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Exciting Quantized Vortex Rings in a Superfluid Unitary Fermi Gas

AUREL BULGAC, Univeristy of Washington

In a recent article, Yefsah et al., Nature **499**, 426 (2013) report the observation of an unusual quantum excitation mode in an elongated harmonically trapped unitary Fermi gas. After phase imprinting a domain wall, they observe collective oscillations of the superfluid atomic cloud with a period almost an order of magnitude larger than that predicted by any theory of domain walls, which they interpret as a possible new quantum phenomenon dubbed "a heavy soliton" with an inertial mass some 50 times larger than one expected for a domain wall. We present compelling evidence that this "heavy soliton" is instead a quantized vortex ring by showing that the main aspects of the experiment can be naturally explained within an extension of the time-dependent density functional theory (TDDFT) to superfluid systems. The numerical simulations required the solution of some 260,000 nonlinear coupled time-dependent 3-dimensional partial differential equations and was implemented on 2048 GPUs on the Cray XK7 supercomputer Titan of the Oak Ridge Leadership Computing Facility.