# Soliton motion, dissipation, and death in quantum superfluids

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## ABSTRACT

Solitons are fascinating non-linear phenomena that occur in a diverse array of classical and quantum systems. In particular, they are known to exist in quantum superfluids, and have been demonstrated experimentally in Bose-Einstein condensates and fermionic superfluids. In this talk, I will first review the general theory of solitons in superfluids and present an exact solution to the problem of a moving soliton in a one-dimensional superconductor. Connections to the inverse scattering method and supersymmetric quantum mechanics will be emphasized. Using these exact methods, the full soliton spectrum will be derived along with its"inertial" and "gravitational" masses. The former will be shown to be orders of magnitude larger than the latter. This results in slow motion of the soliton, consistent with recent experiment [T. Yefsah et al., Nature 499, 426, (2013)]. In the second part of my talk, I will discuss the soliton decay and derive the quasiclassical equations of motion containing a non-local in time friction force. Interestingly, Ohmic friction is absent in the integrable setup and the Markovian approximation gives rise to the Abraham-Lorentz force (i.e., a term proportional to the derivative of the soliton's acceleration), which is known from classical electrodynamics of a charged particle interacting with its own radiation. These Abraham-Lorentz equations famously contain a fundamental causality paradox, where the soliton/particle interacts with excitations/radiation originating from future events. We show, however, that the causality paradox is an artifact of the Markovian approximation, and our exact non-Markovian dissipative equations give rise to physical trajectories. In the end, I will show results of recent experiment that observed soliton diffusion and decay in superfluids, well described by our theory.

## References

[1] Dmitry K. Efimkin, Johannes Hofmann, Victor Galitski, *Non-Markovian quantum friction of bright solitons in superfluids,* Phys. Rev. Lett. **116**, 225301 (2016)
[2] Dmitry K. Efimkin and Victor Galitski, *Moving solitons in a one-dimensional fermionic superfluid,* Physical Review A **91**, 023616 (2015)