Anisotropic and hindered diffusion of colloidal particles in a closed cylinder

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Video microscopy and particle tracking were used to measure the spatial dependence of the diffusion coefficient (D_α) of colloidal particles in a closed cylindrical cavity [1]. Both the height and radius of the cylinder were equal to 9.0 particle diameters. The number of trapped particles was varied between 1 and 16, which produced similar results. In the center of the cavity, D_α turned out to be $0.75D_0$ measured in bulk liquid. On approaching the cylindrical wall, a transition region of about 3 particle diameters wide was found in which the radial and azimuthal components of D_α decrease to respective values of $0.1D_0$ and $0.4D_0$, indicating asymmetrical diffusion. Hydrodynamic simulations of local drag coefficients for hard spheres produced very good agreement with experimental results. These findings indicate that the hydrodynamic particle−wall interactions are dominant and that the complete 3D geometry of the confinement needs to be taken into account to predict the spatial dependence of diffusion accurately.

[1] H.B. Eral, J.M. Oh, D. van den Ende, F. Mugele, M.H.G. Duits, Langmuir, 26(22), 16722, 2010