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Steve Shkoller, UC Davis

Recent developments in the geometry of hydrodynamics

Fluid dynamics is an extremely interesting and challenging field of mathematics, which relies upon PDE theory, numerical analysis, and geometry to reveal its many secrets. Traditionally, only the first two areas, PDE and numerics, benefited greatly from one another's successes, but recent advances in the geometry of the volume-preserving diffeomorphism group has served to unify all three areas.

We shall describe these geometric developments and explain how they have been used to show the equivalence between seemingly unrelated fluids models, as well as provide well-posedness results previously unavailable by traditional techniques. In a surprising twist, we shall explain how the mathematical equations of non-Newtonian fluids which model polymer flow are, in fact, the famous vortex numerical method for integrating the Euler equations of inviscid incompressible fluids. Both of these systems are geodesics of new subgroups of the volume-preserving diffeomorphism group with respect to a recently discovered Riemannian metric. Other hydrodynamical systems will be discussed in this context as well.