Superglass formation in an atomic BEC with competing long-range interactions

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The complex dynamical phases of quantum systems are dictated by atomic interactions that usually evoke an emergent periodic order. Here, we study a quantum many-body system with two competing and substantially different long-range interaction potentials where the dynamical instability towards density order can give way to a superglass phase, i.e. a superfluid disordered amorphous solid, which exhibits local density modulations but no long-range periodic order. We consider a two-dimensional BEC in the Rydberg-dressing regime coupled to an optical standing wave resonator. The dynamic pattern formation in this system is governed by the competition between the two involved interaction potentials repulsive soft-core interactions arising due to Rydberg dressing and infinite-range sign changing interactions induced by the cavity photons. The superglass phase is found when the two interaction potentials introduce incommensurate length scales. The dynamic formation of this peculiar phase without any externally added disorder is driven by quantum fluctuations and can be attributed to frustration induced by the two competing interaction energies and length scales.

References

[1] S. Ostermann, V. Walther, S.Yelin, arXiv:2109.14709 (2021)

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