
THE BRITISH SOCIETY OF RHEOLOGY



BSR BULLETIN
2009, Vol. 50, No. 1

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ISSN 1469-4999

EDITORIAL

In 2008, the British Society of Rheology continued its success in serving fellow members across different disciplines and industrial sectors, by promotion of science and dissemination of knowledge in rheology. The BSR Council has decided to award two distinguished theoretical rheologists, Professor Mike Cates at University of Edinburgh and Professor Tom McLeish at Universities of Leeds/Durham, with the BSR Gold Medal at the European Rheology Conference in Cardiff in April 2009. The BSR Annual Award and the Vernon Harrison Doctoral Prize for the best PhD thesis of the year were awarded to Professor Peter Olmsted at University of Leeds and to Dr Lucio Isa of Edinburgh University, respectively, at the BSR Winter Meeting on 15-16 December 2008 held in the University of Leeds.

A series of high quality meetings on rheology have been organised. The BSR Spring Meeting, held jointly with the Institute of Non-Newtonian Fluid Mechanics at the University of Liverpool in March 2008 on the theme of ***Complex Flows of Complex Fluids***, attracted many distinguished rheologists. Sessions were devoted to, amongst others, micro-fluidic flows, purely-elastic and inertio-elastic instabilities and turbulence in non-Newtonian liquids. The BSR Winter Meeting on ***Rheology and Microstructure*** had a full programme of excellent talks, including keynote speakers, Professor Han Meijer from the Dutch Polymer Institute, Professor Wilson Poon from the University of Edinburgh, Professor Alexei Likhtman from the University of Reading, and the prize winners' lectures by Professor Peter Olmsted (2008 BSR Annual Award) on shear banding and by Dr Lucio Isa (the Vernon Harrison Doctoral Prize) on capillary flow of dense colloidal suspensions. Many research students presented high quality posters and discussed their research with more experienced rheologists as well as learning from each others. The BSR-TA Instruments poster prize was awarded to Miss Yuanyuan Dong from the University of Nottingham. The BSR also actively engages in various activities organised by the European Society of Rheology and the International Committee of Rheology. There was a large delegation of the BSR at the XVth International Congress on Rheology at Monterey, California (3-8 August, 2008). The BSR is currently organising the 5th Annual European Rheology Conference to be held at Cardiff, 15-17 April, 2009. Travel bursaries will also be provided to student members of the BSR to encourage them to disseminate their research in the international arena.

The BSR continues to successfully run the Non Newtonian Club (NNC), an excellent forum for industrial and academic rheologists to meet together regularly and to discuss a range of topical issues in rheology. It is usually held in a relatively informal and friendly environment and is ideal for young rheologists to present their work in progress. With TA Instruments sponsorship, the 5th NNC meeting was organised by Dr Job Thijssen and held in the Centre for Science at Extreme

Conditions in the University of Edinburgh on Thursday 3rd July 2008, with approximately 35 delegates. The best presentation prize was awarded to Mr Oliver Henrich from the University of Edinburgh. The 6th NNC meeting was held in the Department of Chemical Engineering at the University of Birmingham on 21st October 2008, and sponsored by Anton Paar Ltd. It was organised jointly by Dr Serafim Bakalis, Dr Jason Stokes and Mr Steve Goodyer. There were around 40 delegates in the meeting. The best presentation prize went to Miss Yan Yan from the University of Birmingham.

2009 is the 50th anniversary of the BSR Bulletin. In the 50th volume, you will find a series of articles written by our BSR members, including the 2009 BSR Gold Medallists, to mark such a special occasion. The BSR strives to improve our service to fellow members and to attract more scientists to participate in the various activities of the Society. We welcome all kinds of articles which are relevant to rheology and helpful to the further development of the BSR community. The BSR Bulletin is an ideal platform to share your personal thoughts, experiences, concerns and ideas with our fellow members. Please keep sending them in.

Xue-Feng Yuan
Hon BSR Bulletin Editor
15/01/2009

SUBMISSIONS TO THE BULLETIN

Submissions to the Bulletin may be made by any practical means – post, email, disk, fax, pigeon, donkey, guide dog, *et cetera* but electronically is preferred (saves typing...). Most packages supported (Word, TeX, LaTeX, WordPerfect, ASCII, RTF) but always provide a contact name, address, e-mail, or telephone number in case of problems. The next copy date will be in June 2009 and, as always, all contributions are gratefully received. Late copy can sometimes be accommodated, however the facilities of the BSR and ESR web sites may also be appropriate. Please contact the Editor (xue-feng.yuan@manchester.ac.uk) for details.

COVER ILLUSTRATION

The image in the cover, courtesy of Kevin Stratford (University of Edinburgh), shows a snapshot of sheared binary fluids, looking along the flow axis with the vorticity direction horizontal. It shows the interface between the fluids, with colours indicating the two sides of the interface. The further details can be founded from the paper in Phys. Rev. E **76**, 030501(R) (2007) by K. Stratford, J.-C. Desplat, P. Stansell and M. E. Cates.

We are always looking for appropriate images for the front cover of the Bulletin and Rheology Abstracts (preferably of a rheological nature!). Please contact either Xue-Feng Yuan (xue-feng.yuan@manchester.ac.uk) or Nick Hudson (n.e.hudson@strath.ac.uk). Contributions are always welcome!

AIMS OF THE SOCIETY

The way liquids flow and solids deform affects all aspects of life.

Extraction and processing of crude oil, moulding of plastics, use of toothpaste, spreading of margarine, painting and the lubrication of joints in the human body are all examples of processes depending upon rheological behaviour. Rheology is defined as the science of the deformation and flow of matter.

If your work is concerned with rheology in any way, then you have much to gain by joining the British Society of Rheology - publications, conferences and access to fellow members who, while working in a different discipline or industry, may be facing similar problems to yours. The Society is non-profit making and is registered as a charity.

You are warmly welcome to visit our web site <http://bsr.org.uk/> or <http://innfm.swan.ac.uk/bsr/>, and to apply for membership on-line.

Some Rheological Reflections

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2009 BSR Gold Medallist -
Professor Michael E. Cates

It is a great honour to receive the Gold Medal of the BSR. It is especially pleasing to be receiving it in the same year as Tom McLeish, with whom I shared an office at the Cavendish Laboratory in Cambridge in the 1980s. Tom and I did not collaborate directly then, but we did have some joint papers in the early 1990s, by which time Tom had moved to Sheffield. One of these [1], with my then-student Neil Spenley, was on shear-banding in wormlike micelles. It developed the idea that the mechanical instability inherent in a nonmonotonic flow curve will lead to coexistence of layers of material with different shear-rates at a common stress. Although this idea had been considered previously (for instance by Tom and Robin Ball in the context of polymer melts [2]),

entangled micelles offered a unambiguous example of the effect, in an easily-studied class of experimental systems. (These comprise solutions of amphiphilic molecules, such as detergents, that then aggregate into flexible, linear structures resembling polymer chains. They are widely used in shampoos, thickened bleach and similar products [3].) Since then, wormlike micelles have become a testing ground, not just for shear banding, but for a range of rheological instabilities, with links to diverse aspects of dynamical systems theory [4].

OF MICELLES AND MEN

I first heard about these micelles from Fyl Pincus in 1986, when I was a post-doc at UCSB. Sam Safran (then at Exxon) had recently visited and showed Fyl some rheological data, I think from Jean Candau's group in Strasbourg, for the scaling of the viscosity with concentration. This seemed not too far from the prediction of reptation models, but Fyl had a worry: the micelles, unlike conventional polymers, must undergo breakage and fusion events. One day he asked me whether I thought there was any way of handling this within entanglement theories (hoping perhaps that reptation-like scaling would survive). Within a short while I had found that there was a way to do it – but that breakage and recombination can change everything.

It took a few months to figure out some new scaling laws and the linear elastic

modulus $G(t)$ – which approaches a Maxwellian (single exponential) form in the fast breaking regime [5]. This feature had already been seen (but was not known to us physicists) by Heinz Rehage and Heinz Hoffmann, then both at Bayreuth. For me it was a blind prediction; and I'm told that the experimental confirmation of this result convinced P-G de Gennes that the model was, after all, a good one. (Despite later conversations with him on many subjects, I never did find out what his objections had been!) Another year's work was needed to obtain a constitutive equation [6], and a couple more to spot that this predicted nonmonotonic flow curves, and therefore shear banding. The latter realization was prompted by discussions with Rehage and Hoffmann, who by then had shown me a flow curve with an unexplained stress plateau extending for decades in shear rate (reproduced in [1]). Our shear banding picture predicted this to be a composite curve, with coexisting bands in the plateau region – as was later confirmed in many experiments.

