2017 Superconductivity Gordon Research Conference and Gordon Research Seminar, June 4-9, 2017, Waterville Valley, NH

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Project Narrative

General Objectives

The Superconductivity Gordon Research Conference (GRC) is held every two years, oscillating between US, Europe, and Asia. This is one of the key events in superconductivity and quantum materials research. Traditionally, this conference brings together some of the leading senior scientists from around the globe, as well as many junior scientists. The goal is to present and discuss the latest results in the field of modern superconductivity, discuss new ideas and new directions of research in the area.

The field of superconductivity has witnessed yet another rapid developing in the last few years. There has been a strong revival of interest to superconductivity in the cuprates, primary due to new ideas about the interplay between superconductivity and competing orders, and a plethora of new high-quality experimental results on photoemission, X-ray scattering, neutron scattering, resistivity and Hall conductivity, NMR, etc. In particular, recent high-quality laser angle-resolved photoemission data by Zhou's group from Beijing were argued to nail down the frequency dependence of the bosonic propagator responsible for both superconductivity (the pairing glue) and strong fermionic scattering in the normal state. This experimental development re-ignited the hope that the pairing mechanism in the cuprates will be firmly established in the very near future. The results of recent Hall conductivity measurements by Taillefer and his collaborators from Sherbrooke in turn re-ignited the discussion on whether one can have Fermi surface reconstruction (and induced strong changes in supercoducting Tc) without doubling of the unit cell, which is normally associated with a magnetic order. These are fundamental questions whose relevance extends far beyond cuprates.

There have been also exciting new developments in the area of superconductivity in Fe-pnictides and Fe-selenides. These include the observation of superconductivity with Tc above 100K in monolayers of FeSe. On theory side, the new ideas have been proposed about truly novel superconductivity in multi-orbital systems, about the interplay between superconductivity and competing orders (e.g., nematicity), and about the role of spin-orbit coupling for unconventional superconductivity. There have been substantial advances in the computational approach to superconductivity in strong-coupling regime, in particular several groups obtained novel Quantum Monte-Carlo results on non-BCS superconductivity near quantum-critical points.
In parallel, superconductivity has been extensively studied in other monolayers, including doped graphene. There are new reports on superconductuivity in Iridates and over the last year there have been exciting new developments on superconductivity under external conditions such as light-induced superconductivity and superconductivity under pressure. In particular, Iowa/Ames Lab and Kyoto groups recently obtained new results on FeSe on the interplay between growing superconductivity under pressure and the nematic order. Another area of rapid progress, both experimental and theoretical, is topological superconductivity. Besides, there have been

substantial advances in the last 1-2 years in the search of new superconducting materials with tailored properties.

The conference focused on all these areas, and, in line with Gordon Research Conferences tradition, we dedicated Thursday afternoon to discuss the latest experimental and theoretical developments in the area. It is a long-standing tradition of the Superconductivity Gordon Research Conference that the vast majority of participants and substantial portion of speakers are junior scientists. We put special emphasis to recruit more junior speakers and establish gender equality. We had 10 female speakers, some of them junior researchers. This is much higher number than on previous Superconductivity Gordon Research Conferences. We had a large number of participants from many US Universities, and, in selecting the participants, will put special emphasis on gender equality among participants and on participants from ethnically under-represented groups. DOE funding for the conference was primarily be used to support junior researchers, particularly those from under-represented groups.

The conference was held together with Superconductivity Gordon Research Seminar, where almost all speakers and participants will be junior scientists, chosen from submitted abstracts. Meetings were held in line with Gordon Conferences tradition – Morning session with 6 speakers, time for informal discussions after lunch, poster session in the afternoon, dinner, and evening session after dinner. Each session started with the presentation by the discussion leader, who summarized the status of the field and moderated the discussion after every talk. We had at least 10 minutes for discussions after every talk. Gordon Research Conference provided equipped meeting and poster rooms, accommodations, dining facilities, audiovisual support and a staffed office. The conference site was accessible for people with disabilities and when registering for the conference such people were able to identify any special needs so that the conference organizers could accommodate those needs.

Information about the conference (including the program) is available through the website https://www.grc.org/programs.aspx?id=13945.

Broader Impact

Research in unconventional superconductivity is relevant to broader DOE office of Science mission which includes the discovery of novel materials with controllable properties. Superconducting power applications boast several properties that can prove them environmentally advantageous over conventional electric power applications. Such are, for example, up to 50% lower losses, which means savings in electricity and thus savings in greenhouse gas emissions from electricity production, and less raw materials required to construct devices resulting in lower environmental impact of manufacturing.

Commonly, the superconducting transition is just one of many phase transitions revealed by unconventional superconductors. These phase transitions can be controlled by various external stimuli, offering potential for future technologies. Sunday PM and Thursday PM sessions were dedicated to search for new materials with exotic properties, including superconductivity.