Hamiltonian Based on Resonant States – Easy Way to Describe Microcavity with Periodically Modulated Dielectric Tensor

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Optical microcavities are extensively studied for their ability to showcase interactions between massive photons with a parabolic dispersion relation and the materials within the cavity. The presence of a birefringent liquid crystal inside the cavity not only facilitates the tunability of modes but also significantly enhances the spin-orbit interaction for confined photons. This effect generates synthetic magnetic fields for photons, with light polarization acting as the spin for electrons. The interaction between two orthogonally polarized modes gives rise to phenomena analogous to those seen in solid-state physics, such as Rashba-Dresselhaus interactions, merons and antimerons, and the persistent spin helix.

In our work, we introduce a novel structure where the birefringent material in the cavity forms a uniform lying helix, causing the liquid crystal director to rotate in space and the elements of the dielectric tensor to oscillate [1]. These oscillations periodically alter the refractive indices for the two orthogonally polarized modes, creating a photonic potential that leads to band structure formation. The rotation of liquid crystal molecules in space is complex and typically relies on thermodynamic functions and material-specific parameters. Our method utilizes an effective Hamiltonian based on the resonant states of the cavity [2] and expands the elements of the dielectric tensor into a Fourier series, where each amplitude effectively descirbes the nontrivial dependence in the direction perpendicular to the mirror planes. The dispersion relations are obtained by diagonalization of the discretized effective Hamiltonian. The band structure obtained from this model well reproduces the experimental data, as shown in Figure 1. The results show that our approach can be used as a simple method to describe systems with periodically modified external potential.

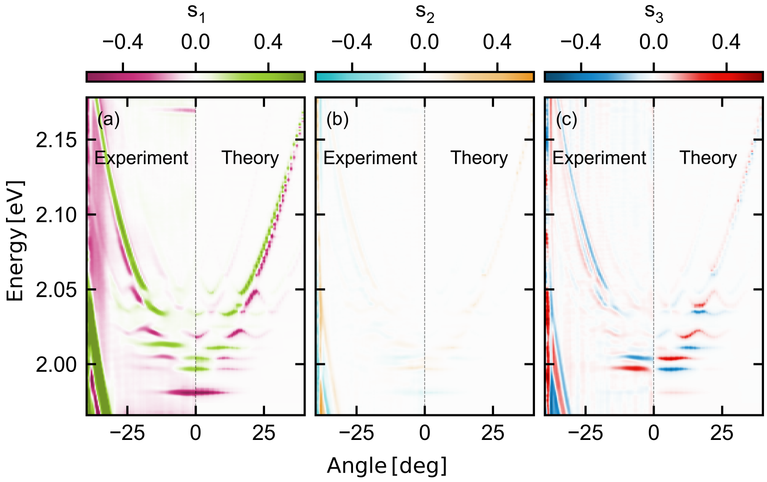

Figure 1 Comparison of Stokes polarization parameters S_1 (a), S_2 (b) and S_3 in reciprocal space between experiment (left part) and theory (right part).

[1] M. Muszyński, et al. Manuscript in preparation.

[2] P. Oliwa, et al. accepted in *Physical Review Research*.