

**Report to the 2002 General Assembly for 1999-2002
Berlin, Germany
October 7-12, 2002**

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

From 1999 to 2002 C3 sponsored in the year 2000 a topical conference on New Trends in the Fractal Aspects of Complex Systems (FACS 2000), Maceio, Brazil, 16.-20. October 2000, with about 150 participants, and in 2001 the 21st International Conference on Statistical Physics, STATPHYS 21, in Cancun/Mexico, 15.-20. July 2001. This is the main large conference that the commission C3 sponsors, and it is held in a three years cycle. While the "normal" attendance to STATPHYS Conferences is about 1000 to 1200 participants, and in 1998 (in Paris) even the exceptionally high number of 1800 participants was counted, this time the number of participants decreased to about only 800, which was expected because flight tickets to Mexico are expensive from almost all countries of the world. Originally, (in 1998, when Mexico was chosen) it had been planned to hold the conference at UNAM Campus in Mexico City, but a violent student strike which lasted for more than a year and created a lot of disarray had made the shift of the conference to Cancun necessary.

The conference program consisted of 7 plenary talks (including the 2 Boltzmann Award lectures), 60 invited talks (of 30 minutes duration each) 200 oral contributed talks (of 15 minutes duration each), and about 500 poster contributions, which were presented in three poster sessions. Both invited and contributed talks were held in four parallel sessions. The facilities of the Cancun Convention Center, where all four conference rooms, the poster hall and the lobby where coffee and soft drinks were served throughout, allowed to switch between sessions very easily, and were also very favourable for an intensive interaction among the attending scientists. Thanks to the efforts made by the International Advisory Committee and the Steering Committee, the conference succeeded in maintaining a very high scientific standard, and the most recent advances from the 12 topical categories were presented and discussed. These topics were "1. Rigorous results and exact solutions, general aspects of statistical physics; 2. Phase transitions and critical phenomena (equilibrium and non-equilibrium; renormalization group); 3. Non-equilibrium processes (transport theory, relaxation phenomena, random processes); 4. Pattern formation in systems far from equilibrium (growth processes, chemical relaxations, hydrodynamic instabilities, granular flows); 5. Dynamical systems and turbulence; 6. Liquid matter (atomic, molecular and ionic fluids, freezing; metastable liquids; structure and dynamics of granular matter); 7. Soft condensed matter (colloids, polymers, liquid crystals, microemulsions, foams, membranes, etc.; Interfaces, wetting confined systems; 9. Quantum-mechanical

problems (strongly correlated fermions; Bose-Einstein condensation; mesoscopic quantum phenomena, etc.); 10. Disordered systems (glass transition, localization, etc.); 11. Biologically motivated problems (protein folding models; neural networks; molecular motors; etc.); 12. Other applications of statistical physics (econophysics, earthquake models, traffic flows, population dynamics, astrophysical applications, etc.)."

A particular highlight of the conference was the Boltzmann Medal Ceremony, in which Berni J. Alder received a Boltzmann Medal for "inventing the technique of molecular dynamics simulation and showing that with such "computer experiments" important discoveries in the field of statistical mechanics can be made, in particular the melting/crystallization transition of hard spheres and the long-time decay of auto-correlation functions in fluids", and Kyozi Kawasaki received a Boltzmann Medal for "his contribution to our understanding of dynamic phenomena in condensed matter systems, in particular the mode-coupling theory of fluids near criticality, and nonlinear problems, such as critical phenomena in sheared fluids and phase separation".

