Deficiency of the Conventional Polarizability Concept for Dense Composite Materials

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The polarizability is a fictitious quantity that describes the first order scattering response (i.e. the dipolar response) of an atom to an electromagnetic wave. It is defined as the ratio of the dipole moment induced in the atom by the applied field to this applied field. The polarizability concept can be used to model scattering from an electrically small object by replacing it with an infinitesimal electric dipole.

The polarizability of an object may be calculated in two alternative approaches: a) by comparing the scattered field with the field radiated by an infinitesimal electric dipole, and b) by averaging of the displacement and/or conduction current over the volume of the object. Both definitions are valid only when the size of the object is much smaller than the wavelength of the incoming wave so that the higher order multipole moments are negligible compared to the dipole moment.

In the analysis of composite materials, formed by periodic arrangements of scattering objects, the polarizability is generally calculated using either of the aforementioned approaches, *under plane wave illumination, regardless the density of the objects* forming the composite. However, in high-density mixtures, the scatterers are inter-coupled and, as a result, the total wave incident on each scatterer is *not* a simple plane wave anymore, and hence these approaches are not applicable.

To explore this issue, this presentation will compare the polarizabilities obtained for plane wave illumination and for Hertz dipole illumination, where the latter qualitatively describes the effect of inter-coupling in a dense composite. It will show, analytically, the polarizabilities obtained for the two illuminations are generally different. From this demonstration, it can be inferred that the aforementioned approaches fail to model dense composites. We will suggest some directions to address this issue.