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Diffusion and dynamic scaling in concentrated charge-stabilized colloidal suspensions

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We present a joint theory, simulation and experimental study of collective and self-diffusion in concentrated suspensions of charged colloidal particles. The study is based on the generalized Smoluchowski diffusion equation accounting both for direct and solvent-mediated hydrodynamic interactions, and it spans the range from the colloidal short-time to the long-time regime. Owing to the large size asymmetry between the colloidal macroions and the neutralising microns, the degrees of freedom of the latter can be integrated out, resulting in an effective (microion-dressed) colloid pair potential characterised by a renormalised colloid charge and Debye screening parameter. Various state-of-the-art methods of calculating such an effective colloid interaction potential are compared for suspensions in osmotic equilibrium with a salt reservoir. The effective colloid potential is used as input in our accelerated Stokesian Dynamics (ASD), Brownian Dynamics (BD) and self-consistent mode-couling theory (MCT) calculations of intermediate and self-intermediate scattering functions and particle mean-squared displacements. On basis of these numerical results that are compared in addition with dynamic light scattering data on silica particles suspensions, the influence of hydrodynamic interactions on self- and collective diffusion, and the accuracy of the MCT method are quantified. A proposed time-wavenumber scaling relation between short- and long time diffusion properties is shown to be violated in general.

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