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Gravitational Control in Neutron and/or X-ray Scattering via In Situ Centrifugation

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In situ centrifugation introduces a controllable gravitational field directly during neutron or X-rays scattering experiments, making it a new thermodynamic control parameter, on par with temperature, pressure, or magnetic fields. By applying high gravitational accelerations (up to several thousand g), it enables real-time observation of structure and phase evolution in soft matter systems (colloidal suspensions, aggregates, micelles, liquid crystals, etc.). We have developed a new generation of sample environment based on a vertical centrifugation principle, using soft centrifugation, meaning between 1 000 g and 6 000 g (g=9.81 m/s2 on Earth). First experiments have been performed on colloidal suspensions of silica nanoparticles (Ludox type) at low volume fraction by neutron scattering (D22, ILL). We have demonstrated how a density gradient is established and stabilized during the centrifugation as function of time at different centrifugal force. While Brownian motion dominates at atmospheric pressure and particles stay dispersed (no sedimentation), under centrifugation the Perrin length drops below 1 µm, a steady state profile is reached in few hours (reversibly) with a very steep gradient at the bottom due to the high Peclet number. All these observables can be tuned to favor aggregation or phase separation, as the short-time kinetics of the gradient formation is known.

Abstract Title

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