ESRF	**Experiment title:** Study of the collective dynamics in semi-crystalline polymers using inelastic x-ray scattering	**Experiment number**:hs2069
Beamline: ID28	**Date of experiment**: from:July 1st, 2003 to:July 8th, 2003	**Date of report**: July 15, 2003
Shifts: 18	**Local contact(s)**: A. Beraud	*Received at ESRF:*

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Report:

The experiment was organized as follows: three shifts were dedicated to the measurements of the resolution functions and the remaining shifts were used for the PE study, including the the empty cell measurements.

The purpose of the experiment was to investigate the collective dynamics of semi-crystalline polyethylene (sc-PE), and more particularly to identify the origin of the two inelastic excitations appearing in the $S(Q,\omega)$ spectra.

To this aim, our first experiment consisted in heating sc-PE well above its melting point (T_m=127ºC) so that the collective dynamics only reflect the disordered network, without any contribution of the crystalline phonons. Figure 1 shows typical inelastic scans recorded at Q=5 nm^{-1}, in the liquid phase at T=140ºC and in the semi-crystalline phase, at T=24ºC. As it can be seen, the liquid spectrum can be described by one strongly overdamped excitation, while the semi-crystalline spectrum shows two inelastic components. A full dispersion curve could be measured in the liquid phase. This dispersion curve is found to compare well with that derived from the lower energy component of the room temperature measurement, in terms of overall shape and energy values. We thus ascribe the origin of the low energy inelastic excitation to the amorphous phase. Although the amorphous phase stands above its glass transition temperature (T_g=-180ºC ?) in both cases (room temperature and 140ºC), the thermal expansion may influence the phonon dispersion curve. Therefore, we performed measurements as a function of temperature, going from -213ºC up to 140ºC in the liquid state. As can be seen in Figure 2, the temperature variation of the "amorphous sound velocity"

(below complete melting at 135ºC) extrapolates to the liquid state. In addition, the amplitudes of the two inelastic contributions observed in the semicrystalline state are close to the values that can be deduced from the crystalline ratio, as deduced from calorimetric or $S(Q)$ measurements. These findings thereby firmly establish the nature of the low energy excitation as the amorphous contribution.

The second study of our proposal, aiming to investigate the effect of local morphology onto the collective dynamics of both amorphous and crystalline phases (using samples with different crystallinity rates), could not be addressed due to a lack of beamtime. In fact, it will be the subject of our next proposal.

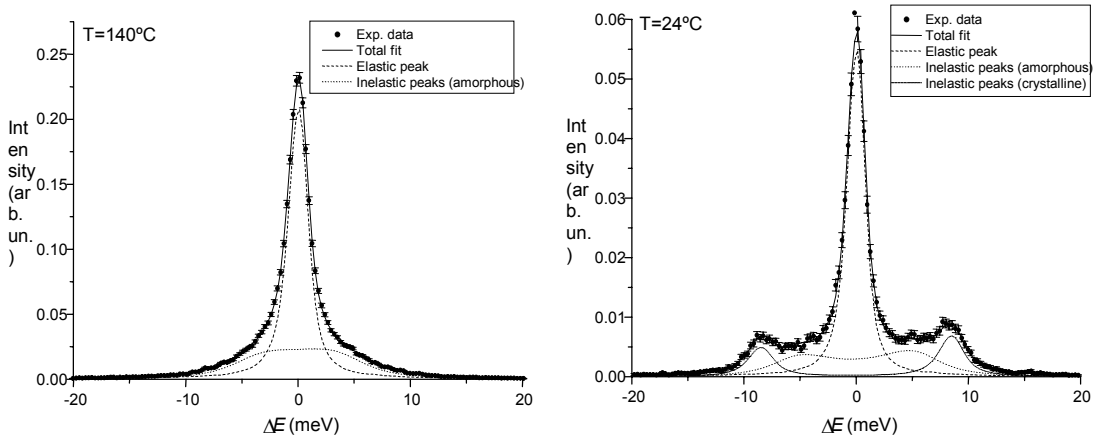

Figure 1. *Inelastic X ray scattering spectra of liquid (left) and semicrystalline (right) polyethylene.*

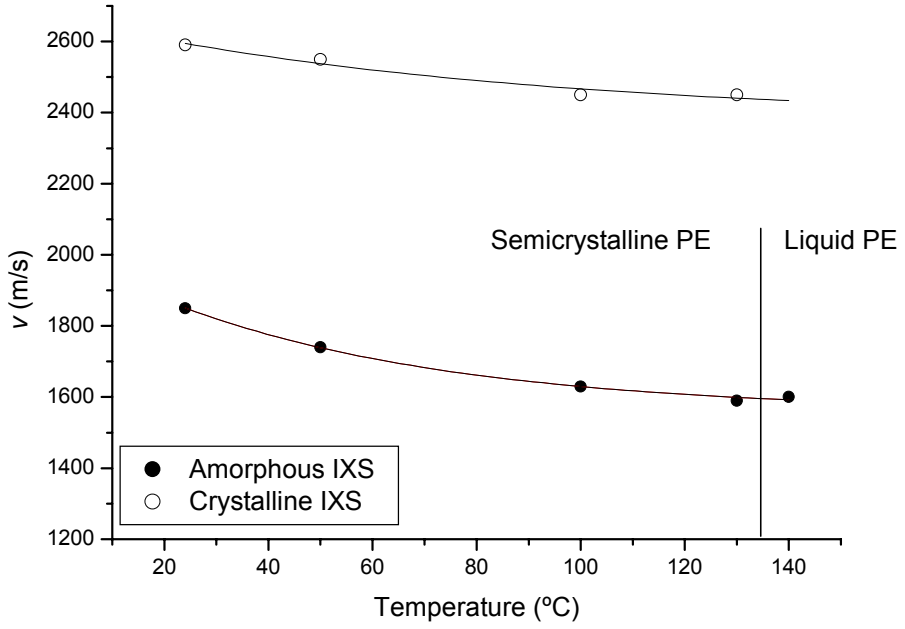

Figure 2. *Sound velocities inferred from dispersion curves of the inelastic X ray scattering contributions of amorphous and crystalline phases of polyethylene at different temperatures, below and above complete melting of the cristallites.Lines are guides to the eye.*