# Quantum Oscillation in $Fe_2As_2$ Compounds

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## Introduction

The iron-pnictide family of superconductors has recently attracted significant interest because they exhibit superconductivity with critical temperatures $T_c$ that had previously been reserved to the cuprate family of superconductors, surpassing even $MgB_2$ with $T_c$ ~ 40 K. The Fermi surface is quasi-two dimensional in the oxypnictides [1,2]and growing evidence has emerged of the Fermi surface for the ternary compounds from recent ARPES and quantum oscillation experiments [2,3], though it is still unclear how to marry the two measurements. Quantum oscillations are a bulk measurement of the Fermi surface and are therefore extremely important in understanding the electron dynamics and they provide compelling evidence that not only do coherent quasiparticles exist, but also gives their effective mass, lifetime and illustrate how much of the Fermi surface has been reconstructed.

## Experimental

Magnetic oscillation experiments were performed at the National High Magnetic Field Laboratory (Los Alamos) in the short pulse 65T magnet. These high fields quantize the electron energy spectrum into Landau levels, whose occupation is periodically evacuated as these levels cross the chemical potential. For the torque magnetometry experiments, piezoresistive microcantilevers were used at temperatures down to 0.4 K. The torque felt by the cantilever is dependent on the anisotropic magnetization of the sample. Samples used for the torque cantilever were typically .2x.2x0.08 $mm^3$. Oscillations in the torque are thus manifestations of the de Haas-van Alphen effect. Another sample of dimensions 2x2x0.3$mm^3$ was mounted with its tetragonal c axis parallel to the field direction. The face of the sample is then attached to a compensated coil that forms part of the tunnel diode oscillator (TDO) circuit. The oscillator resonates at frequency ~ 75 MHz in the absence of an applied field, dropping by ~ 300 kHz at 65T in response to the magnetoconductivity of the sample. As the skin depth changes due to the Shubnikov-de Haas effect, the coil resonance frequency is correspondingly altered.

## Results and Discussion

Two different samples of $BaFe_2As_2$ have been measured by torque and the TDO technique. Using the first technique we resolve a Fourier peak at Fg=T, but higher frequencies cannot be reliably distinguished. A second Fb and third Fa frequency emerges in the TDO, which are not apparent in torque data. One reason for this could be due to a lack of anisotropy in these larger pockets, which would lead to a dramatic reduction in the torque signal. The former may be a harmonic of the Fg, but the latter is certainly a new feature. From the angle dependence of Fg we are able to confirm that this is either an eccentric ellipsoid of a quasi-2D cylinder. From the temperature dependence we find an effective mass for this pocket of $m^*=1m_e$. Our data confirms a complete reconstruction of the Fermi surface as materials enters the magnetically ordered state.

## Conclusions

We observe quantum oscillation in the magnetically ordered state of the parent pnictide $BaFe_2As_2$, which, when doped with either electrons or holes, becomes superconducting. We observe two small pockets which illustrate a completely. It is currently unclear what drives the magnetic ordering in these compounds and whether the magnetism competes with superconductivity. These measurements should place significant limits on the nature of the magnetism and the relationship to superconductivity in these compounds and must be explained by any theoretical candidate for superconductivity in these materials.

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## References

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