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Quantum Transport of Strongly-Correlated Photons in Waveguide QED HUAIXIU ZHENG, DANIEL J. GAUTHIER, HAROLD U. BARANGER, Duke University — We present an exact solution of the quantum transport problem of multi-mode photons in a waveguide quantum electrodynamics (QED) system, which may be realized in a variety of circuit-QED, plasmonic, photonic, or cold-atom contexts. The bosonic modes are strongly coupled to a local atomic or qubit system, which can be a two-level, Gamma-type three-level, or N-type four-level system. We show that strong coupling produces dramatic quantum optics effects. In particular, multi-photon bound states emerge in the scattering of two or more photons. Such bound states have a large impact on the transport of coherent-state wave-packets. For a two-level system, the single-photon probability is suppressed while multi-photon probabilities are strongly enhanced, resulting in non-classical statistics. For a three-level system, as one tunes the coupling strength and the control field, the transmitted light can show bunching or antibunching, indicating effective attractive or repulsive interactions. Finally, for a N-type four-level system, we demonstrate that the multi-photon components can be largely suppressed, leading to a potential single-photon filter.

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