# Cascade of Solitary Waves in a Fermionic Superfluid

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Topological excitations are found throughout nature, in proteins and DNA, as dislocations in crystals, as vortices and solitons in superfluids and superconductors, and generally in the wake of symmetry-breaking phase transitions. In fermionic systems, topological defects provide bound states for fermions that often play a crucial role for the system's transport properties. Famous examples are Andreev bound states inside vortex cores, fractionally charged solitons in relativistic quantum field theory, and the spinless charged solitons responsible for the high conductivity of polymers. Strongly interacting fermionic superfluids of ultracold atoms represent a fascinating new host material for the study of solitary waves  it is a system for which we do not yet know the precise form of the wave equation governing these excitations. We have created solitons in a strongly interacting fermionic superfluid by imprinting a phase step into the superfluid wavefunction [1, 2], and directly observe the decay cascade from solitons to vortex rings and finally to single solitonic vortices. The remnant vortices are seen to precess for long times in the superfluid. The long period and the correspondingly large ratio of the inertial to the bare mass of the vortex are in good agreement with estimates based on superfluid hydrodynamics that we derive from the known equation of state in the BEC-BCS crossover. In future work we may be able to directly observe and control Andreev bound states  superpositions of particles and holes  trapped inside solitary waves.

[1] Tarik Yefsah, Ariel T. Sommer, Mark J.H. Ku, Lawrence W. Cheuk, Wenjie Ji, Waseem S. Bakr, Martin W. Zwierlein, Nature **499**, 426-430 (2013).

[2] Mark J.H. Ku, Wenjie Ji, Biswaroop Mukherjee, Elmer Guardado-Sanchez, Lawrence W. Cheuk, Tarik Yefsah, Martin W. Zwierlein, Phys. Rev. Lett. **113**, 065301 (2014).