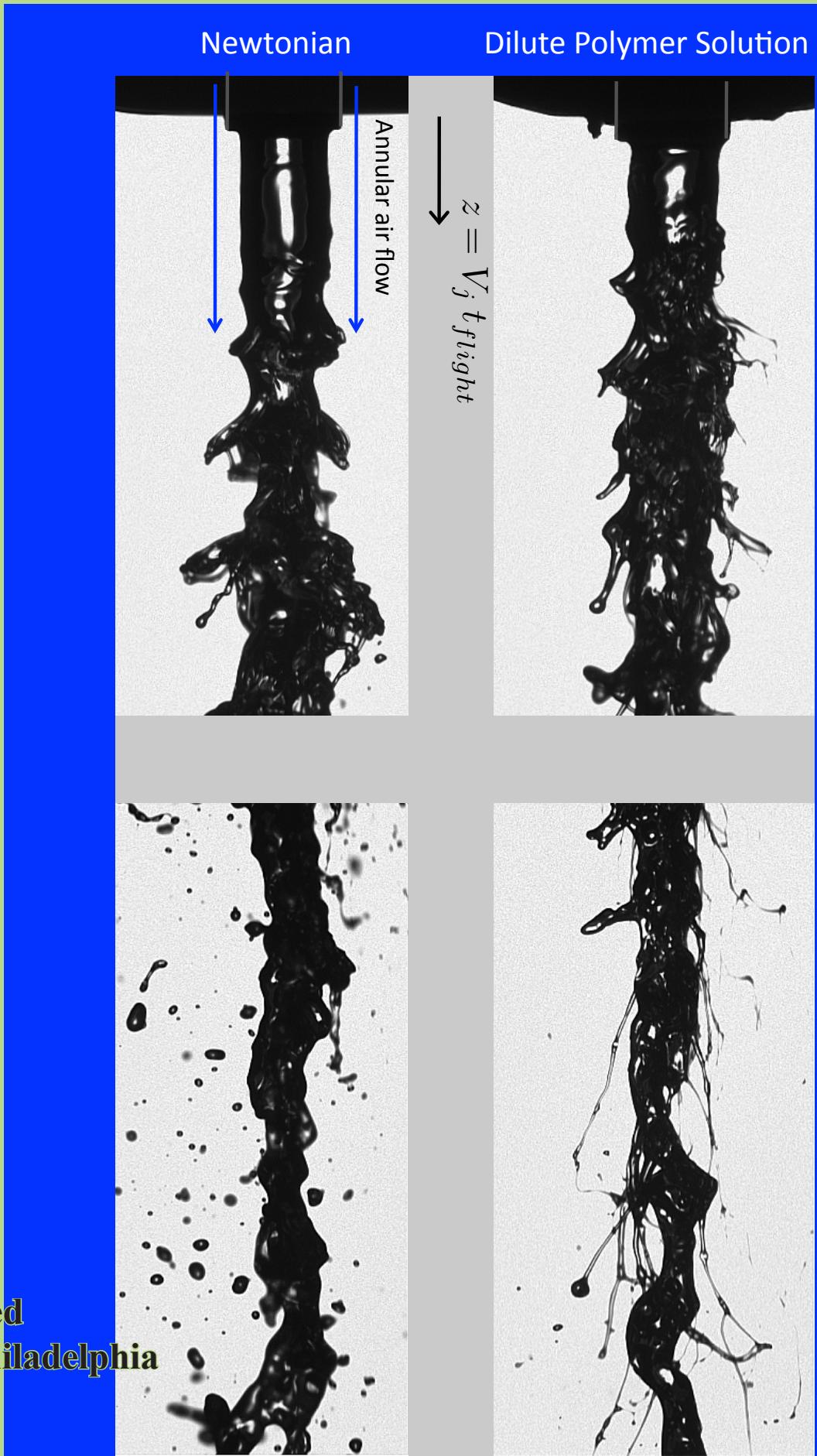


# Rheology Bulletin



## Inside:

- Rheology of ... Cats?
- Open Access Explained
- Annual Meeting in Philadelphia
- 2014 Society Awards



# Executive Committee

(2013-2015)

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	Dimitris Vlassopoulos
	Norman J. Wagner

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## On the cover.

Digital video strobe-imaging provides a comparison of near and far field flows in an atomized spray jet for water (left column) and PEO/water (right column) (Photo by Bavand Keshavarz and Gareth McKinley from the Massachusetts Institute of Technology). Essentially, the near field is almost unchanged, but the far field (where time scales are fast and length scales are small) is dramatically modified with beads on strings, etc. See page 27 for the rheological details.

The *Rheology Bulletin* is the news and information publication of The Society of Rheology (SOR) and is published twice yearly in January and July. Subscription is free on membership in The Society of Rheology. Letters to the editor: [rheology@aip.org](mailto:rheology@aip.org).

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*International Committee on Rheology (2012-2016)*

Faith A. Morrison  
A. Jeffrey Giacomin  
Eric Shaqfeh  
Gerald G. Fuller



# A Message from the President

Dear SOR Members,

I am delighted to report that The Society of Rheology continues to be in excellent condition. Our most important activities, our Annual Meetings and the publication of the *Journal of Rheology*, serve to disseminate the knowledge of the science and engineering of rheology to the broader community. Our Annual Meeting agenda is full through 2018 with the upcoming meeting in Philadelphia coming together under the leadership of Michael Mackay for the local arrangements and of Amy Shen and Maryam Sepehr for the technical program. As of this writing, we have an early record number of submitted abstracts and have yet to receive poster submissions.

Our 2015 meeting will be in Baltimore, (Kalman Migler local, Rajesh Khare and Susan Muller, technical program). The 2016 meeting is the year of the International Congress on Rheology (ICR), so we will be having a winter meeting in February 2017 in Tampa Bay (Don Baird, local) while the Fall of 2017 will see us in Denver (Matthew Liberatore, local) and Fall 2018 will see us in Houston (Jason Maxey, local). Your vice-president, Gareth McKinley is soliciting organizers for our 2019 meeting. These dates come quickly and we continue to try to select the sites of our meetings to balance geographical access and to provide opportunities for membership participation.

In addition to these main activities, the SOR supports educational programs and we have an active educational committee now headed by Jonathan Rothstein. In addition to organizing the short courses that are so successful during each annual meeting, this committee has now developed a STEM outreach project that will be debuted at the Philadelphia Meeting (see page 19). The SOR will be hosting with the Franklin Institute in Philadelphia a day of experiments in rheology that are developed to intrigue and excite K-12 students. We are looking forward to this event.

- **Society Updates**
- **Proposed Amendments to Rules**
- **Open Access as it Affects SOR**
- **Possible SOR Fellow Status**

Also, I, with the Executive Committee have been looking at several things of importance to the membership. The first of these is that, based on recommendations brought to us by a special committee headed by Gerry Fuller, teaming with Faith Morrison and Eric Shaqfeh, we have proposed some clarifications and amendments to the Society Awards: The Bingham Medal, the Publication Award, and the Metzner Award. As this letter is being published, you are being asked to vote on these changes. They are straightforward:

- For the Bingham Medal, in order to make it clear that this is truly an award open to all rheologists worldwide, we propose to strike the phrase "who is a resident of the North American Continent or a member of The Society" from the Rules.
- The committee also recommended modifying the Publication Award described in Section 3 of Article VII of the Rules to bring the Rules into line with the actual practice of that committee.
- The third change relates to the Metzner Award for early career investigators. This award has already been made to multiple young researchers, but has not been included in the SOR Rules. Rather, it is currently based on a document that was published some time ago in the *Bulletin* of the SOR. The committee on awards recommended to the Executive Committee that this award be put into the Rules with some minor changes to the award. The biggest change is that it would now go to investigators within 12 years of the terminal degree rather than to persons under 35 years of age.

You are invited to vote for these amendments to the Rules of the SOR and should have already received a ballot announcement by electronic mail.

As indicated above, the publication of the *Journal of Rheology* is one of our most important activities as a society. The current state of the *Journal* is excellent and our Editor Ralph Colby is actively building on the past strength of the *JOR* and preparing for the future.

When I took office, one of my first actions was in response to a lively discussion at the Business Meeting in Montreal where the subject of open access publishing was brought to the attention of the membership and the society officers as a potential issue that will affect the long term viability of the *Journal of Rheology* and, consequently, the SOR itself (see article on page 10). I appointed a committee headed by Gareth McKinley with members Tom McLeish and Roseanna Zia, and with Jeff Giacomin and Ralph Colby serving on an *ex officio* basis. The committee reported to the Executive Committee in May and made it clear that the problem of electronic publishing and open access continue to present challenges to the publishing industry in general. Fred Dylla, the Executive Director and CEO of the American Institute of Physics (AIP) also shared with the ExCom the AIP views on this complicated subject. Currently, the committee has been re-appointed and will continue to study the issue and make recommendations on how the SOR should proceed. Because the committee only had six months to work, it did not make recommendations at this time on open access rules for our journal and these remain items for discussion. It did, however, look into the copyright form used by the *JOR* and recommended that it be revised to be in-line with the AIP (who publishes the *JOR*) copyright form. These changes will take effect as soon as exact wording has been established. On the electronic publishing and open access, please do not hesitate to talk to the committee headed by Gareth McKinley or to any of the SOR ExCom members. It is an extremely important and long term issue that will eventually affect all of our efforts.

Finally, in looking towards the future, the committee on awards headed by Gerry Fuller mentioned above also made some recommendations, at my request, concerning the establishment of a designation of "Fellow of the Society of Rheology," something that the SOR does not have. A majority of the Executive Committee recommended that we should move forward with establishing such a recognition for our membership, but there were also some concerns raised during our discussions at the ExCom meeting. The benefits of such a designation are multiple. It provides recognition to those who make major contributions to the SOR both for technical and service activities but who may not win one of our other awards. It is the type of recognition that many other societies give to their active and productive members and is one that I think important. However there were also some concerns: 1). That this new category might upset the unifying spirit we enjoy in the Society; 2). How would one avoid monopolizing the early-stage process with current and past presidents, current and past ExCom members, Bingham awardees, and the like. Without going into details of proposed solutions, the ExCom invites the membership to contact Gerry Fuller's committee members (Gerry, Faith, Eric) or the ExCom with ideas. Also, be prepared at the Philadelphia meeting in October to discuss this at the Business Meeting where we will provide a presentation of the thinking that is going into the possible creation of the designation "Fellow of the Society of Rheology" and so that you can provide feedback in that open forum.

I look forward to continuing to serve you and to seeing you in Philadelphia.

Greg McKenna  
President, The Society of Rheology





# Bingham 2014 to Norman Wagner

*Profile by*

*Bill Russel*

*Princeton University*

*with input from*

*Kate Gurnon and Eric Furst*

*University of Delaware*

The 2014 Bingham Medal of The Society of Rheology is being presented to Norman J. Wagner of the University of Delaware, USA.

Wagner earned a Bachelor of Science in Chemical Engineering from Carnegie Mellon University in 1984. After an undergraduate thesis that yielded four publications on metal support interactions in supported catalysts, he turned to colloid science for his graduate research at Princeton. His dissertation, advised by William B. Russel, addressed "Nonequilibrium Statistical Mechanics of Concentrated Colloidal Dispersions" and included collaborations with Gerry Fuller (Stanford), Bruce Ackerson (Oklahoma), and Kees deKruif (Utrecht) that produced the first applications of optical techniques to the rheology of dispersions. After receiving his Ph.D. in 1988 he spent a year as a NATO Postdoctoral Fellow with Rudolph Klein and colleagues at the University of Konstanz, which introduced him to large-scale Brownian dynamics simulations of colloidal systems and further development of nonequilibrium statistical mechanics via mode coupling approximations. His exposure to simulations was reinforced by further postdoctoral work taking advantage of the computational facilities at Los Alamos National Laboratory.

Since joining the Department of Chemical Engineering at the University of Delaware Norm has deployed and further developed these tools, while characterizing the structure and rheology of a wide range of complex fluids, for example bimodal and polydisperse hard spheres, sticky spheres, liquid crystalline polymers (lyo- and thermotropic), polymeric and colloidal glasses, AOT microemulsions, dendrimers and hyperbranched



polymers, wormlike micelles, and carbon nanotubes. His effort to understand as well as characterize this wide range of complex fluids stimulated a constant search for additional rheological tools, techniques to monitor the effect of shear on structure, and more powerful theory.

