Exploring Spontaneous-emission Phenomena with Matter Waves *

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The quantitative understanding of spontaneous emission harks back to the early days of QED, when in 1930 Weisskopf and Wigner, using Dirac's radiation theory, calculated the transition rate of an excited atom undergoing radiative decay. Their model, which describes the emission of a photon through coherent coupling of the atom's dipole moment to the continuum of vacuum modes, reflects the view that spontaneous emission into free space, driven by vacuum fluctuations, is inherently irreversible. We have recently studied [1] spontaneous emission in a novel context that allowed us to go beyond the model's usual assumptions. For this purpose, we created an array of microscopic atom traps in an optical lattice that emit single atoms, rather than single photons, into the surrounding vacuum. Our ultracold-atom system, which provides a tunable matter-wave analog of photon emission in photonic-bandgap materials, revealed behavior beyond standard exponential decay with its associated Lamb shift. It includes non-Markovian backflow of radiation into the emitter, and the formation of a long-predicted bound state in which the emitted particle hovers around the emitter in an evanescent wave. My talk will conclude with an outlook on using our new platform for studies of dissipative many-body physics and matter-wave quantum optics in optical lattices.

References:

[1] L. Krinner et al., Nature 559, 589 (2018); M. Stewart et al., Phys.Rev.A 95, 013626 (2017)

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