Dynamics of Meso-scale fluctuations in liquid chalcogens near the metal-nonmetal transition

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Liquid Te-Se mixtures exhibit a metal-nonmetal (M-NM) transition in a relatively narrow temperature range [1]. This transition is accompanied by anomalies in thermodynamic properties such as the thermal expansion coefficient and compressibility. Recently, sound attenuation measurements for liquid Te-Se mixtures revealed that there occur dynamic anomalies in the M-NM transition region [2]. From the frequency dependence of the sound attenuation coefficient \( \alpha \), their relaxation time is estimated to be of the order of nano-seconds. These anomalies may be related to the relaxation between the metallic and non-metallic states in the liquid, and it is interesting to study the space-and time-structure of the mesoscale fluctuations. Neutron spin-echo (NSE) is a powerful technique which gives information on the intermediate scattering function \( I(Q,t) \). However, to our knowledge, there is no NSE measurement under such high temperature conditions.

In the present work, we developed a new electric furnace which can be used for NSE measurements up to \( \sim 600^\circ C \). In order not to disturb the magnetic field around the sample, we used non-inductive resistance heaters. By using this furnace, we measured NSE signals for liquid Te\( \text{7} \)Se\( \text{3} \) mixture.

Figure 1 shows the intermediate scattering function \( I(Q,t)/I(Q,0) \) observed at \( 490^\circ C \). It is noticed that \( I(Q,t)/I(Q,0) \) increases with decreasing the wave vector \( Q \). These data can be expressed by a superposition of two exponential relaxation processes as follows:

\[
I(Q,t)/I(Q,0) = A_{\text{fast}} \exp(-t/\tau_{\text{fast}}) + A_{\text{slow}} \exp(-t/\tau_{\text{slow}}).
\]

Here \( A_{\text{fast}} \) and \( A_{\text{slow}} \) represent the fraction of the fast and slow components, satisfying \( A_{\text{fast}} + A_{\text{slow}} = 1 \), and \( \tau_{\text{fast}} \) and \( \tau_{\text{slow}} \) are the relaxation times of the fast and slow dynamics, respectively. From a curve fitting analysis, the relaxation times are estimated as \( \tau_{\text{fast}} \sim 0.1 \text{nsec} \) and \( \tau_{\text{slow}} \geq 10 \text{nsec} \). The slow component becomes dominant in the low-\( Q \) region, and this process may lead to the anomalous sound attenuation.

References