The outcomes of this quarter of a century of productivity can be characterized in a number of ways. The 180 publications in scholarly journals have generated more than 3,200 citations by others with a rate of citations that has doubled in the past four years. Much of the research focuses on colloidal dispersions, which is captured beautifully in the book

*Colloidal Suspension Rheology* (Cambridge University Press, 2011) coauthored with Jan Mewis (KU Leuven). That book was molded by their short courses that the two have presented regularly for more than a decade at rheology meetings and a variety of other venues (the course will run again in Philadelphia; see page

15). Another more recent initiative that will benefit the community broadly is his demonstration of rheo-SANS (small-angle neutron scattering) instruments implemented at the D22 SANS beam line (Institut Laue-Langevin, Grenoble, France) for time-resolved large amplitude oscillatory experiments and the novel Rheo-SANS instrument developed at the National Center for Neutron Research (NCNR, NIST, Gaithersburg, MD). Results from these experiments provide clear connections between non-equilibrium structure and rheology.

One striking theme in Norm's work is that of shear thickening in concentrated colloidal dispersions, a phenomenon initially highlighted by Rich Hoffman in 1974, who attributed it to a shear-induced order-disorder transition. Brady and Bossis (1985) with their early Stokesian dynamics simulations, D'Haene, Mewis,





Norm Wagner at Carnegie Mellon University circa 1982, working in the catalysis laboratory of the late Professor Ed Ko.

and Fuller (1993) through dichroism experiments, and Bender and Wagner (*Journal of Rheology* **40**(5) 899-916 1996) with further flow dichroism measurements proved conclusively that hydrodynamic interactions generate very large, anisotropic aggregates of particles that produce the shear-thickening transition. The key distinction from an order-disorder transition is that hydrodynamic clustering is reversible, which an order-disorder transition is not. Norm's group pursued that theme in several other well-cited papers (e.g. B.J. Maranzano & N.J. Wagner *Journal of Rheology* **45**(5) 1205-1222 2001; Y.S. Lee & N.J. Wagner *Rheologica Acta* **42**(3) 199-208 2003) and then joined forces with Brady for a popular summary in *Physics Today* (2009). In parallel with the science, Norm recognized a striking application described dramatically in "The ballistic impact characteristics of Kevlar® woven fabrics impregnated with a colloidal shear thickening fluid" (*J. Materials Science* **38**(13) 2825-33 2003) and "Stab resistance of shear thickening fluid-treated fabrics" (*Composites Science and Technology* **67**(3-4)

565-578 2007).

Optical techniques for characterizing rheology have a long history but the fundamental connections between the signal and the stresses have not always been clear. With J.W. Bender (*J. Colloid and Interface Science* **172** 171 1995) Norm verified a fundamental stress-optical relationship that "enables the use of optical dichroism measurements to distinguish between thermodynamic and hydrodynamic contributions to the stress tensor." This motivated them to "show that the shear thinning...is attributable to changes in the thermodynamic forces' contribution to the stress, consistent with both theory and simulation...[and] that shear thickening is attributable to increased hydrodynamic interactions."

Another theme in Norm's work is the use of rheologi-

(continues, page 26)



Members of the Wagner group on the annual Earth Day hike April 2014 in the White Clay Creek State Park in Newark, Delaware. Attendees included (left to right): Matt Armstrong, Norm Wagner, Dan Greene, Stijn Koshari, Melissa Gordon, Yun Soo Kim, P. Doug Godfrin, Michelle Calabrese, Paul Mwasame, Stephen Ma, Ru Chen, Jingsi Gao, Colin Cwalina, A Kate Gurnon, Simon Rogers and Fiona Rogers.

# 2014 Metzner Early Career Award: Randy H. Ewoldt

Randy H. Ewoldt, Assistant Professor in the Department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign, has been awarded the *2014 Arthur B. Metzner Early Career Award* of The Society of Rheology. This award is given to a Society member younger than 35 who has distinguished him/herself in rheological research, rheological practice, or service to rheology.

Ewoldt obtained his B.S. in mechanical engineering from Iowa State University in 2004, and his M.S. and Ph.D. degrees in mechanical engineering from the Massachusetts Institute of Technology in 2006 and 2009, respectively. After a post-doctoral position at the University of Minnesota, he joined the faculty of the University of Illinois at Urbana-Champaign in 2011.



At MIT (co-advisors Gareth McKinley and Anette (Peko) Hosoi), Ewoldt studied nonlinear rheology with contributions to bioinspired robots and theoretical definitions of rheological material functions. He developed rheological design rules for using non-Newtonian fluids for adhesive locomotion, the crawling strategy used by snails. This work led to a demonstration of a synthetic fluid which enabled a battery powered crawler known as "Robosnail" to climb a vertical surface and traverse upside-down, successfully biomimicking adhesive locomotion. This work has been reported by the Discovery Channel, German Public Television, and Nova ScienceNOW. Also during his graduate studies, Ewoldt pioneered new rheological material functions for characterizing nonlinear viscoelasticity using large amplitude oscillatory shear (LAOS). The newly defined material functions have been implemented into commercially available rheometer software produced by rheometer manufacturers.

During his post-doc at Minnesota, mentored by Christopher Macosko, Ewoldt interacted with leading researchers in the field of rheology and fluid mechanics from a wide range of disciplinary backgrounds. Within this environment, he independently pursued research on the rheology of biological materials (hagfish slime, suspensions of actively-swimming microalgae), and collaborated on a substantive review article on LAOS. Other work at Minnesota included producing a patent with Macosko on nonlinear rheological signatures of chewing gum.

Ewoldt's research at Illinois focuses on three themes: rheological design; inferring molecular structure from macroscopic rheology with asymptotically nonlinear LAOS; and novel biomaterial rheology. His work is both experimental and analytical, with a strong interest in biological and bioinspired systems, and often involves interdisciplinary collaborations, including engineering (materials, chemical, civil), chemistry, biology, entomology, and art/design.

Design with rheological-complexity involves design *with* complex fluids as well as design *of* complex fluids. Ewoldt's efforts to integrate rheology with design (both engineering design and product design) are underway in the laboratory and in the classroom in a highly collaborative fashion that includes colleagues in the School of Art+Design at Illinois.

Ewoldt's work in the area of inferring molecular structure from macroscopic rheology is based on low-dimensional LAOS. In contrast to the typically high-dimensional LAOS data, Ewoldt has outlined the theoretical definitions and physical interpretations of the four asymptotically-nonlinear shear material functions in LAOS.

Ewoldt's research in biomaterial rheology includes continuing studies on the mechanics of hagfish defense gel. Collaborative efforts also include shark vertebral columns in large-amplitude oscillatory bending (LAOB) and ant venom foam. Ewoldt's efforts to educate and serve the rheology community include a free piece of software he has co-written with Peter Winter and Gareth McKinley (*MITlaos*) that processes rheology data from oscillatory tests, which is currently used by more than 145 research groups worldwide. He also lectures at short courses in the U.S. and internationally, and has developed an outreach effort called "The Rheology Zoo."

*Profile by Charles L. Tucker III*



The *SOR Early Career Award*, established in 2009, is named for Art Metzner, distinguished rheologist, university professor, Editor of the *Journal of Rheology*, and 1977 Bingham medalist.





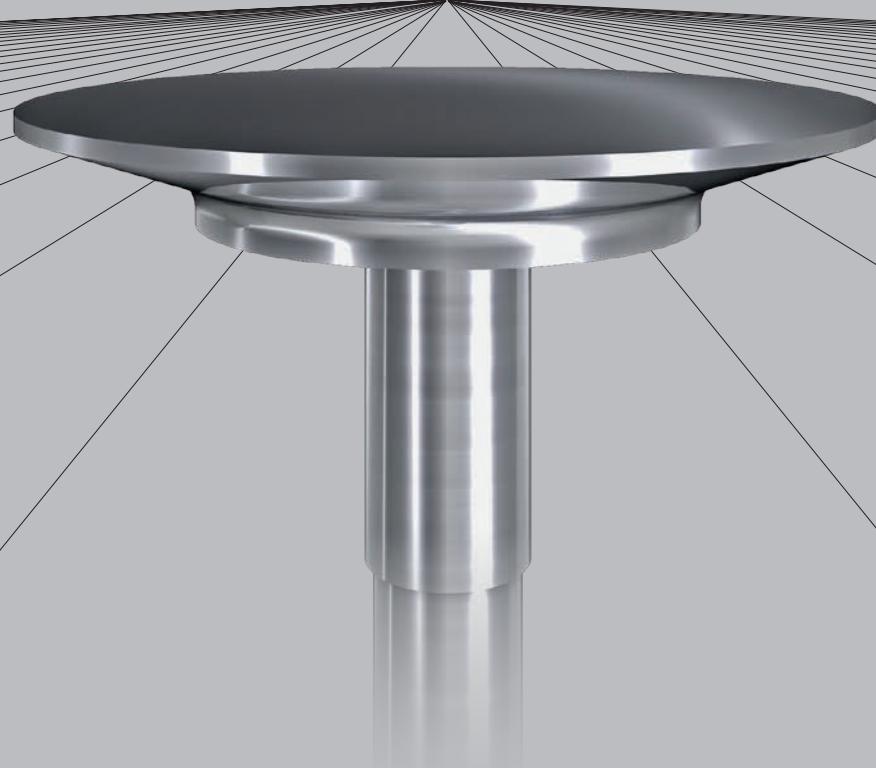
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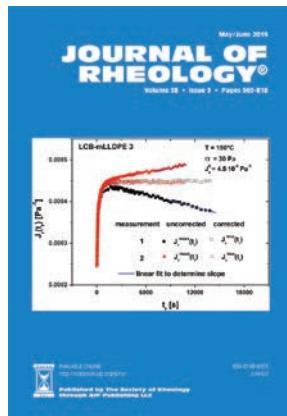
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# Open Access and Electronic Publishing

Gareth H. McKinley, *Chair, SOR ad hoc Committee on Electronic Publishing*  
Faith A. Morrison, *SOR Designee to the AIP Governing Board*

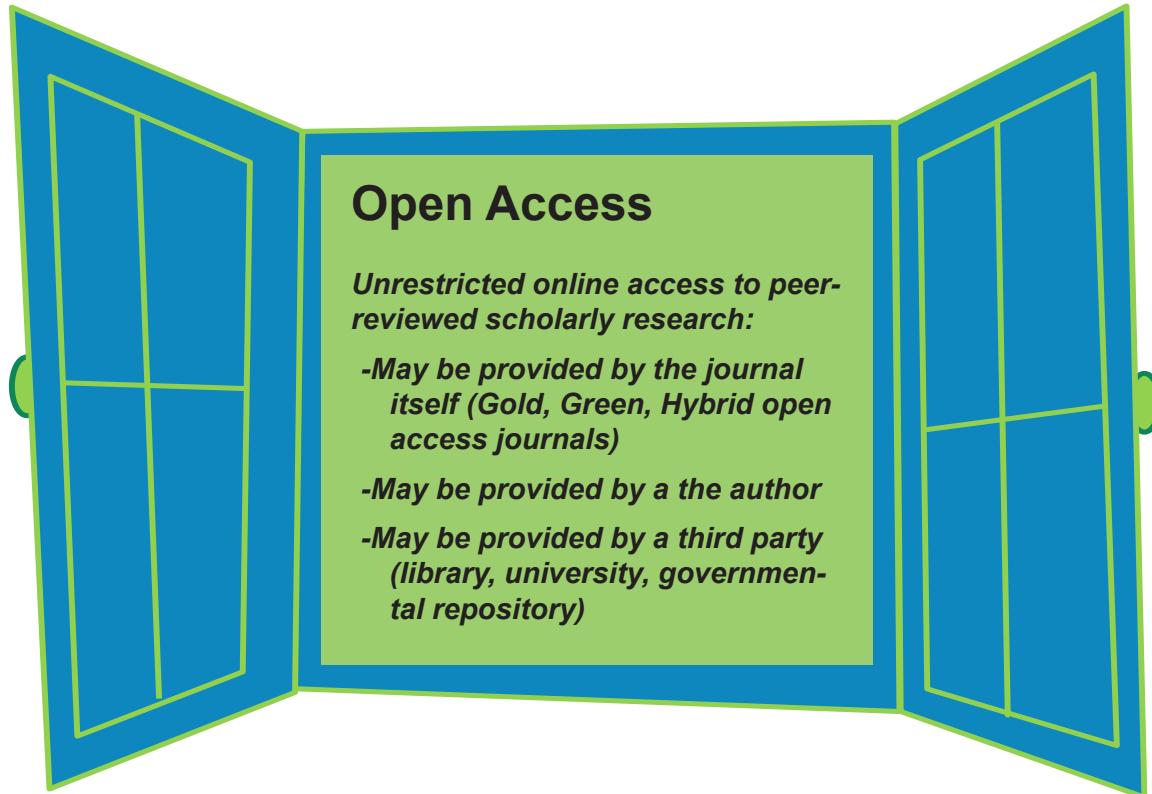
As many members of the Society of Rheology know, the world of scientific publishing is changing rapidly with increasing momentum gathering behind the Open Access movement. There was a spirited discussion on this topic at the annual Business Meeting of The Society of Rheology in Montreal in October 2013, and Fred Dylla, the CEO of the American Institute of Physics (AIP) shared his thoughts regarding AIP open-access initiatives in the January 2014 *Bulletin*. Following the discussion at the last Annual Meeting, particularly with regard to electronic access and distribution of preprints, SOR President Greg McKenna convened an *ad hoc* Committee on Electronic Publishing composed of three members, Gareth McKinley (chair), Tom McLeish, and Roseanna Zia, plus two ex-officio members, Ralph Colby (*JOR* Editor) and Jeff Giacomin (SOR delegate



to the board of AIP Publishing, our publishing partner). The committee's ongoing mission is to assess and monitor the changing landscape of electronic publishing and Open Access and to make recommendations to the SOR Executive Committee. Since January, the *ad hoc* committee has been corresponding extensively by email, meeting by videoconference and gathering background information from a wide variety of sources. One of us (GHM) presented the committee's provisional findings at the SOR Executive Committee meeting, held at AIP Headquarters in May 2014, and he will present a concise overview of these discussions at the next Business Meeting in Philadelphia. Some additional links to resources for further reading on the issue of Open Access publishing are given at the end of this article (see page 29) for those interested in the background of the subject.

