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Stanley Corrsin Award Talk: The role of singularities in hydrodynamics

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If a tap is opened slowly, a drop will form. The separation of the drop is described by a singularity of the Navier-Stokes equation with a free surface. Shock waves are singular solutions of the equations of ideal, compressible hydrodynamics. These examples show that singularities are characteristic for the tendency of the hydrodynamic equations to develop small scale features spontaneously, starting from smooth initial conditions. As a result, new structures are created, which form the building blocks of more complicated flows. The mathematical structure of singularities is self-similar, and their characteristics are fixed by universal properties. This will be illustrated by physical examples, as well as by applications to engineering problems such as printing, coating, or air entrainment. Finally, more recent developments will be discussed: the increasing complexity underlying the self-similar behavior of some singularities, and the spatial structure of shock waves.