This entire sequence of events represented a string of good luck for me as a scientist, coming as it did quite early in my postdoctoral career. On the other hand (according to Pasteur) 'chance favours the prepared mind'. As it happened, my mind had been exceptionally well prepared – not just for this turn of events but for an entire scientific career – by my PhD supervisor, Sir Sam Edwards. Sir Sam led by example as much as by instruction, and during my PhD I had spent several months studying in detail his series of papers on reptation with Masao Doi [7]. These works remain an inspiring example of how statistical physics can contribute to rheology. But there was no direct link with my thesis project: I had read the Doi-Edwards papers for the pleasure of watching these masters in action, and learning some of their craft. Yet my postdoctoral work on micelles directly used all this knowledge within a couple of years of my gaining it.

There is a lesson here, perhaps, for PhD students and early postdocs: of course you have to get the project done, but reading around your subject for the fun of it is not time wasting! It is an essential part of preparing one's mind for future chances unknown.

LIFE AT THE CAVENDISH, CIRCA 1990

I returned to the Cavendish in 1988, first as a Trinity College Research Fellow, then in turn a Royal Society URF, University Assistant Lecturer, and Lecturer. Perhaps I'd had too much early success, because at one stage I became convinced I would never do anything useful again and was seriously preparing to give up physics. Rescue from this state of mind came by way of a collaboration on shear-induced phase transitions [8] with Scott Milner (then at Exxon). As we discussed this problem and its unexpected subtleties, compulsive curiosity about the science gradually overcame my feeling of uselessness. (Lesson two: Don't lose heart just

because you achieve nothing for a while. If the threat of failure never haunts you, perhaps you're not aiming high enough!)

This was at a time when the telephone was the normal way of communicating across continents, rather than email; it was also quite expensive. I remember regularly migrating into the secretary's office so as to be able to dial transatlantic after the University switchboard had closed for the day, and there having two-hour phone discussions with Scott concerning our calculations. Incidentally, my PhD thesis had itself been written on a freestanding word processing machine in the same office just a few years earlier. The machine, which served the entire research group, had a booking sheet and large (20cm diameter) floppy disks for storage. To add Greek letters, each sheet of paper had to be fed through the printer for a second time; despairing of this, the equations in my thesis were hand written. (Lesson three to young scientists: when it comes to IT, you don't know how lucky you are!)

At the Cavendish I was fortunate to have many excellent colleagues. I worked not only on micelles but also on several other topics, including granular materials. The granular work had two themes. One was avalanche dynamics in surface flows, which I studied with J-P Bouchaud, Ravi Prakash, and Sir Sam Edwards [9, 10]. This work was well-received, particularly after de Gennes showed that several puzzling phenomena, relating to segregation by size during avalanches, could be explained by extensions to our model. The other theme was on stress propagation in static granular media – of which more below.

In the mid 1990s there was an obvious logjam for promotion at Cambridge: it was not unusual to gain an FRS before being promoted to a Chair (this happened to both John Hinch and Sir Richard Friend). To avoid having to wait patiently for a decade or two, I accepted a Chair in Edinburgh which I took up in 1995.

BUILDING ON SAND?

Work on static granular media continued in Edinburgh, in collaboration with Joachim Wittmer, J-P Bouchaud and Philippe Claudin. Our ideas were radical, and set aside a large body of prior literature. Much of this earlier work rested on the validity, for cohesionless powders, of plasticity concepts that had been developed for conventional solids such as metals, and never fully validated outside that domain. (Arguably, not within it, either – but that's another issue!) While closer study of the literature might have saved us some trouble, it might also have extinguished prematurely the flickering flame of a new, simple, and experiment-provoking idea.

With hindsight, though, perhaps we should not have submitted our work to as prestigious a journal as *Nature* [11]: the outcome was some ruffled feathers and chorus of criticisms (ranging from the cogent, to the genuinely parrot-like). This episode culminated in a rather fraught workshop at Cargèse, attended by J-P

Bouchaud, myself, and two or three of our staunchest critics. For the only time in my career, a scientific debate became genuinely soured by animosity – to the point where rational communication was, *de facto*, suspended. Having stayed up all night adapting my talk to rebut views expressed the day before, and furious at being forced to lose a night's sleep, I needed to calm myself down if the talk was not to degenerate into purely a slanging match. To this end, I missed the two talks before mine, and went for a 45 minute run, finishing in time to shower in my room and stroll back to the lecture hall. Suitably purged of adrenalin and mellowed by endomorphins, I got through the talk without losing my cool (or the argument).

Having recounted this story to people in various disciplines, it appears that in many fields such episodes form a quite normal part of academic life! Which brings me to lesson four: We are lucky to work in an area where collegiality far outweighs antagonism, most of the time.

In the end, our simple new idea was rather too simple, and subsequent experiments did not bear out some of its most distinctive predictions. (That said, they did not bear out anyone else's theories either.) For a while we were undecided whether to attempt life-saving surgery on our model or, in the memorable words of Joachim Wittmer, "give it a good funeral". While it never became a predictive tool for the statics of frictional powders, the work helped usher in progress by others in understanding 'isostatic' packings of frictionless grains. It also remains a useful modelling paradigm for 'fragile matter': materials, such as jammed colloids, whose solid structure only arises because of the stress they are under, melting away again when this stress is removed [12].

A TOUGH OF GLASS

A big attraction of Edinburgh was, and still is, the presence of a lively crowd of experimental soft matter physicists – headed first by Peter Pusey and now by Wilson Poon. A decision I made soon after arrival was to join their group rather than set up a separate theoretical one. I am proud of the group's subsequent expansion to embrace nonequilibrium dynamics, large scale simulation of complex fluids, and statistical mechanical modelling of flowable materials (as well as, latterly, biophysics).

Although rheological constitutive equations are the main focus of this essay, they do not make good cover art. So, when asked to provide some for this issue, I chose an image, generated by Kevin Stratford, from a lattice-Boltzmann simulation of immiscible binary fluids under shear. Such simulations are increasingly powerful for addressing rheological questions that continue to elude traditional theory – in this case, whether sheared binary fluids coarsen indefinitely or reach a steady state with finite, albeit anisotropic, domains [13].

For the past decade, a central concern for both experimentalists and theorists in

our group has been the detailed study of colloidal arrest [14]. In a sufficiently dense suspension, Brownian motion of the colloids becomes so hindered that, on the timescales relevant to experiments, each particle is trapped quasi-permanently in a cage formed by its neighbours. The result is an amorphous solid, with a yield stress, called the ‘colloidal glass’.

The yield stress is very modest (say 1–100 Pascals) and thus easily overlooked if samples are not handled carefully. Nonetheless, colloidal glasses serve as an important model system for understanding soft solids, sharing with many other such materials (such as pastes, emulsions and foams) the property of local structural disorder. Moreover, none of these systems, even in the absence of flow, reaches a state of Boltzmann equilibrium. Having no equilibrium state to start from, one needs to use ideas from an active but incomplete area of statistical mechanics – glass physics.

To address the wider class of ‘soft glassy materials’, Peter Sollich, Francois Lequeux, Pascal Hebraud and I created a minimal rheological picture of arrested matter. Our ‘SGR model’ [15] shows several interesting regimes including Herschel Bulkley behaviour (which has a yield stress) and power law fluids (which do not, but have infinite zero-shear viscosity). The work was later extended by Sollich, myself and our then-student Suzanne Fielding to address the rheology of aging materials [16].

The SGR model has interesting constitutive behaviour, but is rather vague on detail. Within the narrower domain of colloidal glasses, the rheology of arrested states can be scrutinized theoretically in a more comprehensive fashion. This entails the extension to flow conditions of some formal techniques, known as mode-coupling theory (MCT), which I learned about from Matthias Fuchs (now in Konstanz) while he was a visitor in Edinburgh. The MCT approach predicts only shear thinning behaviour, although shear-thickening can be addressed by plausible extensions of it [17]; it includes a description of arrest, but currently excludes both aging effects and hydrodynamic interactions. In recent work with Matthias Fuchs, Joe Brader and Thomas Voigtmann, this avenue has proven very fruitful, first for steady-state flow curves [18], then for time-dependent shear [19], and finally in the development of a fully tensorial constitutive model [20]. An important future challenge is to confront this model (or simpler ones inspired by it) with a wider range of experimental data – particularly in non-shear flows.