One concrete proposal that came out of the committee discussions, and which was voted on by the Executive Committee, concerns the Copyright Transfer Agreement (CTA) that authors sign when submitting an article to the *Journal of Rheology*. Our CTA has remained unchanged since at least 1990 and is now rather dated in language and intent. Specifically, it does not address the question of posting electronic versions of the article (i.e. an electronic preprint) on authors' websites, or in collective

(continues page 28)





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## Historical Philadelphia

and the Loews Hotel is the venue for the 86<sup>th</sup> Annual Meeting of the Society of Rheology 5-9 October 2014. Our host in Philadelphia is Michael Mackay (University of Delaware), with the support of his local arrangements team.

The Loews hotel is located in the first skyscraper ever built in Philadelphia, the "City of Brotherly Love." The hotel is downtown in a very walkable district. You can find your way back to the conference by looking for the famous PSFS sign that illuminates the Philadelphia skyline. PSFS is the acronym of the Philadelphia Savings Fund Society, the first savings bank in the United States. The building was converted to the Loews hotel in 2000. The interior retains some of the historical charm of its original incarnation as a bank: the once three-story banking room is now a banquet space that retains the bank's safe, Cartier clocks, and original marble.

The Philadelphia meeting will be preceded by two short courses the weekend before, the 2-day **Rheology of Colloidal Suspensions** course, offered by Jan Mewis and Norm Wagner, and the 1-day Sunday course, **Rheology of Foods**, offered by the team Peter Fischer, Rakesh Gupta, and Mahesh Padmanabhan. See page 15 for more on the short courses.

For those not taking the courses, there will be two additional Sunday events, an **Industry/Faculty/Student Forum and Mixer**, and a new rheology outreach event at the Franklin Institute, sponsored by the SOR Education Committee. The Industry/Faculty/Student Forum (4-6pm Sunday in the Loews Hotel), this year cosponsored by the Dow Chemical Company and the American Institute of Physics (AIP), has become a tradition at SOR meetings. The forum, organized by Maryam Sepehr and Amy Shen (SOR) and Philip "Bo" Hammer (AIP) allows attendees to see what industrial problems a rheologists can dig into; students also can see how a career in rheology might develop.

The newest Sunday event is a **Fun with Rheology outreach event**, held at the Franklin Institute. Conceived by the Education Committee (Jonathan Rothstein, Chair) as an annual event, the *Fun with Rheology* event (organized by Mike Boehm) is a collaboration with a local science center, museum or school, providing hands-on demonstrations aimed at children and adults. The event will spread the gospel of rheology using the most able evangelists imaginable – members of the Society of Rheology! The outreach activities in Philadelphia will take place Sunday 5 October 2014 from 1pm until 4pm at the

nearby Franklin Institute; this schedule gives all those who participate plenty of time to make the transit to the Welcoming Reception, which takes place at the Loews hotel at 6:30pm. Note: Volunteers are still needed for Philadelphia; contact the event organizer if you can help (see the article page 19 for contact information).

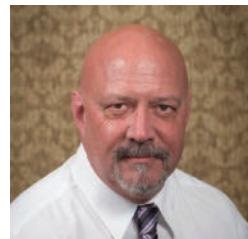
As indicated above, the Welcoming Reception, hosted by TA Instruments, will take place Sunday 6:30-8:30pm on the 33<sup>rd</sup> floor of the Loews Hotel. Registration is on the 2<sup>nd</sup> floor from 3pm-6:30pm. Sessions begin on Monday and flow through Thursday noon, as usual. The social program continues on Tuesday at 6:45am (yes! in the morning) with another first-time event, the **Rocky Rheology Run**. Fans of the movie "Rocky" will remember the training runs Rocky would make up the front steps of the Philadelphia Art Institute. According to the plans of Michael Mackay and Wes Burghardt, we rheologists (and guests) will reenact this event on Tuesday morning (on a voluntary basis only, of course!). See the notice on page 14 for details and for instructions on how to register.

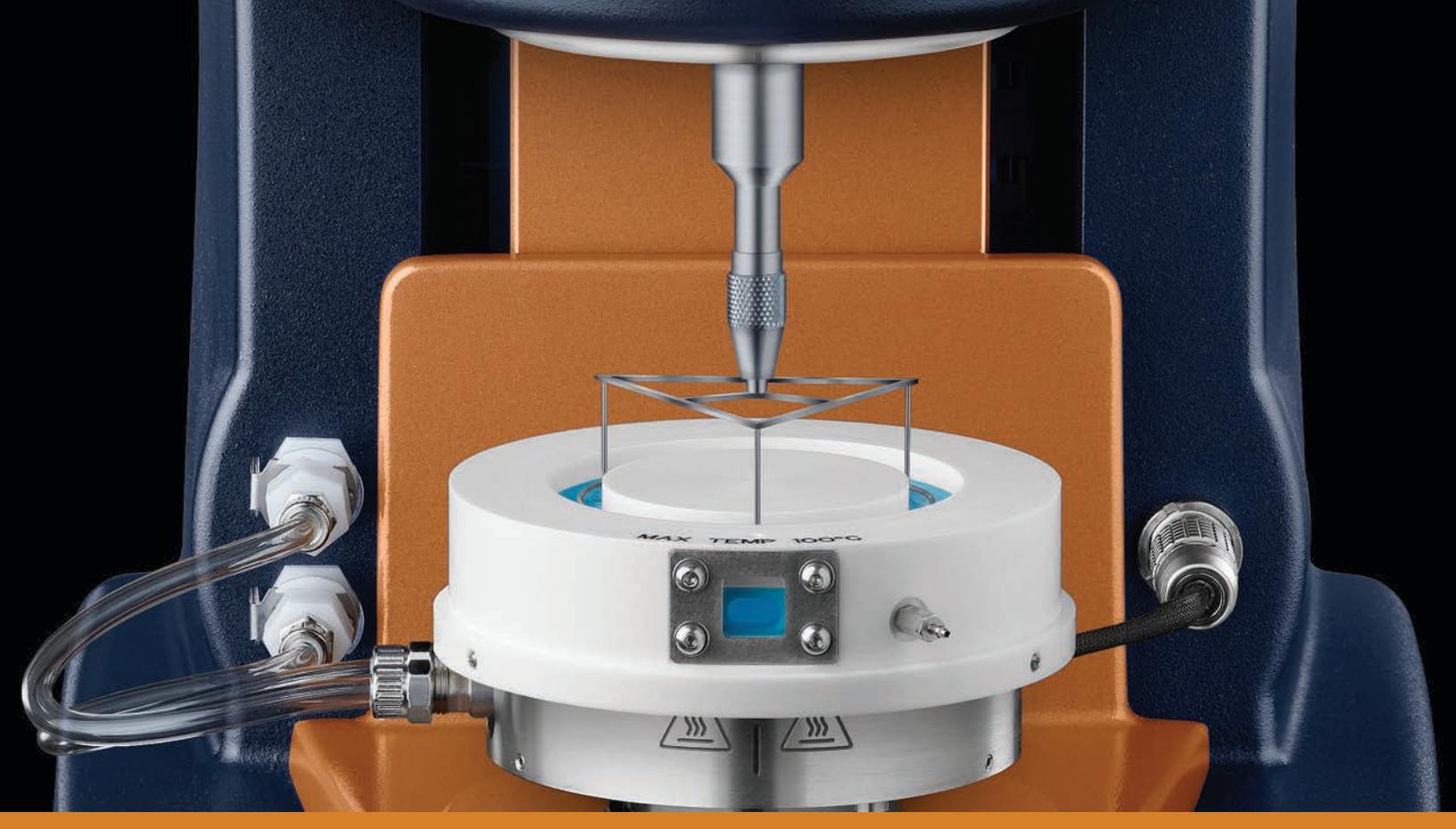
Also on Tuesday is the Society Business meeting, which takes place at the lunch hour; a limited supply of box lunches will be available. Tuesday evening is reserved to fete the 2014 Bingham medalist, Norm Wagner, at the Society Banquet. The Banquet is preceded at 7pm by the Awards Reception, sponsored by Xpansion Instruments; the banquet begins at 8pm in Millennium Hall of the Loews Hotel. The final social event of the meeting is the reception during the poster session on Wednesday, sponsored by Anton Paar and taking place from 6-8pm in Millennium Hall as well.

We'll be busy in Philly, but make time to see the historical sites such as Independence Hall (home of the Liberty Bell) and the many art museums, including the unique Barnes Collection. If you plan to see the Barnes Collection, you will need to buy tickets ahead of time online—the museum is only open to ticket holders, and popular times sell out well ahead (your *Bulletin* editor can testify that it's worth the trouble).

Check the website for more details.  
See you in Philly!

**Michael Mackay**  
**Local Arrangements Chair**  
Materials Science and Engineering  
Chemical & Biomol. Engineering  
University of Delaware  
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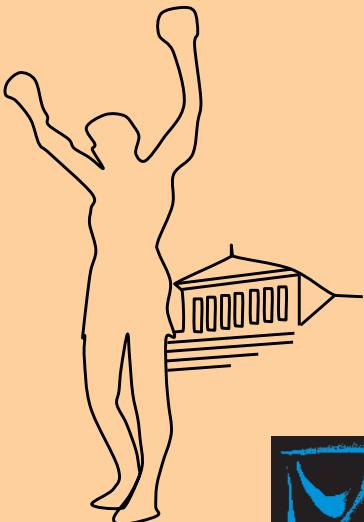
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# First Annual Rocky Rheology Run

## During the 86<sup>th</sup> Annual Meeting of The Society of Rheology

**Tuesday, 7 October 2014 at 6:45 am  
Philadelphia Loews Hotel Lobby**



Join your *Rocky Rheology Run* hosts **Michael Mackay** (who can't run but will smile as you leave) and **Wes Burghardt** (who can run and will guide you through the run) in the lobby of the Philadelphia Loews Hotel to retrace some of that iconic run up the stairs of the Philadelphia Art Museum.

It's a two-mile run along the Ben Franklin Parkway from the hotel to the museum where you can run up the stairs, turn around, raise your arms and shout with glee that air is not a viscoelastic fluid! After your elation, which will be caught on film, run the two miles back to the hotel and get ready for the Bingham Lecture. So, come run and participate in a truly unique Philadelphia experience.

Sign up (it's free!) on the web: [www.rheology.org/sor/annual\\_meeting/2014Oct/RockyRheolgyRun.htm](http://www.rheology.org/sor/annual_meeting/2014Oct/RockyRheolgyRun.htm).

**The first 50 registrants receive a free tee shirt  
courtesy of the Department of Chemical and  
Biomolecular Engineering  
at the University of Delaware.**

*Photo by: Jim McWilliams for the Philadelphia Convention & Visitors Bureau*

# SOR Short Courses for Philadelphia

## Rheology of Colloidal Suspension

Saturday and Sunday, 4-5 October 2014

Instructors: Jan Mewis and Norman J. Wagner

The Society of Rheology is offering this intense and extremely practical two-day short course, which is perfect for students and practitioners of colloid rheology in industry and academia. Taught by two renowned rheology experts, Jan Mewis and Norman J. Wagner, the short course provides an introduction to the rheology of colloidal dispersions with emphasis on measurement and interpretation of rheological measurements on colloidal dispersions. This suspension course builds on the fundamental understanding of how various properties of colloids and their interactions lead to the observed rheological behavior in a systematic treatment.

The course content starts with systems where only purely hydrodynamic effects are present (i.e., suspensions with non-colloidal particles). Next, colloidal particles are introduced; with Brownian motion but without any particle interaction force. After that, systems with additionally repulsive interparticle forces are discussed: that is, colloidally stable systems. Finally, attractive forces are added, which can lead to flocculated suspensions and colloidal gels. The methods of rheological measurement design and execution are discussed, treating the special difficulties that arise in the case of suspensions. Case studies will be analyzed to illustrate the basic concepts of the course. Special advanced topics including emulsions and rheology modeling will be discussed, as well as other topics depending on participant interests.

