

# A tribute to Lev: A fresh look at magnetic solitons

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Among the many topics to which Lev Pitaevskii has made an essential contribution, solitons occupy a central place. Lev explored many facets of their properties, such as the physical characterization of their mass, momentum and equation of motion [1]. In this talk, we will briefly review some types of solitons that have been observed in the context of quantum gases, before focusing on “magnetic solitons”. These arise when two overlapping condensates have interaction parameters close to the mixing-demixing transition [2]. Their dynamics are then similar to those of ferromagnetic materials with easy axis (immiscible case) or easy plane (miscible case) anisotropy. In particular, we will describe the first experimental observation of a counterintuitive phenomenon that has long been predicted [3] and that has been the subject of several physical interpretations [4]: when such a soliton is subjected to a constant force, it undergoes periodic motion. The appearance of periodic behavior in this context is reminiscent of either the Josephson effect or the Bloch oscillation of an electron in a perfect crystal – despite the fact that there is no underlying periodic potential in this setup.

[1] See for example: S. Novikov, S.V. Manakov, L.P. Pitaevskii, V.E. Zakharov, *Theory of solitons: the inverse scattering method*, Springer (1984); V.V. Konotop and L.P. Pitaevskii, *Phys. Rev. Lett.* 93, 240403 (2004); V.A. Brazhnyi, V.V. Konotop, L.P. Pitaevskii, *Phys. Rev. A* 73, 053601 (2006); R.G. Scott, F. Dalfovo, L.P. Pitaevskii, S. Stringari, *Phys. Rev. Lett.* 106, 185301 (2011); G.E. Astrakharchik and L.P. Pitaevskii, *EPL* 102, 30004 (2013); L.P. Pitaevskii, *JETP* 119, 1097 (2014); L.P. Pitaevskii, *Physics-Uspekhi* 59, 1028 (2016)

[2] C. Qu, L. P. Pitaevskii, and S. Stringari, *Phys. Rev. Lett.* 116, 160402 (2016)

[3] A. M. Kosevich, V. V. Gann, A. I. Zhukov, and V. P. Voronov, *J. Exp. Theor. Phys.* 87, 401–407 (1998)

[4] L.-C. Zhao, W. Wang, Q. Tang, Z.-Y. Yang, W.-L. Yang, and J. Liu, *Phys. Rev. A* 101, 043621 (2020); X. Yu and P. B. Blakie, *Phys. Rev. Lett.* 128, 125301 (2022); X. Chai, L. You, and C. Raman, *Phys. Rev. A* 105, 013313 (2022); S. Bresolin, A. Roy, G. Ferrari, A. Recati, and N. Pavloff, *Phys. Rev. Lett.* 130, 220403 (2023)

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