Special issue

Fluids out of equilibrium

We live in a world of fluids—air, water, blood, gasoline. In fact, fluids are so vital and familiar to everyday life that one can easily take their varied and fascinating properties for granted. Many household products exist because they make use of some exotic flow phenomena. A cookbook is a storehouse of fluid facts. Our industrial civilization began when the change of water to steam—really an extraordinary occurrence in its own right—was appreciated and applied. Fluids, then, have intrigued scientists for hundreds of years and their diverse behavior means that their study is rich in concepts and models and draws upon and contributes to many fields; it is truly multidisciplinary, in fact.

Progress through the years has been uncertain, however, with periods of success amid long periods of frustration and fragmentation of effort. But today we are on an upswing. In particular, it seems that we may be close to understanding quantitatively why a fluid out of equilibrium can behave as it does—long an untractable problem. Two tools especially have contributed: the laser and computer simulation. These tools, the one experimental, the other theoretical, yield unambiguous results that allow one to test theories (some of which were proposed long ago) and that suggest paths for further study.

Interest in fluids also comes from industry: The energy and chemical industries are adapting to materials and experimental environments new to them. The engineer thus needs information and data that sometimes are sparse or simply not available. It is up to the physicist and chemist to help meet this challenge.

The National Bureau of Standards organized a conference on nonlinear fluid behavior in June 1982 to bring together workers coming from different disciplines and having various approaches but with a mutual interest in nonequilibrium fluids. The conference was reported in *Physica*, **118A** (1983).

This increasing interest in nonequilibrium fluids is also the reason for this special issue of PHYSICS TODAY. Much of the very recent progress in understanding fluid behavior has indeed come from the interactions between the specialists in fluid dynamics and people in other disciplines. Perhaps the articles in this issue will spark even further synergy. Two themes are emphasized here to illustrate some of the exotic behavior possible from a sheared fluid and to show progress in understanding macroscopic nonequilibrium phenomena from the microscopic viewpoint.

There are five articles. Denis Evans, Howard Hanley and Siegfried Hess (page 26) discuss the structure, properties and thermodynamics of a sheared fluid. R. Byron Bird and Charles F. Curtiss (page 36) discuss flow phenomena in polymeric liquids and outline the state of the theory. William G. Hoover (page 44) reviews nonequilibrium molecular dynamics. Berni Alder and W. Edward Alley (page 56) discuss how far one can take macroscopic ideas into the microscopic level. E. G. D. Cohen (page 64) reviews the status of kinetic theory.

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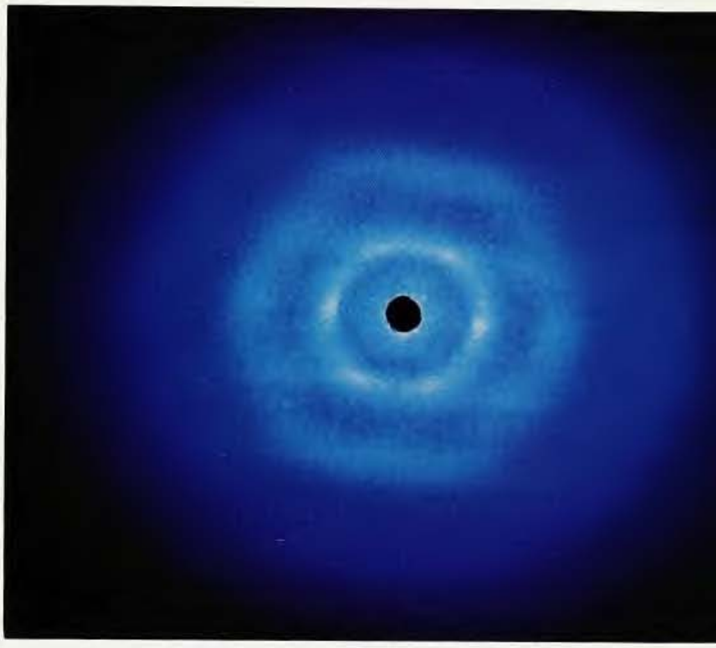

Intensity pattern for scattered laser light from a colloidal suspension of microspheres that is crystalline in equilibrium. The photos show a striking example of nonlinear nonequilibrium fluid behavior: shear-induced melting. At a low shear rate (above) one sees remnants of the pattern characteristic of a hexagonal crystal lattice. As the shear rate is increased, there is an abrupt change to the sort of pattern seen in the lower photo. The elliptical distortion is characteristic of fluids under shear. (See also the computer-generated results shown on page 26.) (Photos by Noel A. Clark, University of Colorado, Boulder, and Bruce J. Ackerson, Oklahoma State University, Stillwater.)