



	Experiment title: Inelastic x-ray scattering study of intrinsic double-plasmon excitations	Experiment number: HE-2028
Beamline: ID16	Date of experiment: from: 23-Nov-2005 to: 1-Dec-2005	Date of report: 1-Mar-2007
Shifts: 21	Local contact(s): Dr. S. Huotari	<i>Received at ESRF:</i>
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Report:

We performed an experimental study, confronted with theoretical calculations, on double-plasmon excitations in beryllium, lithium, potassium, sodium and magnesium. The experiment was a continuation of an earlier experiment HE-1793 (Dynamic correlation effects in electron gas) where we performed similar measurements on aluminium and sodium (the latter was now remeasured with higher resolution).

The excitations are analyzed in terms of their intensity, spectral shape, and dispersion as a function of momentum transfer. The double-plasmon excitation probability at the critical plasmon cut-off momentum was found to vary between 0.3 – 1.0% in the investigated electron-gas density range $r_s=2.07-3.93$. The overall agreement between experiment and theory is very good, while remaining discrepancies may be due to high-order correlation effects beyond reach of the most advanced many-body theories.

The experiment was performed at the beamline ID16. The radiation was monochromatized by a double-bounce Si(111) monochromator and in case of potassium, lithium and sodium the incident bandwidth was further narrowed with a help of a Si(220) channel-cut. The energy resolutions were respectively 1.5 eV and 0.5 eV. The spectra of scattered radiation were analysed with the help of a backscattering bent-crystal spectrometer using the Si(444) or Si(555) reflections.

The polycrystalline alkali metal samples were prepared in an Ar atmosphere and then kept in vacuum. The Be sample was a single crystal and the plasmon response was measured in the crystallographic directions [100] and [001]. The Mg sample was polycrystalline.

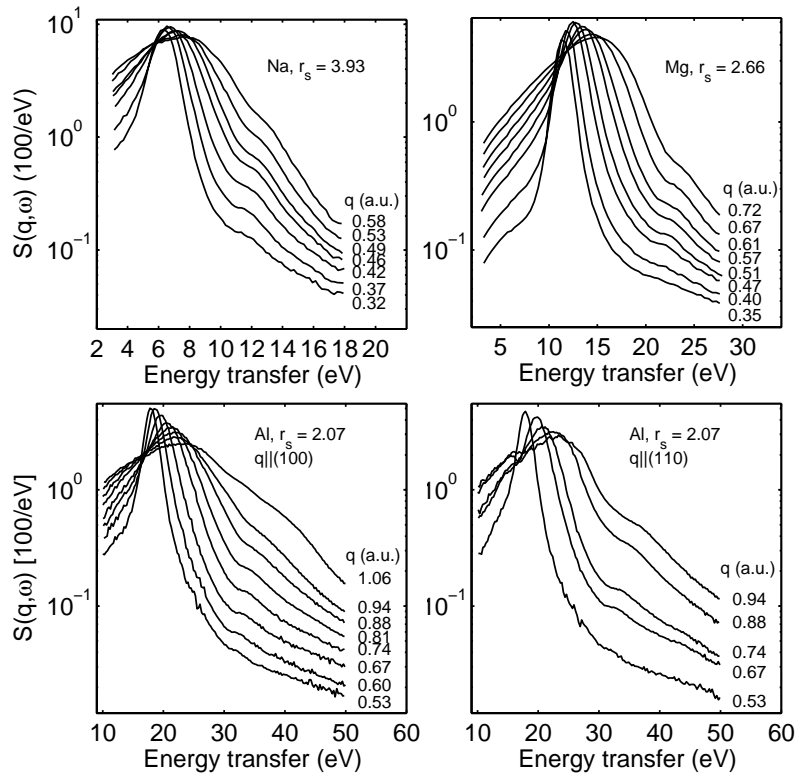


Figure 1. The measured dynamic structure factor of Na, Mg and Al in two different crystallographic directions as a function of momentum and energy transfer around the critical momentum q_c . The Al data from experiment HE-1793 are reproduced here for comparison. Note the logarithmic ordinate axis.

The spectra of inelastically scattered x-rays were measured by keeping the analyzer fixed and tuning the incident photon energy in the range of energy transfers 0–100 eV. The dynamic structure factors were extracted from the measured spectra by (i) subtracting a small constant background measured with an empty cell, (ii) fitting the low-energy part to remove the elastic line tail, (iii) normalizing using the f -sum rule and an extrapolation of the spectra above the $L_{2,3}$ edges. The pl-pl peaks were extracted from the continuously decreasing main plasmon line by fitting a sum of a Pearson VII and an exponential function to the plasmon tail and subtracting it from the data.

It was found, as expected, that all plasmon spectra from all samples around the critical cut-off momentum q_c have a clear double-plasmon peak around roughly twice the plasmon energy, confirming that it is really a universal property of electrons at least in metals. The contribution of trivial multiple scattering was confirmed to be very small by measuring different thicknesses of the Na sample, giving exactly the same double-plasmon intensity.

A manuscript of the experimental results is currently being prepared and is to be submitted soon.