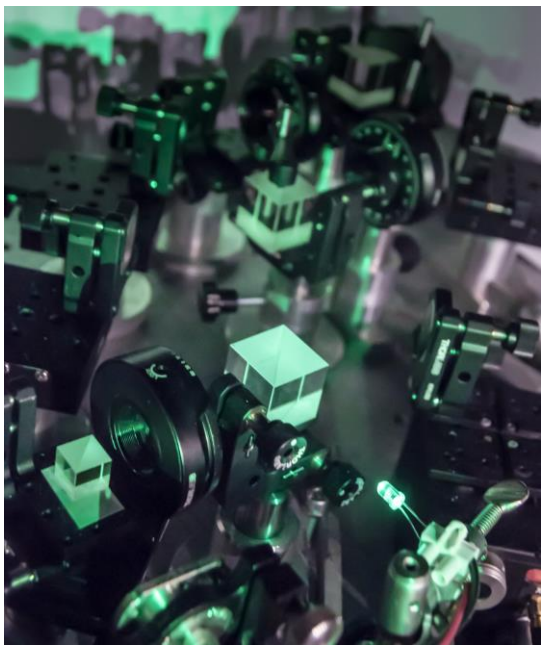
Q@TN Lab SEMINARS



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Cavity quantum-electrodynamics with strongly correlated Fermions

June 25, 2021 – h 14.00

Videoconference

ABSTRACT

Cavity quantum electrodynamics (QED) is one of the most powerful framework to observe quantum systems with high sensitivity. While it has been thoroughly studied for simple quantum systems such as two-level systems or harmonic oscillators, it has only recently become available for complex, correlated quantum many-body systems.
We have developed a setup combining cavity QED with quantum degenerate Fermi gas with tunable interactions, realizing the simultaneous control of both atom-atom and light-matter interactions up to the strong coupling regime [1,2]. In this talk, I will present the observation of strong coupling between photons in a high-finesse cavity and Fermions in a strongly correlated superfluid. I will then show that in addition to single atom coupling, photons also couple strongly to Fermion pairs via molecular transitions, yielding a new type composite excitations, pair polaritons. We show that the pair polariton spectrum faithfully maps the strong correlations in the ground state of the Fermi gas, bridging up a two-orders of magnitude gap in energy between the Fermi energy of the gas and the scale of optical excitations [3].
By coupling the gas to the atoms dispersively, we demonstrate weakly destructive, repeated measurements. For a stronger drive, we observe a strong optomechanical non-linearity arising from the coupling of density fluctuations to the cavity field. This gives access to the density response function of the strongly correlated Fermi gas in the BEC-BCS crossover, allowing for a comparison with ab-initio calculations.
The convergence of quantum optics tools with correlated Fermions physics opens many perspectives, from light-induced phases of matter to quantum limited measurements of many-body dynamics.

[1] K. Roux, H. Konishi, V. Helson and J.P. Brantut, Nature Communications 11:2974 (2020)
[2] K. Roux, V. Helson, H. Konishi and J.P. Brantut, New Journal of Physics 23, 043029 (2021)
[3] H. Konishi, K. Roux, V. Helson and J.P. Brantut, Nature (in press), arXiv:2103.02459 (2021)

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