Singular Nonlinear Bound States and Vortices in Attractive Potentials

B A Malomed[1]

[1] *Tel Aviv University, Tel-Aviv, Israel. Contact Phone: +972-509499338*
Contact Email: malomed@tauex.tau.ac.il

The talk aims to produce an overview of results for states with an integrable density trapped in the potential of attraction of an electric dipole to a central charge, $U(r) = -(U_0/2)r^{-2}$. The linear Schrödinger equation with this potential gives rise to the *quantum collapse* at $U_0 > 1/4$ in 3D, and at any $U_0 > 0$ in 2D. On the contrary, the 3D Gross-Pitaevskii equation (GPE) with the cubic self-repulsion suppresses the collapse and creates a ground state (GS) with an integrable density singularity $\sim r^{-2}$, at all values of $U_0 > 0$ [1]. In the framework of the quantum many-body theory, this mean-field (MF) GS corresponds to a metastable state secured against collapse by a high potential barrier [2]. In 2D, the GS, with integrable density singularity $\sim r^{-4/3}$, is created by the Lee-Huang-Yang-Petrov (LHYP) *quartic* self-repulsive term, which represents a correction to the MF produced by quantum fluctuations [3]. The same 2D setting supports singular vortex states with orbital quantum number l. These states are stable if the strength of the attractive potential is large enough, *viz.*, $U_0 > (7/9)(3l^2 - 1)$.

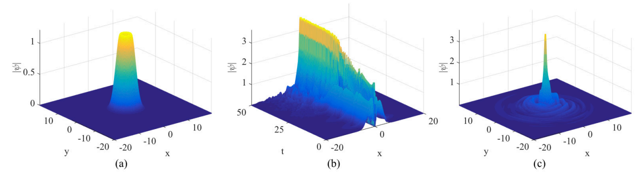

Figure 1: (b): Self-trapping of a vortex state with $l = 1$ and 2D-integrable density singularity (c) from a regular input with the same vorticity (a), produced by simulations of the GPE with the LHYP quartic self-repulsion, as per [3]

References

[1] H Sakaguchi and B A. Malomed, Phys. Rev. A **83**, 013607 (2011)

[2] G E Astrakharchik and B A Malomed, Phys. Rev. A **92**, 043632 (2015)

[3] E Shamriz, Z Chen and B A Malomed, Phys. Rev. A **101**, 063628 (2020)