Bragg-spectroscopy of a dissipation-induced instability in an atom-cavity system

Gabriele Natale
Alexander Baumgärtner, Justyna Stefaniak, Simon Hertlein, David Baur, Dalila Rivero, Tobias Donner, and Tilman Esslinger

Institute for Quantum Electronics,
Otto-Stern-Weg 1, CH-8093 Zürich, Switzerland

gnatale@phys.ethz.ch

The study of collective excitations is a powerful tool to gain insight into a many-body system. By examining the low-lying energy spectrum and its modes, we can identify imminent phase transitions and better understand the nature of different phases. In our experiment, we load a Bose-Einstein Condensate (BEC) into a high-finesse cavity. The coupling of the BEC and the cavity produces long-range interactions, which can result in two roton-like excitation modes. These modes correspond to two exotic superradiant phases that have been previously observed and studied [1].
Due to inherent dissipation in our system, these two modes couple when their energies are close leading to a topological pump [2]. At this exceptional point, the eigenvalues and eigenvectors related to the two modes are expected to hybridize.
To measure these two low-lying excitations simultaneously, we use Bragg-spectroscopy. We observe the individual softening of the two modes as they approach their respective phases, along with a diverging susceptibility. By leveraging the full tunability of our non-Hermitian system, we explore a parameter regime where the two modes coalesce, causing an exceptional point and the associated dynamical instability.

References

[1] L. Xiangliang et al., Phys. Rev. Res. 3, L012024 (2021).
[2] D. Dreon et al., Nature 608, 494–498 (2022).