This brings us just about up to date, and thus to the end of this essay. Alongside all those mentioned by name above, I’d like to thank the other colleagues I’ve worked with over the years, including many on projects unrelated to rheology. (There are far too many of these colleagues to mention individually, but it is impossible to leave out Tom Witten or Didier Roux.) Collaborations, and the lifelong friendships that stem from them, remain one of the great benefits of choosing a scientific career. (And if anyone wants a fifth lesson, let that be it!).

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Rheology and Mythology: 25 Years of Computer Simulation

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2009 marks the 25th anniversary of the appearance of the first mesoscopic simulations in the field of “computational rheology”. Professor Les Woodcock, author of one of those early papers in 1984, offers a personal reflection, and asks “why have the computational science research community, in a field that promises so much, 25 years on, delivered so little ?”.

ANIMATION OR RESEARCH?

In the dark ages of science, before the advent of computers, there was just theory and experiment. During the early stages of computational sciences, theoreticians would refer to simulation as “experiments”, and experimentalists would refer to it as “theory”. In fact, the development of a computer model to simulate a process, whatever the level, continuum fluid mechanics, molecular dynamics or the sub-atomic electronic level, computer modelling with many-parameter models is neither “theory” nor “experiment”. Moreover, it’s not research, its “animation”!

We can differentiate between the two applications of simulation: computer modelling, which can be a valuable tool in engineering applications or for scientific, educational or communication purposes, and computer experimentation which can be a research tool. When the number of parameters in a computer model greatly exceeds the number of points of contact with real experiment, computer modelling cannot be construed as research tool for discovery. At first sight, a computer molecular model of a macromolecule undergoing shear flow appears to offer all kinds of wonderful new insights into the processes and mechanisms of “molecular rheology”. This type of “animation”, however, can only be used to communicate the modeller’s preconceived perception of what a sheared macromolecule might look like to the uninitiated, or the readers of journals who now publish this popular science, such as Nature, but that’s all, there’s nothing new, it’s not research.

In order to undertake “research”, i.e. make discoveries, using computer simulation, one must perform “experiments” upon a well-defined computer model with some circumspection in relation to the prevailing theory or experimental observation of the real system. These computer experiments must be conducted with scientific principles, just as the laboratory scientist performs experiments on a real fluid, well defined by its purity and fixed state variables of temperature and

pressure, and at thermodynamic equilibrium. The computational scientist has some advantages, however, over his laboratory counterpart; he can play tricks that are not available to the real experimenter. The most valuable technique for developing research to enable discoveries regarding chemical equilibria at the molecular level is known as “Hamiltonian surgery”. It’s not what we put into a simulation that tells us something new; it’s what we leave out! The same applies to computational rheology.

Take, for example, the use of a modern molecular dynamics software package to calculate the viscosity of water. These atomistic, site-site, pair-wise additive Hamiltonian MD models, with tens or hundreds of pair-potential parameters, can always produce a value of the viscosity that will undoubtedly be in the experimental ball park, but “what’s new?” , nothing! By contrast, we can calculate the viscosity of a molecular model of water over its liquid range with just one parameter, a hard-sphere diameter. The discrepancy with experiment, albeit large, is informative. It would tell us that the hard-sphere model is very poor model for water at liquid temperatures, and might only improve very slightly with temperature. This, nonetheless, is what research is about.

THERMODYNAMICS: THE NEGLECTED LINK?

We usually apply the term “rheology” to a fluid (solid, liquid or gas that flows!) with a nonlinear viscous or viscoelastic response on the timescale of the observation of flow. All pure materials in thermodynamic equilibrium have thermodynamic properties which are state functions. In fact, we can even use this concept to restate the first and second laws; enthalpy and entropy are state functions, respectively (given the standard definitions of enthalpy ($U + pV$) and entropy (Q_{rev}/T)). Just as the concept of the definition of a state function is central to thermodynamics and an understanding of all physical and chemical equilibrium, so it also applies to linear transport coefficients such as shear viscosity, and is no less fundamental in steady-state fluid mechanics. We can even propose a 1st law of fluid mechanics: “viscosity, given its usual phenomenological definition ($=\rho_{xy} dy/dv_x$), is a state function”.

For over 50 years now [1], we have time-correlation functions for calculating viscosity of fluids in equilibrium from molecular dynamics simulations. The viscosity equation-of-state of a fluid is as important to the predictions of fluid mechanics, as thermodynamic equations of state are to prediction of reaction or phase equilibria. The computation of the viscosity of a computer model of liquids as a state function should have been an important research objective of central importance, but it has hardly been addressed since the early days of molecular simulation applications in the 1970s. We haven’t achieved this basic objective for even the simplest of liquids. As recently as 4 years ago, the viscosity of a model atomic or molecular liquid at its triple point [2] had not been computed more accurately than to within 10%. What’s gone wrong with the development of this

important area of computational science one might reasonably ask? This failure is now a part of the history of science [3].

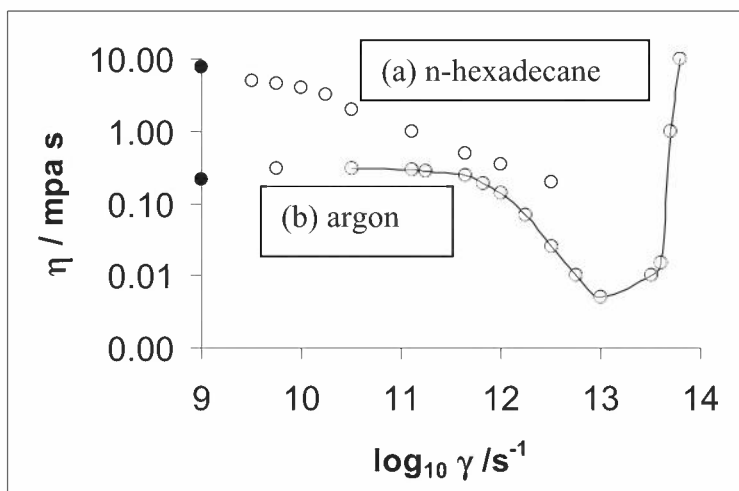
One reason could be the distraction caused by a somewhat misguided development in the last 25 years, of an area of science that doesn't even exist, except in some computers, "molecular rheology".

NEMD: RHEOLOGY OR MYTHOLOGY?

Non-equilibrium molecular dynamics (NEMD) are computer "experiments" performed upon otherwise equilibrium molecular dynamics (EMD) computer models of molecular fluids. Just as EMD simulations may be carried out on systems that don't exist, by Hamiltonian surgery, to aid the computer experimentalist as a research tool, so NEMD computer "experiments" may be carried out on processes that don't exist. Continuous NEMD processes are idealised steady-state simulations which may, in principle, be used to obtain linear transport coefficients such as shear viscosity. Applications of NEMD for obtaining nonlinear rheological constitutional properties as a function of shear rate, however, have been based upon some misconceptions.

The alternative NEMD method of calculating the viscosity of an equilibrium fluid was pioneered in the early 1970s by Hoover and co-workers [4]. They were able to demonstrate that, by applying a shear stress directly to a computer model, in a manner analogous to a real laboratory experiment, the viscosity of some very simple model fluids, such as a Lennard-Jones liquid, could be approximately obtained by interpolating the limit of zero shear. In order for this method to be applicable, the shear rate at which the viscosity is calculated from its definition, $\langle \text{stress} \rangle / \text{shear rate}$, must be so small that it does not significantly change the thermodynamic state of the system, but at the same time be very large, of the order 10^{10}s^{-1} , to obtain a sensible response above the fluctuations to calculate viscosity the state function with sufficient accuracy. For some simple model fluids, with low viscosities, such NEMD computations of the viscosity are marginally feasible, only just so!

