STATIC AND DYNAMIC CORRELATIONS IN MAGNETIC NANOMATERIALS STUDIED BY SMALL ANGLE NEUTRON SCATTERING TECHNIQUES

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The performance of new techniques developed for Small Angle Neutron Scattering (SANS) is illustrated by investigations on magnetic colloids. Polarised neutrons have been used as a special type of contrast variation for magnetic systems where low magnetic contrasts had to be analysed beside strong nuclear contributions or vice versa. In Ferrofluids magnetic core-shell composite particles and magnetic aggregates could be precisely evaluated beside non-magnetic micelles and free surfactants of similar sizes. In more concentrated Ferrofluids an external magnetic field induces a pseudo-crystalline ordering which coexists with chain like arrangements of particles. Ordering and relaxation processes of magnetic moments in nanoparticles have been monitored by time-resolved SANS. In stroboscopic experiments, time-frame data acquisition has been synchronized with a periodic external magnetic field. In conventional SANS, the shortest accessible time range was limited to few ms resulting from the wavelength spread. A breakthrough of time resolution into the micro-second range was achieved with the pulsed frame overlap TISANE technique, which allows us to exploit a dynamical range similar to that of X-ray photon-correlation spectroscopy. The analysis of time-dependent SANS data as a function of frequency, field and temperature allowed i) to determine the underlying statistics describing the particle moment orientation, ii) to extract the effect of field-induced inter-particle correlations, iii) to monitor the slowing down of the dynamics of moment rotation with decreasing temperature, iv) to study the effect of freezing of the solvent on the dynamics of the particle moments, and v) to work out the possible relaxation mechanisms (Néel and Brownian).