SUPERPOSING BOUND STATES IN WAVEGUIDE QED

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The spontaneous emission process of a quantum emitter coupled to a finite bandwidth waveguide can lead to a fractional decay into a bound state if the transition frequency of the emitter lies outside the band. The resulting steady state has a nonzero excited state population and a photonic cloud is localized around the emitter. These type of bound states are known in the literature as bound states outside the continuum.
Alternatively another approach to generate bound states within the context of waveguide quantum electrodynamics is to have more than a single coupling point in the waveguide. In such set ups the bound state is generated due to interference effects between the light emitted from each of the coupling points to the waveguide. Because the energy of these bound states lies within the bandwidth of the waveguide they are usually referred to bound states inside the continuum.

In this work we describe the dynamical generation of a superposition of bound states both inside and outside the continuum involving two emitters coupled to a cavity array waveguide. We show how under the proper choice of parameters the process of spontaneous emission of one of the emitters can lead to a steady state of up to three superposing bound states. We obtain analytical and numerical descriptions of the dynamics that generate these states and we fully characterize their behavior and the conditions for their appearance.
These superpositions of bound states yield oscillating atomic populations of both emitters and the photonic populations of in the cavities in between them creating a breathing mode. We also utilize these states to generate entanglement between the two emitters in a superposition of a single bound state outside the continuum and a bound state inside the continuum.