

Quantum theory of electron tunneling into intersubband cavity polariton states

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Recent absorption[1-2], photovoltaic[3] and electroluminescence[4] experiments on microcavities embedding quantum wells have shown strong coupling between a planar cavity photon mode and the transition between two conduction subbands, being the lowest one filled with a dense two-dimensional electron gas. A considerable research activity is currently flourishing along two interesting directions, namely the ultrastrong coupling cavity quantum electrodynamics[5] and the electrical injection of intersubband cavity polariton excitations [4,6,7].

Through an analytical non-perturbative theory[7], we show that the nature of an electron in the excited conduction subband can be profoundly modified by the strong interaction with the cavity vacuum field. For electron wavevectors larger than the Fermi one, the electron spectral function in the excited subband has a non-trivial structure reminiscent of a Fano resonance, resulting from the coupling between the bare electron and the continuum of the intersubband cavity polariton modes (with different photonic wavevectors). In the case of a spectrally narrow injector, these electron states can be selectively excited by resonant electron tunneling and can give rise to ultrahigh efficient intersubband electroluminescence. Our theory provides a deep and elegant insight into the fascinating link between semiconductor cavity quantum electrodynamics and electronic transport in the considered system, paving the way to exciting progress in fundamental quantum opto-electronics.

References

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