

Raise and fall of a bright soliton in an optical lattice

Piero Naldesi^{a,*}, Juan Polo Gomez^a, Boris Malomed^{b,c}, Maxim Olshani^d, Anna Minguzzi^a et Luigi Amico^{e,f,g,h,i}

- a. Université Grenoble-Alpes, LPMMC, F-38000 Grenoble, France and CNRS, LPMMC, F-38000 Grenoble, France
- b. Department of Physical Electronics, School of Electrical Engineering, Faculty of Engineering, Tel Aviv University, P.O.B. 39040, Ramat Aviv, Tel Aviv, Israel
- c. Center for Light-Matter Interaction, Tel Aviv University, P.O.B. 39040, Ramat Aviv, Tel Aviv, Israel
- d. Department of Physics, University of Massachusetts Boston, Boston, MA 02125, USA
- e. Dipartimento di Fisica e Astronomia, Via S. Sofia 64, 95127 Catania, Italy
- f. Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543, Singapore
- g. MajuLab, CNRS-UNS-NUS-NTU International Joint Research Unit, UMI 3654, Singapore
- h. CNR-MATIS-IMM & INFN-Sezione di Catania, Via S. Sofia 64, 95127 Catania, Italy
- i. LANEF '*Chaire d'excellence*', Université Grenoble-Alpes & CNRS, F-38000 Grenoble, France

* piero.naldesi@lpmmc.cnrs.fr << Piero Naldesi >>

We study an ultracold atomic gas with attractive interactions in an one-dimensional optical lattice. We find that its excitation spectrum displays a quantum soliton band, corresponding to N -particle bound states, and a continuum band of other, mostly extended, states. For a system of finite size, the two branches are degenerate in energy at small interactions, while a gap opens above a threshold value for the interaction strength. We find that the interplay between degenerate extended and bound states has important consequences in both static and dynamical properties of the system. In particular, the solitonic states result to be protected from spatial perturbations and random disorder. We discuss how such dynamics implies that our system effectively provides an example of quantum many-body system that, as function of the bosonic lattice filling, crosses over from integrable non-ergodic to non-integrable ergodic dynamics, through non-integrable non-ergodic regimes.