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

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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 $\boldsymbol{S}_i \cdot (\boldsymbol{S}_j \times \boldsymbol{S}_k)$ [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.

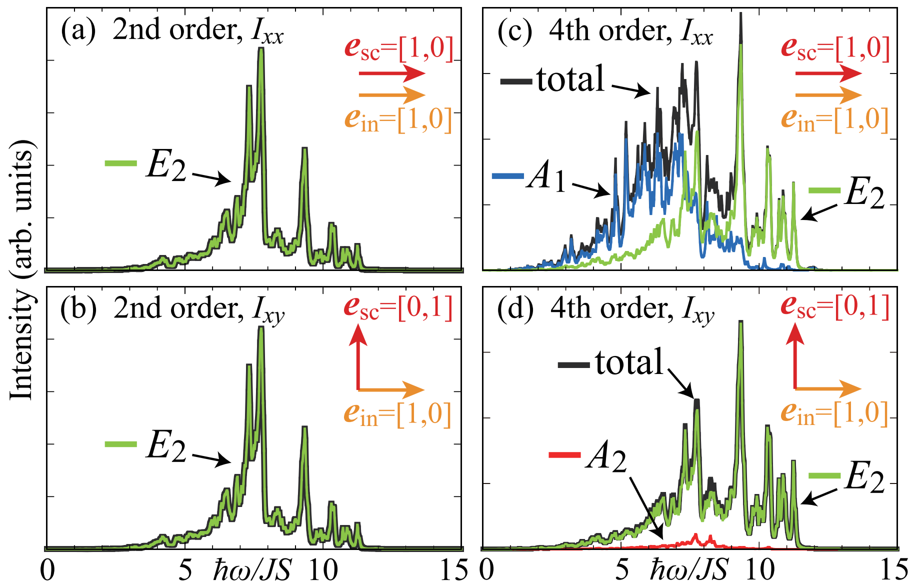

Fig. 1. Symmetry-definite magnetic Raman spectra of the spin-$\frac{1}{2}$ model within [(a) and (b)] and beyond [(c) and (d)] the second-order perturbation LF mechanism. $\boldsymbol{e}_{\mathrm{in}}$ and $\boldsymbol{e}_{\mathrm{sc}}$ are the polarization vectors of incident and scattered photons.

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