This is well illustrated with data from the textbook by David Heyes on the Liquid State [5]. The figure reproduced below shows the "NEMD flow curves of liquids n-hexadecane and argon, under the heading "liquids far from equilibrium". The caption reads: *"Figure 6.2 The shear rate dependence of the shear viscosity of (a) n-hexadecane at $T=204.4^\circ\text{C}$ and $\rho = 896 \text{kg m}^{-3}$ (Chynoweth and Michopoulos 1994 and (b) liquid argon using the LJ potential ($\epsilon/k_B = 119.8\text{K}$ and $\sigma = 3.405\text{\AA}$) from Heyes 1986a). The filled in circles are experimental data in the limit of zero shear rate. For argon the experimental viscosities are taken from (Boon, Legos and Thomaes, 1967)"*



(Reproduced by kind permission of D.M. Heyes from reference [5] p136)

It's not just the lack of any theory for the interpolation over 10 orders-of-magnitude from NEMD to real experiment, but there is also another problem. 160 years ago, whilst performing the experiments leading to the 1st law of thermodynamics, James Joule showed that any work done on a thermodynamic system, must generate an equivalent amount of heat. Einstein later quantified the law: the shearing force works on the system and is converted to heat according to $Q = \text{viscosity} \times (\text{shear rate})^2$, where Q is the heat generated per unit volume per unit time. Clearly, the heat has to be removed, otherwise a homogeneous steady state cannot prevail.

There now exists a detailed literature of the development over a period of 25 years of theoretical research, principally by Hoover and his collaborators [4, 6], of “thermostats” for both EMD, and many NEMD systems which involve new definitions of temperature and which enable NEMD to become a valid method alongside EMD for computing the viscosity of any prescribed model molecular Hamiltonian.

So far, so good; removal of the heat to impose homogeneity, and to obtain a viscosity value, is OK. It's the application of these techniques to “computational rheology” that raises questions about unprincipled science. When a fluid is sheared at a rate so fast that it exceeds the equilibration relaxation time, it becomes nonlinear. The data in the graphs above show that liquid argon would appear to become non-Newtonian shear thinning at a shear rate around 10^{10} s^{-1} and shear thickening around 10^{13} s^{-1} . In fact, if it were possible to shear liquid argon at a steady state until it became nonlinear, in the laboratory it would only appear to do so when the heat generated was such that its thermodynamic equilibrium became vitiated by the temperature gradient, i.e. at a much lower shear rate.

NEMD algorithms that do work on thermodynamic systems by the imposition of a constrained shear field, but produce no heat [6], have given rise to an industry of science that doesn't exist. James Joule would turn in his grave at the thought of these computer simulation processes that perform work on systems but produce no heat. The "research" literature in this area is now quite extensive with papers on subjects such as "the rheology of n-hexadecane" in the figure above, and even "the rheology of gases" [7].

Computational rheology has yet to deliver any new scientific discoveries in the area of molecular rheology. Indeed, "molecular rheology" as it has been defined in the modelling literature is an area of science not yet in existence, and may rank alongside other classic scientific fiascos, such as "polywater", the "hexatic mesophase", and "cold fusion".

WHAT ARE "NON-NEWTONIAN" FLUIDS?

Before computational rheology, a religious belief prevailed that each and every type of non-Newtonian fluids existed because of an inherent molecular complexity [8]. Early discoveries from simulations in 1984 [5,9], however, showed that shear thinning, shear thickening, and their time-dependent counterparts thixotropy and rheopexy could all be seen in simple soft-sphere model fluids. All equilibrium crystals have a finite shear modulus and are Bingham plastics! Non-Newtonian phenomena are not a consequence of molecular complexity; that simply scales the time scale on which we observe it. Moreover, phenomena like thixotropy may have its origins in a shear perturbation of any thermodynamic phase equilibria [10]. Non-Newtonian behaviour is inextricably connected to the non-equilibrium state, which manifests itself via irreversible thermodynamic processes.

Systems that do not exhibit a linear viscosity on the timescale of the observation include all solid materials, colloidal suspensions of solid particles, and macromolecular systems such as polymers and plastisols. The first observation one can make about all these so-called "non-Newtonian fluids", is that most, if not all, only exist in a state of non-equilibrium. If they are not in a state of thermodynamic equilibrium, it follows that the state at which they do exist depends upon the process by which they were produced. These materials are more often not well-characterised for scientific research. Many are produced by uniaxial compaction batch processes and are inherently inhomogeneous.

Consequently, when work is performed on a non-Newtonian fluid in shear flow, not only does it anneal the fluid, initially in the direction of thermodynamic equilibrium, but it also changes the thermodynamic state of the system by changing the pressures and also temperature at which it exists. It creates gradients of temperature and of the pressure elements with normal pressure difference anisotropy. There is a vast experimental literature of non-reproducible results in the quest to obtain a flow curve as a function of shear rate. This is what Dr. David

Cheng had to say, 25 years ago, about suspension rheology, in the BSR Bulletin [11].

“All these literature and Warren Springs Laboratory results point to the conclusion that dense suspensions are inherently two-phase systems and cannot be treated as homogeneous, even with neutrally buoyant particles. During flow, phase separation takes place (described variously as particle migration, or changes in local concentration or particle packing density or structure) and this governs the overall behaviour of the suspension. The details of the micro-rheological behaviour depend on the exact flow situation involved, in a complicated way, such that there is no unique viscosity (Newtonian or non-Newtonian). It (that is the viscosity) depends on the geometry and dimensions of the viscometer used”.

Whilst even a well-characterised suspension of sub-micron particles, i.e. equilibrated by Brownian motion, may have a thermodynamic state, and hence a viscosity, it is nigh impossible experimentally to maintain a homogeneous sheared suspension at uniform concentration. The thermodynamic state variable that is maintained uniform is osmotic pressure and particles will migrate to maintain a balance [12]. This important concept has been overlooked by both experimental and theoreticians alike, and continues to be the neglected state variable of dispersion and solution rheometry.

For one-component non-equilibrium (non-Newtonian) fluids it is the hydrostatic pressure that varies with shear rate. Any experimental measurement of the effect of shear on a non-Newtonian fluid must specify the thermodynamic constraints. This raises doubts about the very existence of constitutive “rheology” as an *independent* area of material science. The conclusion is that fluids which appear to exhibit non-Newtonian behaviour do so because the thermodynamic state is changing with shear rate in space and time; they do not possess a property which is a well-defined function only of its steady state, and often referred at its “constitutive rheology”. Whereas thermodynamic equilibria, viscosity and Newtonian fluid mechanics can all be described as independent sciences, rheology and non-Newtonian fluid mechanics are inextricably one and the same science!

MESOSCALE MODEL: WHAT IS “SOFT MATTER”?

It also follows that the reasons for non-Newtonian behaviour is little to do with physics at the atomistic or molecular level, but with degrees-of-freedom of assemblages, or segments of macromolecules, inhomogeneities in supercooled liquids or glasses, or dislocations in Bingham solids, all of which conspire to fluctuate on time scales many orders of magnitude greater than atomic and molecular motions. The theoretical physics community have introduced the collective term for these non-equilibrium materials: “soft matter” (in violation of a “law of rheology”: i.e. you can’t use rheology to characterise states of matter!) It’s the shear modulus, i.e. thermodynamics, that distinguishes solid from liquid. Can anyone give us a definition of “soft matter”?

To establish what is, or what is not, important in the Hamiltonian in determining a non-Newtonian property, the computational rheologist must first set up a model system that can, in principle, contain all this essential physics and on which he can then perform experiments. Then, if we wish to undertake research, i.e. to make discoveries about the origins of an experimental rheology, as with EMD and Hamiltonian surgery, experiments on the computer models must be very carefully contrived to answer specific questions.

Mesoscale modelling is, in a sense, an extreme example of Hamiltonian surgery; the characteristic that all mesoscale models share is that they are based on a defined subunit. Exactly what these subunits are depends upon the system being modelled, but they will always discard atomic detail. Mesoscale model Hamiltonians, therefore, are quite unlike atomistic and quantum models which always use the same basic unit, i.e. the atom or the electron respectively. The most common mesoscale model is the hard sphere, colloidal particle or polymer segment.

