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The Emergence of Small Scales in Vortex Ring Collisions

RYAN MCKEOWN, RODOLFO OSTILLA MONICO, Harvard University, ALAIN PUMIR, ENS Lyon, MICHAEL P. BRENNER, SHMUEL RUBINSTEIN, Harvard University — When two vortex rings collide head-on, the initially smooth flow structures rapidly become unstable as they develop complex three-dimensional dynamics that result in the vortex cores either reconnecting or breaking down into a fine-scale turbulent cloud. As the vortex rings first approach one another, they are stretched radially along the collision plane. The close-range interactions of the counter-rotating vortices lead to the development of perturbations in the vortex cores. Long-wavelength perturbations develop into tents that bridge the cores and reconnect or break down. Short-wavelength perturbations cause the cores to become locally kinked and break down before contacting. We use high-speed flow visualization techniques with a scanning laser sheet to reconstruct the intricate, three-dimensional dynamics of the interacting vortex cores. For both perturbation modes, we observe that the breakdown of the vortex cores is caused by the local flattening of the cores into vortex sheets, which break down into smaller vortex filaments. These secondary filaments break down again in an iterative manner to produce fine-scale turbulent smoke. This iterative cascade could be indicative of a possible mechanism by which kinetic energy is conveyed to small scales in turbulent flows.

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