ESRF	**Experiment title:** Dynamics and rheology in colloidal gels under flow	**Experiment number**: SC-2917
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Report:

Results published in:
Fluerasu, A.; Kwasniewski, P.; Caronna, C.; Destremaut, F.; Salmon, J.-B. & Madsen, A. Dynamics and rheology under continuous shear flow studied by x-ray photon correlation spectroscopy *New Journal of Physics, 2010, **12**, 035023*

Abstract:

X-ray photon correlation spectroscopy (XPCS) has emerged as a unique technique allowing the measurement of dynamics of materials on mesoscopic lengthscales. One of the most common problems associated with the use of bright x-ray beams is beam-induced radiation damage, and this is likely to become an even more limiting factor at future synchrotron and free-electron laser sources. Flowing the sample during data acquisition is one of the simplest methods allowing the radiation damage to be limited. In addition to distributing the dose over many different scatterers, the method also enables new functionalities such as time-resolved studies. Here, we further develop a recently proposed experimental technique that combines XPCS and continuously flowing samples. More specifically, we use a model colloidal suspension to show how the macroscopic advective response to flow and the microscopic dissipative dynamics (diffusion) can be quantified from the x-ray data. Our results show very good quantitative agreement with a Poisseuille-flow hydrodynamical model combined with Brownian mechanics. The method has many potential applications, e.g. in the study of dynamics of glasses and gels under continuous shear/flow, protein aggregation processes and the interplay between dynamics and rheology in complex fluids.

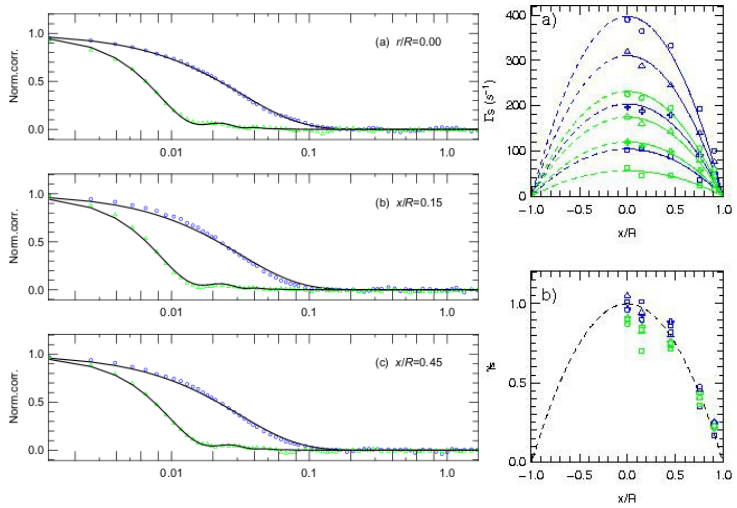

Fig. 1 Left side plots - normalized correlation functions and fits for $q = 2.8\times10^{-3}$ Å^{-1} and flow rate 40 µl/h measured at different locations across the flow cell x/R, right side plots – (a) fitted shear induced relaxation as a function of position (x/R) for four different flow rates: 20 µl/h (squares), 40 µl/h (crosses), 60 µl/h (triangles) and 80 µl/h (circles) and two values of q: 1.6×10^{-3} Å^{-1} (blue) and 2.5×10^{-3} Å^{-1} (green). Solid lines show fits with a parabolic profile equation; the dashed lines (extension to negative values of x) are guides to the eye. (b) Scaled relaxation rates for the same values of the flow rate and wave vector q collapse on a single parabolic profile across the tube.

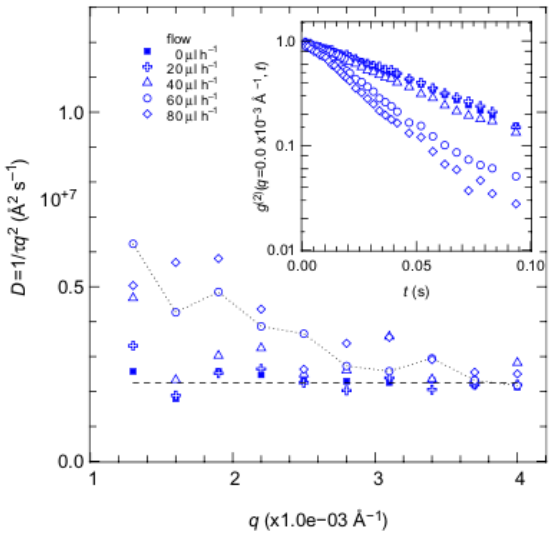

Fig. 2 Free diffusion coefficient obtained from single exponential fits of the transverse flow correlation functions—shown in the inset for a single value of $q = 2.5\times10^{-3}$ Å^{-1} . In the low-flow limit (<40 µl/h) the correlation times (τ) are independent of the flow rate and τq^2 are q-independent and equal to the inverse of the free diffusion coefficient $D_0 \approx 2.2\times10^6$ Å^2 s^{-1} .

Conclusions:

The results presented here show, for the first time, that XPCS can be used to measure both the advective response to applied shear (Fig. 1) and the diffusive dynamics (Fig. 2) of a colloidal suspension under continuous flow. The data show very good quantitative agreement with a simple Poiseuille-flow hydrodynamical model.

Possible future applications of this method include the study of the response to shear and the interplay between dissipative effects (diffusion) and advective motion in colloidal gels, glasses and other non-Newtonian fluids. The XPCS-flow method also provides a very useful way to avoid radiation damage. For many applications, using high-aspect-ratio flow tubes where the velocity profile is more constant (approaching a plug-flow shape) is advantageous.