Transient Terahertz Polaron Conductivity of Magnetite

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Abstract: After a brief discussion of the polaron concept, the static and transient terahertz conductivity across the Verwey insulator-to-metal transition of magnetite, the textbook example of polaron physics, is presented.

Although the concept of polaron was introduced by Salomon Pekar in 1946 to describe a composite quantum object consisting of a charge carrier dressed by a cloud of virtual phonons (lattice polaron), its meaning was quickly expanded to include other couplings, such as spin waves (magnetic polaron), eventually leading to the introduction of more complex states where electric charges form bipolaron or multipolaron quasi-particles. Polarons significantly influence the equilibrium electrical conductivity and optical properties of materials, being fundamental to reduced charge mobility and to induce metal-to-insulator transition (MIT) phenomena. In this talk, after a brief overview of our research on polaronic physics [1,2,3], we will discuss both equilibrium and transient (time-dependent and non-linear) terahertz properties of lattice polarons. In particular, we will present examples of polaronic behavior in magnetite (Fe_3O_4) [4], utilizing advanced static and pump-probe Terahertz optical techniques.

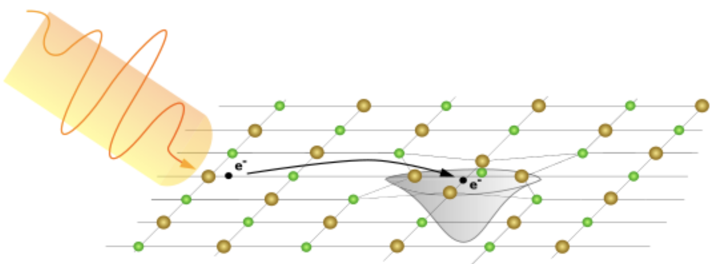

Fig.1 | A metastable polaronic charge survives over hundreds of nanosecond time scale in magnetite after a femtosecond photodoping.

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References

[1] I. Lo Vecchio et al., Phys. Rev. B 90, 115149 (2014)

[2] S. Lupi et al., Phys. Rev. Lett. 102, 206409 (2009)

[3] S. Lupi et al., Phys. Rev. Lett. 83, 4852 (1999)

[4] L. Mosesso et al., submitted (2025)