Thus, the classical idealized model of a non-Newtonian fluid is the suspension of monodisperse hard spheres in an otherwise Newtonian medium deemed to be continuous. This important mesoscale model has been the subject of many types of computational study, beginning with the pioneering papers 25 years ago by Bossis and Brady [11] of low Reynolds number, Stokesian hydrodynamics simulations of many-particle systems. In the intervening years, the computations have become many orders of magnitude faster, and been extended to include Brownian dynamics, for systems in thermodynamic equilibrium, and granular dynamics when the fluid resistance is negligible, inertia dominates and the particles collide inelastically. Despite all these technical advances, we still don't have a map of what the viscosity surface of this important model system looks like, as a function of its two reduced state variables, a Reynolds number and a Peclet ratio, as a function of density. Again, this can be regarded as a delivery failure of computational rheology 25 years on!

At least, James Joule would have no problem with the mesoscale approaches of Brownian dynamics, Stokesian dynamics or granular dynamics. Unlike non-equilibrium molecular dynamics (NEMD), the heat generated is dissipated into either the heat capacity of the medium (deemed infinite) or on inelastic collision of the particles. These software tools of the computational rheologist, including mesoscale models of one-component polymeric and macromolecules may now be used to take the subject forward. Whilst molecular structures change in response to changes in thermodynamic state variables, there is little evidence for the existence of a "molecular rheology" in the real world. Mesoscale modelling can capture the inhomogeneities in non-equilibrium states that give rise to nonlinear effects. It can also be applied directly to large scale fluid mechanics situations to obtain the theoretical description of the changes in thermodynamic states in various flow geometries.

After 25 years of mesoscale modelling, from Stokesian-, and/or Brownian- or granular-dynamics with full inertia, we still appear to be a long way from *ab initio* prediction of the fluid mechanics of an ideal monodisperse neutral buoyant dense suspension of spherical particles in a simple geometry, e.g. laminar flow in a Couette rheometer!

WHAT FUTURE COMPUTATIONAL RHEOLOGY?

The traditional perception of non-Newtonian fluids was that every such fluid had associated with it a rheological constitution, i.e. a steady-state stress function only of rate of shear strain and T , p , analogous to the equilibrium state function viscosity (T , p) [8]. This simple myth has bedevilled the experimental study of non-Newtonian fluids, and is more self-evident in computer models. Materials that exhibit a non-Newtonian rheology do so because they are not in a uniform thermodynamic equilibrium state under shear flow. In reality, a fluid exhibits a nonlinear steady-state response for two reasons. Firstly, it is nonlinear because the imposed momentum gradient changes the thermodynamic state of the system, and secondly it is also nonlinear because of inhomogeneities, either inherent or induced; a shear force can only be imposed at an interface.

In the last 20 years there have been major developments in the thermodynamics of small systems using density functional theory (DFT); there have also been theoretical developments in the area of irreversible thermodynamics [3,4,5,6]. Rheology can be reinvented as the “irreversible thermodynamics of small fluid systems”. On the theoretical side, therefore, it seems likely that the existing tools may be applicable. DFT accurately predicts the thermodynamic profiles of inhomogeneous molecular fluids in the vicinity of interfaces, and using the local density approximations from known equations-of-state of viscosity, could be able to predict and understand apparent non-Newtonian responses in inhomogeneous steady shear flows.

Finally, I would like comment upon a result of the study of the hard-sphere fluid in two corresponding thermodynamic states. The viscosity in the Newtonian linear viscous flow of a fluid in thermodynamic equilibrium, in the limit of low shear, is EXACTLY THE SAME phenomena, with no new physics, as the non-Newtonian shear-thickening, shear-dilatant flow of a system of granular spheres in the high-shear limit of rapid granular flow [14]. A simple scaling relation relates the two phenomena; there is no difference in the underlying physics. If we have a description, and hence understanding, of one “exotic” non-Newtonian flow and its related effects [15], could other non-Newtonian fluids be explained from the standpoint of underlying thermodynamic state functions one wonders?

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A Family Tree of Instrumentation

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With this being the 50th anniversary of the Bulletin of the British Society of Rheology, it does encourage us to start to reminisce about what has happened over the past decades. The rheological community is growing and it seems many aspects of the subject have developed, from the theoretical, mathematical or computational, industrial, as well as more demands for more simultaneous and combined studies. I guess this is not surprisingly since this is a science without one particular allegiance to any one mainstream subject. However it is times like this that we ask where did it all begin, and I am glad to say that many of the people involved with evolving the subject are still active today, though obviously many of the laws and theories that provide the very essence of the science date back to the midst of time and find themselves included in the very foundations of most sciences. Of course it should not be forgotten that the longest recorded scientific experiment is a rheological one, the pitch drop at Queensland University.

With any science one often charts progress by thinking about the evolution of instrumentation involved. TA Instruments, as a company, is about to celebrate its own 20th anniversary next year, so most would think that it's part would be relatively recent, even though there is little doubt that its record has been nothing but significant, (but this can be reviewed later). However, it is only when you appreciate that TA Instruments represents the current form of many an innovator of rheological instrumentation that you realise that just like the bulletins, "TA Instruments" have played their role in history.

Before we take a stroll through the annals of history at the rheological instrumentation, let us remember that in today's array of rheological instruments, there are many type of rheometers, however it is rotational devices that are by far the most common. Even with this device there are two fundamental designs – controlled stress and controlled strain, so it seems sensible to trace the family trees of both as part of this review.

Many would cite the Weissenberg Rheogoniometer R1 as the first scientific rheometer back in 1948, over 60 years ago, when Karl Weissenberg combined air bearing, torsion wire/bar, a normal force sensor in a controlled strain/speed cone and plate system. This instrument really was the birth of rheological instrumentation and also provided the basis for the first controlled stress rheometer when in the mid-1960s Jack Deer re-engineered a "old" Weissenberg Rheogoniometer to perform controlled stress creep tests. So if we consider Karl Weissenberg and Jack Deer as the two founding fathers of modern rotational rheometers, then who are the sons and daughters. After several different owners Carri-Med purchased the Weissenberg licence and they were really responsible for

its rebirth using the technology of the time, which saw the Rheogoniometer evolve from a room filling instrument, with its massive gearbox and motor assemblies to a bench top unit and with all the enhancements in performance required. Unfortunately every rheometer has its time and the Weissenberg Rheogoniometer has, like its inventor, sadly passed, but will never be forgotten.

It was the same company, Carri-Med, that in the early 1980s first successfully commercialised Jack Deer's design and was really the start of commercial rheology manufacturing in the UK. With the addition of an Apple micro-processor, a major technological innovation at the time, the founder of the modern controlled stress rheometer emerged. Carri-Med would have celebrated its 25th anniversary last year if it wasn't now part of a much larger organisation – TA Instruments, when it was purchased in 1993. Since the Deer concept was never patented, other manufacturers emerged over the years. Bohlin (now Malvern) produced their first controlled stress rheometer in the 1986, whilst it wasn't until the early to mid 1990s that the other rheometer manufacturers of today introduced their first instruments to the market place.

So on our travels through time we have seen that TA Instruments represent the ancestors of the founders of controlled stress and kept the spirit of the original controlled strain Weissenberg going for as long as possible, but what of today's controlled strain instrumentation, where does that come from?

In the controlled strain side of the rheological family tree the only survivor is the ARES, an instrument that has evolved from the first mechanical spectrometer, introduced by Chris Macosko and Joseph Starita at the start of the 1970s. The introduction of the RMS605 represented the first real rheometer from the Rheometric family and over the next 40 years the Rheometrics brand became accepted as the Rolls Royce of rheometers. In 2003, Rheometrics became part of TA Instruments and so again the family trees of all founder members of the rheology instrumentation have joined together under the banner of TA Instruments. So with such a pedigree, it is good to see that TA have accepted the responsibility to maintain such a respected reputation and have continued to provide innovation to the science, with such introductions of the first commercial magnetic bearing instrument, the AR-G2, and recently the completely redesigned and enhanced ARES-G2, which now represent the very pinnacle of state of art rheometers available, as well as an increasing list of patents for various components and technology. As for the future, well the commitment is there from TA, but it should be remembered that the driving force for any development is the end user and so who knows what the future really will bring.

The Life and Opinions of ...

A Rheologist

The problems of holding body and soul together would have been easier to bear if my companion had not been looking so confoundedly content. “Do you not understand,” I demanded, “the dire straits into which your so-called research into malt whisky has plunged our account? The bank now declines to pay any interest on our savings, and, at your present rate of consumption, our capital will soon be exhausted. Why do you waste your time in reading when the world’s financial system teeters on the brink?”

