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Driving orbital magnetism in metallic nanoparticles through plasmonic effects

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The topic of this contribution is the generation of large magnetic fields in non-magnetic materials through polarized laser fields.

Transfer of angular momentum from helicity-controlled laser fields to a nonmagnetic electronic system can lead to the creation of magnetization. The underlying mechanism in metallic nanoparticles has been identified as the inverse Faraday effect (IFE), whereby a quasi-static magnetic field is generated by an external oscillating lase field and is proportional to the laser intensity.

Here, we show that the IFE can be strongly amplified in small gold nanoparticles thanks to plasmonic effects. If the laser frequency matches the plasma frequency of the conduction electrons in the metal (surface plasmon resonance), a strong oscillating electric field is excited in the nanoparticle. Through the IFE, this internal self-consistent field generates a sizeable magnetization, of the order of tens of Bohr magnetons. The primary contribution to the magnetization comes from surface currents generated by the self-consistent field. The effect is maximum for circularly polarized laser fields and disappears for linearly polarized fields.

This plasmonic IFE is studied here using both a simplified quantum hydrodynamic model [1] and fully quantum simulations based on time-dependent density functional theory [2].

This is an important step in the ultrafast manipulation of magnetic effects in nano-objects via electromagnetic waves, which may find applications for the storage, writing, and reading of information based on optical means.

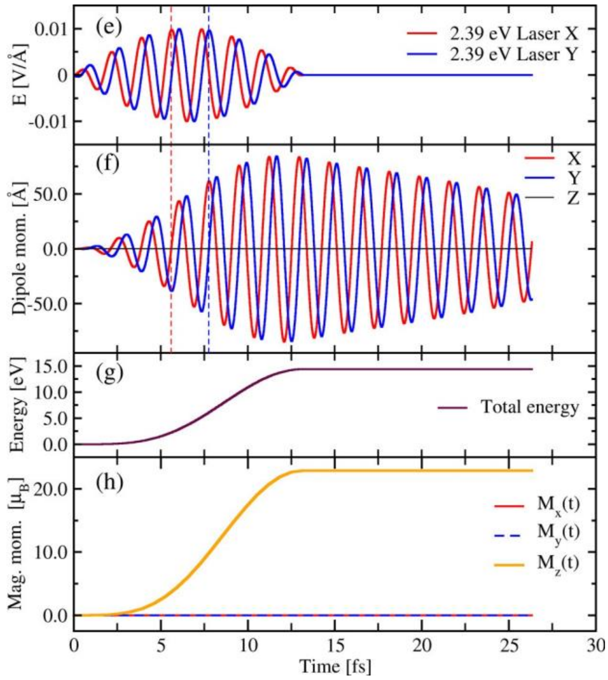

Figure 1: Circularly polarized laser excitation of a potassium K_{561} cluster. From top to bottom, the panels show: the time dependence of the *x* (red) and *y* (blue) components of the laser electric field (e); the three components of the dipole moment (f); the total energy absorbed by the electronic system (g); and the three components of the magnetic moment, in units of the Bohr magneton μ_B (h). From Ref. [2].

References

[1] J. Hurst, P. M. Oppeneer, G. Manfredi, P.-A. Hervieux, Magnetic moment generation in small gold nanoparticles via the plasmonic inverse Faraday effect, Phys. Rev. B **98**, 134439 (2018).

[2] R. Sinha-Roy, J. Hurst, G. Manfredi, P.A. Hervieux, Driving Orbital Magnetism in Metallic Nanoparticles Through Circularly Polarized Light: A Real-Time TDDFT Study, ACS Photonics **7**, 2429-2439 (2020).