

Conflicts and discrepancies around nanoparticle (NP) size effect on the optical properties of metal NPs of sizes below the mean free path of electron can be traced to the internal damping effect of the hybrid resonance of the inner band (IB) and the conduction band (CB) electrons of the noble metals. We present a scheme to show how alternative mathematical formulation of the physics of interaction between the CB and the IB electrons of NP sizes  $<50$  nm justifies this and resolves the conflicts. While a number of controversies exist between classical and quantum theories over the phenomenological factors to attribute to the NP size effect on the absorption bandwidth, this article shows that the bandwidth behavior can be well predicted from a different treatment of the IB damping effect, without invoking any of the controversial phenomenological factors. It finds that the IB damping effect is mainly frequency dependent and only partly size dependent and shows how its influence on the surface plasmon resonance can be modeled to show the influence of NP size on the absorption properties. Through the model, it is revealed that strong coupling of IB and CB electrons drastically alters the absorption spectra, splitting it into distinctive dipole and quadrupole modes and even introduce a behavioral switch. It finds a strong overlap between the IB and the CB absorptions for Au and Cu but not Ag, which is sensitive to the NP environment. The CB modes shift with the changing refractive index of the medium in a way that can allow their independent excitation, free of influence of the IB electrons. Through a hybrid of parameters, the model further finds that metal NP sizes can be established not only by their spectral absorption peak locations but also from a proper correlation of the peak location and the bandwidth (FWHM).