“The Life and Opinions of Tristram Shandy will probably endure rather longer than any rescue package that I could devise for the economy,” observed Holmes, “and I venture to suggest that reading them would, by lighting a smile in your soul, strengthen you sufficiently to find a path through these troubled times. Mr Sterne himself was persuaded that ‘every time a man smiles – but much more so, when he laughs - it adds something to this Fragment of Life’.”

I was determined that Holmes should take the present crisis seriously. Some gentle flattery might, I thought, assist in motivating his great mind. “Holmes,” I ventured, “in the past, you have made some contributions to resolving the mysteries that confound us, and the present financial problems appear to be of a rheological nature. Unimaginably large quantities of money have been committed to saving the economy, but there appears to be a blockage in the system that prevents that money from circulating. Surely theoretical rheology can resolve the issues now facing the nation.”

Holmes started from his chair in agitation, his precious first edition of Tristram Shandy falling to the floor. “Watson,” he fulminated, “have you learned nothing in your long association with me? The problems in the banking sector are because of the meddling by theoreticians and because of the credence given to them. Those well-meaning but egregious fools have thought that, by propounding economic ‘laws’ and proclaiming economics a ‘science’ of which they are the high priests, they can control matters; instead, they have simply exacerbated the problem. They have deluded themselves into thinking that their observations on economic models represent truth that gives them a predictive capability. So intricate, and so numerous, are their theories that, inevitably, some of them – for a time – do indeed appear to have predictive capability. Alas, what they always forget is that these theories themselves interact with and modify the environment that they seek to explain. The inevitable result is that the whole thing spins out of control until someone observes that ‘the Emperor has no clothes’.”

Somewhat chastened, I mumbled: “So Holmes, is there no hope to be had from science?”

He laid a comforting hand upon my shoulder and observed: “Your rheological theoreticians may try, but I doubt that they will have more success than the

advocates of your profession who, faced with the same symptoms – unimaginably large quantities of liquid assets injected into a system encountering a blockage that prevents circulation – would probably recommend a purge or blood-letting. I doubt that their effects would be much different except that, in the medical solution, one would at least be prepared for the mess that had to be cleaned up afterwards and be sensible of the inherent dangers of the treatment. No Watson, unless politicians and economists can be taught to constrain their studies to a single text – ‘The Wealth of Nations’ by Adam Smith – the only political answer lies in what Sir James Mackintosh described as ‘masterly inactivity’ so that equilibrium can once more re-establish itself.”

“Such a counsel of despair cannot be tolerated,” I protested.

“If you must intervene,” Holmes mused, “perhaps you should practice mending balloons that have been popped at a party. But surely, Watson, your rheological colleagues would be much better occupied in solving those outstanding problems of the physical sciences.”

“Apart from ‘The Case of the Missing Industrialist’, there are certainly still outstanding issues like the existence of Yield Stress that appear totally intractable,” I offered.

Holmes reflected for some moments before responding: “As Laurence Sterne observed, ‘there is no disputing against HOBBY-HORSES.’ Indeed, no progress is likely in that area until a body of science has been established in the field of Morphorheology, where simultaneous measurements are made of structure and deformation. The advances in instrumentation that have been seen in the last fifty years must surely now allow direct measurement of such phenomena on a routine basis. After all, it is this that Heraclitus was urging more than two millennia ago; when he proclaimed ‘Panta rhei’, it was to the structure of society that sage was referring.”

“Negative Normal Stress Differences!” I exclaimed. “Now I see what you are driving at, Holmes. The Structure of Society indeed! And economics is just one branch of that structure. Truly those who have for so long proclaimed ‘Panta rhei’ must hold the key to the salvation of the economy. I must contact Downing Street at once!”

“Steady, Watson,” cautioned the smiling Holmes. “Damn all that enthusiasm. First, you must advise the Prime Minister to read Tristram Shandy.”

BSR NEWS

Annual Award 2008 Professor Peter Olmsted

I have the honour to make the Annual Award of the British Society of Rheology to Peter Olmsted.

Peter is the personal embodiment of the well known saying that “there is nothing so practical as a good theory”. Born and brought up in New Hampshire, he received a BA in Physics from Cornell University and an MS and PhD from the University of Illinois at Urbana-Champaign for work on the effect of shear flow on the isotropic-nematic transition in liquid crystals and this work on phase transitions has been a major theme of his transatlantic scientific career. After his PhD he worked in Exxon Corporate Research Laboratories in New Jersey, then a 2 year postdoc in Cambridge UK, then back to the University of Michigan for a year before coming to Leeds in 1996 as, first, research fellow, then lecturer, reader and now, since 2005, Professor of Physics.



His research interests cover a wide spectrum including equilibrium and non-equilibrium condensed matter, statistical physics; phase transitions, phase separations, rheology and critical phenomena; hydrodynamics; polymers, elastomers, surfactant systems, liquid crystals and other complex fluids. Basically Peter is interested in modelling complex fluids. Some of his best known work in rheology is in classifying flow-induced transitions in shear-banding fluids where the stress/strain rate relationship is not monotonic and leads to chaotic data. Peter has the ability to take very complex experimental results and develop a theory which enables classification, points to further experiments and leads to understanding, and his research publications have a strong theme of crystallisation,

banding, onion skins structuration, phase separation and rheology in complex fluids. According to Web of Knowledge at least four of his papers have been cited over 100 times and several others are not far behind.

Peter is an active member of the academic community with successful research projects and PhD students, teaching of physics degree courses and many invited talks at scientific meetings. He is a founder member and committee member of the Institute of Physics liquids and complex fluids group, and sits on several journal editorial boards.

Peter has been a regular and active member of the British rheology community for the last decade. He has taken a prominent role in the Leeds-based “Microscale Polymer Processing” project that has involved many UK Universities and Companies. Peter is always enthusiastic, interested and also prepared to play his own trumpet (literally) on social occasions.

In conclusion, it gives me great pleasure to present the Annual Award of the BSR for 2008 to Peter Olmsted in recognition of his work in theoretical soft condensed matter physics.

Phil Banfill

19th December 2008

Student Travel Bursaries

The 301st Council Meeting established the principle that student travel grants have the objective of encouraging students to disseminate their research. Applicants for a student travel bursary must be a member, may be working worldwide and presenting research at a conference, by paper or poster. The grant will be made on receipt of a report on the event.

The British Society of Rheology wishes to establish a transparent mechanism for the award of travel bursaries and to solicit applications from its student membership. Travel bursaries are available to student members of the Society to present their research at a conference that contains a strong rheological element, in situations where no other sources of funding are available to cover the whole cost of the meeting. Suitable conferences include the International Congress of Rheology, the Annual European Rheology Conference and conferences organized by the Society.

The closing dates for consideration of the award of a travel bursary are 31st March and 31st October with successful applicants notified by 30th April and 30th November, respectively. Applicants should include in their submission the name and location of the conference, the title, authors and abstract of the paper submitted to the conference, a breakdown of the projected costs of attending the meeting and a supporting letter from their research supervisor. The support of the British Society of Rheology should be mentioned in the conference presentation. The Society's logo may be used for this purpose. Payment of the bursary will be made on receipt of a report on the conference. The conference report will be published in the Bulletin of the Society.

Applications for a travel bursary should be sent to the Secretary:

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The Non-Newtonian Club (NNC) is an informal rheology discussion group which provides low-cost, informal, one-day meetings which provide an excellent forum for industrial and academic rheologists to meet together informally to present work in progress, raising key needs and concerns, and discussing unresolved practical and modelling issues that may be inhibited at more formal conferences. The agenda of the most recent BSR NNC meeting and the corresponding abstracts can be found at <http://innfm.swan.ac.uk/bsr/frontend/nonnewtonianclub.asp>.

The Non-Newtonian Club Meetings are held 2 - 3 times a year and provide a forum for those practising rheology to meet. Presentations (typically 20-30 minutes) are made by academic and industry-based scientists, as well as young scientists, presenting on a range of topics that involve rheology in a relatively informal and friendly environment. To encourage PhD students and 'young' scientists to present, we offer an award for the best presentation from PhD students or 'young' scientists. We endeavour to keep these meetings free. Should you wish to host, sponsor, or participate in such an event, please let me know.

