Electromagnetic Scattering from Single-Walled Carbon Nanotube Dimers

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The study of dimers represents the first step beyond a single nanoparticle in understanding the electromagnetic response of an assembly of nanoparticles. In this work, we focus on quantifying the electromagnetic response of metallic Single Walled Carbon Nanotube (SWCNT) dimers using the Method of Moments (MOM) formulation for Arbitrary Thin Wires (ATW). Similar to gold and silver nanoparticles, we show that SWCNT dimers in close proximity exhibit hybridization in their plasmon frequencies. This hybridization leads to shifts in the resonance frequencies and the emergence of bonding and antibonding modes, which are also termed bright and dark modes. Antibonding modes are only detectable when there is asymmetry between the two SWCNTs in the dimer. For example, we show that for straight SWCNTs the antibonding mode is detectable when the two SWCNTs differ in length, orientation, and/or axial conductivity. Moreover, the main contribution of this work is to show that, in addition to the previous factors, asymmetry in the shape of the SWCNTs also leads to the appearance of the antibonding mode even when the two SWCNTs have the same length, electrical conductivity, and general orientation. Using the MOM formulation for ATW, we quantified how the dimer resonances varied with the contour lengths and the persistence length, which is a measure of the general curvature of the SWCNTs. We show that the large aspect ratios of SWCNTs increase the number of possible shapes that they can exhibit, thereby increasing the potential for optimizing the properties of the antibonding mode. Finally, we use our full wave MOM computations to show the range of validity of the coupled dipole approximation.