Dynamics of elongated particles in supercooled liquids

Report Proposal SC 3026 – Beamline ID 10

In these experiments, we have followed by means of XPCS the dynamics of a concentrated suspensions (Φ=0,52)of ellipsoidal hematite particles (spindles) suspended in glycerol.

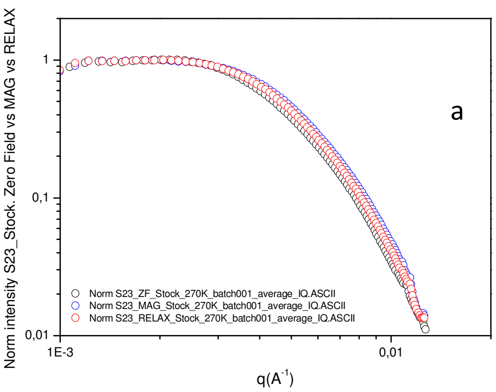
Two kinds of experiments were performed.

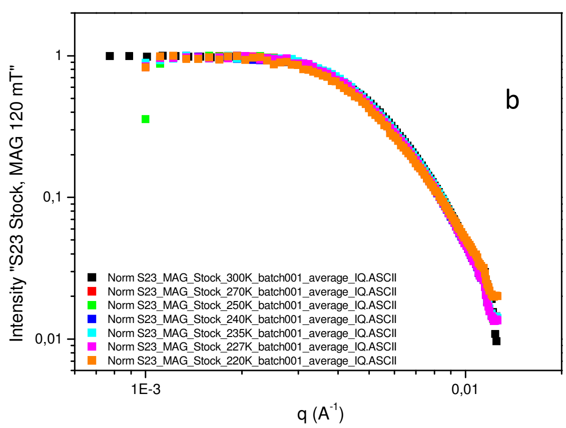
1) In the first set of experiments, the suspension was studied in isotropic conditions (no magnet). A serie of measurement along the time axis was performed, starting from the temperature were the dynamics appears in the „XPCS time window“ down to 220 K. The sample was let to equilibrate before the measurement.

2) In the second set of experiments, we used the magnet assembly available at ID 10. A magnetic field was applied (B_{max}=120 mT) then released ($B_{residual}$=120 mT). We proceeded as follow. the temperature is cooled down from the room temperature under a magnetic field of 120 mT until reaching the chosen temperature. The sample is then let to equilibrate and measured. After the measurement at 120 mT, the magnet is set at 20 mT, the sample is let to equilibrate again and the measurement is performed.

RESULTS:

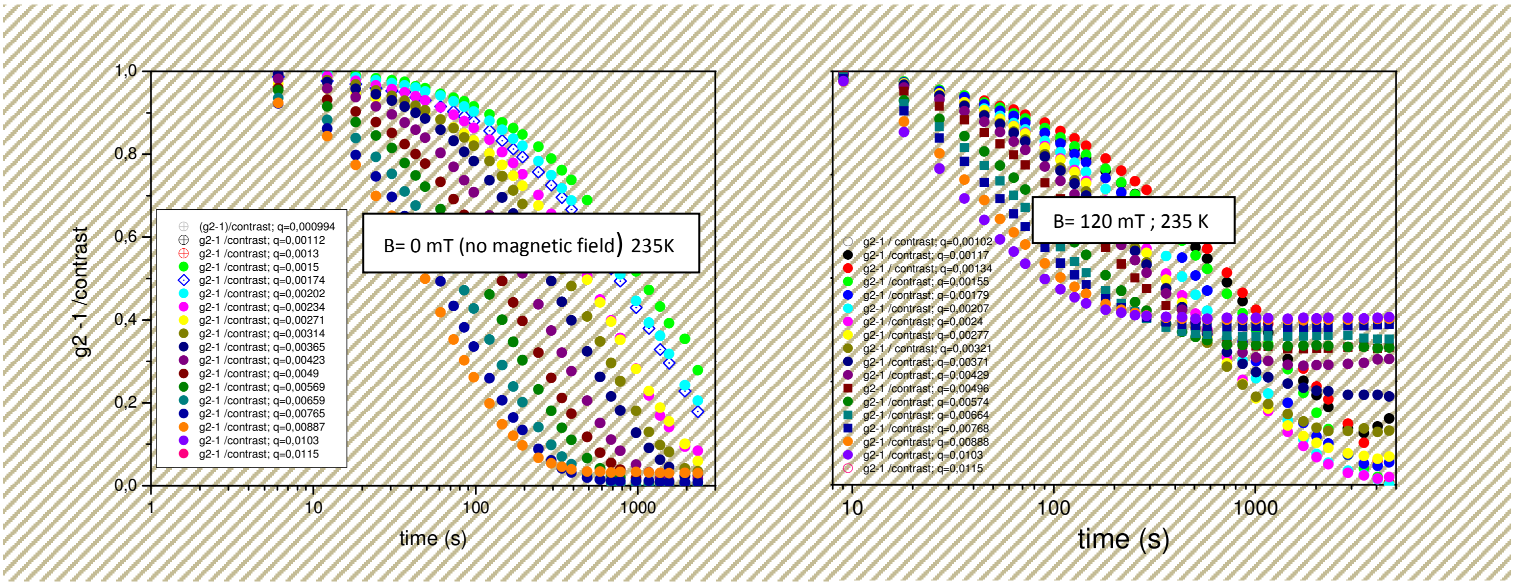
1) Comparison „Zero field“ vs „Magnetic field (B=120 mT)“ vs „Relaxation“ ($B_{residual}$=20 mT):
   Figure 1a) shows the statics measurements for differents magnetization at a given temperature. When a magnetic field is applied, the particles align perpendicularly to the magnetic field (blue dots). When the magnetic field is released ($B_{residual}$=20 mT, red dots), the particles become less oriented but never reach the „zero field state (black dots), due to the fact that the susceptibility of the hematite particles is high enough to keep them oriented when the field is reduced to 20 mT. Moreover, the structural parameters are independant of temperature, for all magnetic field (figure 1b).





b) Dynamics under magnetic fields: comparison with no field

Our experiments performed under magnetic field shown that the dynamic is slowed down when a magnetic field is applied. Indeed, when a magnetic field is applied, one degree of freedom is quenched slowing down the overall velocity of the particles. Moreover, we observe a strong loss of ergodicity when a magnetic field is applied. The „loss of ergodicity“ increases with the wave vector q. At a given wave vector, the loss of ergodicity increases with the concentration of the sample. Indeed, the loss of ergodicity is accompanied with a decrease in the amplitude of the correlation function.



Conclusion:

This serie of measurements allowed us to evaluate the effect of freezing one degree og freedom by applying a magnetic field. The dynamics changes drastically when a degree of motion is quenched and a strong loss of ergodicity is observed. This loss of ergodicity is q-dependant and concentration-dependant, but is not temperature dependant. Indeed, at a given q, the amplitude of the correlation function does not dependant on temperature.

These results should be completed with measurement at an intermediate concentration to provide us a complete understanding of system whose one degree of rotation is kept frozen.