Course materials will include class notes as well as a paperback copy of *Colloidal Suspension Rheology*, authored by Jan Mewis and Norman J. Wagner, and published in 2011 by Cambridge University Press (ISBN-13: 978-1107622807).

### Benefits:

- Gain a qualitative understanding of the various phenomena that contribute to the rheology of suspensions.
- Use scaling relations and quantitative laws to predict the basic rheology of such systems.
- Apply what you learn to develop strategies for measuring, characterizing and designing suspensions with well-defined processing or application properties.
- Network and engage with colleagues in the field, discussing relevant and practical problems.

## Rheology of Foods

Sunday, 5 October 2014

Instructors: Peter Fischer, Rakesh Gupta, and Mahesh Padmanabhan

Convenience, appearance, flavor and texture together govern the human perception & acceptance of foods. However, the motivation to understand and quantify food properties such as texture—its creation, stability, perception and destruction—remains high since it is critical to the manufacture of food products that delight and satisfy food consumers, while delivering nutrition and health. Thus, the understanding of structure and mechanical properties of food products is critical to its overall properties and quality perception.

During processing, the formulated food system is physically and chemically modified while building the structure, all of which combine to impart the desired material properties and hence the texture to the final product. With health and nutrition becoming increasingly important the role of foods in preventing and managing diseases has gained a lot of attention—thus understanding of the rheology from the destruction of the food in the mouth, its subsequent manipulation and transportation through the stomach, the gut and beyond have become important fields of research today.

In view of the above, processing-structure-property relationships and materials science understanding of the observed rheology and texture are critical to the formulation, processing, product performance and human consumption and satisfaction of foods.

This course builds on the fundamentals of rheology and seeks to introduce the participant to the intriguing world of complexities entangled in the bowl of food rheology and texture. Where appropriate, comparisons and contrasts are made to the behavior of polymeric fluids and colloidal systems.

**For more information and to register for the short courses, go to the SOR meeting website:**

[www.rheology.org/sor/short\\_course/2014Oct/](http://www.rheology.org/sor/short_course/2014Oct/)

# On the rheology of cats

M.A. Fardin<sup>1, 2, 3, \*</sup>

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<sup>2</sup>The Academy of Bradylogists.

<sup>3</sup>Member of the Extended McKinley Family (EMF).

(Dated: July 9, 2014)

In this letter I highlight some of the recent developments around the rheology of *Felis catus*, with potential applications for other species of the felidae family. In the linear rheology regime many factors can enter the determination of the characteristic time of cats: from surface effects to yield stress. In the nonlinear rheology regime flow instabilities can emerge. Nonetheless, the flow rate, which is the usual dimensional control parameter, can be hard to compute because cats are active rheological materials.

$\pi\alpha\nu\tau\alpha\ \rho\epsilon\iota!$  Everything flows! This famous aphorism used to characterize Heraclitus' thought is also the motto of *rheology*. “Everything flows and nothing abides; everything gives way and nothing stays fixed.” a recipe for insubordination actually from Simplicius and Plato. Everything flows? Well, it depends on the definition of a *flow*; if sufficiently general, there is no doubt that there are no exceptions to the rule! What is a flow? What is a fluid? As pointed out from the start by Reiner, the essential value of rheology is to recognize that states of matter are a matter of time(s). The first time, is a *time of observation T*. What is true today may not be true tomorrow. Time over time, one day 49, the next 50.

Historically, the popular distinction between states of matter has been made based on qualitative differences in bulk properties. Solid is the state in which matter maintains a fixed volume and shape; liquid is the state in which matter maintains a fixed volume but adapts to the shape of its container; and gas is the state in which matter expands to occupy whatever volume is available. Following these common sense definitions, a meta-study untitled “Cats are liquids” was recently published on [boredpanda.com](http://boredpanda.com). I propose here to check if the panda’s claim that the cats are liquid is solid, by using the tools of modern rheology.

First of all, ‘maintains’, ‘adapts’ or ‘expands’ are verbs. They describe actions unfolding with a characteristic time scale  $\tau$ , which we will call *relaxation time*. From  $T$  and  $\tau$  we can define the *Deborah number* as:

$$De \equiv \frac{\tau}{T} \quad (1)$$

Usually  $T$  is just the duration of the experiment, but for oscillatory flows it is the inverse of the frequency (and thus  $De$  is analogous to a Strouhal number). The relaxation time  $\tau$  can have a variety of origins. When one seeks the difference between gas and liquid, ‘relaxing’ will mean ‘expanding’ and so  $\tau$  will be linked to the characteristic rate of expansion of the material. The expansion

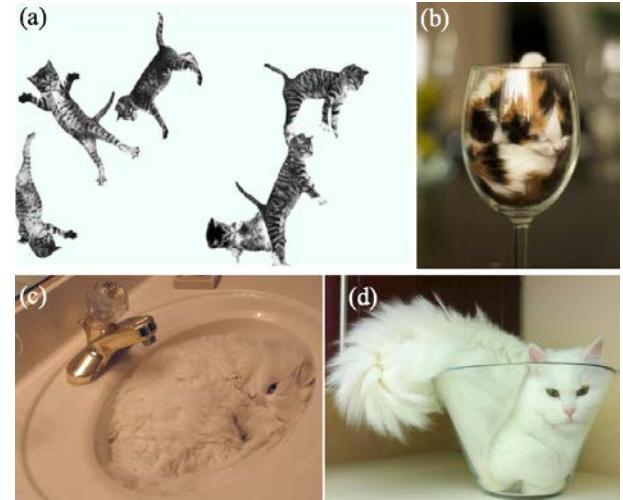


FIG. 1: (a) A cat appears as a solid material with a consistent shape rotating and bouncing, like Silly Putty on short time scales. We have  $De \gg 1$  because the time of observation is under a second. (b) At longer time scales, a cat flows and fills an empty wine glass. In this case we have  $De \ll 1$ . In both cases, even if the samples are different, we can estimate the relaxation time to be in the range  $\tau = 1$  s to 1 min. (c-d) For older cats, we can also introduce a characteristic time of expansion and distinguish between liquid (c) and gaseous (d) feline states. [(a) Courtesy of <http://cat-bounce.com>, (b) <http://www.dweebist.com/2009/07/kitten-in-wine-glass/>, (c) <http://imgur.com/gallery/UuNSR>, (d) <http://imgur.com/s7JtV> ]

is a type of flow. In this case, we will say that we have a gas if  $De \ll 1$ . When one seeks the difference between liquid and solid, ‘relaxing’ will mean ‘adapting’ and so  $\tau$  will be linked to the characteristic rate of adaptation of the shape of the material to its container. The adaptation of the shape of the material is a type of flow. In this case, we will say that we have a liquid if  $De \ll 1$ . Solids ‘maintain’ their shape and volume, *i.e.* they do not flow. But solids can be deformed under stress. Note finally that any flow is intrinsically made of deformations.

As illustrated in Fig. 1a, for  $De \gg 1$  a cat appears

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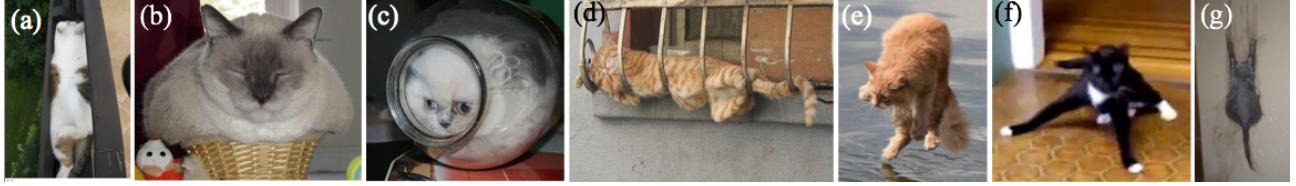


FIG. 2: (a) Extensional rheology of a cat before capillary break-up. (b) Cat on a superfelidaphobic substrate showing a high contact angle. (c) Tilted jar experiment showing the yield stress of a kitten. (d) Spreading of a cat on a very rough substrate. (e) Low affinity between cats and water surfaces. (f) Sliding cat on smooth floor. (g) Adhesion of a cat on a vertical wall. [Courtesy of (a) facebook.com, (c) <http://metro.co.uk/2011/02/18/ksyusha-the-kitten-is-cat-in-a-jar-639735/>, (d) <http://www.theyfailed.com/cats-sleep-anywhere/>, (f) <http://www.mirror.co.uk/news/world-news/youtube-watch-hilarious-viral-of-two-882779>, (g) [http://amazinghandpaintedmurals.com/picture\\_gallery--page\\_3](http://amazinghandpaintedmurals.com/picture_gallery--page_3)]

solid, whereas for  $De \ll 1$  it seems liquid. From these preliminary experiments, knowing  $T$  we can estimate the relaxation time to be in the range  $\tau = 1$  s to 1 min, for normal cases of *Felis catus*. Note that the samples used in Fig. 1a-b are relatively young. Older cats may have a shorter relaxation time, and thus become liquid more easily than agitated kittens, for which  $\tau$  can reach values as high as a few hours. The assumption of incompressibility may also fail for older cats, which can acquire gaseous properties like in Fig. 1c-d. In this letter, we will tend to ignore this thixotropic behavior. There's an old saying in investing: even a dead cat will bounce if it is dropped from high enough. Where, of course, the dead cat bounce refers to a short-term recovery in a declining trend.

Overall, the Deborah number is the dimensionless expression of the concept of linear viscoelasticity. The greater the Deborah number, the more elastic/solid the material; the smaller the Deborah number, the more viscous/fluid it is. Thus, rheology suggests only two states of matter: solids that deform; and fluids that flow. Both gases and liquids flow, they are fluids, the first compressible, the other incompressible. In general, both the fluid-like and the solid-like properties of a material can be complex, in the sense that the solid part may not be purely elastic, and the fluid part may not be purely viscous. For simple incompressible and athermal molecular fluids, the relaxation time will simply be the viscous dissipation time  $\tau = \delta^2/\nu$ , where  $\delta$  is the thickness of the momentum boundary layer and  $\nu$  is the kinematic viscosity. For more complex fluids,  $\tau$  can have a large range of origins, which often require chemistry and/or biology to be well understood.

In the first part of this letter I wish to highlight the potential factors that have to be taken into account in computing the value of  $\tau$  for cats. Fig. 2a shows the capillary bridge formed during extensional rheometry of *Felis catus*. First, in the introduction, we assumed  $\tau$  to be a scalar, but it can have a higher dimensionality. Usually the time scale is considered as a contribution to viscosity, which in the most general case is a tensor of rank 2. For simple incompressible fluids symmetry considerations reduce this tensor to a scalar. The extensional viscosity is simply 3 times the shear viscosity. For complex

fluids, the extensional viscosity can be orders of magnitude different, usually larger than the shear viscosity for polymeric materials. For cats, the determination of the Trouton ratio is complicated but the situation seems opposite. In the absence of reliable extensional rheology data, we can only point to the fact that when cats are deformed along their principal axis, they tend to relax more easily, suggesting that the extensional time is smaller than the shear time. Transient strain-hardening can nonetheless occur. Second, because, flows of cats are usually free surface flows, the surface tension between the cat and its surrounding medium can be important and even dominant in the rheology, especially in CATBER (Capillary thinning and breakup extensional rheometer) experiments. The capillary number becomes important  $\tau = f(Ca)$ , with  $Ca \equiv \eta U / \gamma_{LV}$ , where  $\eta$  is the shear viscosity,  $U$  is a characteristic flow velocity and  $\gamma_{LV}$  is the surface tension (not to be confused with the deformation). Let us recall that even water droplets bouncing on hydrophobic substrates can behave elastically, with a response time  $\tau = \sqrt{\rho R_0^3 / \gamma}$ , where  $\rho$  is the density and  $R_0$  the size of the drops. When the fluid is complex, the situation can be even more entangled.

