Photon Torpedoes and QED Pinwheels: Theoretical Modeling of Novel Geometries in Non-Equilibrium Casimir Physics

M. T. Homer Reid

Massachusetts Institute of Technology, US

Email of Presenting Author: homereid@mit.edu

We present new theoretical tools for accurate and efficient modeling of non-equilibrium fluctuation-induced phenomena---including non-equilibrium Casimir forces, thermal self-propulsion and self-rotation, and near-field radiative heat transfer---involving bodies of arbitrarily complex shapes and material properties. Our numerical tools are based on discretized integral equations, including both *surface integral equations*—valuable for efficient simulation of one or more homogeneous isotropic dielectric bodies—and *volume integral equations,* which allow modeling of complex material configurations, including anisotropic materials and bodies of continuously spatially varying dielectric permittivity. Using our new tools, we obtain new predictions of non-equilibrium fluctuation phenomena in novel geometries that would be unwieldy or impossible to treat using any other theoretical method; examples include *photon torpedoes* (asymmetric nanoparticles that accelerate in a characteristic direction when heated or cooled) and *QED pinwheels* (chiral nanoparticles that spontaneously begin to rotate when heated or cooled). In both of these cases, the motion of the nanoparticle is a recoil effect arising to balance a surplus or deficit of linear or angular momentum carried away by thermal radiation. Our new tools are available online as free, open-source software; documentation and tutorials may be found at http://GitHub.com/HomerReid.

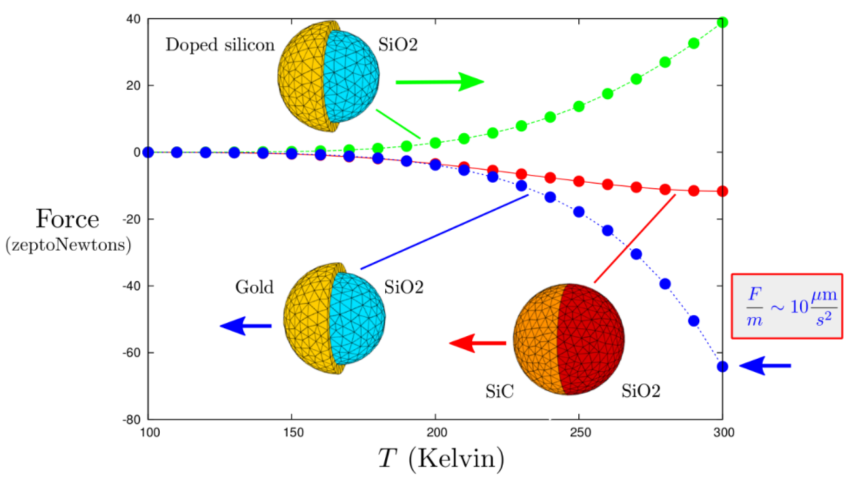

Figure 1: Self-propulsion force vs. temperature on *photon torpedoes*—nanoparticles of diameter ~ 2 µm formed by juxtaposing various pairs of materials—embedded in a cold (0 K) environment.

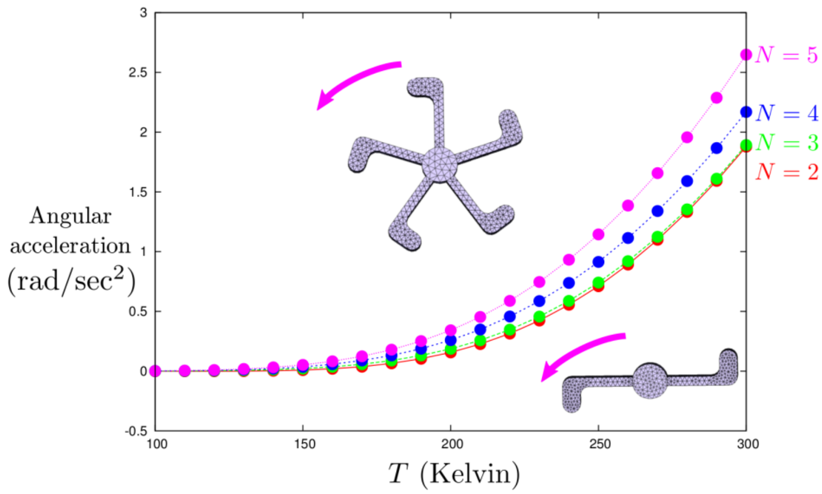

Figure 2: Angular acceleration due to self-rotation torque vs. temperature on *QED pinwheels* - (chiral gold nanoparticles of thickness ~ 250 nm and diameter ~ 2 μm) embedded in a cold (0 K) environment.