Quantum Criticality in Heavy Fermions: an Experimental Perspective

(Under the aegis of MHRD-Global Initiative for Academic Networks-GIAN)

22nd to 28th March 2018, at IISER Mohali, Punjab

Overview

When a ferromagnet is warmed above a critical temperature, it loses its ferromagnetism and becomes a paramagnet. This is an example of a classical (finite temperature) phase transition. Such transitions are mostly continuous or second order phase transitions and can be understood within the paradigm of Landau free energy and involves the existence of an order parameter (the magnetization in the case of the ferromagnet) that is zero in the disordered (paramagnetic) state and becomes finite below the critical temperature. Most finite temperature phase transitions can be understood within this paradigm. In the vicinity of the critical temperature there are fluctuations of the order parameter.

Continuous phase transitions that occur at zero temperature are called quantum phase transitions (QPT). These are accompanied by quantum critical fluctuations that influence the properties of the material even at finite temperatures making it possible for experimentalists to study such QPTs. These quantum critical fluctuations lead to anomalous temperature dependences in various transport and thermodynamic properties that cannot be understood with existing theories for classical phase transitions.

This course will introduce and describe the novel and exotic properties of QPTs with real life examples in solid state materials that can be synthesized in the lab. Experimental techniques and measurements required for the crystal growth and physical property study of such phase transitions will also be introduced and briefly described.

Course participants will learn these topics through lectures and hands-on experiments. Also case studies and assignments will be shared to stimulate research motivation of participants.

Topics	• Fundamentals of phase transitions in general and Quantum Phase transitions in particular • Physics of normal Landau Fermi Liquids and the novel Heavy Fermion materials • Providing exposure to examples of the above behaviors in several real solid state materials • Providing an overview of the experimental techniques and measurements required to identify the QPT's and the associated novel behaviors like non-Fermi liquid behavior and heavy Fermion superconductivity • Crystal growth and characterization techniques used for synthesizing high quality materials required for such studies • Lab exposure to participants for an introduction to the state of the art equipment used for the synthesis and physical property measurements on the synthesized materials. **Number of participants for the course will be limited to fifty (50).**
Who can attend?	• Students in the final year of their 5yr BS/MS or BTech programs, and students pursuing MSc, MTech, or equivalent programs and with an interest in Condensed Matter Physics. • PhD students and Post-doctoral scholars in Physics or Chemistry. • Faculty and scientists from reputed academic or technical institutions, industry, or R&D labs.
Fees	The participation fees for taking the course is as follows: **Participants from abroad : USD $500** **Industry/ R&D Organisations: INR 25,000** **Academic Institutions: Faculty (INR 15,000), Postdocs/Students (INR 10,000)** The above fee includes lodging and local hospitality, all instructional materials, tutorials and assignments, and 24hr free internet facility.

The Faculty:

Prof. Philipp Gegenwart is chair professor at the Center for Electronic Correlations and Magnetism at Augsburg University, spokesperson of the Transregional Collaborative Research Center “From electronic correlations to functionality” of the German Science Foundation (DFG), and member of the DFG Review Board “Experimental Condensed Matter Physics”. His research focuses on the exploration of novel quantum states of matter such as non-Fermi liquid behavior, quantum criticality, unconventional superconductivity, and quantum spin liquid behavior. His group synthesizes and investigates thin film heterostructures as well as single crystals of transition metal and rare-earth based compounds with emphasis on strong electronic correlations. The group uses various thermodynamic, magnetic and transport techniques at multiextreme conditions (very low temperatures, very large magnetic fields, high pressure).

Prof. A. Thamizhavel is an associate professor at Tata Institute of Fundamental Research (TIFR), Mumbai. His research is in the studies of anisotropic physical properties of strongly correlated electron systems. His expertise is in single crystal growth of oxide and intermetallic materials and their physical property characterization.

Prof. Yogesh Singh is an associate professor in Physical Sciences at IISER Mohali, India. He specializes in the design, discovery, and crystal growth of novel materials and in the characterization of their thermodynamic properties under extreme conditions of low temperature, high pressure, and high magnetic field. His group’s current areas of research are (i) Quantum Spin Liquids, (ii) Mott insulators in the strong spin-orbit limit, (iii) unconventional superconductors, (iv) Topological materials and phases.

Local Co-ordinator:

Prof. Kapil H Paranjape

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