Jason Stokes

Report on the 6th BSR Non-Newtonian Club Meeting

The 6th meeting of the Non-Newtonian Club (NNC), organised by the British Society of Rheology (BSR), was held in the Department of Chemical Engineering at the University of Birmingham on 21st October, 2008. The meeting was to be hosted by Dr. Serafim Bakalis who is a research fellow at Birmingham. At the last minute Serafim was unable to attend but fortunately the groundwork that he and Jason Stokes had put into organising the event meant that everything ran smoothly. Two students helped organise seating and power point duties as well as making sure that food and drink arrived in the appropriate place at the appropriate time. Dr. Ralph Oliver, who has given distinguished service to both Birmingham University and the BSR, stepped into the breach as Chairman.



Ralph Oliver was chairman on the day.

The NNC meetings continue to grow in popularity and around 40 people managed to fit into the meeting room with a couple of people having to squeeze onto a windowsill for some seating. Dr. Tom Waigh from the Biological Physics group at Manchester University kicked off the lectures with an interesting talk regarding the viscoelasticity and dynamics of glycoprotein networks. Tom has great experience in microrheology and scattering techniques and successfully conveyed his recent research to the audience.

Yan Yan from Chem. Eng. at the University of Birmingham was the first student to deliver a presentation and spoke confidently about the influence of geometric confinement on the flow of complex fluids. In order to carry out this research she had designed and constructed her own rig. Tim Watts, a student from Medical Sciences at Birmingham, then discussed the effects of bloods' non-Newtonian behaviour with regard to the adhesion of white blood cells and platelets to the walls of model blood vessels. The final lecture before lunch came from Dr. Gerry Meeten of Schlumberger Cambridge Research. Gerry has been involved with rheology for many years and his experience showed in a most entertaining presentation relating to his adventures in foam measurement. As with Yan Yan, Gerry had designed his own squeeze flow rig and regaled the audience with advice relating to rheometry, rheology and shaving foams....pleading poverty when it was noted that he had been measuring low cost "own brand" supermarket foams. Gerry also showed that he validated his data and that they were not to be relied upon at small gaps.

Our seasoned chairman had been aided by some well-timed presentations and lunch was taken punctually. News filtered through that Rob English from Glyndŵr

University (formerly NEWI) would definitely not be able to make his afternoon slot as the M6 had been closed southbound. Rob was to present some work on the extensional properties of polyacrylamide solutions but his imposed absence meant that the only thing being stretched later on was Prof. Pacek's lecture.

John Duffy from Chem. Eng. at Nottingham University did an admirable job in the post lunch "graveyard slot" illustrating how coking mechanisms can be investigated using rheometry. It was interesting to see some work being carried out at higher temperatures (up to 500°C) and John did well in relating his measurements to industrial applications. Steve Prigent showed some fascinating work carried out with Unilever whilst he was at Manchester University and explained how rheology influences the impact of droplets into liquids. Steve showed some impressive high speed photography to illustrate his points and, I believe, is now employed by Unilever. Ourania Gouseti (Chem. Eng., Birmingham) used rheomicroscopy to examine the morphology and rheology of emulsions simultaneously, measuring samples with different volume fractions and viscosity ratios. Ourania had again obtained some nice images which had related the emulsions' rheology to its microstructure. Sala Odeen from the same department as Ourania explained the challenges faced in making absolute rheological measurements of complex cosmetic emulsions such as mascara. It was good to hear that Sala did not treat his rheometer as a black box and thoroughly investigated the inconsistencies that his commercial instrument provided him with. Shaomin Sun from Food Sciences at Nottingham University was the final student to speak. She showed a myriad of data which she had collected during her studies on amorphous cellulose and cellulose derivatives, all of which was well received.

Following a day of varied rheological entertainment a slightly extended coffee break was welcomed. A triumvirate of rheologists had been assembled earlier in the day in order to help judge which student should be awarded with a prize for the best presentation. The competition was close and Prof. John Mitchell, Dr. Ralph Oliver, Dr. Gerry Meeten and myself struggled to agree on an outright winner, hence the slightly extended coffee break. Deadlock was resolved by considering the panels' 2nd and 3rd places which resulted in a well deserved 1st place for Yan Yan and 2nd place for John Duffy.

Before the prize giving Prof. Pacek presented some impressive work carried out with Dr. Ping Ding (Chem. Eng., University of Birmingham), "pH induced rheology of nanoparticles". The kinetics of deagglomeration in diluted suspensions of goethite nanopowder strongly depends on pH, thus pH also affects the rheology and morphology of these suspensions. At pH 3, nanopowder can be dispersed as separate nanoparticles, and the resulting suspension is Newtonian, with a viscosity only slightly higher than that of water. At pH 5-12, nanoparticles tend to reaggregate and form weak aggregates/flocs. Morphology changes from a

Newtonian suspension of primary nanoparticles to a non-Newtonian, shear-thinning suspension of large, porous, interconnected flocs with the yield stress reaching a maximum at an isoelectric point. Results were shown to illustrate that this was a reversible process.



*Steve Goodyer presents Yan Yan with a copy of
Rheology Reviews on behalf of the BSR.*

In Jasons' absence I was privileged to award both Yan Yan and John Duffy with a copy of Rheology Reviews on behalf of the BSR. Following this Ralph Oliver kindly gave some heartfelt advice to the students in the audience with regards to presentations and public speaking. Unfortunately space prevents me from recalling this advice but it was well received and followed by a hearty round of applause. Maybe Ralph could put pen to paper on this subject for a future issue of the BSR Bulletin.

Thank you to Anton Paar Ltd. for sponsoring the food and drink at the meeting and to Serafim and Jason for organising a meeting to run so smoothly in their absence. Last but not least thank you to Ralph Oliver for his help throughout the day.

Steve Goodyer
Anton Paar Ltd

The 5th Annual European Rheology Conference (AERC)

Cardiff, UK

15-17 April 2009

AERC 2009 is being organized by the INNFM (Wales) and the BSR in Cardiff, the capital city of Wales. The aim of AERC 2009 is to contribute to the advancement of Rheology by bringing together interested researchers from Europe and the rest of the world, and bridging traditional themes with modern trends.

Following the tradition of previous European Rheology meetings, AERC 2009 will be a three day conference split into symposia that reflect mainstream or emerging areas of Rheology. There will be minisymposia on blends, copolymers and nanocomposites; process modelling; rheometry and beyond: advanced experimental methods; interfacial phenomena, surfactants and foams; suspensions and colloids; viscoplasticity, solids rheology; biopolymers, biorheology and food rheology; constitutive modelling; non-Newtonian fluid mechanics; computational modelling; flow-induced phase transitions and instabilities; industrial rheology and processing.

Cardiff is home to many national institutions including the National Museum of Wales and the much-admired Millennium Stadium. The city centre skyline is testimony to its heritage and ambition, with landmark buildings ranging from the ornate civic centre to the historic Cardiff Castle. Cardiff is well established as 'Europe's Youngest Capital' but its history dates back more than 2000 years to the Romans. It was once one of the busiest ports in the world, exporting the coal which fuelled the industrial revolution.

Plenary Speakers

Christian Bailly (Universite catholique de Louvain, Belgium)

Jae Hyun (Korea University, Korea)

Gareth McKinley (Massachussetts Institute of Technology, USA)

BSR Gold Medal Lectures

Mike Cates (University of Edinburgh)

Tom McLeish (Durham University)

In addition, the meeting will include the 2009 Weissenberg Award Lecture.

Keynote Speakers

The follow keynote speakers have been confirmed for the conference (more to follow):

Patrick Anderson (TU Eindhoven, The Netherlands)

Michel Cloitre (ESPCI-CNRS, Paris, France)

Ian Frigaard (University of British Columbia, Canada)

Cris Gallegos (Universidad de Huelva, Spain)

Michael Graham (University of Wisconsin, Madison, USA)

Bamin Khomami (University of Tennessee, USA)

Rudy Koopmans (Dow Europe, Switzerland)

Kurt Kremer (Max Planck Institute, Mainz, Germany)

Malcolm Mackley (University of Cambridge, UK)

Mario Minale (Seconda Universita di Napoli, Italy)

Dave Weitz (Harvard University, USA)

Key Deadlines

Abstract submission for oral presentations: December 5, 2008

Notification of authors (oral): January 16, 2009

Abstract submission for poster presentations: December 12, 2008

Notification of authors (posters): January 23, 2009

Deadline for early registration: February 20, 2009

Deadline for registration: March 13, 2009

For more information see:

<http://www.rheology-esr.org/AERC/2009>

Rideal Lecture 2009:

“It was gravity which pulled us down...”

with supporting symposium

Society of Chemical Industry, Belgrave Sq., London

20 April 2009

Programme:

14:00 Cracking in coatings from colloidal dispersions: An industrial perspective.

