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| | Experiment title: The Fermi surface of the layered magneto-resistive oxide $\text{La}_{1.2}\text{Sr}_{1.8}\text{Mn}_2\text{O}_7$ | Experiment number: HE-674 |
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Report:

Since the discovery of colossal magnetoresistance (CMR) in doped-manganese oxides [1,2], there has been intense activity in ascertaining the mechanisms responsible. At low temperatures, appropriately doped systems are ferromagnetic metals, while at high temperatures they are paramagnetic insulators, and it is with the metal-insulator transition that the explanation of the CMR effect is thought to lie. However, significant question marks remain over the nature of the metallic state. Although the resistivities of these sample just qualify them as being metallic, the temperature dependence deviates strongly from typical metallic behaviour [3]. This proposal is aimed at investigating the metallic state of one such compound, $\text{La}_{1.2}\text{Sr}_{1.8}\text{Mn}_2\text{O}_7$, through measurements of its Fermi surface.

While the technological potential of these materials is high, the dearth of electronic structure information has been a major obstacle in achieving an understanding the physics of the manganites. Moreover, what little experimental data there have been so far are contradictory. From their angle-resolved photoemission (ARPES) data, Dessau *et al.* [3] have reported a large “ghost” Fermi surface where the spectral weight associated with the occupied part of the band falls off rapidly as the band approaches the Fermi level, E_F . Moreover, the ARPES features were found to be unusually wide, and did not sharpen up as the band approaches E_F (Fig. 1), indicating strong deviations from what might be expected from a description involving single, Fermi-liquid-like quasiparticle excitations. They interpreted their data in terms of the existence of a “pseudogap”, which is wider in the paramagnetic phase. They speculated that this pseudogap might explain the huge changes in conductivity.

Using the high-resolution Compton spectrometer on beamline ID15B, we have measured 7 directional Compton profiles between $[100]$ and $[110]$ in order to perform a 1D to 2D reconstruction. Since the Brillouin zone is quasi-2D, this should be adequate to understand the Fermi surface. We used Cormack's method, previously employed in positron annihilation 2D to 3D reconstructions of the momentum density.

Below we show the radial anisotropy of the reconstructed $[001]$ projection of the electron momentum density, along with the positron annihilation measurement for comparison. It can be seen that the Compton result shows similar features. The Compton measurements represent the first tomographic reconstruction from high-resolution profiles of an electronically complex material.

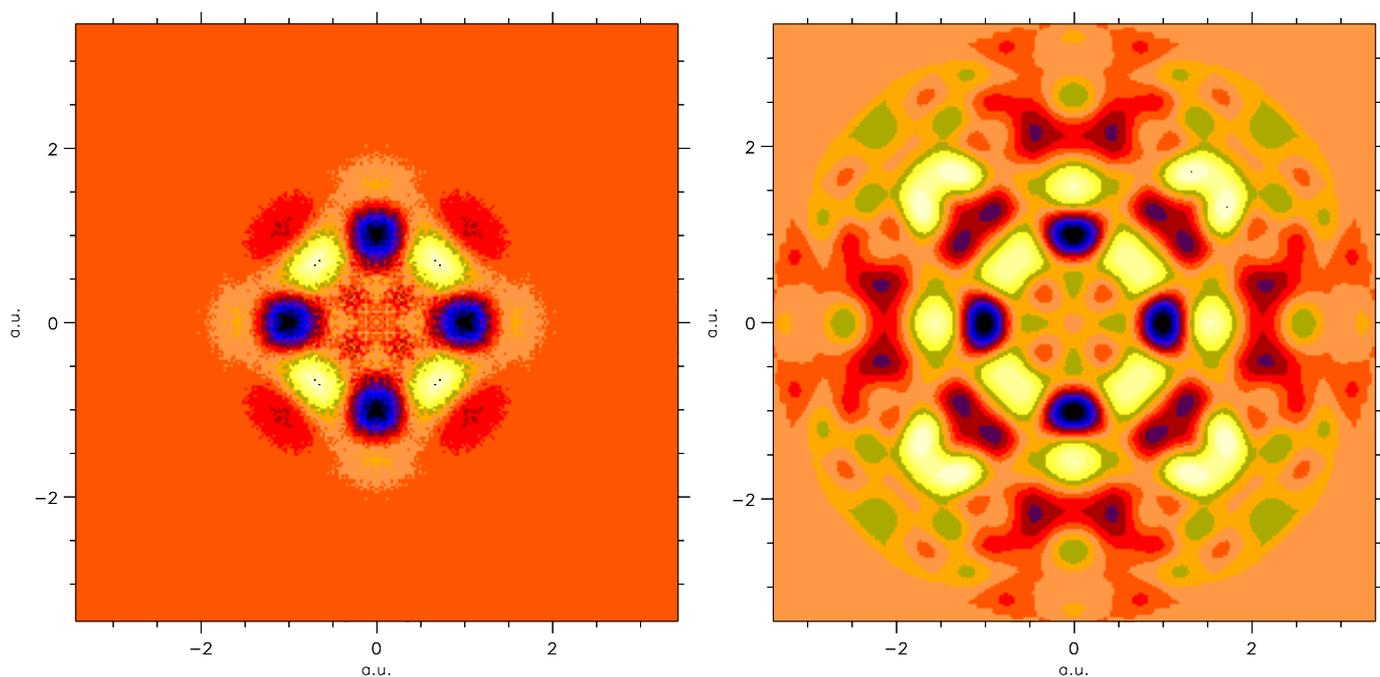


Figure 1. $\text{La}_{1.2}\text{Sr}_{1.8}\text{Mn}_2\text{O}_7$. Anisotropy of experimental electron-positron momentum density (left) and experimental electron momentum density (right).

It should be noted that the structures extend to much higher momentum in the case of the Compton data; the reason is that the positron is repelled from the core regions due to its positive charge, and hence its wavefunction does not overlap strongly with the high-momentum electrons. Further analysis, in terms of the extraction of a Fermi surface topology, is underway.

References

- [1] R. M. Kusters *et al.*, *Physica* **155B** 362 (1989).
- [2] S. Jin *et al.*, *Science* **264** 413 (1994).
- [3] D.S. Dessau *et al.*, *Phys. Rev. Lett.* **81** 192 (1998).