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A phenomenological theory of magnon sidebands in the spectra of magnetic insulators

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The work of this thesis presents a simple phenomenological model for calculating properties of magnetic insulators when an exciton-magnon interaction is involved. The advantage of the model is its simplicity while still being able to explain the essential features of observations of the phenomena studied. The model is solved exactly and therefore allows precise physical interpretation of the results.

In Chapter I we present a discussion of the forms of the hamiltonians necessary for the calculation, and discuss the effect of a substitutional spin impurity on the form of the crystal hamiltonian and therefore on the crystal spectrum. We present a discussion of the means of calculating the optical absorption of a crystal using Green function methods.

Model calculations of magnon sideband lineshapes in pure ferromagnetic and antiferromagnetic insulators are presented in Chapter II. The main features of the results are discussed with respect to specific examples of face centred cubic ferromagnetic crystals such as EuO and perovskite antiferromagnetic crystals such as $RbMnF_3$. For a wavenumber-independent exciton-magnon interaction strength g it is found that the magnon side-band lineshape is closely approximated by the shape of the corresponding magnon density of states, the sideband being situated on the high-energy side of the parent exciton frequency and of width given by the maximum value of the magnon energy.

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The effect of substitutional spin impurities on the magnon sideband have been studied in Chapter III using a Koster-Slater type model. Calculations have been given for both ferromagnetic and antiferromagnetic crystals with the changes in the spectrum of the pure crystal examples discussed in Chapter II given in some detail. It is found for certain values of an impurity parameter γ that local modes may occur outside the pure crystal absorption band separated by an amount dependent on the absolute magnitude of γ. For all positive values of γ it is found that a local mode will occur on the high-energy side of the band for both the *fcc* and perovskite crystals studied. When γ is negative there may occur local modes on the low energy side of the band, for certain values of γ.

The possibility of the occurrence of resonance modes within the band has been considered for certain values of γ for which there will be no local modes. It is found that for both the *fcc* and perovskite examples used that the criteria for resonance modes to appear are not all satisfied and it is therefore expected that these will not be observable.

In the appendices we present discussions of the forms of exciton-magnon and perturbation hamiltonians that have been used in the model; a discussion of how the calculation may be done exactly for a more realistic form of the impurity part of the hamiltonian; a description of the methods used to perform the numerical calculations which were done using a Monte-Carlo method and also with the help of a Fourier series expansion, and a discussion of some aspects of the model calculation when the crystal has an infinite number of ions in its lattice. It is shown that the form of the results obtained for a finite crystal still applies. An indication of how the model may be solved exactly for the case where the exciton has some dispersion, and the exciton-magnon interaction strength has some **k**-dependence, is given also.