In addition to the STATPHYS 21 conference itself, 7 satellite conferences were held (four in the preceding week, in Oaxaca, Merida, and two in Cocoyoc, three in the following week, including one in Cancun, another in La Havana/Cuba, and the last one in Athens, Georgia, USA). These satellite conferences contributed to make the STATPHYS 21 even more rewarding to the many participants that travelled from all over the world to Mexico at this occasion. In conclusion of this report, it can again be said that STATPHYS 21 proved that statistical physics is a very active and rapidly developing field, which many relations to other fields of physics. This fact was also apparent from the many exciting new results that were reported both in the contributed and invited paper at all these conferences. Here we only mention the plenary talks at STATPHYS 21 - Mezard reported on progress achieved with the understanding of the glass transition, Tang described applications of the concepts of self-organised criticality, Mukamel reported progress of understanding the nature of phase transitions in biopolymers, and Weitz described astonishing scaling properties in the aging dynamics of strongly inhomogeneous materials. Finally, a particular highlight was the talk by Ketterle on Bose-Einstein condensation (note that his work won him the 2001 Physics Nobel prize!)

The proceedings of STATPHYS 21 have already been published as a special issue of the Journal *PHYSICA: Statistical Mechanics and its applications* (Vol. 306). The 22nd International Conference on Statistical Physics, STATPHYS 22, will be held in Bangalore, India, July 4-9, 2004.

2. NEW DEVELOPMENTS

The research in statistical physics is still very active, as the growth of journals such as *Physica A* and *Physical Review E*, for instance, shows. The emphasis is on areas such as the statistical mechanics of soft condensed matter (polymers, colloids, liquid crystals, microemulsions, etc.), on biologically inspired model problems (protein folding, molecular motors, biological membranes and their functions, statistical analysis of time series of biological signals such as heart beats and search for scaling behaviour, etc.), on quantum problems (experimental and theoretical aspects of Bose condensation, quantum phase transitions in correlated electron systems), on non-equilibrium problems (pattern formation in various kinds of driven systems far from equilibrium, complex hydrodynamic flows, statistical mechanics of friction, etc.). A particular activity has developed on the statistical mechanics of the glass transition: understanding the mechanism by which an under-cooled fluid transforms in an amorphous solid is still one of the grand-challenge problems in the statistical mechanics of condensed matter, and many new theoretical concepts have been prepared and worked out and a comparison with experiment has been often attempted. While on many aspects considerable progress has in fact been obtained, a fundamental

breakthrough in our understanding of this problem is still lacking. We emphasize also that the research in this case is very interdisciplinary - involving not only statistical mechanics in a narrow sense, but also physical chemistry, computational physics and chemistry, and related fields make contributions.

Another area of great recent activity is the statistical mechanics of fluids confined in narrow pores, channels, or wedges, and associated wetting phenomena, - a field that finds also growing practical applications in materials science and nanotechnology. Spectacular phase transition phenomena (such as the critical phenomena associated with the "filling transition" of a wedge, for instance) have been analyzed in this context.

Of course, much of this research has aspects of great relevance for other Commissions as well: problems such as Bose condensation, quantum hall effect, modelling of high temperature superconductivity (all these discoveries were honoured by Nobel prizes!) are of great interest both for the Commission on Statistical Physics and the Commission on Low Temperature Physics (C5); problems such as protein folding and biological membranes are also of interest for the Commission on Biological Physics (C6); statistical mechanics of magnetic model systems continues to be active and is of interest for the Commission on Magnetism (C9); the research on soft condensed matter clearly relates to the interests of the Commission on the Structure and Dynamics of Condensed Matter (C10); Statistical mechanics of lattice gauge theory relates to the interests of the Commission on Particles and Fields; of course, there are particularly close connections to the Commission on Mathematical Physics (C18) and Computational Physics (C20), since both the methods of mathematical physics and computational methods such as Monte Carlo and Molecular Dynamics computer simulation are very important tools in statistical physics. Therefore the commission C3 has Associate Members from several of these other Commissions, and occasionally also conferences are sponsored together, e.g. C3 has also supported the IUPAP Conference on Theoretical Physics in Paris (France) this July. In this way, research in statistical physics maintains an interdisciplinary character, both within physics and even outside of it - e.g. the recent trend of developing models for economic processes ("econophysics") is an example for the interaction of statistical physics with such other disciplines.

Kurt Binder (C3, Chairman)