Roton-phonon interaction: from superfluid helium to quantum magnets

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High-energy gapped quasiparticles (rotons), which interact with low-energy acoustic excitations (phonons), are ubiquitous in condensed matter physics. I discuss two recent examples which exhibit novel features. The high-precision neutron spin-echo measurements of rotons in the superfluid helium reveal a non-monotonous temperature dependence of the roton gap [1]. We explain this new phenomenon by competition between the standard roton-roton scattering effective above ~1K, and the roton-phonon three-particle processes, which appear due to the presence of the Bose-Einstein condensate in the superfluid helium and dominate in the sub-Kelvin region.

In the second example, an optical magnon in an easy-plane collinear antiferromagnet interacts with acoustic spin waves. I consider the effect of disorder in such systems and demonstrate that it has a profound effect on the temperature dependence of the relaxation rate of optical magnons. The usual random-potential scattering yields a T-independent contribution whereas the impurity-assisted magnon scattering gives the leading temperature correction. The new impurity mechanism exceeds greatly the effect from magnon-magnon interaction in the bulk. The theoretical prediction finds confirmation in the high-resolution neutron measurements on BaNi2(PO4)2 [2].

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