Characterization of a single sphere using amplitude and phase Fourier spectrum of its light-scattering profile

Andrey V. Romanov[1,2*] and Maxim A. Yurkin[1,2]

[1] *Voevodsky Institute of Chemical Kinetics and Combustion SB RAS, Institutskaya Str. 3, 630090, Novosibirsk, Russia*

[2] *Novosibirsk State University, Pirogova Str. 2, 630090, Novosibirsk, Russia*

[*] *corresponding author's e-mail: avm.romanov@gmail.com*

Measuring light scattering of single particles is one of the most promising approaches to their non-invasive characterization, since the corresponding inverse problem is usually well posed. Along with the technical aspects, the solution of such inverse light-scattering problems is of great complexity [1]. One of the possible approaches is the compression of information in the measured light-scattering profiles or patterns (LSP) into several parameters that determine the model characteristics of the particle under study. Such methods usually possess advantages of high-speed performance and the robustness with respect to diverse distortions contributed both by experiment and by the particle model imperfection. Several recent examples include spectral methods for determining the size and refractive index of spheres [2,3] and for non-sphericity estimation [4].

In particular, an accurate and robust sphere characterization was based on extraction of two parameters from the Fourier spectrum of the one-dimensional LSP: the main peak position and the zero-frequency amplitude, which highly correlated with the size and refractive index, respectively [2]. However, the zero-frequency amplitude has one-to-one (monotonous) correspondence with the refractive index, only for relatively low values of the latter. Thus, it cannot be used for a common task of characterization of polystyrene beads in a liquid.

Analyzing the Rayleigh-Gans-Debye and Wentzel–Kramers–Brillouin approximations, we obtained an analytical representation of the refractive index influence on the Fourier phase spectrum of the LSP. The obtained results confirmed the linear dependence of the spectrum phase on the refractive index m at the first-order approximation in powers of $(m-1)$, previously observed in the rigorous Lorentz-Mie theory. Based on this general theory, we developed a specific characterization method for characterization of polystyrene beads from the LSP measured with the scanning flow cytometer. This fast method uses two spectral parameters: the position of the main peak and the phase value at that point. The details of its performance on both synthetic and real experimental data will be reported at the conference.

References

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