Breathing and Fission of Magnetic Multi-solitons

Sarah Philips,[1,*] Guillaume Brochier,[1] Yifan Li,[1] Sarah Wattelier,[1] Franco Rabec,[1] Sylvain Nascimbene,[1] Jean Dalibard,[1] and Jérôme Beugnon[1]

[1] *Laboratoire Kastler Brossel, Collège de France, CNRS, ENS-PSL University, Sorbonne Université, Paris, France*

We experimentally study multi-soliton states in a uniform quasi-one-dimensional two-component Bose gas. [1] In the immiscible regime, the spin dynamics are described by the easy-axis Landau–Lifshitz equation, which is gauge-equivalent to the attractive nonlinear Schrödinger equation.

Using this correspondence, we deterministically prepare multi-soliton states and observe their characteristic breathing dynamics, in quantitative agreement with integrable theory. This enables the realization of both conventional nonlinear Schrödinger multi-solitons and a broader class of magnetic solitons associated with the underlying spin-chain description.

Finally, we explore controlled integrability breaking. A weak, localized perturbation induces the fission of a multi-soliton into its fundamental constituents, revealing its composite structure and making its scattering data experimentally accessible. This provides an experimental analogue of the inverse scattering transform and opens perspectives for studying nonlinear waves and nearly integrable quantum systems.

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[1] G. Brochier *et al.*, arXiv:2603.09357 (2026).

* sarah.philips@lkb.ens.fr; https://quantumgases-pariscdf.fr/