Martin Murray, Akzo Nobel.

15.00 Pickering emulsions produced using hydrophilic particles - stability and rheology. *Bill Frith*, Unilever.

15.30 Self consistent field studies of mixed interfacial polymers and biopolymers in melts and solutions. *Rammile Ettelaie*, University of Leeds.

16.00 Tea

16.30 Charge in non-aqueous systems. *Paul Bartlett*, University of Bristol

17.00 What thin-film cracking says about compressional rheology, *Lee White*, University of South Australia.

17.30 Delayed sedimentation: From formulation to physics and back again. *Alan Parker*, Firmenich

18.00 refreshments

18.20 Rideal Lecture: "It was gravity which pulled us down...". *Richard Buscall*.

19.10 Conference dinner (optional).

Further details: <http://www.soci.org/SCI/events/details.jsp?eventID=EV1287>

INDUSTRY NEWS

TA Instruments Ltd

BSR-TA Rheometric Prize

Another BSR meeting and another chance for TA Instruments to offer their support to the rheological community by rewarding the efforts of those keen to show the fruits of their studies in presenting in the poster session. The Mid-Winter meeting held at Leeds University had an impressive number of submissions, all of the high standard normally seen. TA Instruments were proud to present the BSR-TA Rheometric Prize for the best poster to Miss Yuan Yuan Dong, of the University of Nottingham for her poster on *“Rheological Analysis of Chemically Crosslinked Protein Gels in Absence or Presence of an Anionic Polysaccharide”*. I watched as the various BSR council members read with interest each entry and must admit that I am glad that such a task falls upon them as I would have found it hard to reach an outright winner.

Along with the usual certificate, the winner was awarded a substantial travel grant (via the BSR travel grants award scheme) to present their work at another rheology conference, maybe Miss Dong will consider a submission to the AERC conference in Cardiff (another event where TA will reward the best poster entry)

It is believed that this partnership between TA Instruments and the BSR will continue to encourage both an increase in the number of entries at subsequent poster sessions, but also increase the exposure, of both participants and delegates, to the very varied and wonderful fields of rheological studies going on around the country and even world today.

I would also add that this second award has again gone to someone from the University of Nottingham and so believe that other academic institutions should pick up the gauntlet to break this monopoly, and applaud the University of Nottingham for their excellent record and challenge them to go for the hat-trick.

CONFERENCE DIARY

2009	CONFERENCES & MEETINGS
9-10 March London	The Royal Society Discussion Meeting: Colloids, Grains and Dense Suspensions: under Flow and under Arrest Professor Michael Cates FRS The Royal Society, 6-9 Carlton House Terrace, London SW1Y 5AG http://royalsociety.org/event.asp?id=7432&month=2
15-17 April Cardiff	5th Annual European Rheology Conference (AERC 2009) Prof Timothy N. Phillips, Cardiff School of Mathematics, Cardiff University, Senghennydd Road, Cardiff CF24 4AG. Tel: 02920 874194 ; Fax: 02920 874199 PhillipsTN@cardiff.ac.uk : http://www.rheology-esr.org/AERC/2009/
20 April London	Rideal Lecture 2009: "It was gravity which pulled us down..." Society of Chemical Industry, Belgrave Sq., London Further details: http://www.soci.org/SCI/events/details.jsp?eventID=EV1287
10-13 May Rome Italy	ICheaP9: the 9th International Conference on Chemical and Process Engineering Prof. Sauro Pierucci, (ICheaP-9 Conference Chair) AIDIC Conference Department, Via Giuseppe Colombo 81A, I-20133 Milano, Italy Tel. +39-02-70608276, Fax. +39-02-59610042 E-mail: icheap9@aidic.it ; http://www.aidic.it/icheap9
15-18 June Zurich Switzerland	5th International Symposium on Food Rheology and Structure Zurich, Switzerland - Peter Fischer - x41-44-6325349 x41-44-6321155 - secretary@isfrs.ethz.ch - www.isfrs.ethz.ch
20-22 July Groningen The Netherlands	Faraday Discussion 144: Multiscale Modelling of Soft Matter Chair of the Organizing committee Dr Mark Wilson, Department of Chemistry, University of Durham South Road, Durham, DH1 3LE Tel: +44 (0) 191 334 2144; Fax: +44 (0) 191 384 4737 http://www.rsc.org/ConferencesAndEvents/RSCConferences/FD144/index.asp
18-22 October Madison Wisconsin USA	81st Annual Meeting of The Society of Rheology Professor A. Jeffrey Giacomin, Rheology Research Centre, the University of Wisconsin-Madison, Mechanical Engineering Building, 1513 University Avenue, Madison, Wisconsin 53706-1572, USA. Email: giacomin@wisc.edu . Conference website: http://rrc.engr.wisc.edu/sor2009.html
2010	CONFERENCES & MEETINGS
29-31 March Lake Vyrnwy Wales	Institute of Non-Newtonian Fluid Mechanics Easter Meeting

11-16 July Glasgow	IUPAC 2010 World Polymer Congress (Macro2010) Contact: Professor Peter A. Lovell, School of Materials, the University of Manchester, email: pete.lovell@manchester.ac.uk ; Tel: +44(0)161 306 3568; Fax: +44(0)161 306 3586.
1-6 August Sapporo Japan	5th Pacific Rim Conference on Rheology Hokkaido University, Sapporo, Hokkaido, Japan Conference Website: http://prcr2010.com
2009 COURSES & WORKSHOPS	
19 May Coventry	Rheology and Methodology Seminar Organiser: Natasha Murrell, Brookfield Viscometers Ltd. Email: n_murrell@brookfield.co.uk . Telephone: 01279 451774.
26-29 May Glasgow	Process Rheology CONTACT: Dr Nick Hudson, Dept Pure & Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow, UK T: +44(0)141 5482162; F: +44(0)141 5484822 E: n.e.hudson@strath.ac.uk
27-28 May Manchester	TA Rheology training course: For further information, contact Olivia Gibson; TA Instruments, Fleming Centre, Fleming Way, Manor Royal, Crawley, West Sussex, RH10 9NB; T: +44 1293 658900; F: +44 1293 658901; e-mail: Olivia.gibson@taeurope.co.uk
24-28 August Cuernavaca/ Termixco, Mexico	5th International Workshop on Non-equilibrium Thermodynamics IWNET 2009 Local organisers: Mariano Lopez de Haro, Miguel Angel Olivares, Federico Vazquez Hurtado Tentative topics: Interfacial phenomena, Biological systems, Fluctuations, Small systems, Complex systems, Granular matter. Website: http://www.nonequilibrium-thermodynamics.ethz.ch/
30th Sept – 1st Oct Ireland	TA Rheology training course: For further information, contact Olivia Gibson; TA Instruments, Fleming Centre, Fleming Way, Manor Royal, Crawley, West Sussex, RH10 9NB; T: +44 1293 658900; F: +44 1293 658901; e-mail: Olivia.gibson@taeurope.co.uk
October Nottingham University	Rheology Workshop Steve Goodyer, Anton Paar Ltd, 13, Harforde Court, John Tate Road, Hertford, SG13 7Q T: +44 (0)1992 514730; F: +44 (0)1992 514739 E: steve.goodyer@anton-paar.com
25-26 Nov Crawley	TA Rheology training course: For further information, contact Olivia Gibson; TA Instruments, Fleming Centre, Fleming Way, Manor Royal, Crawley, West Sussex, RH10 9NB; T: +44 1293 658900; F: +44 1293 658901; e-mail: Olivia.gibson@taeurope.co.uk
2010 COURSES & WORKSHOPS	
12-15 Jan Glasgow	Process Rheology CONTACT: Dr Nick Hudson, Dept Pure & Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow, UK T: +44(0)141 5482162; F: +44(0)141 5484822 E: n.e.hudson@strath.ac.uk