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Gregory S. Boebinger
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Upper critical field reaches 90 tesla near the Mott transition in alkali-doped fulleride superconductors

User: Y. