# Vienna, 1997

An annual conference organized by and for PhD students was held last year in Vienna. **Helen Fraser**, currently studying for a PhD at Cambridge University, went to the conference having won her ticket in a lecture competition run by the Institute of Physics in the UK. Her report, below, first appeared in the IOP's student newsletter *Nexus*

## There's plenty of wine in Wien And some Physics, too

"Ladies and gentlemen, this is your captain speaking. Please note that the Fasten Seatbelts sign is now illuminated. There is cloud ahead and we may experience turbulence on our approach to Vienna." All around, nature was displaying the beauty of the ionisation process: pent-up electricity forking across a peat-black sky. But when I'd boarded this plane in England the weather had been sunny and warm. Moreover, my guidebook had specifically stated that Vienna boasted sticky hot summers, so I'd packed only one jumper. Still, who cared about the weather when there would be plenty of physics on offer? I certainly wasn't going to Vienna with the intention of sunbathing (although I am told there are a number of beaches, including some of the rather nude variety, along the banks of the Danube).

As I was the 1997 postgrad-winner of the Nexus Lecture Competition, the Institute of Physics had sent me to the International Conference for Physics Students (ICPS) to give a repeat performance of my lecture [based on her PhD in tunable far-infrared spectroscopy], and interact with physicists of all nationalities. The week was certainly non-stop. Food, beer, wine, lectures, lab tours, sightseeing and parties featured in no particular order until all seemed to merge into one. Students from first year undergraduate to final-year PhD level rubbed shoulders together, discussing the finer points of Newton's Laws, especially as applied to Austrian pasta.

The ICPS acts as a focal point for physics students of all nationalities, and I made some good friends from across Europe and from Canada. Many students came from the former 'Eastern Block' countries (*eg* Russia, Poland, Romania) and were generally very clever. But unfortunately, one of the Russians had failed to realise that the official conference language was English, not Russian, but I probably understood more of his severely theoretical lecture that way anyhow. In fact, though I tried to avoid theoretical talks I heard students talk eloquently on a feast of subjects from fire walking to meteorology, and models of sonar searches for oil to Bose-Einstein condensation.

Whatever your interest there was a subject for you, and as a PhD student it was great to attend such a diverse conference. There was none of the usual conference stuffiness where people stick to their own friends and colleagues, or gawp in awe at gurus of their chosen speciality. Interspersed among the half-hour student lectures were invited lectures by professors, most of whom were from the Technical University in Vienna, though one turned out to be from Leeds University [in the north of England]. We were subjected to gory pictures of corneas being removed from eyes during the 'Lasers in Medicine' lecture, and some clever mathematics trying to model the muscle contractions which occur in the heart during a heart attack. Physics made a solid return, however, with a superb talk on the state of theoretical physics today.

For those students who were not confident enough to 'have a go' at talking to an audience of willing listeners, or who preferred to take a back seat, there was also a poster session, which included an outstanding poster showing photographs of comet Hale-Bopp. And 'Hail Bop' was indeed the call each evening. For there were two aims to the conference: physics and interaction. Newton would have stated that interaction is part of physics and therefore should not be a second aim, but I mean social interaction. The very first night we were in Vienna four of us decided to meet and go to eat. Then someone met someone they knew from a previous conference, and they had a friend who had a friend, and so on... Eventually 30 of us sat down to dinner. But it was excellent – I even managed to sit opposite a Romanian girl called Andrea who was about to start a PhD in the same field as me. Considering that there were just 240 people at the conference, and far infrared/sub-millimetre research is in its infancy, this was no mean feat.

The first evening was followed by an opening party, held in the 'Manchester Club'. Wow, was I excited? Not since my undergraduate days had I been clubbing in Manchester: good old Indie music, or even funky rave. But no. Obviously, not many Austrians had been to Manchester. But despite the 'interesting' music and damp room, the company was superb and I met many new faces. Another party followed – the National Party. One has, or ought, to be warned about the drink during this part of the conference: each country gives you some of its potent fire-water, and within half an hour mayhem breaks out. Groups were expected to get up on stage and give a flavour of their national culture to the inebriated audience. Armed with Scottish Jigs, our British team soon had the whole room attempting the 'Gay Gordons' and 'Stripping the Willow'. And so the parties went on. It was get up, get breakfast, get lectured, get sight-seeinged, get merry, get .... get the picture? And I haven't even mentioned how beautiful Vienna is.

This year the conference will be in Portugal, at the University of Coimbra, another beautiful location. As part of their successful bid to host ICPS98, the Portuguese students presented an amazing display of Physics to us in the form of a 'circus'. If they organize this year's conference even half as well it'll be fabulous. But actually it wouldn't matter if the conference was held in my back yard. The Physics I was reminded of, the new facts and friends that I brought away with me from the week, and the opportunity to share time and ideas with other enthusiastic students, were well worth the turbulent landing in Vienna.

The Portuguese Association of Physics Students is organizing the **13th International Conference for Physics Students 1998 (XIII ICPS98)** in the Department of Physics at the University of Coimbra, Portugal, from 9th to 16th August 1998. The ICPS is the annual Conference of the International Association of Physics Students. *Website* www.fis.uc.pt/~icps98/

Young physicists may also be interested in the annual **Physique En Herbe** conference (*en herbe* is a French expression indicating a promising future) which is organised by and for PhD students.

This year it will be held at Rouen, in the French region of Normandy, from the 6th to the 10th of July 1998 at the Faculté des Sciences et Techniques of Mont-Saint-Aignan. The conference is 14 years old and gives European physicists at the doctorate level the opportunity to present their work and, of course, meet fellow young-minded physicists. *Website* www.citeweb.net/PEH98

# Santa Barbara, 1997

The Jamming and Rheology programme at the Institute for Theoretical Physics (ITP), University of California was spread out over four months up to December of last year. It was long, but it wasn't laid back:"I thought it was actually quite intense. It lasted a long time but we had continual seminars, discussions, meetings *etc*. New visitors arrived all the time so that I for one was exhausted at the end of it," **Sidney Nagel**, the author of the following report, told *Europhysics News*

The programme on Jamming and Rheology attempted to focus on the similarities that exist between a whole variety of systems spanning a range of sizes from the microscopic to the macroscopic. Because jamming occurs at the transition between where flow occurs and where motion stops, one hopes that there may be universal features that describe this transition in all systems

Several topics were the focus of intense study during this program. These seem to naturally divide into several categories.

- What is the nature of the jammed state?
- How does one get into the jammed state?
- Are there similarities between getting jammed due to driving or forcing the system (*ie* kinetic effects) and getting jammed due to thermal effects as in the glass transition in molecular liquids?

## Fluctuations, temperature and the fluctuation-dissipation theorem

Ball, Cugliandolo, Edwards, Kurchan, Langer, Liu (experimentalists: Nagel)

One question that appears over and over again in all out-of-equilibrium systems is whether there is a useful concept of temperature. This appears naturally in the subject of supercooled liquids where the term 'fictive temperature' has long been used to describe the characteristic out-of-equilibrium temperature thermal characteristics of the system. More recently, the question has been addressed of whether there exists for these systems a fluctuation-dissipation theorem. The existence of such a theorem relies on there being a temperature. Generalizations of such theorems have been produced for supercooled systems although there have been no experimental confirmations of the predictions. There have been other attempts to define a 'temperature' for athermal systems such as granular materials, foams and colloids. One question, studied during the program, is whether the fluctuations in a driven steady-state system that is far from equilibrium can be used to define a temperature. Are all the temperatures that one defines in this way consistent with one another? Is there a zeroeth law of thermodynamics (*ie* is there a notion of equilibrium)? For static systems in some metastable state, can one define a quantity similar to temperature which describes the state of the system?

## Force chains in jammed systems

Alexander, Ball, Coppersmith, Goddard, Kob, Langer, Levine, Liu, Mehta, Narayan, Sokolar, Tarjus, Thornton, Witten (experimentalists: Bideau, Clement, Nagel)

