# Green's function formalism for near field analysis of planar layered media in nano-photonics

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The Green's function (GF) for multilayered planar media is a useful tool for analytical modeling of radiation and near field problems, such as encountered in the study of optical metamaterials and the electrodynamic properties of nano-particles on layered substrates. The numerical evaluation of the Sommerfeld integrals in the expression of the scattering GFs, however, is not always trivial. Therefore, improving the computation of the GF for multilayered media has been a topic of interest, either through numerical methods for faster and more accurate computations, or through the use of asymptotic or closed form solutions that are accurate enough for specific applications.

One of the areas in which scattering GF for planar layered media can be very useful, is the analysis of nanoparticles and molecules on top of a (multilayer) substrate. Examples include the calculation of molecular excitation rates or the photo-induced force exerted on a particle upon laser illumination. Often, in these applications, one aims to calculate the electric field at the location of the nano-particles, considering the effects of the substrate. Image dipole theory, for instance, is a well known approximation that falls into the same category of problems, providing reasonably accurate results in many applications, while avoiding calculation of the GF.

In this contribution, we start from the angular domain representation of the GF and present a method for the efficient computation of the integrals in the evaluation of the scattering GF. For the relevant scenario where the source and observer are along the normal of the planar substrate, we provide closed form expressions of the dominant part of the integrands, where the remaining part decays much faster. In many cases, the modification due to the remaining integrand is less than 5% and the closed form expression is sufficiently accurate in the calculations. In addition, our formalism provides a more accurate representation of the quasi-static image dipole which includes the propagation phase. The propagation phase effect can be substantial in cases where the nanoparticle has a strong coupling with the substrate (e.g. spatial resonance). Based on this formalism, we also revisit the definition of the effective polarizability of the nano-particle, and investigate optical phenomena such as the photo-induced force, where not only the electric field, but also the field gradients are concerned.