フォトニック結晶ナノ共振器を用いた光軌道角運動量－電子スピンメディア変換の検討

Scheme for Optical Orbital-to-Electronic Spin Angular Momentum Media Conversion using a Photonic Crystal Nanocavity

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Orbital angular momentum (OAM) of light is promising for quantum communication applications such as OAM-entangled photonic qubits and their interface with stationary matter qubits [1]. These applications will demand for devices that could generate, interact and detect OAM in light. We previously reported a scheme to generate twisted light from a spin-polarized quantum dot using photonic crystal (PhC) nanocavity modes [2]. Here, we propose an inverse scheme, which converts optical orbital to electronic spin angular momentum by employing a 2D PhC nanocavity. Our numerical simulations show that twisted light excitation gives local electric field with non-zero spin angular momentum within the nanocavity.

In our scheme, we make use of two degenerate quadrupole modes supported by a H1-type PhC nanocavity (Fig. 1a) as they couple suitably with the twisted light. Excitation with twisted light results in rotating modes which are linear combinations of the two degenerate modes with a relative $\pi/2$ phase difference. Figure 1b shows the field energy density distribution of one of the rotating modes. In addition, as a result of strong optical spin-orbit interaction within the nanocavity, there are locally rotating electric fields, corresponding to right or left circular polarization (Fig. 1c, 1d). The sign of the degree of spin polarization can be controlled by the sign of OAM (±l), consistent with the conservation of angular momentum. Regions within the nanocavity with large degree of polarization and field energy density will give the most efficient conversion of angular momentum. Therefore, by placing a quantum dot at such a region, the OAM in the excitation light can be converted into confined electron (and hole) spins within the quantum dot.

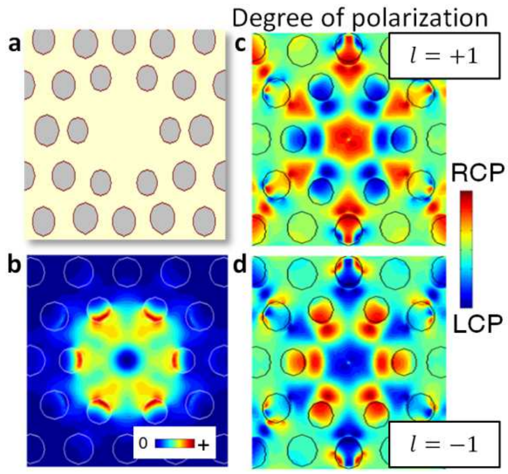

Fig. 1 (a) Schematic of the H1 PhC nanocavity. (b) Total electric and magnetic field energy density under linearly polarized twisted light excitation. The same distributions are obtained for both $l = \pm 1$. (c, d) Color plot of the degree of polarization under twisted light excitation, with red (blue) indicating right (left) circular polarization. Twisted light with OAM of $l = \pm 1$ gives polarization of opposite signs.

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