Minicolloque n° 27 ☐ **Oral** ☒ **Poster**

Spins and charges dynamics across Verwey transition in thin Fe_3O_4 films

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In Fe_3O_4, the presence of the metal-insulator transition (MIT) known as Verwey transition makes it a really interesting candidate for spintronics, nanoelectronics applications [1]. However, even huge progresses have been made to understand the Verwey transition [2], there are still open questions due to the interplay between the different degrees of freedom. To our knowledge, this work is the first study as a function of the temperature of time-resolved magneto-optical signals in Faraday (transmission) configuration on thin Fe_3O_4 films. We show that ultrafast magneto-optics is a perfect tool not only to discriminate clearly insulating and conducting states controlled by the environment temperature but also as the transition is optically induced.

We show that ultrafast charges and spins dynamics have different signatures across the Verwey temperature (Tv) and for different density of excitation of the laser. Regarding the charges dynamics, we observe clearly a step-like behaviour of the electron-phonon relaxation time that undergoes a decrease in the metallic phase. This is accompanied by a faster transfer of heat to the environment at longer timescale. Additionally, above a threshold of the pump laser fluence, the differential transmission at short timescale under Tv has an anomalous behaviour, in line with previous works on Fe_3O_4 crystals [3] that has been associated to the creation of metallic areas in insulating phase. At a timescale of 400ps, this scenario is confirmed by the corresponding time-resolved differential transmission that have the characteristic behaviour of a metal.

In our configuration, the magnetization dynamics demonstrate a precession behaviour with a large amplitude under Tv. These temporal features show also a different behaviour from each side of the transition. In particular, the reorientation of the effective field, which the sample experiences, is drastically different in the two states (Fig. 1a). This is associated to the structure modification which manifests in the magneto-crystalline anisotropy. Additionally, the damping parameter of these periodic oscillations is larger in the insulating state (Fig. 1b), demonstrating also a step-like behaviour at Tv. Previously, through Raman spectroscopy on thin Fe_3O_4 films, it has been proposed that the anomalous line-shape parameters of the Raman modes below Tv are linked to stronger spin-phonon coupling under Verwey transition [4]. This interpretation is in adequation with our results.

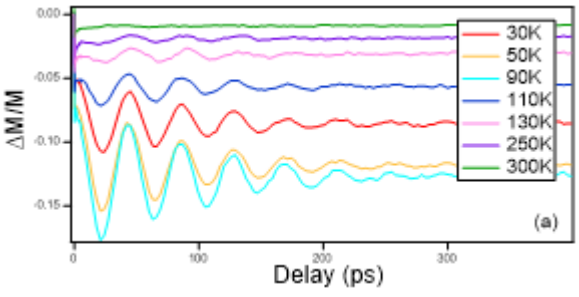

Fig.1(a): ΔM/M for 157.5μJ/cm²

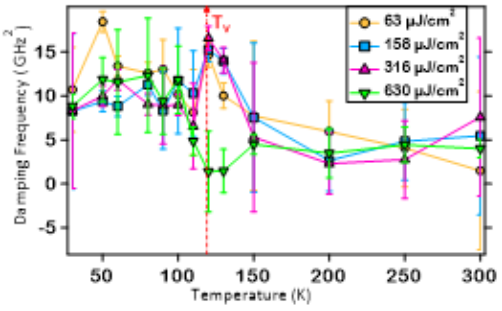

Fig1(b): Damping for different pump fluences

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[4] A. Kumar et al., "Evidence of electron-phonon and spins-phonon couplings at the Verwey transition in Fe3O4", Phys. Rev. B 90, 024302 (2014)