ESRF	Electron Correlation Effects at High Pressure	number: HE-451
Beamline: ID15B	**Date of experiment:** from: 23-Jan-99 to: 02-Feb-99	**Date of report:** 5-Aug-99
Shifts: 30	**Local contact(s):** J.E.McCarthy	*Received at ESRF:*

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Report:
We have studied the behavior of nearly free electron gas under high pressure (up to 4.2 GPa) utilizing Compton scattering of high energy x-rays. By applying a pressure on a sample of polycrystalline sodium, we were able to vary the electron density parameter r_s *in situ*. The experiment was successful and the resulting scientific article is being submitted for publication. The results agree well with the free electron theory.

The sample was 99.95% pure commercially available Na metal. The pressure was applied by using two different pressurizers, a diamond anvil cell (DAC) and a large volume cell (LVC). In the DAC the pressure is applied by mechanically compressing two diamonds on each other with the sample in between. In the large volume cell (LVC) two large hard metal anvils are hydraulically pressed on each other. The sample is contained in a hard boron gasket with boron nitride caps so that the pressure is uniform throughout the gasket. With the DAC we measured Compton scattering spectra in pressures of 1.0 and 3.8 GPa, and with the LVC in 0.068, 0.54, 1.0, 2.3, 3.3 and 4.2 GPa.

We used monochromatized and horizontally focused x-rays with energy 56 keV. The beam size was 150 μm horizontally and 80–350 μm vertically, depending on the pressure. The scattering angle was 165°.

The spectra of scattered x-rays were recorded with a Ge solid state detector. The energy resolution was 380 eV at the elastic line, which resulted in a momentum resolution of 0.56 a.u. at the Compton peak. In the DAC both the incident and scattered x-rays pass through the diamonds. This, combined with the fact that the actual sample is very small compared with the diamonds, results in large background from Compton scattering from the diamond. The signal-to-noise ratio was only 20%, and the difference of Compton signals in 1.0 GPa and 3.8 GPa was buried in statistical noise. Thus we couldn't draw any conclusive results using the DAC. Using the LVC, however, we were able to collect scattering from pure Na with less than 1% of boron nitride background. This is ensured in Fig. 1, which shows one set of raw data in 10 GPa, as the Na K absorption edge is clearly visible in the Compton spectrum. The count rate was $\sim$10 cps at the Compton peak ($\Delta E = 31$ eV). Data were acquired for $\sim$15 hours in each pressure, which resulted in a statistical inaccuracy of 0.2%. The effect of changing Fermi momentum is clearly seen and agrees well with the Sommerfeld free electron theory. The change in electron-electron interaction is too small to be distinguished with our statistics. Because there were no vertical focusing and also the horizontal focus was larger than the sample, we lost more than two orders of magnitude in intensity due to the small sample size. Thus it might be possible to see the change in electron correlation by simply improving the focusing optics.

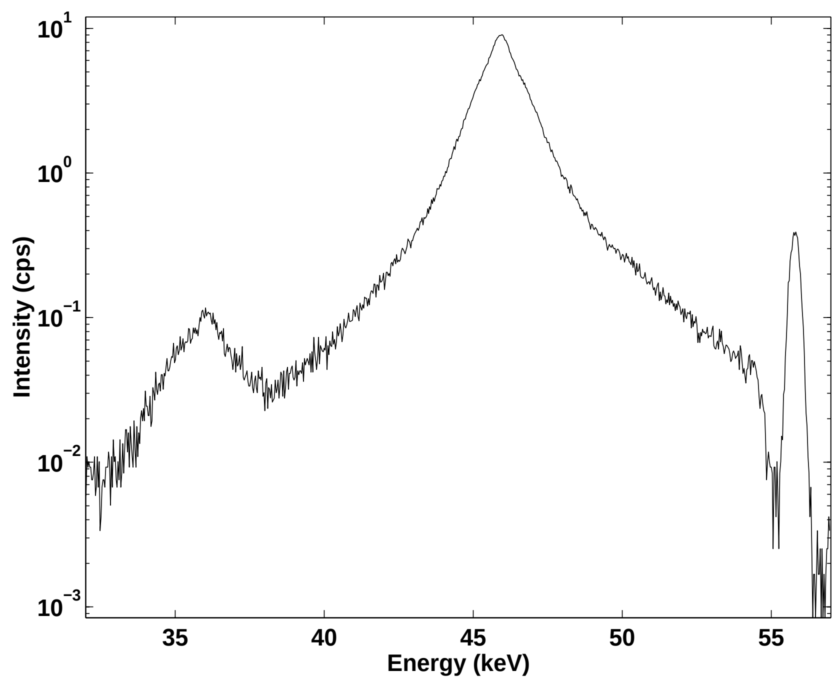

Fig. 1: An example of raw data in 1.0 GPa with the LVC after 20 minutes of acquisition. The elastic line is on the right, the actual Compton scattering signal in the middle and its escape peak on the left. The Na K absorption edge is also clearly visible near the elastic line.