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Quantum nonlinear light emission in nanoplasmonic waveguides

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Generation of single and entangled photons in compact structures amenable to chip-based integration are important for future quantum communication and signal processing systems. Quantum nonlinear optic processes, including spontaneous parametric downconversion and spontaneous four wave mixing, are promising candidates for quantum light generation. However, the weak nonlinear interactions and high dispersion of homogeneous materials constrain the ability to simultaneously achieve the required high photonic mode density and phase matching required for enhancing nonlinear parametric processes. In this work we examine theoretically nonlinear light emission in subwavelength nanoscale plasmonic waveguides. We develop a theoretical model that describes spontaneous nonlinear downconversion with realistic models for losses and dispersion. We further show that by engineering the light dispersion in nanoplasmonic waveguides, we can simultaneously achieve phase matching, efficient mode mixing, and spontaneous photon emission. We study several waveguide motifs based on slot waveguides and hybrid plasmonic waveguides, and show that in tightly confined waveguides, photon emission rates comparable with bulk crystals are attainable with greatly reduced material interaction lengths.

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