being the properties of search trees used for data storage and retrieval.

Given the broad sweep of problems that are of interest in statistical physics, it is not surprising that there are strong links with areas covered by several other Commissions. For instance, the collective behaviour of ultra cold bosons and fermions is of interest to the Commissions on Low Temperature Physics (C5) and Atomic, Molecular and Optical Physics (C15). The statistical properties of magnetic systems with and without disorder are of interest to the Commission on Magnetism (C9). Studies of random fractals using Schramm-Loewner evolutions is of direct interest to the Commission on Mathematical Physics (C18), while the well entrenched use of computational methods in statistical physics makes for a natural link with the Commission on Computational Physics (C20). Problems in soft condensed matter physics are also of interest to the Commission on the Structure and Dynamics of Condensed Matter (C10). The growing interaction between statistical physics and biology, discussed earlier, makes for a commonality of research interests with the Commission

on Biological Physics (C6). This sort of interfacing with problems from diverse fields is an essential characteristic of statistical physics, and gives the subject its unique flavour. The linkages of research areas are reflected within C3 by its Associate Members, who are drawn from various other Commissions, with one member being from another Union (Chemistry). The linkages with other fields have also led to the active participation of C3 in the IUPAP activity on Nanoscience, along with other Commissions of the Union.

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