Picoplasma optoelectronics

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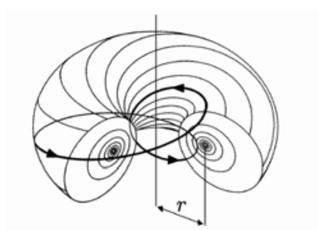
Optical interaction with a picoplasma is discussed, motivated by the prospect of resonant scattering by surface plasmon excitation on axially symmetric nanoparticles. Device applications in memory and switching are envisioned.

Magic number silicon nanospheres in colloidal suspension can be fabricated electrochemically [1]. They adopt five discrete diameters, in the 1–3 nm range. Along with the usual optical resonances based on band structure and excitons, quantized interband and intersubband transitions, the prospect arises for a circumferential surface plasmon mode. The charge distribution required to support this mode might derive from surface state band-bending to produce a (spherical) 2DEG, or from extended π-like or σ-like orbitals formed by surface bonds. At this nanoscopic dimension, a single mobile electron introduces sufficient charge density to support a plasma frequency in the optical domain, while the dispersion of the coupled excitation conveys short wavelengths.

Analyzing the modal structure of the driven electron (surface plasmon) resonance on a sphere has led to an investigation of the precepts governing plasma flow. An electron confined to such small dimensions exhibits a non-localized distribution such that its behavior more nearly mimics continuous flow than discrete point-like properties. Movement of the charge constitutes current, with concomitant magnetic field; it is essentially a bound picoplasma.

Faraday's Law describes the interactions of currents and magnetic fields, apparently accurate at all scales. A mathematical exploration of stable iterates of this expression leads to Beltrami fields via the curl eigenvalue equation: $\nabla \times A = \alpha A$ [2]. Its most straightforward eigenfunctions are toroidal-poloidal flows (see sketch) [3]. As in the spherical harmonic description of the quantum hydrogen atom, these flows exhibit cyclic periodicity and are constructively interferometric.



This view suggests a picoplasma description of an electron. It also suggests that an external periodic perturbation might modify the character of the flow trajectory, however stable its intrinsic nature. We explore the interaction of an electron, derived from the flow of the vector potential field, with an optical field, assuming two postulates: three dimensional analyticity, and conformity to Faraday's Law.

1. G. Belomoin, *Appl. Phys. Lett.* **80**, 841 (2002).
2. H. Zaghloul and O. Barajas, *Amer. J. Phys.* **58**, 783 (1990).
3. G. E. Marsh, *Force-Free Magnetic Fields*, Singapore: World Scientific, 1996.