Power deposition of multiple nano-scale multilayer particles excited by plane waves

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In this work, the power absorption in multiple nano-scale multilayer particles is evaluated by the integration of surface Poynting vector, which can be obtained by using the surface integral equation (SIE) method. To solve the surface integral equation efficiently, an iterative solver for multiple objects is applied.
The iterative solver can be seen as a kind of domain decomposition method and can be simply described in the following steps: 1) solve the surface currents for a single particle excited by the original source independently; 2) calculate the interaction coupling between particles via the Stratton-Chu representation formulas; 3) modify the original source by the interaction coupling; 4) solve surface currents for the single particle excited by the modified source; 5) go back to step 2 until convergence.

Since the nano-scale particles we concerned are always bodies of revolution (BoR) or could be seen as BoRs, an efficient and accurate method called the BoR-SIM is applied as the single BoR solver for Step 1 and 4.BoR-SIM is a combination of the spectral integral method (SIM) and the conventional BoR method. Like the conventional BoR method, this method takes the advantage of decomposing the current into different orthogonal modes, where the current of each mode can be solved independently. On the other hand, this method expands the current along the generatrix by the Fourier series as SIM does. By this SIM strategy, a bit more than two unknowns per wavelength are adequate to achieve a convincing accuracy according to the Nyquist theorem. Consequently, the total number of unknowns of this method is still far less than the conventional BoR method. Furthermore, being accelerated by FFT, this method also shows a significant advantage in time consumption.

It is noteworthy that the BoR-SIM or conventional BoR method cannot be applied in the interaction between different objects. To evaluate the interaction coupling in Step 3, the current represented by the BoR-SIM should be mapping into a local basis function. Thus, the multilayer fast multipole algorithm (MLFMA) can be applied to solve the matrix-vector product (MVP) of interaction coupling, which will reduce the time and memory complexity of MVP from $O(N^2)$ to $O(N\log N)$.

In this work, some numerical results are demonstrated to show the efficiency and accuracy of this method. And the capability of the method in solving absorbed power problems including a huge number of particles randomly distributed in large-scale space is also proved by a specific case. Some discussions based on the numerical results are also given here.