Shubnikov de Haas (SdH) and de Haas van Alphen (dHvA) study of the Fermi surfaces of lithium isotopes at ambient and under pressure

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Experimental

The experimental work was performed in SCM2 using both TDO and Cantilever systems at base temperature. Samples of polycrystalline lithium were covered by mineral oil and grease and were cut to expose a shiny surface and immediately loaded inside both ambient pressure coils and also loaded into a DAC using mineral oil as pressure transmitting medium and were transferred to the cooling system. To prevent loss of information due to preferred orientation in the samples we have rotated the cell between 0-90degrees and collected numerous data by ramping the field between 12-18 T. We also tested the QO of Na samples that were prepared in home lab embedded in paraffin wax. Na is more reactive than lithium and QO in this system indicate the successful methodology and is also useful as a magnetic field calibrant.

Results and Discussion

The careful design of TDO circuit and sample loading done in MagLab allowed successful TDO measurements at ambient pressure. TDO measurements are critical for DAC experiments and this was an important verification. The data collected show a distinct NMR signal of ^{7}Li and a strong peak from dHvA oscillations of lithium at 41-42kT. This peak however, is clearly split into several peaks which have not been seen before. These details allow us to determine the maximum distortions of the lithium Fermi surface and provide important information about its ground state structure. Extreme care was taken in the preparation of the sample to insure reliable results. In addition to the strong ^{7}Li NMR peaks in all runs which confirms the sample identity, we did extensive sample characterization (Mass SPEC, RRR=1200, XPS surface characterization and XRD) to assure sample purity. The location and shape of the peak supports a mixed bcc+fcc structure. We are currently analyzing the data. Na samples also showed the QO consistent with literature and confirmed reliability of our sample preparation method as well as demonstrating a path for passivation of Na surface. Our DAC measurements on lithium are not yet fully analyzed and require better statistical analysis which we are working on but also the signal is not nearly as good as ambient pressure and we identified non-hydrostaticity as a potential problem which we would like to overcome in the next run by use of hydrostatic conditions. Passivation of the surface of the sample is our next plans and will allow us to use hydrostatic pressure transmitting medium. On the theoretical side we have performed calculations on the changes in the FS of lithium under pressure. We are hoping to be able to verify these predictions experimentally. (Fig. 2)

Conclusions

We have determined the distortions of the fermi surface of bcc lithium at low temperature for the first time and have high resolution data that also shows distinct peaks from lithium's low temperature structure. We have also showed a pathway to use Na samples kept at normal room conditions and use their QO for calibrations. In the next steps we plan to extend these measurements to high pressures and include both isotopes of lithium.

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