The wetting and general tribology of cats has not progressed enough to give a definitive answer to the capillary dependence of the feline relaxation time. Fig. 2b gives an example of a lotus effect of *Felis catus*, suggesting that the substrate is superfelidaphobic. This behavior is usually distinguished from the yield stress that cats can also display, as shown in Fig. 2c, where the kitten cannot flow because it is below its yield stress, like ketchup in its bottle. It is still unclear what physical and chemical properties generate superfelidaphobicity, but a Cassie-Baxter-like model seems plausible. Here, the roughness of the cat's fur would be as determinant as the roughness of the substrate, but probably with somewhat opposite effects. Indeed, cats are often found to spread on rough substrates as seen in Fig. 2d, but they have low affinity for substrates that smooth their fur, like water in Fig. 2e. Significant wall slip and shear localization can also be involved in some experiments, like shown in Fig. 2f, where there is a very significant relative velocity between the substrate and the cat. Counter-intuitively, gravity seems

(continues page 30)

# Barry Bernstein 1930-2014

In January of this year the rheology community lost a pioneer in the field and dear friend when Barry Bernstein died peacefully at his home in Chicago. Barry was a native New Yorker—he was born in Brooklyn, attended high school in the Bronx, and received his B.S. in mathematics from the City College of New York. He received his Ph.D. in mathematics-mechanics from Indiana University in 1956. The first 15 years of Barry's career were spent at the Naval Research Laboratory and the National Bureau of Standards (now NIST), where he published papers on a wide range of topics with coauthors that included C.A. Truesdell, J.L. Erickson and R.A. Toupin. In the early 1960's, with collaborators E.A. Kearsley and L. J. Zapas, Barry published a series of papers on a rheological constitutive equation known simply as the 'BKZ model.' Barry also made important contributions in areas that include hypo-elasticity, thermodynamics and finite element methods.

Barry joined the faculty of Illinois Institute of Technology in 1966 where he was a professor in the Depart-

ment of Mathematics and then in the Department of Chemical Engineering. During his 40 years at IIT, Barry was actively involved in research, teaching and faculty governance. Barry was a life-long learner with a passion for travel, literature and languages. Those who were fortunate to know him will remember his wit – often expressed in wordplays or poems (for example, see "Rheol-logic" in *Proc. IVth International Congress on Rheology*, p. 31, 1963). After his retirement, Barry spent much of his time traveling with his wife Judith, and visiting with their children and grandchildren. Barry Bernstein was a gentleman and a scholar whose contributions to our field will be remembered for years to come.

*Tribute by Dave Venerus*



Barry Bernstein (center) with fellow Chicago Society of Rheology members Jay Schieber (left) and David Venerus (right) attending an Annual Meeting at Wrigley Field in the summer of 1996. For an update on the Chicago Society of Rheology activities, see photo page 29.

# Howard Brenner 1929-2014

Howard Brenner, 1980 Bingham medalist of the Society of Rheology and professor emeritus of chemical engineering at the Massachusetts Institute of Technology, died on 17 February 2014.

Brenner was well known in fluid mechanics and rheology for his 60 years of scholarship and disciplinary leadership.

He was the co-author of three influential text books and more than 200 scholarly papers. He was the mentor to two generations of rheologists and fluid mechanicians.

A complete obituary will appear in the January 2015 *Bulletin*. A memorial service will be held at MIT in Fall 2014.

# Society Business



## NEWS

### Society of Rheology Treasurer Transition in 2015

SOR Treasurer Monty Shaw, in office since October 1997, has announced that he will not seek re-election in 2015. Shaw's service to the Society for these 17 years (it will be 18 years by the time he steps down) have been exemplary. Candidates interested in serving the Society as Treasurer are invited to contact Shaw to learn more about the position. See the Society's web page for Shaw's contact information.

### AIP Governance Changes in the Works

The Society of Rheology is a member of the American Institute of Physics (AIP), an umbrella society of societies established in 1931. The constitution of AIP has been changed but rarely, and a complete overhaul of the constitution is underway. Faith Morrison (Michigan Tech) is currently designated by the SOR to sit on the AIP Governing Board; she and her predecessors, Mort Denn (Levich Institute) and Jeff Giacomin (Queens University, Kingston), have been active in the governance talks for the past five years.

A significant formal step in the governance change process was taken by the AIP Board in March 2014 when it voted to reduce the Board size and alter the representative nature of the Governing Board (see [www.aip.org/commentary/governance-reform](http://www.aip.org/commentary/governance-reform)). The changes require constitutional amendment, a process that is now underway. Following the current rules for modifying the AIP constitution, any revisions must be voted on by the member societies. It is anticipated that this vote will take place this November, with SOR's vote being cast by the President and Vice President of the Society, by proxy. The details of the wording of the amended constitution are being worked out between

June and November 2014 by a Special Committee on Governance, on which SOR is represented by Morrison.

In addition to the changes in the size and structure of the AIP Governing Board, other significant changes in the AIP constitution are being proposed. SOR leadership will have the opportunity to weigh-in on the proposed changes during a conference call in October. Completion of the new draft bylaws will be followed by a vote of the current Governing Board on November 4 and the proxy vote by the member societies, tentatively scheduled for late November. The new, smaller governing board is expected to be seated by the end of 2014.

### Community Outreach Effort Announced

The Education Committee of SOR, in an effort headed by committee member Mike Boehm (University of Queensland, [m.boehm@uq.edu.au](mailto:m.boehm@uq.edu.au)) has proposed several Community Outreach initiatives for 2014 and onwards. These initiatives are designed to increase SOR's exposure, show that the society is committed to increasing youths' involvement in the sciences, and finally to provide SOR members with a fun and rewarding volunteer opportunity.



The first initiative is to create a database of rheology- and physics-based demonstrations. This database will be available to the public for free. Members are encouraged to share any demonstrations and hands-on activities they have developed. Members may also participate by submitting favorite YouTube videos demonstrating rheological phenomena. The Committee also solicits any other online educational material that members think could be useful for K-12 outreach activities.

For the second initiative, starting with the 2014 Annual SOR Meeting in Philadelphia, the Education Committee, in collaboration with a local science center, museum or school, will provide hands-on demonstrations aimed at children in particular, and adults in general. For

2014, the Committee is collaborating with the Franklin Institute. The Committee will provide the Franklin Institute's patrons an opportunity to learn about rheology and play with interesting materials, for example corn starch in water, and discover that Science really is cool. Currently, the outreach activities are planned for Sunday 5 October 2014 from 1pm until 4pm; this schedule gives all those who participate plenty of time to make the Conference Welcome Reception. Volunteers are still needed for Philadelphia; contact Mike Boehm (m.boehm@uq.edu.au). The demonstrations/activities should last 10-15 minutes and repeat several times during each one-hour block.

## Rheology in the Blogosphere

Searching around for rheology news, your *Bulletin* editor searched for "rheology news" and was led to the blog io9. io9 was launched in 2008 by Gawker Media and focuses on science fiction, fantasy, futurism, science, and technology. Proving how *with it* this blog is, they have a rheology tag (*io9.com/tag/rheology*).

Currently up on the rheology tag are the following: "Your Afternoon Catharsis: Liquid Droplets Coalescing in Slow Motion," "Behold the absolute mind-boggery of a knuckleball in flight," and "This number proves that nothing in the world is solid" (can you guess? Yes, the Deborah number). Next time you're killing some time at the computer, check it out.

## From the Archives: "The Science of Rheology," *Nature*, 146, 580-582 (1940), by V. G. W. Harrison.

"The word 'rheology' was coined in the United States in 1929 to denote the science of the deformation and flow of matter. Though the name is new, the science itself is old, and man has had a practical knowledge of some of the main facts of rheology since very early times. . . If it be of any advantage to man to improve bread, butter, cheese, jam, chocolate, inks, paints, varnishes, textiles, building materials and a host of other everyday commodities—without which civilization as we know it could not exist—then the study of rheology needs no further justification."

Hear hear!

## Travel Grants Offered for Philadelphia

The SOR is supporting student travel to the Philadelphia 86<sup>th</sup> Annual Meeting of the Society of Rheology through its *Student Meeting Travel Grant Program*, administered by SOR ExCom member-at-large Norm Wagner. These grants are available to any graduate student who is a member in good standing of the Society as of 8 August 2014 and whose faculty advisor is also a member as of that date. In addition, the student must coauthor a paper or present a poster at the meeting, and stay in the official meeting hotel, Loews Philadelphia Hotel. See the web for details [www.rheology.org](http://www.rheology.org).

## European Rheology: AERC2015

The 10<sup>th</sup> Annual European Rheology Conference AERC2015, will take place 14-17 April 2015 in Nantes, France, sponsored by the Groupe Français de Rhéologie. The meeting also marks the 50<sup>th</sup> anniversary of the Groupe Français de Rhéologie. For more information, please visit the conference website [rheology-esr.net/events/aerc-2015-nantes/](http://rheology-esr.net/events/aerc-2015-nantes/). Abstracts for AERC presentations are due 30 November 2014.

## World Rheology: ICR2016

The next International Congress on Rheology is scheduled to take place 8-13 August 2016, in Kyoto, Japan (ICR-2016). The contact organizer is Hiroshi Watanabe, Kyoto University, Japan.



ICR-2016 is co-organized by: the Society of Rheology, Japan; the Japanese Society of Biorheology; and the Japanese Society of Polymer Processing in collaboration with: the Institute for Chemical Research, Kyoto University, Japan; Department of Macromolecular Science, Osaka University, Japan; Graduate School of Science and Engineering, Yamagata University, Japan; and the Kyoto Convention Bureau.

The conference website, [icr2016.com](http://icr2016.com), will be updated as planning proceeds. We invite you to make your own plans to join us in Kyoto in 2016.

## Solution Manual and Errata Available

Contact Monty Shaw (montgomery.shaw@uconn.edu) for a copy of the solution manual for the text *An Introduction to Polymer Viscoelasticity* (Wiley, 2005). The solution manual has worked-out solutions to problems from the text that lack appended solutions, and is intended for instructors of courses that use *An Introduction to Polymer Viscoelasticity* as a required text. The *Errata* is available to anyone.

## Minutes of the ExCom Meeting

Sunday, 18 May 2014  
AIP Headquarter, College Park, Maryland

Attending: Greg McKenna, Gareth McKinley, Albert Co, Monty Shaw, Ralph Colby, Shelley Anna (via phone), Dimitris Vlassopoulos, Norm Wagner, Jeffrey Giacomin, Faith Morrison, Andy Kraynik, Gerry Fuller, Chris White, Michael Mackay, Amy Shen, Kalman Migler, Anne M. Grillet (via phone), Jason Maxey (via phone), and Fred Dylla (AIP).

President Greg McKenna called the meeting to order at 7:44 a.m. in Conference Room C, AIP Headquarters, College Park, Maryland.

The minutes of 13 October 2013 meeting were read by Secretary Albert Co. Two typos were noted: "society" in the URL and "Shen." A motion to approve the amended minutes passed.

Monty Shaw reported on the financial status of the Society and *JOR*. Shaw showed spreadsheets of receipts and disbursements. Several entries were discussed. Shaw noted that the finances for the fiscal year 2013 were satisfactory, considering there were two meetings (Pasadena and Montreal) in the year. The Montreal meeting made over \$15,000 and the short course made almost \$5400. There was a small loss of about \$13K for the year. The income and expenses of *JOR* were discussed. Travel expenses for Metzner awardees were discussed but no resolution was made. AIP dues increased from \$4 to \$10 per member. A motion to approve the treasurer report passed.

Ralph Colby gave the *JOR* Editor report. Colby showed the manuscript submission trends over the last five years. New manuscript submissions were up to 180 in 2013, from a typical average of 140. Most submissions are from the US, followed by China. The number of submissions from China has increased sharply. Colby

said that the Chinese Academy of Sciences listed *JOR* as a top journal in the "Mechanics" subcategory. Giacomin was asked to find out more about this designation.

Colby showed various graphs on *JOR* statistics: 49% acceptance rate (72 accepted), 51 days to first decision, and 103 days from receipt to final decision. The Editor is working to reduce the small number of articles that take a long time to get through the process. The use of e-mail alerts to facilitate this was suggested. The most recent impact factor of *JOR* is 2.795 (2012).

A special issue of the *Journal of Rheology* on colloidal gels is planned. This special issue, with George Petekidis as guest editor, will be based on the Crete meeting on July 9 and 10. Colby was asked by Morrison to prepare a short blurb on this editorial innovation for the *Bulletin*.

The continuation of the *subject* and *author* indices that appeared with *JOR* was discussed. The ExCom leaves it up to the editor to decide on continuing or dropping these indices. The use of CrossCheck was brought up. Dylla said that AIP used it to spot check for its own journals and paid a per article charge for the service.

Inviting Metzner awardees to submit papers to *JOR* was suggested. Morrison asked if it would be acceptable to publish parts of the editor's report in the *Bulletin*. There were no objections. Morrison will work with Colby on how this can be done.

A motion to approve the Editor's report passed.

Faith Morrison gave the *Rheology Bulletin* editor report. All is going well. June 16 is the deadline for the July Bulletin. She requested suggestions for the cover graphic. Currently the *Bulletin* has two advertisers, down from six at one point.

Gareth McKinley reported for the *ad hoc* Committee on Electronic Publishing and Open Access Policies, composed of McKinley, Tom McLeish, Roseanna Zia and two *ex officio* members, Ralph Colby and Jeff Giacomin. The differences among gold open access, green open access, and hybrid access were clarified. The current status of the open access initiative in the US and UK were also discussed. Fred Dylla mentioned that publishers have come up with a solution – CHORUS ([chorusaccess.org](http://chorusaccess.org)), which was developed using the CrossRef system. McKinley indicated that the issue of changing the transfer of copyright agreement would be addressed in the executive session. He requested that Faith Morrison be added to the *ad hoc* committee. Morrison agreed and McKenna appointed her. The committee will continue the on-going process of studying SOR policies on electronic publishing and open access.

