Down-conversion of a single photon as a probe of many-body localization

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Decay of a particle into more particles is a ubiquitous phenomenon to interacting quantum systems, taking place in colliders, nuclear reactors, or solids. In a non-linear medium, even a single photon would decay by down-converting (splitting) into lower-frequency photons with the same total energy, at a rate given by Fermi's Golden Rule. However, the energy conservation condition cannot be matched precisely if the medium is finite and only supports quantized modes. In this case, the photons fate becomes the long-standing question of many-body localization (MBL), originally formulated as a gedanken experiment for the lifetime of a single Fermi-liquid quasiparticle confined to a quantum dot. Here we implement such an experiment using a superconducting multi-mode cavity, the non-linearity of which was tailored to strongly violate the photon number conservation. The resulting interaction attempts to convert a single photon excitation into a shower of low-energy photons, but fails due to the MBL mechanism, which manifests as a striking spectral fine structure of multi-particle resonances at the cavity's standing wave mode frequencies. Each resonance was identified as a many-body state of radiation composed of photons from a broad frequency range, and not obeying Fermi's Golden Rule theory. Our result introduces a new platform to explore fundamentals of MBL and related quantum many-body phenomena without having to control many atoms or qubits.

Tuesday, October 18, 2022 11:00am - 12:00pm
ISTA Campus Heinzl Seminar Room / Office Bldg West (I21.EG.101) & via ZOOM

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