Plasmon Waves in Ordered Systems of Metallic Nanoparticles

D. G. Stroud, Dept. of Physics, Ohio State U., Columbus, OH 43210

When a metal particle is small compared to the wavelength of radiation, its electronic charge density has a natural oscillation, usually at a frequency in the visible, called a particle plasmon. For a spherical particle, this frequency is $\omega_p/\sqrt{3}$, where ω_p is the bulk plasmon frequency, usually in the ultraviolet for a typical metal. The restoring force for the particle plasmon is the electric field produced when the electronic charge is displaced from the ionic cores. If the small metal particles are arranged in an ordered one- or two-dimensional structure, the plasmons can couple together, to produce waves of propagating plasmons. The structures effectively behave like very narrow waveguides, in which energy can efficiently propagate far below the diffraction limit. The conditions for these waves to propagate with minimal losses are (i) the interparticle separation, as well as the particle radius, should be small compared to the wavelength of radiation (so that the "quasistatic approximation" is valid), and (ii) the damping of the plasmon excitations within the metal particles should be small.

In this talk, I will present calculations of the dispersion relations for these propagating waves (frequency versus wave number) for both longitudinal and transverse waves in both one and two dimensions, and compare the results with recent experiments. In contrast to previous work, our calculations in one dimension are *exact* in the sense that they include all multipolar interactions between the plasmons on different particles; in two dimensions, they can be made exact with a little further computation. I will also describe how, in one dimension, these waves can go around sharp corners with little loss of energy. Finally, I will discuss the extension of these calculations to lattice structures which, at finite frequencies, have a negative index of refraction.