Australian Society of Rheology

2016 Rheology Lecture Series

In 2016 the Australian Society of Rheology is presenting a lecture series which is open to anyone interested in the flow and deformation of matter. The next lecture in the series is at **RMIT University (City campus)**.

DATE: Thursday, 14th Jan 2016

TIME: 5:30 - 6:30 pm

6**:**30 – 8:30 pm Lygon Street Restaurant Dinner (Sharing)

SPEAKER: **Professor Gareth McKinley**
Department of Mechanical Engineering,
Massachusetts Institute of Technology (MIT), Cambridge, MA – 02139

VENUE: 56.3.82 (building 56 level 3 room # 82, 115 Queensberry Street, CARLTON), RMIT University, City Campus, RMIT University, Vic 3053

TRANSPORT AND PARKING

The City campus is located diagonally opposite Melbourne Central Station. Most Melbourne trams travel along Swanston St. While car parking is not available on the city campus, numerous private car parks offer parking facilities in, or close to the city.

Title: Power-Law Rheology, Fractional Calculus and Yielding of Soft Networks and Multiscale Soft Materials

Abstract:

Many soft materials including foods, consumer products, biopolymer gels & associative polymer networks are characterized by multi-scale microstructures and exhibit power-law responses in canonical rheological experiments such as Small Amplitude Oscillatory Shear (SAOS) and creep. Even in the linear limit of small deformations it is difficult to describe the material response of such systems quantitatively within the classical framework of springs and dashpots – which give rise universally to Maxwell-Debye exponential responses. Instead empirical measures of quantities such as 'firmness', 'tackiness' etc. are often used to describe and compare material responses. G.W. Scott Blair argued that such measures are best thought of as '*quasi-properties'* that capture a snapshot of the underlying dynamical processes in these complex materials. We show that the language of fractional calculus and the concept of a 'spring-pot' element provide a useful ontological framework that is especially well suited for modeling and quantifying the rheological response of power-law materials. We illustrate the general utility of this approach by describing fractional differential forms of the Maxwell and Kelvin-Voigt models and using these models we quantify small-amplitude oscillatory shear responses and creep response in range of soft materials including soft solid foodstuffs such as cheese, gluten and casein gels, skin and soft tissue, filled polymer melts, hydrogen-bonded biopolymer networks and the complex interfacial rheological properties of acacia gum and serum albumins. The fractional exponents that characterize the dynamic material response can also be connected directly with the scaling exponents from microstructural models such as the Rouse model and the Soft Glassy Rheology (SGR) model. Having determined the quasi-properties that quantify the *linear viscoelastic* material response of a power-law gel in a concise form, we show that a fractional K-BKZ framework combining a Mittag-Leffler relaxation kernel with a strain-damping function can be used to quantitatively describe the nonlinear viscometric properties of such materials. Depending on the range of values of the quasi-

Australian Society of Rheology

2016 Rheology Lecture Series

properties the resulting models can have some surprising features, including; agreement with well-known heuristics such as the Cox-Merz rule and the complete absence of a zero-shear-rate plateau in the viscosity and the first normal stress difference.

Professor Gareth McKinley:

Gareth H. McKinley is the School of Engineering Professor of TeachingInnovation within the Department of Mechanical Engineering at MIT. He is a Fellow of the American Physical Society (APS), a member of the US National Committee for Theoretical and Applied Mechanics (USNC/TAM), and the recipient of the 2013 BinghamMedal from the Society of Rheology.
He is also Director of Hatsopoulos Microfluidics laboratory and Program in Polymer Science & Technology (PPST).
Specialties:Rheology, extensional rheology, instrumentation, fluid dynamics, complex fluids, microrheometry, polymer materials, free surface flows

PS: After the conclusion of the lecture, please show your appreciation by joining Gareth for Lygon street dinner with all of us attending his talk. (Everybody pay their share)

For enquiries, please contact Dr. Rahul Gupta,
Rahul.gupta@rmit.edu.au