Fred Dylla gave handouts on CHORUS and AIP/SOR interactions. AIP is revising its bylaws this summer (to be voted in the fall) and its governing board will reduce from 40 members to 15 members. SOR will get one designee for the new board. Dylla proposed a special SOR “belly banded” issue of *Physics Today* to be used to promote SOR.

Joe Anderson of AIP took the meeting attendees on a tour of the Niels Bohr Library.

Gerry Fuller reported for the *ad hoc* Committee on Awards, which consists of Fuller, Faith Morrison and Eric Shaqfeh. The committee proposed amending the Rules to make the Bingham Award a truly international award. Currently the Rules require that the Bingham medalist be a resident of North America or a member of the SOR. The committee recommended removing the restrictions on eligibility. The proposed amendment would be discussed further in the executive session.

Fuller also presented the proposed changes to the Rules to make the Rules align with the current practice of forming the committee for the *Journal Publication Award*. The proposed amendment would be discussed further in the executive session.



Fuller presented the draft of two new sections on Metzner Award, to be added to the Rules. Faith Morrison suggested that the line stating that SOR membership not required was unnecessary; the committee agreed. The proposed amendment would be discussed further in the executive session.

Fuller opened a discussion on creating the category of “fellow” of The Society of Rheology. There was extensive discussion on the pros and cons of this proposed category. McKenna and Fuller will write an article for the *Bulletin* to bring more voices into the discussion. This will be discussed again at the October meeting.

Michael Mackay discussed the arrangement for the Philadelphia (2014) meeting. The meeting budget and the layout of the meeting rooms were discussed. Mackay will work with Amy Shen to finalize the meeting arrangements.

Amy Shen presented the technical program for the Philadelphia (2014) meeting. The schedule grids for the technical program were progressing as planned.

Kalman Migler went over the plans for the Baltimore (2015) meeting. The contracts have been signed. The Monday reception is planned at the Baltimore

Aquarium. McKenna asked Migler to have a detailed budget spreadsheet for review at the 2014 October meeting.

Greg McKenna presented the technical program for the Baltimore (2015) meeting for Rajesh Khare and Susan Muller. It was pointed out that industrial participants do not like a session named “Industrial Rheology,” they prefer that industrial contributions be included in other topical sessions. McKenna will let the chairs know about this.

Andy Kraynik reported that planning for the Tampa (Winter 2017), Denver (2017), and Houston (2018) meetings are all proceeding smoothly. Gareth McKinley indicated that he had contacted groups in Santa Barbara, Chicago, and Boston as possible hosts of future annual meetings.

Jason Maxey called in to give the report of the Membership Committee. Membership is stable at about 1400 members. As usual, members are slow to renew. Should we retain the one-year and two-year unpaid former members, the number would increase to 1900. Sending monthly renewal notices with the current *JOR* cover was suggested to increase the number of renewals. McKinley suggested that we should push the *JOR* Table of Contents to current members and unpaid former members to help build interest in *JOR* and SOR membership. The Membership Committee is continuing the hourglass program for PhD students. It was suggested that this program be publicized more. Faith Morrison asked Maxey for an article on the program, with a picture of the hourglass gift, for the *Bulletin*. She suggested bringing samples of the hourglass to the annual meeting and setting up a display to further publicize the program. Other Membership Committee activities included following up with *JOR* authors; however, it was unclear if these activities were effective. Maxey suggested finding some *JOR* papers to highlight to industrial folks to encourage them to join SOR. The Membership Committee discussed the “belly band” for *Physics Today* but did not come to a consensus to support it, considering the cost. Norm Wagner suggested that we should find out from non-members what would make them join SOR.

Greg McKenna reported for the Education Committee (chaired by Jonathan Rothstein). Suggestions for the short course at the Baltimore (2015) meeting included *Beginning Rheology* and *Microrheology*; the committee is open to suggestions from the ExCom and the membership. The Education Committee is also planning K-12 outreach activities. Morrison will give information to Rothstein about kits for K-12 that she saw at the Assembly of Society Officers of the AIP. A K-12 Outreach Event is planned at the Franklin Institute on Sunday 5 October 2014 1-4pm (start of the Philadelphia meeting) to demonstrate rheology; Morrison will

# Society's Report

contact Michael Boehm to get a *Rheology Bulletin* article on this event.

Albert Co gave the webmaster report. The abstract and registration web sites have moved to a new virtual server. The web sites are being redesigned to be mobile friendly.

Monty Shaw reported that the contribution to the Physics Olympiad had increased from \$1,500 to \$1,650.

Jeffrey Giacomin reported on AIP Publications. The new Scitation platform is slow and is not performing up to expectations. In July the SOR membership data will be moved to the Advantage system.

Greg McKenna reported for Gerry Fuller about international outreach. Two countries are interested in hosting the next International Congress on Rheology scheduled in the Americas.

Faith Morrison gave the AIP Designee report. There is a meeting of the AIP Corporation expected in November at which we are going to be asked to approve new bylaws. Morrison is on the committee working on the new bylaws. There is a retreat in June to do this work and then work will continue by electronic means from July to November.

The meeting entered into executive session at 4:20 pm.

Anne Grillet called in to report for the Nominating Committee. The candidates for the treasurer were discussed and the Nominating Committee presented their recommendation. Monty Shaw made his comments. A motion to accept the report of the Nominating Committee passed.

A motion to send the SOR Rules amendments on the Bingham Award, as recommended by the *ad hoc* Committee on Awards, to the members for balloting passed.

A motion to send the SOR Rules amendments on the *Journal* Publication Award, as recommended by the *ad hoc* Committee on Awards, to the members for balloting passed.

A motion to send the SOR Rules amendments to add the Metzner Award, as recommended by the *ad hoc* Committee on Awards, to the members for balloting passed. Greg McKenna will write a message to the membership on these SOR Rules amendments for publication in the *Bulletin*.

A friendly amendment to combine all the votes on SOR Rules amendments into a single vote passed.

An article describing the proposed “fellow” category will appear in the *Rheology Bulletin*. The topic will be discussed in the Business Meeting at the Philadelphia (2014) meeting.

The changes to SOR Open Access policy was further discussed. A motion to replace the current SOR Transfer of Copyright Agreement with one conforming closely to AIP Transfer of Copyright Agreement (replacing “AIP Publishing LLC” with “The Society of Rheology”) failed, with three yeses and six noes.

An amendment to ask AIP to post manuscripts automatically online, contingent on cost, passed.

The meeting was adjourned at 6:00 pm.

Submitted by

Albert Co, Secretary

## Treasurer's Report

To the Membership:

As is the custom, the report that follows provides information concerning the financial performance and condition of The Society of Rheology for the last couple of years. In addition, a draft budget for 2015 is listed, which will be presented for discussion and approval at the Business Meeting in October.

Due to the timing of the income and expenses for the Pasadena meeting, we anticipated a significant loss or 2013. However, due to the strong financial position of the Montreal meeting and favorable performance of the *Journal*, the result was only a moderate loss, which we can easily accommodate.



Respectfully submitted,

Montgomery T. Shaw, Treasurer

# Treasurer's

**The Society of Rheology, Inc.**

**Balance Sheet**

(all amounts, USD)	2013 Year End	2012 Year End	2011 Year End	2010 Year End	2009 Year End
<b>Assets</b>					
Cash in checking account(s)	147,077	73,886	41,084	13,257	18,330
Securities	0	0	0	0	0
Balance in AIP account	1,595,079	1,685,279	1,545,020	1,435,019	1,425,005
<b>Total Assets</b>	<b>1,742,155</b>	<b>1,759,165</b>	<b>1,586,104</b>	<b>1,448,276</b>	<b>1,443,335</b>
<b>Liabilities and Net Assets</b>					
<b>Liabilities</b>					
Deferred subscription revenue					
Deferred member dues					
Deferred revenue	100,652	114,980	111,633	89,283	125,501
<b>Total Liabilities</b>	<b>100,652</b>	<b>114,980</b>	<b>111,633</b>	<b>89,283</b>	<b>125,501</b>
<b>Net Assets</b>					
Publication reserve	450,000	450,000	450,000	450,000	450,000
Student travel grant reserve	30,000	30,000	30,000	30,000	30,000
Annual Meeting reserve	300,000	300,000	300,000	300,000	300,000
Operating reserve	150,000	150,000	150,000	150,000	150,000
<b>Unrestricted</b>	<b>711,503</b>	<b>714,185</b>	<b>544,471</b>	<b>428,994</b>	<b>387,834</b>
<b>Total Net Assets</b>	<b>1,641,503</b>	<b>1,644,185</b>	<b>1,474,471</b>	<b>1,358,994</b>	<b>1,317,834</b>
<b>Total liabilities and net assets</b>	<b>1,742,155</b>	<b>1,759,165</b>	<b>1,586,104</b>	<b>1,448,276</b>	<b>1,443,335</b>

***Journal of Rheology***

**Receipts and Disbursements**

(all amounts, USD)	2015 Budget	2014 Budget	2013 YearEnd	2013 Budget	2012 Year End
<b>RECEIPTS</b>					
Subscriptions	145,000	142,000	148,137	145,000	145,850
Royalties & Reprint Sales	60,000	80,000	69,736	6,300	108,919
Ad Sales	30,000	45,000	30,800	49,000	39,602
JORO revenue	70,000	78,000	72,872	75,000	84,695
Miscellaneous	2,000	2,000	4,105	2,000	0
<b>TOTAL RECEIPTS</b>	<b>307,000</b>	<b>347,000</b>	<b>325,649</b>	<b>277,300</b>	<b>379,066</b>
<b>DISBURSEMENTS</b>					
Ads	9,000	11,000	8,233	14,000	10,305
Reprints, Single Copy	700	1,300	464	1,200	2,188
Paper, Printing	30,000	27,600	35,858	29,000	27,340
JoR Editorial	45,000	46,000	42,550	45,000	50,272
Production	39,000	38,000	42,120	38,000	35,955
Fulfillment	5,215	5,215	5,118	5,550	5,203
Distribution	23,000	20,900	24,627	19,900	20,630
Electronic publishing	49,500	52,000	49,609	50,000	49,239
Miscellaneous	9,900	7,750	18,187	8,200	4,866
<b>TOTAL DISBURSEMENTS</b>	<b>211,315</b>	<b>209,765</b>	<b>226,765</b>	<b>210,850</b>	<b>205,998</b>
<b>Net</b>	<b>95,685</b>	<b>137,235</b>	<b>98,884</b>	<b>66,450</b>	<b>173,068</b>

**The Society of Rheology**  
Receipts and Disbursements

	<b>2015 Budget</b>	<b>2014 Budget</b>	<b>2013 Year End</b>	<b>2013 Budget</b>	<b>2012 Year End</b>
<b>RECEIPTS</b>					
Dues	48,000	47,000	49,305	44,500	47,100
Interest	1,800	2,700	1,174	3,000	2,736
Journal of Rheology	307,000	347,000	325,649	277,300	379,066
Mailing List Sales	0	0	0	0	0
Donations	0	0	0	0	0
Bulletin Advertising	7,200	8,000	6,340	10,000	7,625
Annual Meeting (net)	0	0	-10,789	0	40,664
Short Course (net)	0	0	-6,376	0	1,961
<b>TOTAL RECEIPTS</b>	<b>364,000</b>	<b>404,700</b>	<b>365,303</b>	<b>334,800</b>	<b>479,152</b>
<b>DISBURSEMENTS</b>					
AIP Dues Bill & Collect.	11,000	11,000	11,033	11,500	11,027
AIP Adm. Services	7,500	8,000	7,500	10,000	7,500
AIP Mem. Soc. Dues	14,000	9,000	13,886	0	3,375
Contributions and Prizes	3,000	4,000	1,500	3,500	3,691
Early Career Award	8,500	9,000	15,100	18,000	0
Journal of Rheology	211,315	209,765	226,765	210,850	205,998
Bulletin	17,000	18,000	16,836	18,000	18,225
Bingham Award	11,000	10,000	20,000	20,000	0
Executive Cmt. Meetings	15,000	18,000	10,710	20,000	16,566
Pres. Discretionary Fund	1,500	1,500	919	1,500	799
Treas. Discr. Fund	1,500	1,500	0	1,500	389
Bulletin Editor Discr. Fund	1,500	1,500	0	1,500	0
Progr. Chm. Discr. Fund	3,000	3,000	1,395	6,000	0
Webmaster Discr. Fund	3,000	3,000	3,000	3,000	3,500
International Activities Fund	5,000	5,000	1,313	5,000	4,292
Office Expenses	1,700	1,500	1,614	500	1,905
Banking Services	120	400	0	160	337
Liability Insurance	5,600	5,500	5,413	5,200	5,079
Membership Broch. & Appl.	500	0	62	0	0
Accountant	2,300	2,400	2,210	2,300	2,240
Student member travel	25,000	25,000	37,675	50,000	21,480
Annual meetings, future	4,000	6,000	1,076	6,000	1,267
Website	1,000	200	819	200	0
Miscellaneous	100	100	0	100	0
<b>TOTAL DISBURSEMENTS</b>	<b>354,135</b>	<b>353,365</b>	<b>378,825</b>	<b>394,810</b>	<b>307,670</b>
<b>Net</b>	<b>9,865</b>	<b>51,335</b>	<b>-13,522</b>	<b>-60,010</b>	<b>171,482</b>

end

# Treasurer's Report



Some members of the Wagner research group gathered at Newark's famed DeerPark restaurant to celebrate a successful PhD defense this past May. From left to right: Paul Mwasame, Stijn Koshari, Colin Cwalina, Doug Godfrin, Norm Wagner, newly minted Ph.D. Kate Gurnon, Matt Armstrong, Ru Chen, Rich Dombrowski, Michelle Calabrese, Dan Greene, Soo Kim, Jingsi Gao, Simon Rogers.

