SOPHIE SHAMAILOV

QUANTUM DARK SOLITONS IN THE LEIB-LINIGER MODEL AS LOCALIZED WAVEPACKETS OF TYPE-II EXCITATIONS

ABSTRACT:

Dark solitons are the lowest-energy excitations of the repulsive 1D Gross-Pitaevskii equation. We attempt to understand them from the quantum-mechanical point of view, as the full many-body problem (the Lieb-Liniger model) is exactly-solvable. The lowest energy excitations of the latter are so-called "type-II" states, and a connection between dark solitons and type-II excitations has been long hypothesized.

We show that with weak repulsion, dark solitons can be constructed as superpositions of type-II eigenstates, and explicitly compute the expansion coefficients. Moreover, by considering various Gaussian superpositions we physically interpret the missing particle number and phase step associated with type-II states.

Finally, taking inspiration from the concept of center-of-mass & relative-motion separation, we are able to identify and study an object which may be defined as the quantum dark soliton across the entire range of interaction strengths & momenta.