

THE BRITISH SOCIETY OF RHEOLOGY MIDWINTER MEETING: COMPLEX FLUIDS AND COMPLEX FLOWS

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The British Society of Rheology Midwinter Meeting for 2011 was held in the Department of Mathematics at UCL. This was not only a convenient location for participants from the provinces but also rather rare being situated directly above the Student Union. The meeting was organised by Helen Wilson (UCL) and Oliver Harlen (Leeds) and was structured around three invited Keynote Lectures, the Vernon Harrison Prize Lectures and a poster session. There was a wide range of excellent contributed talks covering many aspects of rheology – only a few are described in detail in this report.

The meeting began with a Keynote Lecture by John Hinch (Cambridge) on 'Explaining the Flow of Elastic Liquids'. His lecture was based around five benchmark problems for which the experiments were reproducible and the numerical simulations were consistent. The motivation was the search for explanations for some of the interesting effects observed in complex flows of non-Newtonian fluids such as the large upstream vortex in contraction flows and the long wake in flow past a sphere. His message was that non-Newtonian fluids exhibit behaviour that cannot be explained by appealing to the theory for viscous fluids or elastic solids. Stress relaxation is a special property of non-Newtonian fluids. The use of FENE-type models, in which the deformation of the microstructure is limited, overcomes some of the deficiencies of the Oldroyd B model and is able to predict some of the non-Newtonian effects observed in experiments.

In his Keynote Lecture, Malcolm Mackley (Cambridge) began by comparing his longevity in rheology to that of Mick Jagger in the music world. Malcolm displayed a picture of himself in his youth on the promenade in Aberystwyth during an early rheological visit alongside a photo of Jagger allowing participants to draw their own conclusions! In his talk, Malcolm gave an interesting account of some of the contributions he had made in his career in linear viscoelasticity of polymer melts, inkjet printing and, more recently, polymer opals. He explained that in order to obtain quantitative agreement between experiments on branched polymer melts performed in the Cambridge Multipass Rheometer and numerical simulations it was necessary to use a multi-mode pom-pom model. The reasonable agreement that had been obtained had given him a 'satisfying moment'. A multi-mode model was also necessary to obtain quantitative agreement between simulations and experiments in the ink-jet project.

The third Keynote Lecture was given by Christian Wagner (Saarland) on the subject of 'Blistering of Viscoelastic Filaments'. He described some of the interesting viscoelastic phenomena observed in filament stretching devices such as CaBER. For example, when a polymer solution experiences capillary thinning, the finite time singularity of the pinch off process is suppressed and an almost uniformly cylindrical thread is formed. The reason for this effect is the high resistance of polymers against extensional flow. He explained that in the last stages of thinning, when polymers have become fully stretched, the filament becomes prone to several instabilities that ultimately give rise to a Rayleigh Plateau instability followed by a blistering pattern of beads on the filament. For sufficiently high polymer concentrations, the filament eventually separates out into a solid phase of entangled polymers, connected by fluid beads.

Rob Poole (Liverpool) described some engineering applications of elastic turbulence. In the viscoelastic regime, turbulence is driven by elastic forces not inertia ($Re \ll 1$). He explained that efficient mixing and heat transfer is difficult for Newtonian fluids under creeping flow conditions. However, the addition of a small amount of high molecular weight polymer to a Newtonian fluid and the use of elastic turbulence can pro-



Figure 1:
The Vernon Harrison Prize
Winner for 2011, David Hoy-
le (Leeds, now at Durham)
with the president of the
BSR, William Frith.

duce efficient mixing. The creation of emulsions is one example of an industrial application of this work.

Neil Morrison (Leeds) described the 'drop on demand' printing process and the role of the time-dependent driving velocity in realising suitable droplet characteristics. The use of the FENE-CR constitutive model within a Lagrangian FEM enabled quantitative agreement with experiments to be obtained. He emphasised the potential of shear-thinning fluids to improve printing behaviour in that their use increased the overall percentage of ink in the main droplet, decreased the volume and number of satellite drops.

Suzanne Fielding (Durham) presented a criterion for predicting the onset of linear instability with respect to the necking of a filament of polymeric fluid undergoing uniaxial extension. She explained that contrary to the widely discussed Considère criterion, the onset of instability is found to relate closely to the onset of downward curvature in the time evolution of the axial component of the molecular strain. She considered a wide range of models – Oldroyd B, Rolie-Poly, Giesekus and FENE-P – and argued that her result was quite generic.

Adam Burbidge (Nestlé) presented a talk on dysphagia and swallowing mechanics and addressed the question – can we make rheology easier to swallow? This was not a talk for the squeamish participants and fortunately the talk wasn't scheduled just prior to lunch. He presented a mathematical model that coupled the fluid mechanics of squeezing and muscular contractions. The model was solved numerically for Newtonian fluids with expected predictions. He explained that the next phase of the work would incorporate non-Newtonian fluids.

There was a poster session during an extended tea break on the first day. There were sixteen posters on display. The BSR is grateful to TA Instruments for sponsoring the poster prize which was awarded to Robyn Moorcroft (Durham).

The Vernon Harrison Prize Winner for 2011, David Hoyle (Leeds, now at Durham), presented the main findings of his PhD thesis – Constitutive modelling of branched polymer melts in non-linear response. In his talk, David described his quest to predict the W-cusps in the stress birefringence patterns observed in the cross-slot geometry using the pom-pom model, which

is the simplest model polymer molecule with multiple branch points. He explained that the key to obtaining agreement between experiments and simulations was the choice of parameters in the model. A problem with using software such as REPTATE to obtain model parameters is that there are many competing sets of model parameters that fit the data equally well. Using LAOS, David found that varying the number of arms in the model had very little effect on the predictions. However, varying the ratio of the orientation and stretch relaxation times had the desired effect and this turned out to be the missing piece in the modelling puzzle. This year a second prize was awarded to Hao Yu (University of Sheffield) for his thesis on Structural and rheological properties of cellulose ether hydrogels: the coupling process of phase separation and gelation.

The Prize lectures brought an end to a very successful and stimulating meeting. As a number of more mature British rheologists head into the sunset of their careers, it was good to reflect on the number of younger rheologists who participated at this event. It bodes well for the health of rheology in the UK. The stated aim of this meeting was to provide an overview of current research across the whole spectrum of complex fluids in complex flow situations – encompassing theory, simulations and experiments. The organizers and speakers through their contributions helped to make this a memorable meeting and the aim was certainly fulfilled. An important feature of the meeting was the time available for formal and informal discussions and many participants commented on how useful this aspect of the meeting had been for them.

The next BSR Midwinter Meeting which will be held in Aberystwyth and organised by Simon Cox and David Binding will have Extensional Flows as its theme.

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