When a system becomes jammed, it is held rigid due to propagation of forces from one boundary surface to another. One common feature of many jammed systems is that this propagation of forces is very heterogeneous. Thus, for example, in a granular system one can actually see the 'force chains' by placing the stressed material between two crossed circular polarizers. Simulations of granular materials under a variety of loads also clearly show this heterogeneous force propagation. These fluctuations in the forces can be very large – as large as the average force itself, and there is a high fraction of the contacts between particles that carry zero, or close to zero, force. Experimental measurements and numerous computer simulations seem to indicate that the distribution of the forces is very robust – that is, it varies at most only slightly between one system's preparation conditions and another. Several questions naturally arise. Are these fluctuations reminiscent of a temperature? How does one model these fluctuations? Clearly there is disorder, but it is not clear how one puts disorder into a theory. In particular, it is not apparent how to model the disorder: should one assume complete randomness or should one build in correlations? (This is different from what one has for a thermal system where one has an ergodic assumption that all accessible states are equally possible.) Most of the studies of 'force chains' have been on granular systems. One focus of the present programme at ITP has been to ask whether similar force heterogeneities are seen in other jammed systems such as foams and (microscopically) molecular glasses. One is after a comprehensive theory that would describe how the force distributions differ between foams and granular materials. For example, why is the distribution of forces exponential at large force in a granular material but appears to be Gaussian for a foam?

## Force propagation in granular materials

Alexander, Ball, Cates, Edwards, Goddard, Halsey, Levine, Prakash, Witten (experimentalists: Cody, Durian, Evesque)

A related question to the one about how to treat force heterogeneities, is how to treat the average propagation of forces in a granular material. Is it appropriate to use conventional theories of elasticity or elastoplasticity to treat these very hard but delicately balanced materials? Recently, in the literature, there has been an assault on this approach in which a different set of constitutive relations have been proposed to close the equations. These new equations are not based on elastic behaviour but rather are based solely on relations between various components of the stress tensor in the material. One question that has been investigated at length in this programme is whether the new approaches allow one to explain experimental results that could not be understood by the more conventional theories. That is, are the two approaches really fundamentally different? Another question that has been discussed at length is: What is the nature of the plastic region in the more conventional theories and what experimental implications does the plastic region have? In relating this topic to the previous one on force inhomogeneities, one is also led to ask whether that is the consequence for a material of having such a broad spectrum of fluctuations? In particular, many of the observations of the force distributions show that there is a high fraction of particle pairs that have zero, or close to zero, force between them. If so many contacts are on the verge of breaking, does this imply a particularly sensitive assembly for which an ordinary elastic response theory might fail? A technical issue is whether the equations that govern the static stress patterns are elliptic or hyperbolic. The more recent theories assert that the equations are hyperbolic so that stresses will propagate along lines like a wave. This has the consequence that the stress needs only to be specified along a (*eg* top) surface and the stress then propagates (downward) due to those applied forces. Is this scenario experimentally justified? The issue is still a subject of heated debate.

## Friction in confined systems

Baljon, Carlson, J. Langer, S. Langer, Liu, Robbins (experimentalists: Durian, Gollub, Knobler)

When a fluid is confined in a narrow region a small stress may not be sufficient to force the system to move: there is a yield stress. For stresses slightly greater than this yield stress, there is 'stick/slip' motion where the fluid flows in short bursts. As the stress is increased still further, the motion becomes more and more smooth. Such behaviour is seem in many other systems such as granular materials (in avalanches as well as in forced flow between plates), foams and colloids and goes by different names depending on the context. On the largest scale, this stick/slip motion is felt in earthquakes. The relation to jamming is obvious: the flow only stops because the particles get jammed and new force chains are set up that span the entire system. Questions that have been asked are: What is the nature of the rearrangement events during one of these processes? Can the stick/slip event be predicted from other external observations of the system? How do the stick/slip events change their character as the stress is increased? Recently, experiments and simulations have been able to observe the nature of the individual 'avalanche' events. It appears that there is not a diverging length scale to the size of the events as the stress increases. One of the focuses of this programme has been the study of the similarities in the behaviour of all of these different systems.

## Glass transition

Chakroborty, Glotzer, Klein, Kob, Obukhov, Oppenheim, Tarjus (experimentalists: Borjesson, Ediger, Nagel, Torell)