cal techniques to deduce interparticle forces between colloidal particles. For example, Norm and Norbert Wilenbacher of BASF employed torsional resonators at a range of frequencies (23–358 kHz) to determine the high frequency modulus of dispersions of polystyrene latices with grafted layers of poly(methacrylic acid). From those data they determined that the complex electrosteric forces were dominated by the excess osmotic pressure generated when the grafted layers overlap. Recent publications (e.g. *Langmuir* **28** 1866–78 2012) demonstrate how far his group has come in this direction. This work with collaborators at NIST and Universidad de Guanajuato in Mexico employed TEM and densitometry to characterize the silica particles with grafted octodecyl chains; a stress-controlled cone and plate rheometer to characterize the linear viscoelasticity as function of temperature, frequency, and concentration; fiber-optic quasi-elastic light scattering to characterize the pair potential and detect the gel transition; and small-angle neutron scattering to characterize the structure as a function of temperature and volume fraction. This determines the gel line and the spinodal and verifies the liquid-crystal transition, i.e. the thermodynamics as well as the rheology.

Norm's research on surfactant solutions with Eric

Kaler might be exemplified by their well-cited paper (*Langmuir* **19**(10) 4079–89 2003) on mixed cationic/anionic wormlike micelles. With rheology, flow birefringence, and small-angle neutron scattering over a broad range of solution compositions, they determined the microstructural length scales (persistence, entanglement, interaction, and contour lengths) that govern the rheology. They concluded that the characteristics of the added salt affect the persistence length and, hence, the microstructure and rheology. Varying surfactant and electrolyte concentration and composition systematically allowed them to span rheological behavior from nonionic wormlike micelles to polyelectrolytes.

The growing breadth of his capabilities is exemplified by two very recent papers, one characterizing the uptake of fluorescent dendrimers into cancer cells in *Biochimica et Biophysica Acta-Biomembranes* and a second applying elastomers to control wrinkles in skin in *ACS Macro Letters*.

Finally, Norm's long-standing and highly productive collaboration with Jan Mewis pulled him into classical issues that many modern rheologists avoid, that is, thixotropy. The basic elements of thixotropy are well reviewed in their paper (*Advances in Colloid and Interface Science* **147-48** 214–227 2009).

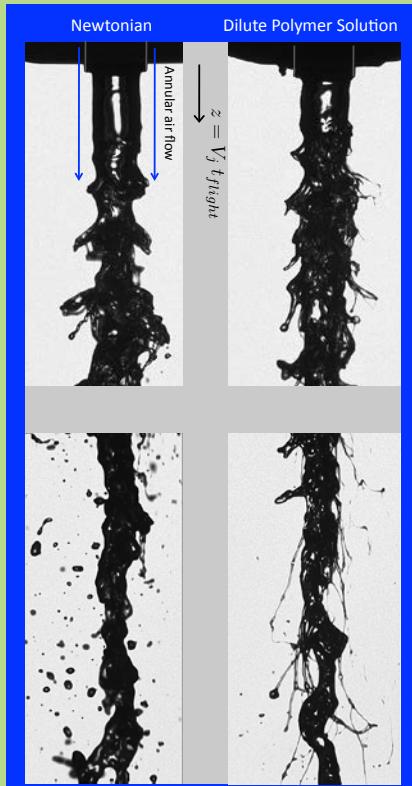
Norm's work on shear thickening fluids has also captured the interest and imagination of many outside of the rheology community. He has shared this work in venues as diverse as National Public Radio (US), the Smithsonian Institution's "Going to Extremes" seminar series, and recently, a White House Office of Science and Technology Google Hangout, "We the Geeks: The Stuff Superheroes Are Made Of."

During his recent sabbatical year after completing his service as the Department Chair of Chemical and Biomolecular Engineering at the University of Delaware, Norm visited colleagues, friends, and family. In true Norm fashion, over a short four month period he packed in visits to Lund University, TU Berlin, KIT Karlsruhe, ETH Zurich, KU Leuven and IIT Madras, all the while keeping up with his research group of undergraduates, graduate students and postdocs back in Delaware and finding time to participate in neutron scattering experiments at the Institute Laue Langevin, Grenoble, France and the NIST Center for Neutron Research, Gaithers-

burg, MD. Nothing seems to charge up Norm more than the graveyard-shift at the neutron beamline.

Lastly, Norm is an indefatigable leader of outdoor adventures, whether it's an Earth Day hike in nearby White Clay Creek (see photo page 7), an annual summer float with his research group and friends down the Brandywine river, or a conference-break jaunt to the summit of Saddle Peak in the Santa Monica Mountains. Norm also enjoys bow hunting, squash, and, in the spirit of Delaware's own Caesar Rodney, horseback riding.

Norm met his wife Sabine while he was a postdoc at the University of Konstanz and she was a student of International Politics, Linguistics, and English Literature. A native of Germany, Sabine teaches World Languages and Cultures at Archmere Academy in Wilmington. Together, Sabine and Norm travel frequently to visit family in Europe and to host study abroad experiences for American students. They live in a quiet neighborhood of rolling hills and cul-de-sacs just outside of Newark.



### More on the Cover Image

Four snapshots showing the process of air-assisted atomization, captured via digital video strobe-imaging. The images show a side-by-side comparison for a Newtonian fluid (water and glycerol 60:40 wt.%) and a dilute polymer solution at two different distances ( $z/R_0 = 0, z/R_0 = 6.7$ ) from the atomizing nozzle (radius  $R_0 = 85\mu\text{m}$ ). In both the Newtonian and viscoelastic cases the core jet of liquid to be atomized is surrounded by a high-speed annular flow of air ( $\text{We}_j \equiv \rho_{\text{air}} V_j^2 R_0 / \sigma = 18$ ). The viscoelastic solution is made by dissolving a small amount of poly(ethylene oxide) (PEO) into the Newtonian solvent ( $c = 0.01 \text{ wt. \% } c/c^* = 0.036$ ); the resulting solution has a shear viscosity very close to the solvent ( $\eta \approx \eta_s = 3.2 \text{ mPa.s}$ ) and the Ohnesorge number for both jets is  $\text{Oh} \equiv \eta / \sqrt{\rho \sigma R_0} = 0.02$  indicating that viscous effects are small. The measured relaxation time for the viscoelastic solution is about  $\tau_E = 60 \mu\text{s}$  and the Deborah number for the viscoelastic jet is therefore  $\text{De} \equiv \tau_E / \sqrt{\rho R_0^3 / \sigma} = 0.03$ . The images show that close to the nozzle viscoelastic effects are negligible and both jets initially evolve similarly with destabilization through a Kelvin-Helmholtz instability. However, far from the nozzle, the polymeric additive increases the elongational viscosity and the enhanced extensional resistance resists the fast nonlinear deformations that occur during the capillary break-up process, leading to the formation of ligaments and much poorer atomization for the viscoelastic jet. Photo credit: Bavand Keshavarz and Gareth McKinley (MIT).

(continued from page 10)

resources such as ArXiv or DSpace. It neither explicitly forbids, nor permits such actions by authors—principally because the idea did not exist when the CTA was written. All of the other journals published by AIP adopted a new, more flexible CTA when AIP Publishing LLC became a separate entity in 2013, but the SOR did not follow suit at the time. The *ad hoc* committee made the recommendation that the *Journal of Rheology* should adopt a version of this new CTA as soon as possible, and in May the Executive Committee voted to approve this recommendation. Amongst other electronic rights, this new CTA gives article authors the right to post the final author-generated (and Editor-accepted) version of their manuscripts (i.e. what is often referred to as a ‘postprint’) on their own websites, company or university websites, as well as in the ArXiv or other collective depositories. We are presently working with AIP Publishing to finalize the legal phrasing of the language in this new CTA, and we expect it to be in place by early Fall.

The change in the *JOR* CTA helps resolve and clarify one of the most contentious issues discussed at the last Business Meeting. Other concerns remain, however, with respect to Open Access initiatives that are being driven by libraries, scientific societies, authors, and government legislation. The principal driving argument of the Open Access movement is that publicly funded research should be freely available to the public, without cost. This philosophy is a challenge to the status quo of scholarly publishing, which historically has rested on subscription revenue to support publishing activities.

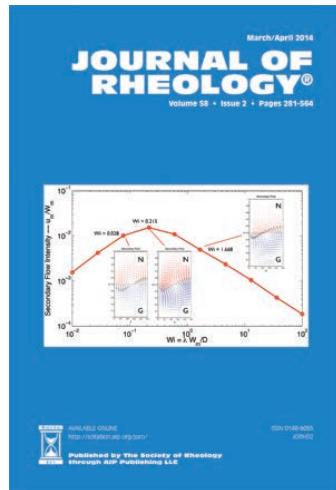
The *JOR* is presently viewed as a “hybrid journal,” which provides options to authors so that they can either (a) publish in the journal at no charge, by giving up their copyright to the publisher (who then restricts access to the type-set and final authoritative version of the published article behind a subscription or pay-wall), or (b) pay an Article Publication Charge or APC (presently \$2500 for the *Journal of Rheology*) that makes the article freely available (for eternity) on the *JOR* website. This is commonly referred to as one aspect of “Green Open Access”—see the URLs at the end of this article for clarification of these terms. Another class of electronic journals is referred to as “Gold Open Access” in which all published articles are accessible to the public, but the authors of those articles must always pay a publication fee. The journal *PLoS One* published by the Public Library of Science is probably the best-known example of such an approach—and it is now the largest scientific journal in the world.

The upcoming changes to the *JOR* CTA resolve the conflict between the current *JOR* publishing policy and the individual use by an author of a university-based or field-based collective repository to provide open access to their work. One aspect of Green Open Access that has not been resolved by the *ad hoc* Committee’s discussions to date regards the possibility of expanding

open access from the use of 3<sup>rd</sup> party repositories to making final published articles available (at no charge) on the publisher’s website after some specified period of time has elapsed (called the ‘embargo period’). The idea of the embargo period is analogous to the patent rights period familiar in the patent process—for the time period of the embargo, the publisher of the article retains exclusive rights to control access to the work, to reward effort and to earn income to offset publishing costs. Embargo periods typically vary from zero (for Gold Open Access, which typically involves a substantial fee), to perhaps 6 months or even

up to 12 or 24 months for some journals, depending on the pace and timeliness of the field. The very real concern to be considered here regards the tension between making the results of *JOR*’s peer-review process freely available to the public and the fact that we are then essentially giving away our Society’s principal ‘product,’ rather than making it available on a fee-basis (through personal or institutional subscription fees). The income from our publishing activities help underwrite other SOR activities such as student travel grants, our website, the *Bulletin*, and outreach efforts.

Action on the Open Access question has evolved from voluntary and hypothetical to essential over the last few years as various governments (including the US in 2013) issued requirements for Open Access rights for all government-funded research (see the memo from the White House Office of Science and Technology Policy, link provided below). Because of the continuing evolution in the Open Access landscape and its impact on *JOR* finances, the Executive Committee has asked the *ad hoc* Committee to continue to convene, with the addition of Faith Morrison (the SOR delegate to the AIP Governing Board) to its ranks. We will be continuing our discussions regarding electronic publishing, and we welcome input from members of the Society, especially regarding the issue of embargo periods and the ‘Green vs. Gold’ Open Access debate.



## Links and Online Resources to learn more about Open Access

Open Access—See the Wikipedia page ([en.wikipedia.org/wiki/Open\\_access](https://en.wikipedia.org/wiki/Open_access)) for more on this general topic.

