EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

ESRF	**Experiment title:** **Studies of the Plasmon as a Function of Electron Density in Li-NH3 Solutions**	**Experiment number**: HE 1144
Beamline: ID 16	**Date of experiment**: from: 04/11/2001 to: 13/11/2001	**Date of report**: 28/02/2002
Shifts: 21	**Local contact(s)**: Dr. Abhay SHUKLA	*Received at ESRF:*

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Report:

We have carried out inelastic x-ray scattering studies of the electronic excitations in Li-NH_3 solutions at several different lithium concentrations. When lithium is put in liquid ammonia, it dissolves, leaving a Li^+ ion and a free electron. These systems have a low electronic density, and electronic correlations play a large role in their properties. The purpose of these experiments is to use the system as a model for the electron liquid. The electron liquid model is usually studied theoretically using the random phase approximation (RPA) to treat the electronic interaction, which replaces the true interaction with an average interaction. This model becomes exact at high electronic densities, but breaks down at lower densities. By studying the electronic excitation (the plasmon) and its dispersion as a function of momentum transfer q we are able to look for the effects of correlations and the breakdown of the RPA in these systems. All theories that go beyond the RPA and treat the electronic correlations more accurately predict a reduction in the plasmon dispersion as compared to the RPA value. Thus by measuring the plasmon dispersion we can test models beyond the RPA.

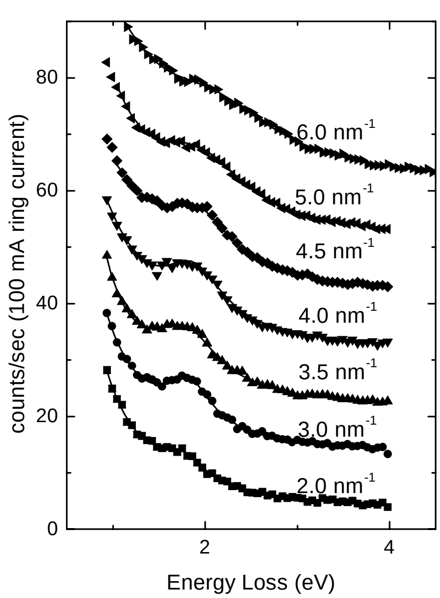

Fig 1. Plasmon in 13 MPM Li-NH_3.

Measurements were taken on beam line ID-16 in a near backscattering geometry. The total energy resolution of the spectrometer was 170 meV and the *q*-resolution was set to be 0.5 nm^{-1}. For each sample we measured the energy loss at different momentum transfers *q*. The sample cell was designed to allow progressive dilution of the sample by addition of ammonia; this eliminated the need to change sample cells and kept the experimental setup untouched for the different concentrations. Extensive measurements were taken at concentrations of 16.5 and 13 MPM, with some additional data at concentrations down to 8 MPM. Concentration errors are less than 0.5 MPM.

A selection of data from 13 MPM and 16.5 MPM liquid solutions at 240 K are shown in Fig. 1 and Fig. 2. Fig. 3 shows the higher *q* value data for the 16.5 MPM solution. The data have been normalized to the incident photon flux and than adjusted to be in units of approximately counts per second. Representative error bars are shown. The large sloping background is coming predominantly from the elastic scattering in the liquid.

From the raw data it is clear that the plasmon disperses out to higher energies at higher *q* values. In addition, the plasmon gets broader. Above a certain cutoff momentum, the plasmon can decay into electron hole pairs, at which point it is no longer be a well defined excitation and so broadens out rapidly and then disappears. This can be clearly seen at the higher momentum data in the 16.5 MPM solution, where the cutoff is near 6 nm^{-1}.

The data shown here have been fit to a simple model where the plasmon is assumed to be Lorentzian in shape, and the background in the region of the plasmon is also assumed to be Lorentzian. The solid lines in the figures are the results of the fits. Other fitting models for the background were used and yielded the same results for the plasmon position and width within error.

For the concentrations we studied, we find a dispersion value which is reduced from the RPA prediction. The disagreement with the RPA grows as we go to lower electronic densities, indicating the growing importance of electronic correlations. Comparisons with models that go beyond the RPA are underway.

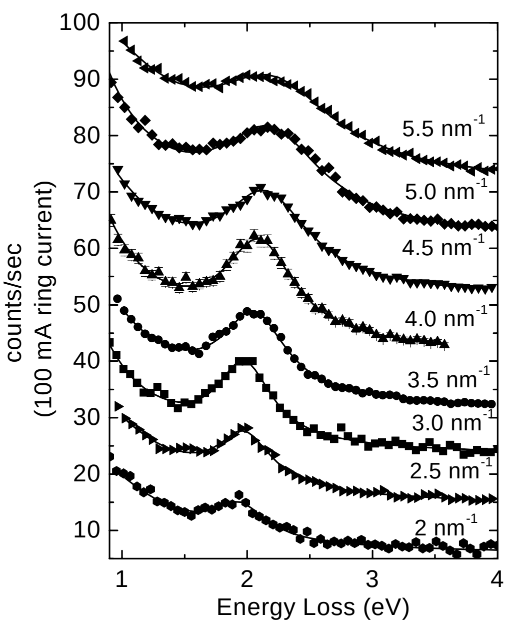

Fig 2. Plasmon in 16.5 MPM Li-NH_3 – low *q*.

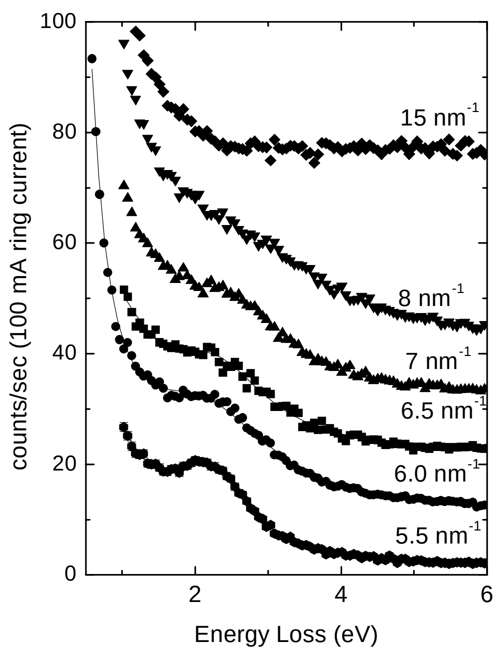

Fig. 3 Plasmon in 16.5 MPM Li-NH_3 – high *q*.