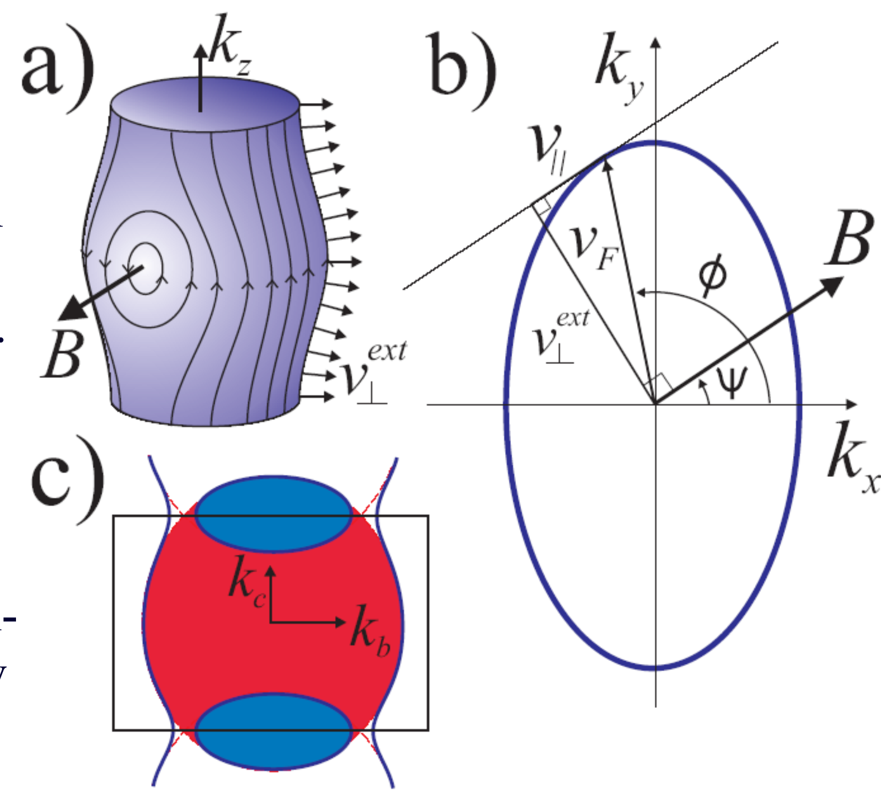
CAREER: Magnetic Resonance - From Materials Research to Science Education

Stephen Hill, University of Florida, DMR-0239481

Angle-resolved mapping of the Fermi velocity in a quasi-2D conductor

We have developed new methods for characterizing the electronic properties of layered superconducting materials, such as the high-temperature superconductors. These methods are based on angle-dependent magnetic resonance measurements in high magnetic fields, such as those available at the National High Magnetic Field Laboratory (NHMFL). The obtained data enable us to map-out 3D contour plots of electronic velocities, information which is vital for theorists attempting to understand many contemporary problems associated with strongly interacting condensed matter systems, including high-temperature superconductivity. In this sense, our new methods are complementary to the more widely used Angle-Resolved Photo-Electron Spectroscopy (ARPES) techniques, which are usually carried out at large scale synchrotron facilities.



Physical Review Letters **91**, 216402 (2003)

Also highlighted in the annual research report of the NHMFL

One of the leading challenges in low-dimensional conducting materials is the determination of the so-called Fermi surface, which describes electronic structure and dynamics. The conventional procedure to approach this problem is through Photo-Electron Spectroscopy (PES), usually carried out at synchrotron facilities, or through magneto-transport and magnetization studies. The Florida Group has used innovative angular dependent methods to allow the rotation of samples with respect to high magnetic fields, whilst simultaneously carrying out microwave spectroscopies. These techniques have led to several new discoveries: 1) the ability to directly determine the Fermi velocity for a specific direction in a crystal – a quantity not directly accessible from standard magnetic measurements, and 2) three dimensional aspects of the Fermi surface topology, including magnetic breakdown dynamics, also not readily accessible by conventional methods. It is likely that these modern high-field microwave methods will evolve over the next few years, thereby becoming a mainstay of how researchers approach fundamental investigations of anisotropic electronic structure, including users at the NHMFL. this work was published in Physical Review Letters, November 2003, and in the NHMFL annual research report highlights.

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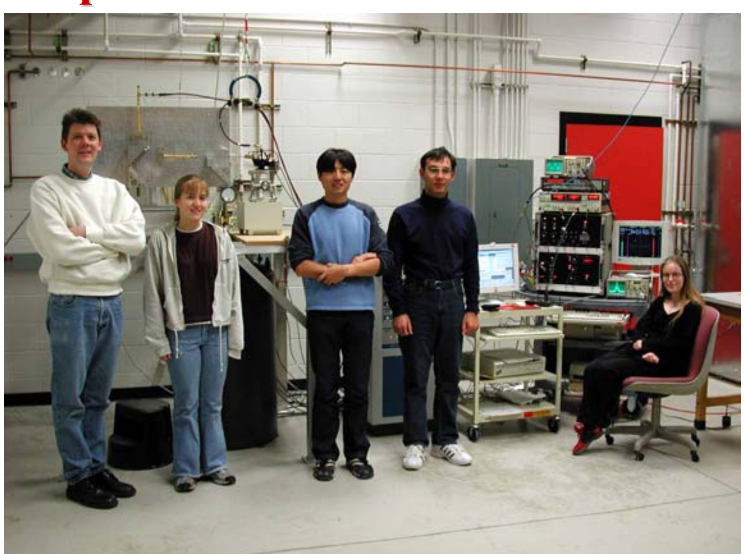
Education and training:

•**One high-school student**: Vincenza Berardo.

•**Two undergraduate students**: Samantha Dizor (summer REU student from the University of North Florida); and Daniel Benjamin (University of Florida).

•**Five UF graduate students**: Susumu Takahashi; Jon Lawrence; Cem Kirman; Norman Anderson; Tony Wilson.

•**Two postdocs**: K. Petukhov and John Lee.



Education highlights:

•The PI developed a web-based daily homework system and presented outcomes at a education meeting.

•A local high-school student participated in the research activities of the group.

•Dan Benjamin accepted to the highly competitive University Scholars Program and published an article in solid state communications as lead author.

Broader impact

•The PI received additional funding from the NHMFL to develop magnetic resonance instrumentation for users of this national facility.

•Research activities under this award will be featured in a color publication sent to UF alumni.