Spin Wave propagation in bilayers of Vanadium dichalcogenides with Dzyaloshinskii-Moriya interaction

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We have analyzed theoretically and numerically the spectrum of spin waves (magnons) in bilayers of two-dimensional Vanadium-based transition-metal dichalcogenides (TMDs), like VX_2 with X=S, Se, Te. [1]. The Vanadium atoms within individual atomic layers are coupled ferromagnetically, while the exchange coupling between Vanadium atoms located in different planes is either ferromagnetic or antiferromagnetic - depending on the type of dichalcogenide (X) atoms. The magnon spectra are considered in bilayers of both T and H stacking. We have analyzed in detail the magnon spectra as a function of in-plane and out-of-plane magnetic anisotropy constants, external magnetic field, and strength of Dzyaloshinskii-Moriya interactions (e.g. due to the inversion symmetry breaking by an external electric field). The spin-wave dispersion relations have been derived analytically within the spin-wave theory, in terms of the Holstein-Primakoff transformation combined with the Bogolubov diagonalization scheme. They have been also simulated numerically. For numerical analysis of analytical solutions, the intra- and interlayer exchange parameters, as well as the magneto-crystalline anisotropy constants, have been computed within the method based on the density functional theory (DFT). In the case of antiferromagnetic TMD bilayers, the system undergoes a field-induced transition to the spin-flop phase, which evolves into the saturated ferromagnetic phase for sufficiently strong magnetic fields. The existence of different phases depends on the interlayer exchange coupling and anisotropy constants. We have analyzed the spin wave spectra in all these phases and showed how the spectra change at the phase transitions, and also how they evolve with increasing magnetic field. We have taken into account both intra and interlayer Dzyaloshinskii-Moriya interactions, and have shown that these interactions lead in general to nonreciprocal spin-wave propagation.

References:

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