Spontaneous Vortex Rings in Free-Propagating and Self-Focused Laser Beams

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Optical vortex rings, an analog of the "smoke rings" in hydrodynamics, appear as Airy rings in the focal area of a circular aperture as well as a result of the destructive interference of a plane wave with Gaussian laser beams. In the nonlinear optical media, vortex rings appear spontaneously on the tails of stable breathing spatial solitons in the nonlocal and saturable media as well as at the self-focusing in Kerr-type media. In this talk we study analytically and numerically the fine details of the birth, annihilation, pairwise nucleation and reconnections of optical vortex rings in the superposition of free-propagating Gaussian beam and a plane wave. The complexity of the system grows considerably when the transverse rotational symmetry of the Gaussian beam is reduced to an ellipse, giving rise to the catastrophes in parameter space of topological transformations. We also discuss the influence of the dynamic and geometric Gouy phases on the topology of vortex rings. This simple model serves as a testbed for numerically observed spontaneous nucleation of vortex rings at self-focusing.