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Vacancy-like dressed states in topological waveguide QED

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We identify a class of dressed atom-photon states forming at the same energy of the atom at any coupling strength. As a hallmark, their photonic component is an eigenstate of the bare photonic bath with a vacancy in place of the atom. The picture allows to formalize and re-interpret all quantum optics phenomena where atoms behave as perfect mirrors, connecting in particular dressed bound states (BS) in the continuum (or BIC) with geometrically-confined photonic modes in a waveguide. Most notably, when applied to photonic lattices, the framework allows to formulate for the first time a general criterion to predict atom-photon dressed BS in lattices with topological properties by putting them in one-to-one correspondence with photonic bound modes whose occurrence is ruled by the known Atland-Zirnbauer classification. The criterion is applied to predict new classes of dressed BS in the photonic Creutz-ladder and Haldane models. In the latter case, states with non-zero local photon flux occur where an atom is dressed by a photon orbiting around it, a phenomenon so far unexplored in quantum optics.

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