Simultaneous characterization of rotational and translational diffusion of anisotropic particles by optical microscopy

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Abstract

We probe the roto-translational Brownian motion of anisotropic particles in suspension with simple and straightforward optical microscopy experiments that do not require positional or rotational particle tracking. In a first configuration, we acquire a movie of the suspension placed between two polarizing elements and we extract the translational diffusion coefficient D_T and the rotational diffusion coefficient D_R from the analysis of the temporal correlation properties of the spatial Fourier modes of the intensity fluctuations in the movie [1,2]. Our method is successfully tested with a dilute suspension of birefringent spherical colloidal particles, whose roto-translational dynamics is found to be well described by theory. In a second configuration, the sample is observed with dark-field illumination. By extending the recently introduced Dark-field differential dynamic microscopy [3], we show that in this condition an extreme sensitivity can be achieved in the detection of the rotational dynamics of particles with a shape anisotropy. This scheme is successfully applied to study of the roto-translational diffusion of fractal aggregates of gold nanoparticles and non-motile bacteria. The simplicity of our approach makes these methods a viable alternative to particle tracking and depolarized dynamic light scattering.

References

[1] F. Giavazzi and R. Cerbino, J. Opt., **16** (2014) 083001.
[2] F. Giavazzi, C. Haro-Pérez and R. Cerbino, J. Phys.: Condens. Matter **28** (2016) 195201.
[3] A.V. Bayles, T.M. Squiresa and M.E. Helgeson, Soft Matter **12** (2016) 2440.

Figures

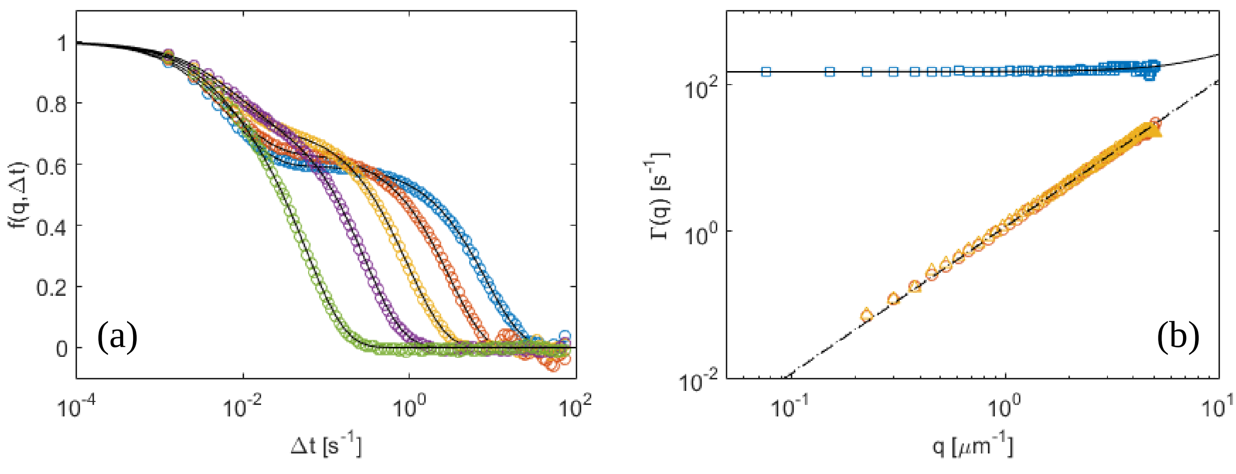

Figure 1 (a) Symbols: intermediate scattering function f(q, Δt) obtained in the polarized microscopy experiment with a suspension of optically anisotropic colloidal particles for different wave vector in the range $0.38\ \mu m^{-1} < q < 3.93\ \mu m^{-1}$. (b) Decorrelation rates obtained from the fit of the structure functions obtained in the polarized (blue squares and orange circles) and bright-field (yellow triangles) microscopy experiments. Lines are best fits of the data with the expressions predicted by the theory for the roto-translational diffusion of a sphere.