Searching for Hole Bands in Iron Pnictides Close to the Quantum Critical Point

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The details of the Fermi surface topology, its tendency towards instabilities as well as the strength of the coupling of the quasi-particles to excitations, are important aspects of developing a complete understanding of the origin of iron based superconductivity. A common feature that links these materials is their unusual electronic structure, which consists of almost nested, quasi two dimensional electron and hole Fermi surfaces. This quasi nesting produces strong peaks in the susceptibility, which in many theories drives the superconductivity via a spin-fluctuation mechanism. These and more local fluctuations also enhance the quasiparticle mass and so studies of the mass and how it changes on the different Fermi surface sheets close to the quantum critical point (QCP) where the superconducting T_c is maximal provides a powerful and direct probe of these interactions.

We have previously observed de Haas-van Alphen (dHvA) quantum oscillations in both LiFeAs/P and $BaFe_2(As_xP_{1-x})_2$ (Ba122) systems [1,2], using micro piezo-resistive cantilevers, however signals from the hole Fermi surface sheets were not clearly resolved in LiFeAs or Ba122. The aim of our last experiment in the 45T hybrid was to search for dHvA signals on the hole bands in LiFeAs and Ba122 and also to further track the changes in mass on the electron sheets of Ba122 as x is tuned towards the QCP.

For Ba122 we were able to observe signals from the hole sheets in a sample with x=0.76, still some way from the QCP but far enough from x=1 to give an indication of how the mass changes with x, especially when combined with other previous data by Analytis et al. [3]. Signals from the electron pockets were found on an x=0.35 sample which is very close to the QCP and showed evidence for a substantial mass enhancement. Some of samples for our experiment were previously characterized using pulsed field (up to 58T) in Toulouse. This allowed us to select the most likely candidates that show the strongest dHvA signals; we observed clear oscillations in the hybrid up to 42T as the signal to noise ratio is considerably higher in the dc field than pulsed field data because of lower temperatures and lower noise levels. Combined with data from pulsed field experiments for larger x, this now gives a very clear picture of how the mass diverges at the QCP. The experiments on LiFeAs on several samples showed clear dHvA oscillations from the electron Fermi surface sheets (see **Figure 1**) but we did not observe any clear signals from the hole sheets. Clearly further improvements in samples quality will be required to observe these.

This work was collaboration between experimentalists based at the University of Bristol and University of Oxford (UK) with samples provide by the group of Y. Matsuda from Kyoto University, Japan.

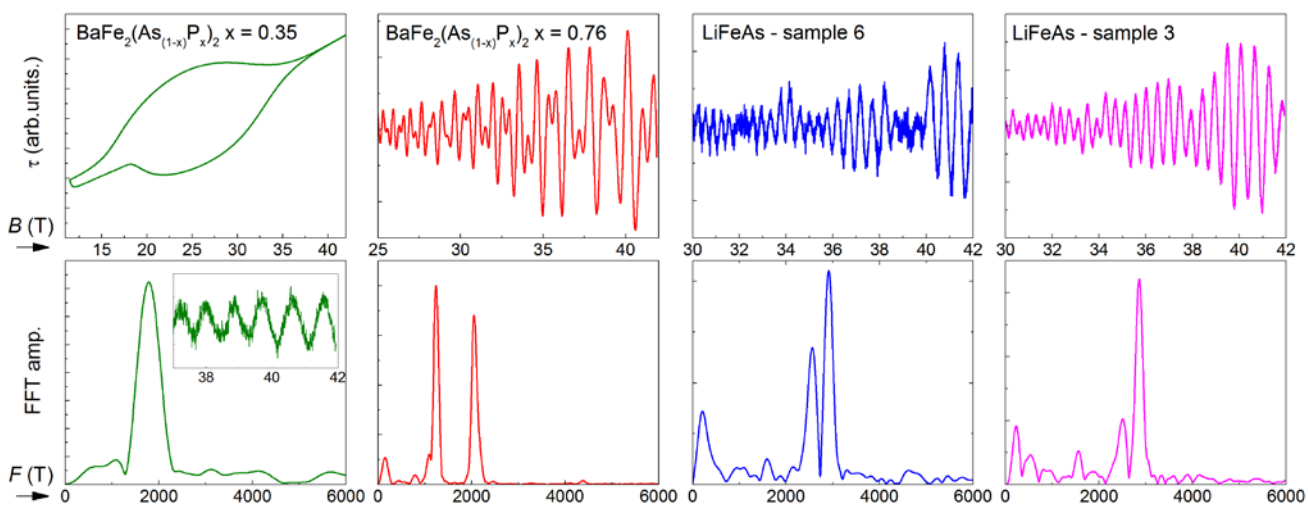

Figure 1. *(Top panel) Oscillatory torque of samples of $BaFe_2(As_xP_{1-x})_2$ and LiFeAs measured at 0.5K showing dHvA oscillations above their irreversibility field. (Bottom panel) Fourier transforms showing peaks which correspond to the extremal areas of the Fermi surface.*

[1] C Putzke *et al.* PRL, **108**, 047002 (2012).
[2] H. Shishido *et al*., PRL **104**, 057008 (2010).
[3] J. Analytis *et al.,* PRL 105, 207004 (2010).