The nature of the glass transition is one of the oldest unsolved questions in condensed matter physics (*see page 46*). In a fundamental sense this is a jamming phenomena: as the temperature of a liquid is lowered, it becomes more sluggish and at a non-zero temperature (if one believes extrapolations) eventually stops moving entirely. This jamming is an equilibrium phenomenon and is caused by the decrease in thermal energy available for molecular rearrangements. Thus, as distinct from many of the cases discussed above, it is not caused because of the jamming due to the kinetics of driving the system out of equilibrium. Despite this difference, are there similarities between these jamming phenomena? Certainly many of the questions asked are similar: What notion of temperature can be used to describe the system as soon as it has left equilibrium? Is there a fluctuation-dissipation theorem below the glass transition temperature? As the glass transition temperature is approached does one become increasingly more sensitive to kinetic jamming due to shear or other forcing of the system? Many experiments appear to indicate that supercooled liquids are very heterogeneous as are the other jammed systems (*eg* force chains, inelastic collapse). Several recent experiments indicate that the time scales for translational diffusion in liquids decouple from those important for rotational relaxation and viscosity. Are there different 'temperatures' that are important as soon as the system begins to jam that govern the different properties? Recent experimental results have also indicated that structural glasses have a great deal more in common with spin glasses than had previously been suspected. There is a tail, extending to high frequencies, that appears in the susceptibility of both systems (as well as in plastic crystals). This ubiquitous feature is not understood although it may imply a definite correspondence between the physics of these systems.

## Kinetic jamming and rheology

Cates, Langer, Lequeux, Levine, Liu, Schwartz, Sollich, Stinchcombe, Tarjus, Weaire (experimentalists: Ackerson, Durian, Knobler, Weitz)

Glassy systems have a peculiar rheology. How does one account for a yield stress and how does one model the response of the system above the yield threshold? How does the shear modulus depend on frequency as the frequency is lowered? Many soft systems (foams, colloids *etc*) have a very non-Maxwellian frequency dependence with both real and imaginary parts of the modulus varying as a fractional power of the frequency as the frequency approaches zero. Molecular glass forming liquids do not have this characteristic as far as we can tell. Can this anomalous frequency dependence be understood in terms of some simple model? Several attempts at constructing such a model have been tried. Some of these focus on the microscopics at the level of the individual bubbles or particles and the forces constraining them. Can one relate the weak regions that occur in these systems to the nature of the force distributions that were discussed above, or is the nature of the weak regions most accurately described by a geometric effect? Other theories operate on a more phenomenological level and coarse grain the system: energy can flow between different cells according to a specified set of rules. Both kinds of theories can produce non-Maxwellian behaviour. Another whole class of theories is based on jamming due to essentially free-volume effects such as the random sequential deposition model. These models can be generalized to treat other dynamical systems such as traffic flow problems.

## Pinning systems

Bhatt, Cugliandolo, Giamarchi, Kurchan, LeDoussal (experimentalists: Mydosh)

Disorder is intrinsic to all of the topics mentioned above. However, in most of those cases it was assumed that the system was always free to rearrange itself so as to anneal away the disorder. Some systems, however, have disorder which is quenched in and cannot be annealed away. These systems include spin glasses and vortex glasses. Such systems also get stuck due to the pinning of degrees of freedom by the externally imposed (*ie* quenched in) disorder. This could be a very different problem from that of jamming which is a case of the system getting stuck, not by pinning to particularly attractive regions created by the disorder, but by the system getting jammed due to disorder created by its own motion. Despite this, there are a number of clear similarities between these two types of systems. The most obvious similarity is in the aging phenomena when a material slowly tries to approach equilibrium after having been driven far away from it. This has been studied most seriously in the case of spin glasses below the spin-glass transition. Many experimental studies measured how properties, such as the remnant magnetization, varied with waiting time and temperature. The theoretical models that have been developed to handle that type of situation have now also been used to predict the aging in molecular glasses. One new aspect of this research has been to address the question of how aging will occur under the presence of shear in such systems as foam. This then relates back directly to the question of jamming in such systems. Another connection between spin glasses and ordinary structural glasses was made by experiment. As mentioned above, there is a high-frequency tail that appears in the dielectric susceptibility of liquids and the magnetic susceptibility of spin glasses. This feature indicates that the disorder, though of different origin in the two cases, leads to similar response and similar physics of the glassy transition.

# Grenoble, August 1998

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## Climb the Peaks of Condensed Matter Research

The seventeenth general conference of the Condensed Matter Division of the European Physical Society will be held on the University Campus in Grenoble between 25 and 29 August 1998 as a joint meeting with the 6ièmes Journées de la Matière Condensée of the French Physical Society.

Within their 10 years of existence the Journées de la Matière Condensée have succeeded in attracting a large number of French physicists. In particular, a substantial effort is made to facilitate the presence of younger colleagues. Also, the structure of the conferences has been based on, aside from the invited plenary or semiplenary sessions, many parallel minicolloquia, the choice of which is the result of a wide enquiry among members of the physics community. It's a way of giving physicists what they want.

