New math captures fluids in unprecedented detail

September 5 2016

Using a newly devised mathematical framework, researchers captured fluid dynamics with unprecedented detail. Here, the framework captures the ripple phenomenon (shown here) caused by surface tension. Credit: R Saye, Lawrence Berkeley National Laboratory

Bubbles in a glass of champagne, thin films rupturing into tiny droplets, and crashing ocean waves—scientists mathematically model these and other phenomena by solving the same series of equations. However, many computational methods for solving these equations cannot accurately resolve the often-intricate fluid dynamics. Developed at Lawrence Berkeley National Laboratory, a new mathematical framework sheds light on how fast a fluid moves in its environment, how much pressure it is under, and what forces it exerts on its surroundings.

The framework captures fluid dynamics at unprecedented detail, and the results could benefit a range of applications, such as optimizing the shape of a propeller blade and the ejection of ink droplets in printers.

Navier-Stokes equations, a set of equations that predict how fluids flow, are used everywhere from special effects in movies to industrial research and the frontiers of engineering. However, many computational methods for solving these complex equations cannot accurately resolve either the fluid dynamics next to moving boundaries and surfaces or the ways these tiny structures influence the motion of the surfaces and the surrounding environment. This is where a new mathematical framework developed by Robert Saye, Lawrence Berkeley National Laboratory, comes in.

By reformulating the incompressible Navier-Stokes equations to make them more amenable to numerical computation, the new algorithms capture the small-scale features near evolving interfaces with unprecedented detail, as well as the impact that these tiny structures have on dynamics far from the interface. The development of these algorithms requires extensive convergence studies and simulation in two and three dimensions by performing a substantial number of simulations, each one using hundreds-to-thousands of cores on Edison. Saye ran many of the computations for this research on the Edison supercomputer at the National Energy Research Scientific Computing Center.

More information: R. Saye. Interfacial gauge methods for incompressible fluid dynamics, *Science Advances* (2016). DOI: 10.1126/sciadv.1501869

Provided by US Department of Energy