Heterodyne Measurement of X-Ray Speckle Fluctuations

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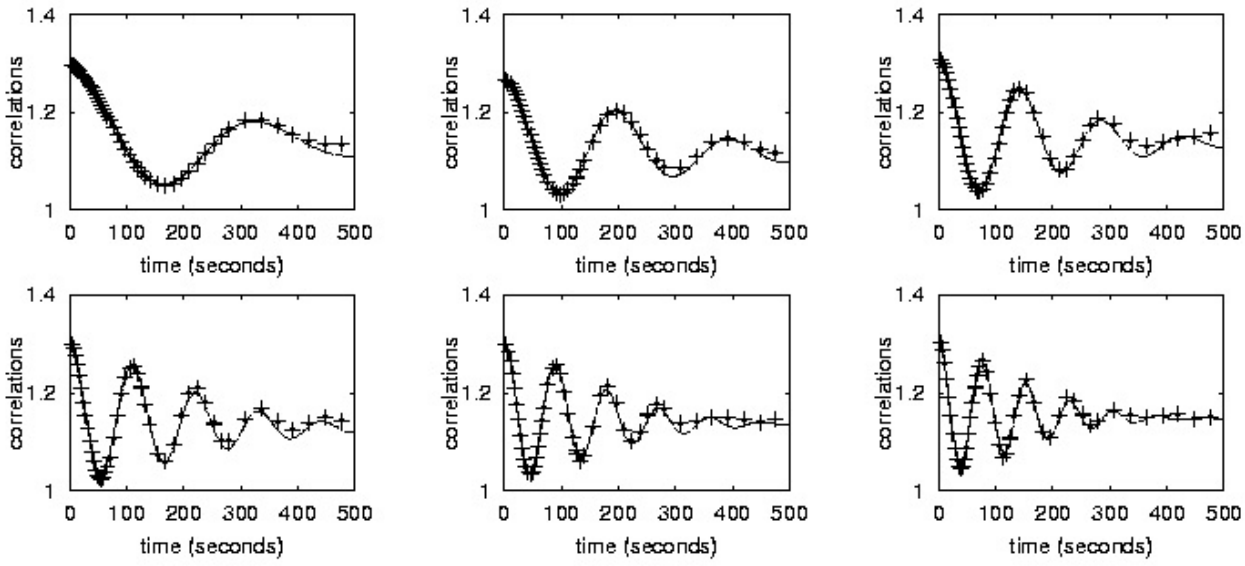
The dynamics of the fluctuations has been studied by coherent small angle x-ray scattering at the APS IMM-CAT beamline. We have used a simple experimental setup in order to obtain homodyne and heterodyne speckle patterns in the same conditions. Measurements were carried out by means of a direct illumination CCD used as area detector. We compare the intensity correlations observed in the case of latex spheres in glycerol. These correlations, averaged over a region of the detector where incoherent intensity is nearly constant, have an exponential behaviour, and we have checked that the heterodyne fluctuation time was twice that of the homodyne one (see [1]).

This method has been extended to the study of the mechanical relaxation of rubber samples made with an elastomer filled with carbon black or fused silica. The relaxation could be observed in the homodyne mode from the movement of the speckles in the detector. In the heterodyne mode, correlations have a strong oscillating behaviour (see Fig. 1) corresponding to the interferences between the moving sample (vector velocity **v**) and the static reference [2]. For a given $|\mathbf{q}|$, the period of the oscillations is connected to the angle ϕ between **q** and **v**. This makes possible the observation of relative velocities as slow as 1.5 nm/s.

Figure 1: The oscillating correlations at $|\mathbf{q}|=6.4\ 10^{-3}$ Å^{-1}, for various angles ϕ between **q** and **v** observed during relaxation of a carbon black filled elastomer.



References

[1] - Cipelletti L., Manley S., Ball R. C. and Weitz D. A., Phys. Rev. Lett., 84, p.2275 (2000)

[2] - Dynamic Light Scattering, Berne B.J. and Pecora R., p. 74, (Eq 5.8.9.), J. Wiley ed. (1976)