Spin-chirality-driven Raman scattering in Penrose-lattice Heisenberg antiferromagnets

Takashi Inoue and Shoji Yamamoto

Department of Physics, Hokkaido University, Sapporo, Hokkaido 060-0810, Japan

We calculate magnetic Raman spectra of Heisenberg antiferromagnets on the two-dimensional Penrose lattice [1]. Shastry and Shraiman [2] formulated Raman scattering in square-lattice Heisenberg magnets within and beyond the Loudon-Fleury (LF) perturbation theory [3]. Fourth-order magnetic Raman operators include the spin-chirality terms $S_i \cdot (S_j \times S_k)$ [4, 5], which are intriguing but hard to observe [cf. Fig. 1(d)].

Figure 1 shows symmetry-definite magnetic Raman spectra of the spin-$\frac{1}{2}$ model. In the Penrose lattice of $C_{5v}$ symmetry, whole the Raman intensity within the LF mechanism belongs to the $E_2$ representations and shows no linear polarization dependence [Figs. 1(a) and 1(b)]. The fourth-order Raman intensities consist of $A_1$ and $A_2$, as well as $E_2$, representations and therefore exhibit strong polarization dependence. We claim that the spin-chirality-driven $A_2$ mode can be extracted from the observations with the use of circularly polarized incident light. We further discuss similarities and differences between the spin-$\frac{1}{2}$ and spin-1 models.

Fig. 1. Symmetry-definite magnetic Raman spectra of the spin-$\frac{1}{2}$ model within [(a) and (b)] and beyond [(c) and (d)] the second-order perturbation LF mechanism. $e_{in}$ and $e_{sc}$ are the polarization vectors of incident and scattered photons.