SHERPA/RoMEO—an online guide to the Open Access Policies of over 3000 Different Journals: [www.sherpa.ac.uk/romeo/](http://www.sherpa.ac.uk/romeo/)

OSTP Memo of February 2013—Public access requirements on US Federally funded research issued by the White House Office of Science and Technology Policy (OSTP) in February 2013: [www.whitehouse.gov/sites/default/files/microsites/ostp/ostp\\_public\\_access\\_memo\\_2013.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf)

EU-Horizon 2020 statement on Open Access: [erc.europa.eu/sites/default/files/document/file/ERC\\_Open\\_Access\\_Guidelines-revised\\_2013.pdf](http://erc.europa.eu/sites/default/files/document/file/ERC_Open_Access_Guidelines-revised_2013.pdf)

CHORUS—Clearinghouse for the Open Research of the United States: [chorusaccess.org](http://chorusaccess.org). CHORUS is a publisher-led system for enabling compliance with the February 2013 OSTP memo. AIP is a member of CHORUS (see January 2014 *Bulletin*).

PubMed Central (PMC)—A free digital repository that archives publicly accessible full-text scholarly articles that have been published within the biomedical and life sciences journal literature.

PubFed Central—The possible name of an expanded PubMed Central to archive journal articles from all disciplines, not just the biomedical and life sciences fields.

SHARE— SHared Access Research Ecosystem: [www.arl.org/focus-areas/shared-access-research-ecosystem-share](http://www.arl.org/focus-areas/shared-access-research-ecosystem-share). SHARE is the proposal from the Association of Research Libraries to build a series of interlinked institutional repositories in order to allow compliance with the February 2013 OSTP memo.

arXiv—A repository of electronic preprints of scientific papers in the fields of mathematics, physics, astronomy, computer science, quantitative biology, statistics, and quantitative finance.

DSpace—An open source repository software package used for creating open access repositories for digital content.

Record of another successful meeting of the Chicago Society of Rheology at Wrigley Field in 2014. The gathering was dedicated to the memory of one of the founders, Barry Bernstein (see obituary, page 18). Attending in 2014, front row, from the left: Randy Ewoldt, Charles Schroeder, Lew Wedgewood, and Dave Venerus. Row behind, from the left: Jay Schieber, Kendra Erk, Vivek Sharma, Charles Sing and Wes Burhardt.



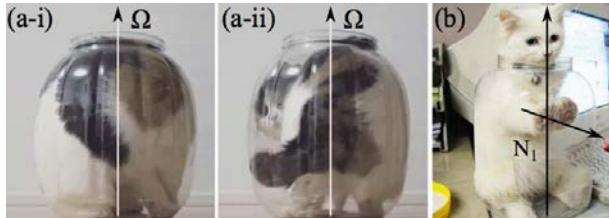


FIG. 3: (a) A cat spontaneously rotates in a cylindrical jar. (b) Normal forces and Weissenberg effect in a young sample of *Felis catus*. [Courtesy of (a) <http://guremike.jp/>, (b) <http://buzzlamp.com/10-weird-places-cats-get-stuck-in/>]

to enhance adhesiveness, as shown in Fig. 2g.

In the last part of this letter, I wish to discuss the possibility of flow instabilities in *Felis catus*. Linear viscoelasticity conceptualizes the fact that if its Deborah number is small a material is flowing. The physics of flow instabilities warns us that, as the characteristic rate of deformation  $\dot{\gamma}$  increases, non trivial secondary flows emerge and eventually become chaotic. Here, the important dimensionless number will be the Reynolds-Weissenberg number (a sort of Péclet number):

$$Rw \equiv \tau \dot{\gamma} \quad (2)$$

The limit  $Rw \ll 1$  defines the *laminar base flow*. Non-trivial *secondary flows* will usually appear around  $Rw \sim 1$ . Finally, the flow will be *turbulent* if  $Rw \gg 1$ . For simple fluids, the relaxation time is the viscous dissipation time, the driving force of instability is inertia and the dimensionless number is just the usual Reynolds number  $Rw = Re$ . For more complex fluids in creeping flow ( $Re = 0$ ) recent progress on instabilities in viscoelastic polymers and micelles solutions suggests that the relevant dimensionless number is the Weissenberg number alone, *i.e.*  $Rw = Wi$  if  $Re = 0$ . In this case elastic turbulence can be achieved without inertia. We speak of viscoelastic flow instabilities.

When taken in its philosophical form, “panta rhei” is *the theory of motion*: the belief that everything is dynamic and that the state of rest is illusory. But for centuries, this ontology was superseded by Aristotle’s viewpoint. He posited that in the absence of an external motive power all objects would come to rest and that moving objects only continue to move so long as there is a power inducing them to do so. Modern physics started when Galileo and his followers put an end to Aristotle’s dogma by showing that, unless acted upon by a net unbalanced force, an object will maintain a constant velocity. This was key to the realization that motion is relative and preceded by the more fundamental concept of *frame of reference*, *e.g.* the train moves *with respect to* the frame of the platform, but the platform moves *with respect to* the frame of the train. Note that even if rheologists have taken Heraclitus’ doctrine as their motto, they depart from his thoughts by a paradoxical but useful conception

of motion or flow, alternatively faithful to Aristotle or Galileo.

Simple fluids like water are “passive”, they continue to move or deform so long as there is a power inducing them to do so. In this case, the typical flow rate  $\dot{\gamma}$  is simply imposed by the operator and  $Rw$  is a natural control parameter. For cats, assuming we have a well-defined relaxation time  $\tau$ , computing  $Rw$  is still challenging because defining  $\dot{\gamma}$  can be difficult since cats are “active” materials. They have their own motive power. Like other biologically active materials (acto-myosin gels, bacterial swimmers, epithelium, packs, flocks, schools, *etc.*), they can exhibit spontaneous rotation as shown in Fig. 3a.

Despite these difficulties, the question remains: are cats prone to flow instabilities when  $Rw$  increases? In a cylindrical flow geometry, instabilities in the purely inertial case (*i.e.*  $Rw = Re$ ) and in the purely elastic case (*i.e.*  $Rw = Wi$ ) lead to vortex flows. In the inertial case, the centrifugal force drives this instability and is also responsible for the deformation of the top free surface, which climbs up the outer walls of the cylinder. In the purely elastic case, the mechanism is opposite: centripetal normal forces (“hoop stresses”) drive the instability and are also responsible for the Weissenberg effect, where the fluid climbs at the center of the free surface. In general, both inertial and elastic effects can occur. In flows of *Felis catus*, significant normal forces can occur and they seem to be able to drive a Weissenberg-type effect, as shown in Fig. 3b.

In conclusion, much more work remains ahead, but cats are proving to be a rich model system for rheological research, both in the linear and nonlinear regimes. Standing questions include the potential implications of the rheology of cats on their righting reflex, and whether the nonlinear self-sustaining mechanism for turbulence in pipe is applicable to streaks of tigers. Very recent experiments from Japan also suggest that we should not see cats as isolated fluid systems, but as able to transfer and absorb stresses from their environment. Indeed, in Japan, they have cat cafes, where stressed out customers can pet kitties and purr their worries away.

### Acknowledgments

No animals were (h)armed in the making of this study. I thank L. and J.F. Berret for providing a reliable technique to load *Felis catus* in different geometries: 1. Bring an empty box; 2. Wait. Illustrations of the protocol can be found on the web ([weknowmemes.com/2012/11/how-to-catch-a-cat/](http://weknowmemes.com/2012/11/how-to-catch-a-cat/), or [youtube.com/watch?v=pX4yK4yG3pE](http://youtube.com/watch?v=pX4yK4yG3pE)). This paper was written in honor of Gareth’s 50th birthday and his Bingham award. Many members of the EMF helped motivating this study, all good things in it can be found in Gareth’s 200+ publications, and all mistakes are mine. Help and encouragements from A. Jaishankar, S. Manneville, V. Sharma and N. Taberlet were particularly valuable.

The Society of Rheology was founded in 1929 to foster the study of the mechanical properties of deformable materials. SOR is a founding member of the American Institute of Physics.

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*24-28 May 2015*

15<sup>th</sup> International Congress of Biorheology and 8<sup>th</sup> International Conference on Clinical Hemorheology, Seoul, Herb Lipowski and Sehyun Shin. (<http://isb-isch2015.org>)

*7-11 June 2015*

31<sup>st</sup> International Conference of The Polymer Processing Society (PPS 31), Jeju City, South Korea, Jae Wook Lee and Jin Kon Kim. ([www.pps-31.com](http://www.pps-31.com))

*10-11 October 2015*

SOR Short Course on Rheology (topic TBA), Baltimore, Maryland USA.

*11-15 October 2015*

87<sup>th</sup> Annual Meeting of The Society of Rheology, Baltimore, Maryland USA, Kalman Migler and Jai Pathak. Technical program by Rajesh Khare and Susan Muller.

**2016**

*June 2016*

Rheological Measurements Short Course, University of Minnesota, Minneapolis, MN USA, Chris Macosko. (<http://research.cems.umn.edu/rheology/>)

*19-22 July 2016*

32<sup>nd</sup> International Conference of the Polymer Processing Society (PPS32), Lyon, France, A. Maazouz. ([www.pps-32.com](http://www.pps-32.com))

*8-13 August 2016*

XVII<sup>th</sup> International Congress on Rheology, Kyoto, Japan, Hiroshi Watanabe (every four years). (<http://icr2016.com>)

*21-26 August 2016*

International Congress of Theoretical and Applied Mechanics, ICTAM, Montréal, Québec, Canada (<http://iutam.org>).

**2017**

*11-12 February 2017*

SOR Short Course on Rheology (topic TBA), Tampa Bay, Florida USA.

*12-16 February 2017*

88<sup>th</sup> Annual Meeting of The Society of Rheology, Tampa Bay, Florida USA, Don Baird.

*April 2017*

10<sup>th</sup> Annual European Rheology Conference AERC2017, location TBA.

*7-8 October 2017*

SOR Short Course on Rheology (topic TBA), Denver, Colorado USA

*8-12 October 2017*

89<sup>th</sup> Annual Meeting of The Society of Rheology, Denver, Colorado USA, Matt Liberatore.

**2018**

*13-14 October 2018*

SOR Short Course on Rheology (topic TBA), Houston, Texas USA.

*14-18 October 2018*

90<sup>th</sup> Annual Meeting of The Society of Rheology, Houston, Texas USA, Jason Maxey.

*August 2020*

XVIII<sup>th</sup> International Congress on Rheology, Americas (tentative, every four years).

*For other meeting notices, see also*

[www.rheology.org/sor/info/Other\\_Meetings.htm](http://www.rheology.org/sor/info/Other_Meetings.htm)

<http://www.rheology-esr.org/Meetings.php>

[www.appliedrheology.org/\(click on conferences\)](http://www.appliedrheology.org/(click on conferences))



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# CALENDAR OF RHEOLOGY CONFERENCES AND COURSES

## 2014

*6-11 July 2014*

IUPAC World Polymer Congress (MACRO 2014)  
Chiangmai, Thailand, Supawan Tantayanon.  
([www.macro2014.com/](http://www.macro2014.com/)).

*20-25 July 2014*

6<sup>th</sup> Pacific Rim Conference on Rheology, Mel-  
bourne, Australia, Prakash Jagadeeshan.  
([www.pacrimrheology.com](http://www.pacrimrheology.com))

*4-5 October 2014*

SOR Short Courses, *Rheology of Colloidal  
Suspensions* by Jan Mewis and Norman J. Wagner  
and a 1-day course on *Rheology of Foods* by Peter  
Fischer, Rakesh Gupta, Mahesh Padmanabhan),  
Philadelphia, Pennsylvania USA.

*5-9 October 2014*

86<sup>th</sup> Annual Meeting of The Society of Rheology, Phila-  
delphia, PA USA, Michael Mackay. Technical program  
by Maryam Sepehr and Amy Shen.

*6-10 October 2014*

3<sup>rd</sup> International Conference on Competitive Materials  
and Technology Processes, Miskolc-Lillafured, Hun-  
gary, László A. GÖMZE. ([www.ic-cmtp3.eu/](http://www.ic-cmtp3.eu/))

**2015**

*11-16 January 2015*

Gordon Research Conference on Macromolecular Mate-  
rials: From Synthesis to Application, Michael Mackay  
and Ronald L. Jones  
([www.grc.org/programs.aspx?id=12004](http://www.grc.org/programs.aspx?id=12004))

*30 March-1 April 2015*

Institute of Non-Newtonian Fluid Mechanics Annual  
Conference on Rheology of Structured Fluids, Ruthin,  
North Wales, Ken Walters.  
([www.innfm.org.uk](http://innfm.org.uk)).

*14-17 April 2015*

10<sup>th</sup> Annual European Rheology Conference AERC2015,  
Nantes, France, Groupe Français de Rhéologie.  
(<http://rheology-esr.net>)

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