Analytical centrifugation with an upgraded ‘food stability analyzer’ to determine the equations of state of concentrated colloidal nanoparticle dispersions

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To investigate the colloidal interactions of nanoparticles in liquid dispersions, we determine the osmotic equations of state by analytical centrifugation.[1] For this, we make innovating use of a LUMiFuge, a low-velocity stability analyzer designed to predict the shelf life of colloidal food products such as ketchup, now converted into an apparatus to measure sedimentation-diffusion equilibrium profiles of nanoparticles. By using homebuilt glass sample cells with an optical path length of only 50 micrometers, osmotic pressures can be measured ranging from pressures as low as 1 Pascal, to pressures exerted by nanoparticle concentrations of hundreds of grams per liter.

We tested our approach on concentrated liquid colloidal dispersions of magnetic nanoparticles. Such dispersions behave as magnetic liquids, [2] of interest for magneto-fluidic [3] and biomedical applications [4] and as dipolar sphere model systems.[5-7] We demonstrate that the equations of state of these concentrated, highly absorbing iron oxide nanoparticle dispersions can be accurately determined. The effects of magnetic interactions on the equation of state are discussed, as well as the influence of polydispersity. Using nanoparticles in a size and concentration range that is still accessible by both sedimentation setups, it is shown that the LUMiFuge results are in good agreement with sedimentation-diffusion measurements from a commercial analytical ultracentrifuge provided with homebuilt high-concentration cells. This being demonstrated, the LUMiFuge holds great potential for measurements on colloids that are not accessible by analytical ultracentrifugation: dispersions of heavier colloidal particles that require lower centrifugation rates.