Suspended Particles in Complex Fluids: From Fracking Fluids to Swimming Worms

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Abstract: Rigid or flexible particles suspended in viscoelastic fluids are ubiquitous in the food industry (e.g. pastes), industrial molding applications (all composites and 3-D printed parts), the energy industry (e.g. fracking fluids), and biological fluids (i.e. swimming of bacteria in mucous). The mathematics of the description of these suspensions is in its infancy. For example, the foundational work in Newtonian suspensions was accomplished by Einstein in 1905 as a mathematical prediction of the shear viscosity of a dilute suspension of particles in Newtonian fluid. That same calculation in an elastic fluid was just submitted for publication now over 100 years later! However, while the mathematics of this subject is subtle the real breakthrough in this area has been the development of a computational simulation of such viscoelastic suspensions, with particle level resolution, such that predictions can be made and tested at all volume fraction loadings. This simulation capability is unique and overcomes the major hurdle in understanding the physics of these suspensions – which in many cases are simply qualitatively different than that of Newtonian suspensions. The simplest flows of such suspensions are not understood at a fundamental level, primarily because the collective behavior of particles in an elastic liquid has no foundation – this will change dramatically in the next few years. I will describe three foundational problems that have now been analyzed using these new computational methods – including fracking fluid design and swimming in mucous.

Biography: Eric Shaqfeh is the Lester Levi Carter Professor of Chemical Engineering at Stanford University. He joined Stanford's faculty in 1990 after earning a B.S.E. *summa cum laude* from Princeton University (1981), and M.S. (1982) and Ph.D. (1986) from Stanford University. He also completed postdoctoral work as a NATO Postdoctoral Fellow at the Department of Applied Mathematics and Theoretical Physics at U. Cambridge (1986) and was a Member of Technical Staff at ATT Bell Labs (1987-1990). In 2001 he received a dual appointment and became Professor of Mechanical Engineering. He is most recently (as of 2004) a faculty member in the Institute of Computational and Mathematical Engineering at Stanford.

Shaqfeh's current research interests include non-Newtonian fluid mechanics (especially in the area of elastic instabilities, and turbulent drag reduction), nonequilibrium polymer statistical dynamics (focusing on single molecules studies of DNA), and suspension mechanics (particularly of fiber suspensions and particles/vesicles in microfluidics). He has authored or co-authored over 180 publications and now serves as an Associate Editor of the *Physical Review Fluids.* He also serves on the boards of four other international journals.

Shaqfeh has received the APS Francois N. Frenkiel Award 1989, the NSF Presidential Young Investigator Award 1990, the David and Lucile Packard Fellowship in Science and Engineering 1991, the Camile and Henry Dreyfus Teacher--Scholar Award 1994, the W.M. Keck Foundation Engineering Teaching Excellence Award 1994, the 1998 ASEE Curtis W. McGraw Award, and the 2011 Bingham Medal from the Society of Rheology. A Fellow of the American Physical Society (2001) and the Society of Rheology(2015), he is also a member of the National Academy of Engineering (2013), and has held a number of professional lectureships, including the Merck Distinguished Lectureship, Rutgers (2003), the Corrsin Lectureship, Johns Hopkins (2003) and the Katz Lectureship, CCNY (2004). He was also the Hougen Professor of Chemical Engineering at the University of Wisconsin (2004) and the Probstein Lecturer at MIT (2011). In 2013, he won the Dean's Award for Industry Education Innovation at Stanford.

Eric was Chair of Chemical Engineering at Stanford from 2011-2015, and has returned as Chair as of September 2016.

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