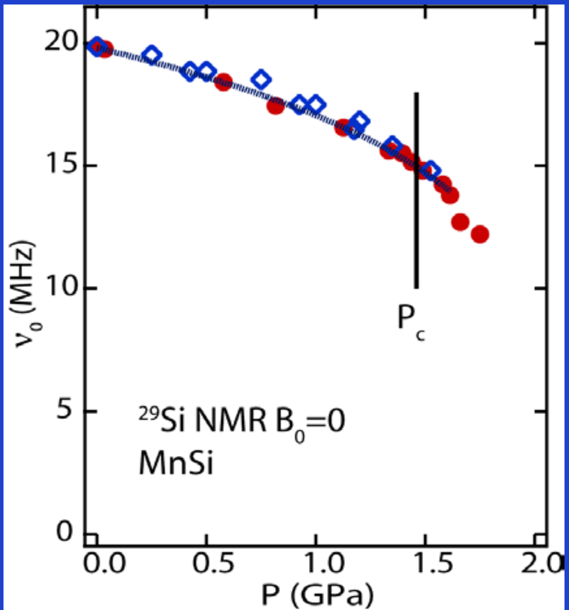
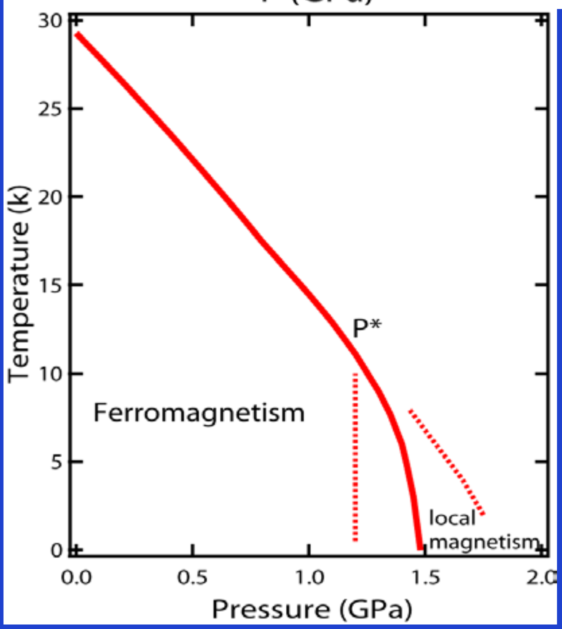
# Exploring competing instabilities of correlated electron systems using solid state NMR

S. Brown, UCLA DMR-0203806

When electron-electron interactions are important, they often lead to situations where ground states of different symmetry are close in energy, and experimentally we can adjust parameters (other than temperature) so as to tune between phases. An example of interest to us is the phenomenon of weak itinerant (metallic) ferromagnetism (FM). Materials that fall into this class include MnSi, $ZrZn_2$ and $Au_4V$. These systems, in contrast to the elemental ferromagnets Fe and Ni, undergo magnetic transitions at a relatively low temperature and the strength of the ordered moments is very small. The transition to the FM state is suppressed by modest pressure, beyond which the ground state at greater pressures is expected to be an ordinary metal. In contrast, our high-pressure $B_0$=0 NMR experiments probe locally the magnetic environment of the $^{29}$Si nucleus in MnSi and provide evidence for a new phase with weak static magnetism, distinct from what is seen at lower pressure. (Phys. Rev. Lett. **92**, 047003 (2004).



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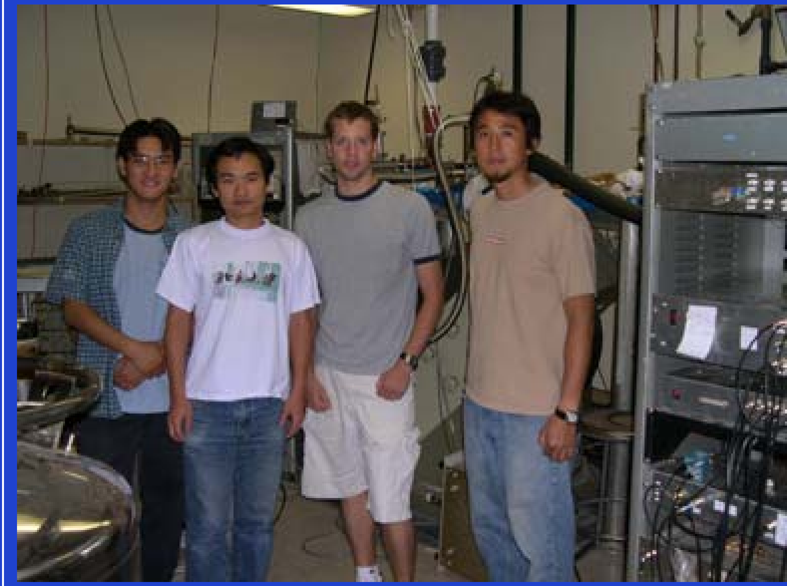
Education and training activities

Graduate and undergraduate students receive training in designing, performing, and analyzing magnetic resonance experiments in the solid state under extreme conditions, including low-temperature, high magnetic fields, and high pressure.

Undergraduates participate at all levels, from building instrumentation and implementing new techniques to conducting experiments. Aside from opportunities for UCLA students, students from other institutions participate in the P.I.'s research program through the new Research Experience for Undergraduates (REU) funded by the NSF at UCLA. This year we are enjoying long term visits from students Boston College and the University of Tokyo.

In a laboratory class taught by the P.I., students learn instrument design and put their ideas to work in projects of their choosing. Among this year's successful student projects were a line-following robot and an instrument for measuring elastic properties of solids.



The research group: Ted Tao (left to right) Fan Zhang, Colin Parker, and Jun Shinagawa; Colin Parker is an undergraduate from Harvey Mudd in the REU program, and Ted Tao is a UCLA undergraduate.

A starting point for the theory of common metals is the assumption that the current-carrying electrons move through the solid independent of one another. A topic of of interest today is what happens when this point of view is no longer valid. That is, where correlations are important, it very often happens that unpredicted phases with sometimes spectacular properties result. Examples of interest to our group include organic conductors, high-$T_c$ superconductors, and ferromagnetic metals that are almost not ferromagnetic. Conventional wisdom holds that if the ferrmomagnetic state can be avoided, then what takes its place is essentially a common metal. We are learning that this is probably not true. We use NMR in a weak ferromagnet as a probe of the magnetic properties of the system, and employ high pressure techniques as a means of avoiding the ferromagnetic state. When we do that, what we find is something unexpected, namely evidence for a metallic state with properties quite different from a common metal, and different from ferromagnetic state found at very low pressure.