Probing Slow Dynamics in Complex Systems with 2D-XPCS

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With a well defined coherent beam X-ray Photon Correlation Spectroscopy (XPCS) experiments can be performed to study the dynamics of complex systems. The visible light counterpart to XPCS is Dynamic Light scattering (DLS) which, however, is subject to two main limitations: **i)** the opacity to light of many samples (thus producing multiple scattering and making the experiment impossible) and **ii)** the accessible Q-range which for DLS implies that nanometre length scales cannot be reached ($Q < 4 \cdot 10^{-3} Å^{-1}$).

XPCS overcomes these limitations and we will present two cases where XPCS performed with a CCD detector (2D-XPCS) was successfully used to investigate the dynamics of complex systems inaccessible by DLS. In particular, 2D-XPCS considerably extends the available Q-range and enables the probe of non-ergodic dynamics of strongly opaque samples.

In the first example an opaque dispersion of hard-sphere colloidal particles in pure glycerol was studied [1]. In the experiment the Q-dependence of the diffusion coefficient D(Q) was measured and 2D-XPCS allowed to access the correlation functions up to QR=19 (where R is the particle radius). On these lengthscales the self-diffusion properties of the system are probed.

The second example is related to the study of aging phenomena in glassy soft-matter, which for the moment attracts considerable interest from the scientific community. These disordered systems are in a meta-stable state far from equilibrium and they typically relax very slowly. As a result, the correlation functions have an unusual behavior far from what is known from systems in equilibrium. If the temporal intensity autocorrelation function is measured over a relatively short period of time, it reflects the quasi-equilibrium properties over the measurement period and hence characterizes the system at a certain age. However, the correlation functions can vary substantially if they are measured at a different age, as the material will have relaxed, or aged, into a new state. In this case, time-resolved 2D-XPCS allows to probe the dispersion relations of magnetic nano-particles in a glassy state i.e. the age- and wavevector-dependence of the α-relaxation [2].

References

[1] - in collaboration with V. Trappe, University of Fribourg, Switzerland and L. Cippelletti, Université Montpellier II (France)

[2] - in collaboration with R. Perzynski, E. Dubois, E. Wandersman, V. Dupuis and G. Meriguet, Laboratoire des liquides ioniques et interfaces chargées, Université Pierre et Marie Curie, Paris (France)