We have prepared this year's European event in the same spirit. Up to 400 grants will be awarded to students to cover most of the accommodation expenses and registration fees. In addition, also in the spirit of the Journées de la Matière Condensée, we have conducted a wide inquiry among European physicists. We have received more than 300 answers, and with these suggestions the international advisory committee has selected 37 minicolloquia. The list of minicolloquia is opposite; it gives a striking picture of the vitality of European research.

We have asked the organizers of each minicolloquium to write a short synopsis in which they stress the breakthroughs and the hot topics which may drive the discussion. You will find these synopses at our Website. The organizers have been given all authority to arrange their minicolloquium as they wish: they may have posters, invited oral contributions and discussion. By looking at our Website you should develop a strong motivation to participate in discussions, and in fact the facility to do just this: submit comments. You will also find information on registration conditions: it may still be possible to apply for a grant and/or send in comments by the time this article appears.

Besides the minicolloquia, you will be pleased to find the traditional events which have built the reputation of the European conferences. We will have 50 invited contributors in five parallel sessions, and eight plenary sessions including that dedicated to the Hewlett Packard Prize. The invited plenary speakers are G. Abstreiter on Si/Ge Nanostructures, M. Bruel on Smart Cut of Si, Ø. Fischer on Superconductivity, J. Pendry on Quantum Friction, Y. Petroff on Synchrotron Radiation, J. Prost on Biophysics and R. Scherm on Neutron Scattering.

There will be also an exhibition of books and scientific equipment. The CMD general conference has the potential to be for European physics an event of similar importance as the March meeting is for American physics. However, the situation can be improved from this point of view. If something can be done to encourage attendance at the conference we are quite ready to do it, and open to other suggestions. We would particularly welcome any initiative which promotes or facilitates the employment of students and exchange opportunities for postdocs. Students who search for a job or a postdoc position will be welcome to pin a CV next to their poster at the conference. During one afternoon a round table discussion on job opportunities after PhD studies will be organized by the Association Bernard Grégory, the French non-profit organisation devoted to industry job hunting for PhD students.

Finally, a word about Grenoble. Besides its outstanding scientific facilities it has plenty of other attractive sides you may wish to discover. It contains several major museums; the medieval centre of the city is very lively at night. At the end of summer, hiking is very popular and can be done in an area spread over three main mountains which are within half-an-hour by car of the city centre.

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*Other EPS conferences are listed on page 62*

# Minicolloquia

**Tuesday 25th August**

1. Vortex matter in superconductors
8. Quantum spin systems
10. Fullerenes, nanotubes and exotic structures
12. Electronic confinement in semiconductors
17. Growth and characterization methods: properties of films
18. Water at interfaces
22. Scattering of waves in random media
23. Mechanics and rheophysics of complex fluids
28. From atoms to microstructures
31. Large-scale computations: Ab-initio electronic structure

**Wednesday 26th**

5. New superconductors
7. Magnetic multilayers and spin electronics
13. Wide band gap semiconductors
19. Phase transitions at surfaces
20. Granular materials
24. Physics of biological functions: motors, membranes, cell adhesion
29. Quasicrystals and metallic glasses
30. Atomic and molecular manipulations by scanning probe techniques: present, state and future prospects
35. Inelastic X-ray scattering

**Thursday 27th**

3. Mesoscopic effects in superconductors
6. Colossal magneto-resistance in oxides
15. Materials, physics and devices for molecular electronics and optics
25. Biomacromolecules: structure and dynamics
27. Adhesion, wetting and contact
32. Large-scale computations: strongly correlated systems
33. Femtosecond spectroscopy of molecules and solids
36. High magnetic fields
37. New infrared emission and detection devices

**Friday 28th**

2. Spectroscopy of high temperature superconductors
4. $^3$He and modern physics
9. Magnetic clusters and nanoparticles
11. Orbital order in oxides
14. Photonic band gap structures and microcavities
16. New frontiers of microelectronics
21. Slow relaxation and vitreous transition
26. Proteins, bio-polymers and polymers at interfaces
34. Rupture dynamics and friction in physics and geophysics

**Saturday 29th**
sessions include the Hewlett Packard Prize Ceremony