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Heisenberg-Kitaev model in a magnetic field: 1/S expansion

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The exact solution of Kitaev's spin-1/2 honeycomb spin-liquid model has sparked an intense search for Mott insulators hosting bond-dependent Kitaev interactions, of which Na_2IrO_3 and α-$RuCl_3$ are prime examples. Subsequently, it has been proposed that also spin-1 and spin-3/2 analogs of Kitaev interactions may occur in materials with strong spin-orbit coupling. As a minimal model to describe these Kitaev materials, we study the Heisenberg-Kitaev Hamiltonian in a consistent 1/S expansion, with S being the spin size. We present a comprehensive study of this model in the presence of an external magnetic field applied along two different directions, [001] and [111], for which an intricate classical phase diagram has been reported. In both settings, we employ spin-wave theory in a number of ordered phases to compute phase boundaries at the next-to-leading order in 1/S, and show that quantum corrections substantially modify the classical phase diagram. More broadly, our work presents a consistent route to investigate the leading quantum corrections in spin models that break spin-rotational symmetry.

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