Bolometric probing of magnetic resonances in (anti)ferromagnetic layered materials

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Recent progress in the studies of two-dimensional crystals, has led to discovery of various layered materials which exhibit magnetic properties. Some of the low-dimensional systems present intra- and inter-layer magnetic ordering, offering intriguing possibilities for research and application.

One of the techniques for testing antiferromagnetic materials is magnetic resonance, (here: AFMR – antiferromagnetic resonance). To simplify, one can think of such a resonance as the excitation of a spin wave (magnon)[1]. The magnetic field-frequency dependence allows us to determine the basic information about the magnetic order. Important characteristics which can be derived from it are the spin-flop magnetic field (B_{flop}), magnons' g-factors and zero-field magnon frequency [2]. However, probing AFMR can be challenging, especially when measuring low-volume crystals, i.e., thin flakes of layered materials.

Here, we present and compare two different approaches to bolometric probing of AFMR in $MnPS_3$. $MnPS_3$ is one of the magnetic layered materials with hexagonal lattice symmetry. Below Neel temperature, the magnetic ions are coupled antiferromagnetically with their nearest neighbors in the plane. Coupling with the nearest magnetic ions from neighboring layers is ferromagnetic. The easy axis (c) is out of the plane of the layer [3,4].

In this work, the main experimental technique is based on the absorption of microwave radiation in resonance with magnons present in (anti-)ferromagnetic state. The absorption can be probed by detecting changes in the local temperature [1]. The first approach uses on measuring the variation of the electric resistance of a thinned-down carbon resistor acting as a bolometer. The sensitivity of this method strongly depends on the volume ratio between the sample and the probe. For the very thin crystals it can be challenging to find a proper probe and obtain good signal to noise ratio.

To adress the limitations of the above-mentioned resistor probing, we tried alternative approach by implementing a different temperature probe - a single (Cd, Mn)Te quantum well (QW) placed near the sample's surface. Due to the strong exchange interaction with photocarriers in (Cd,Mn)Te it is possible to probe the magnetization of the magnetic ions system with the use of the optical signal (Giant Zeeman effect). At the same time, the magnetization of the QW is strongly sensitive to the local temperature. On such a sample, we exfoliated multilayered $MnPS_3$ flakes in order to probe its magnetic resonances by observing the changes in the QW's optical signal.

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