Referee report
on Ph.D. thesis

Investigation of spin structure and dynamics in magnetically ordered thin films

written by Mgr. Tomáš Janda

The Ph.D. thesis by Mgr. Tomáš Janda is studies the readout and manipulation of the spin arrangement in the ferromagnetic materials (Fe, (Ga,Mn)(As,P)) and the antiferromagnetic materials Mn_3Sn a CuMnAs. The thesis is mostly an experimental work, where several direction of research are well arranged into individual chapters.

The thesis starts by introduction of spin, magnetization and magnetic domains and domain walls (Chapter 1), and followed by description of possibilities of spin manipulation and spin dynamics (e.g. domain wall movement, magnetization precession, spin-orbit torque) (Chapter 2). The detailed description of the employed experimental equipment follows, focusing on magneto-optic microscopy, magneto-transport and pump-probe techniques (Chapters 3, 5). Chapter 4 then describes structures of studied ferromagnetic and antiferromagnetic materials (Fe, Ga(Mn,As), CuMnAs, Mn_3Sn).

Then, the thesis describes authors original results:

- the study of domain wall movement induced by light pulse. Here, I would like to point out the observation of transfer of angular momenta from a light to the domain wall, being an unique experiment (Chapter 6).
- GHz spin dynamics in ferromagnetic Fe, induced and measured by pump-probe technique in an unique geometry, where pump pulse creates conductive channel in GaAs substrate, and hence generating pulse of magnetic field (chapter 7).
- readout and manipulation of magnetic domains in non-collinear antiferromagnet Mn_3Sn. This chapter also includes detection of magnetic domains using an unique microscopy technique, where magnetic signal is created by local temperature gradient, created by scanning laser beam (chapter 8).
- observation of magnetic domains in collinear antiferromagnetic CuMnAs (chapter 9).

Each of those chapters provides very interesting and current topics, as demonstrated by authors publications in prestigious journals (e.g. Nature Communications, Physical Review Materials), where the thesis author is the first author of four publication and the second author of one publication.

I consider the thesis to be very well and clearly written, with minima of mistakes and typos. In my best opinion, this is one of the best dissertation avaiable nowadays. I suggest the thesis to be accepted for the Ph.D. defense.

Topics to discussion:

- Chapters 8 and 9 describe microscopic investigations of antiferromagnetic Mn_3Sn a CuMnAs. In the case of Mn_3Sn, the measured signal is interpreted using anomalous Nerst effect, being V_T \sim grad(T) x g, where the detected signal is interpreted to originate from out-of-plane component of the temperature gradient. (i.e. along z-axis, as defined in Fig. 8.1). Hence, the measured signal is interpreted to be proportional to x-component of the g-vector (Chapter 8).

However, in the case of CuMnAs, the temperature gradient along z-axis is not considered to contribute to the detected signal. Is this supported by symmetry arguments or is it experimentally verified that this contribution is small?

- At the beginning of Chapter 8, you mention, that requirement for non-zero anomalous effect (e.g. anomalous Hall effect) is a broken PT symmetry of the structure. Can you explain what broken PT symmetry means?

- In Fig. 7.3. you show spin dynamics of Fe layer deposited on the PIN structure. Why there is only one precession frequency for the highest applied voltage -15V, whereas more complicated MO response is observed for other applied voltages, suggesting presence of several precession frequencies in the dynamics. Furthermore, you interpret the measurements using Oersted field created in the PIN structure. However, as pump and probe spots are on the same Fe layer in distance 8um, is there a possibility of transfer of angular momenta using spin waves?

- In Chapter 6, you present dependence of depinning of the domain wall on polarization of the circularly polarized light. Those finding are interpreted as transfer of angular momenta from light to the domain wall. Can there be a contribution to this depinning due to in-plane temperature gradient through magnetic domain, due to different light absorption (MCD) for different circular light polarizations? Note, similar effect (different values of temperature gradient due to MCD was reported in [1]).

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[1] T. Guillet, A. Marty, C. Vergnaud, F. Bonell, and M. Jamet, *Electrical detection of magnetic circular dichroism: application to magnetic microscopy in ultra-thin ferromagnetic films*, arXiv:2009.03982 (2020)