ESRF	**Experiment title:** Structure and Dynamics of Confined Colloidal Particles	**Experiment number**: SC2333
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Report:

Goal:

We wanted to investigate the structure and the dynamics of colloidal particles confined in the flat interfaces provided by grain-boundaries in soft materials.

Experimental samples and methods:

Samples. The samples used were triblock copolymers (Synperonic F108, $[\text{ethylene oxide}]_{127}$-$[\text{propylene oxide}]_{48}$-$[\text{ethylene oxide}]_{127}$, by Serva) in water seeded with nanoparticles. At low temperature (T~5°C), the polymer is entirely water soluble, while at room T the central polypropylene part becomes hydrophobic and the polymers self-assemble in spherical micelles. For sufficiently large polymer concentration, the micelles arrange themselves on a cubic crystalline lattice. In the presence of particles, our experiments show that the colloids are confined in the interfaces between the crystallites: the particles "decorate" the grain-boundaries). We have prepared samples at different particle concentrations and different crystallization rates in order to vary the particles concentration at the interfaces and the number of interfaces.

We have used two types of particles: silica particles (80 nm diameter), and gold nanoparticles (54 nm diameter). The crystallization rate was varied between 0.01 °C/min to 6°C/min. Three volume fraction of the silica particles were used (1, 2 and 4%). The volume fraction of the gold particles was about 0.014%.

Data analysis. We have first checked for radiation damage. We found that the maximal total exposure time on a sample was 4 sec. Thus, successive data were systematically taken at different locations in the samples (typically 15 positions). The data shown correspond to spatially averaged data. Most data were taken using the CCD detector. The data acquired with the Medipix detector were not conclusive.

We only show here the results with silica particles. Results are similar with gold nanoparticles. Static data (fig. 1) show the form factor of individual particles whatever the heating rate. Hence, we expect that the dynamics of individual nanoparticles is probed (length scale probed 30-300 nm). In figure 2, we show correlation functions for a given sample at different q vectors. Data are well fitted with the following functional form: $\exp[-(t/\tau)^p]$ (eq. 1).

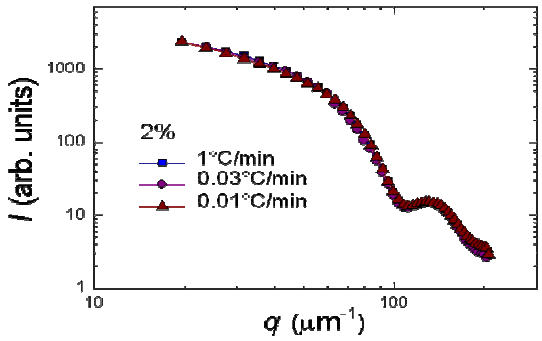

Fig. 1. Scattered iontensity versus q vector for different samples (volume faction of silica particles 2%) prepared with different heating rates.

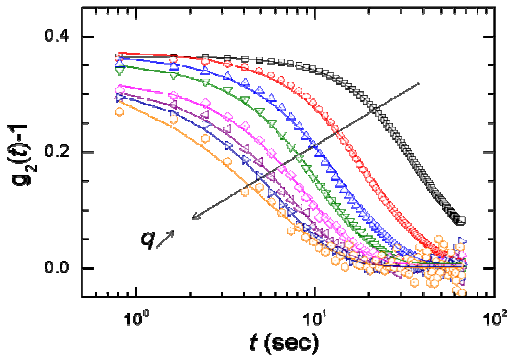

Fig. 2: correlation function for different q vectors. Symbols are data points, and the line are fits to eq (1).

We show in figures 3 and 4, the variation of the stretching exponent and of the characteristic relaxation time for a series of samples. We find, for $q>q^*$ (q^* of the order of 40 μm^{-1}): $\tau \sim q^{-1}$ and $p>1$ and is q-independent. Hence for for $q>q^*$ the dynamics of the nanoparticles is not diffusive but ballistic.

In the last few years, such ballistic motion has been observed forseveral glassy materials (see e.g. Cipelletti et al., PRL 2000 ; Ramos and Cipelletti, PRL 2001 ; Bandyopadhyay et al. PRL 2004 ; Robert et al. EPL 2006 ; Chung et al. PRL 2006 ; Guo et al. PRL 2009 ; Caronna et al. PRL 2008). It is generally interpreted in terms of relaxation of internal stresses.

In our experiments, we found an unexpected collapse of the data obtained for several sample preparations, which we do not yet understand.

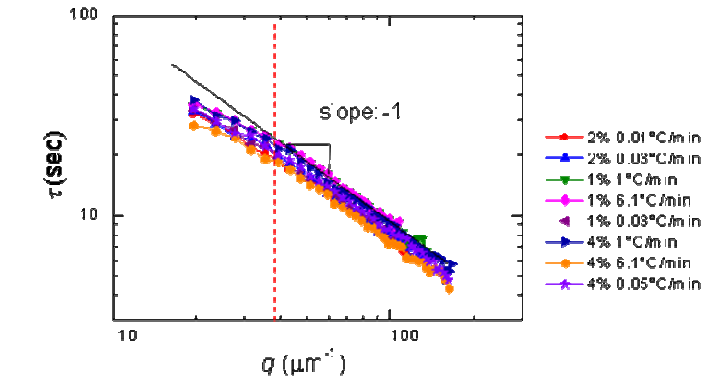

Fig. 3. Variation of the relaxation time with the scattering vectors, for several samples, as indicated.

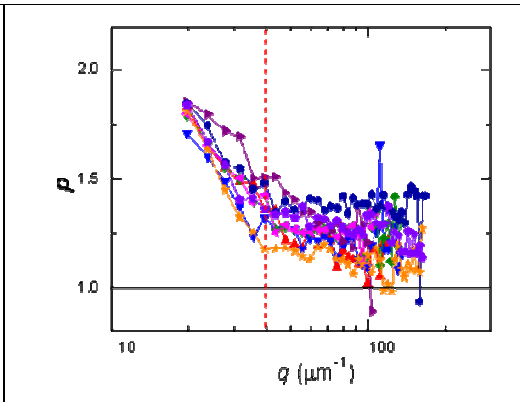

Fig. 4: Variation of the stretching exponent with the scattering vectors, for several samples. Stmbols are the same as in fig. 3.