APPLICABILITY OF EFFECTIVE MEDIUM APPROXIMATION TO LIGHT SCATTERING BY GRANULATED BIOLOGICAL CELLS – FIRST RESULTS

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Our primary interest is constructing and validating simplified models to simulate light scattering by granulated white blood cells (granulocytes). These cells have a complex shape (especially the nucleus) and their cytoplasms contain many granules, which vary in size and concentration. Although use of a realistic model (without any simplifications in morphology and without any approximations in the physics) is tempting, at present it seems unbearable since 1) detailed information on the morphology of granulocytes is sparse, especially on the statistical distribution of relevant parameters (e.g. size and refractive index distribution of granules); 2) a realistic model has many free parameters and computationally intensive methods, such as the Discrete Dipole Approximation (DDA), should be used to simulate light scattering by such complex model. While computational time for one set of free parameters is acceptable (few hours), modeling biological diversity, which implies varying each of the free parameters, increases simulation time by many orders of magnitude.

Therefore we have to simplify the model but in doing so it is important to control the deviation of results from those obtained by using a realistic model. The first simplification, which we concentrate on in this study, is replacing the cytoplasm containing granules by a homogenous medium with some average refractive index. Calculation of this refractive index is performed by an Effective Medium Approximation (EMA). All classical EMAs assume that the size of the inclusions is small compared to the wavelength, however in some cases they are applicable for much larger inclusions [1]. The latter, however, can be verified in any particular case only by comparison of EMA

prediction to exact results. Extensive studies of EMA applicability were performed using experimental [1, 2] and theoretical [1, 3] reference results. However they focused on astrophysical applications (refractive index of 1.6 and larger) and used spheres with inclusions as a model.

We are studying the applicability of EMA to granulocytes, therefore we consider a much lower refractive index and a coated sphere model for the cell, where the inner cell corresponds to the nucleus and the outer shell to the cytoplasm with granules. We use DDA to simulate light scattering for different sizes and volume fractions of granules and compare them to Mie theory applied to a coated sphere, where the refractive index of the outer shell is calculated by EMA. Our first results show that Maxwell-Garnett EMA (which corresponds to the studied topology – inclusions inside the matrix) can be successfully applied for small inclusions over a large range of volume fractions. We are currently studying larger inclusions and relaxing the concentric sphere model by allowing an eccentric nucleus. At the workshop we will present a progress report of our study.

References

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