

## **Microscopic theory of excitons bound by light**

Sangeet S. Kumar, Meera M. Parish, and Jesper Levinsen

*ARC Centre of Excellence in Future Low-Energy Electronics Technologies and  
School of Physics and Astronomy, Monash University, Victoria 3800, Australia*

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We theoretically investigate the scenario of a semiconductor quantum well in a microcavity, where the band structure is arranged such that optically excited electron-hole pairs cannot form Coulomb bound excitonic states. In this case, it is still possible to form exciton polaritons (part-light, part-matter quasiparticles), where the excitons are bound via the exchange of microcavity photons rather than via Coulomb interactions. Using a diagrammatic theory, we determine the spectral response of the semiconductor microcavity, which includes exciton-polariton resonances as well as a continuum of unbound electron-hole pairs. Our method also gives us access to the photon fraction and the electron-hole wave function of the exciton polariton. In particular, we obtain the conditions under which an exciton is bound by photon exchange, and we show that Coulomb interactions can enhance binding at large cavity photon frequencies. Our results for the spectral response are in good agreement with a recent experiment on doped quantum wells [E. Cortese et al., Nat. Phys. 17, 31 (2021)].