ESRF

ESRF	**Experiment title:** Elastic properties of dense sodium	**Experiment number**: HS3192
Beamline: ID28	**Date of experiment**: from: 18/11/2006 to: 27/11/2006	**Date of report**: 28/02/2007
Shifts: 24	**Local contact(s)**: J. Serrano	*Received at ESRF:*

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Report:

It was found that the melting curve of Na goes through a maximum in its bcc phase and then it decreases in its fcc phase [1]. The temperature melting of the element above 100 GPa reaches anomalously low value of 300 K and is accompanied by the appearance of the new low symmetry solid phases. The conventional thinking suggests that at pressures of about 100 GPa the bulk modulus of any material would roughly be at least 400 GPa with sufficiently high shear modulus. The fact that Na becomes liquid at room temperature means that the shear modulus softens to zero values at this pressure. The system with bulk modulus of ~400 GPa and shear modulus of 0 GPa at room temperature was never observed before. The idea of the proposal was to measure the elastic constants of Na at around 100 GPa to see what causes such anomaly and establish the record for measuring elastic constants at such high pressures (the current record for single crystal technique is around 40 GPa [2].

We have measured the dispersion of the longitudinal and transverse acoustic modes of sodium in high symmetry directions (see Fig. 1) at 8 and 29 GPa at this moment the diamonds broke due to the penetration of hot sodium (temperature annealing is needed after every pressure increase to improve the quality of the single crystal which decreases with each pressure change which consumes time but unavoidable) into the diamond surface. We have prepared another sample at 95 GPa and produced very high quality single crystal (see Fig. 2) but due to the small size of the crystal and quite low Z (Z=11 for sodium) the amount of signal was extremely low even after 16 hrs of collection time to properly constrain the data from which the elasticity can be deduced. We would like to continue this very challenging experiment and measure the full set of elastic constants of Na up to 100 GPa and in Li up to 10 GPa for the comparison.

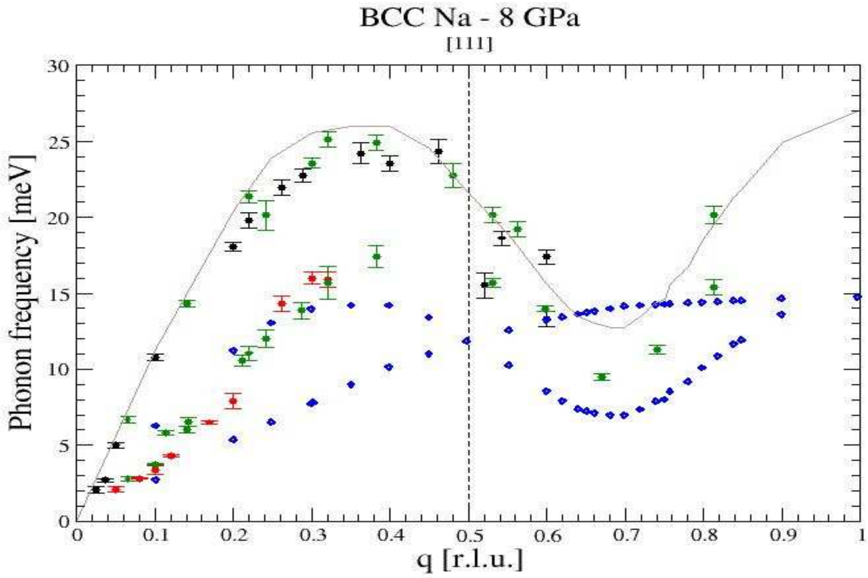

Figure 1: Phonon dispersion curves for Na at 0 GPa blue symbols (measured by neutron scattering by Woods, Brockhouse et al Phys. Rev. 128, 1112, 1962) and at 8 GPa black, red and green symbols measured during the experiment. Surprisingly, since 1962 the phonon dynamics of the alkali metals was not experimentally investigated even though recently sveral theoretical papers appeared: Rodriguez-Prieto, et al., Phys. Rev. B 74, 172104 (2006), Xie et al., *ibid,* 75, 064102 (2007).

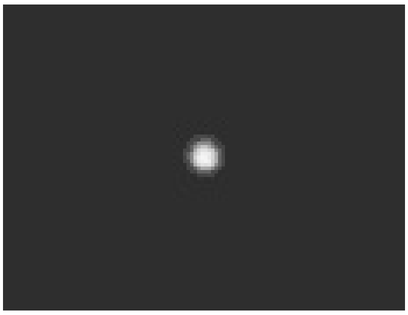

Figure 2. The quality of the Na diffaraction spot at which phonons were measured at 95 GPa.

References:

[1] E. Gregoryanz *et al*., Phys. Rev. Lett. 94, 185502 (2005).
[2] D. Antonangeli *et al*., Phys. Rev. Lett. 93, 215505 (2004).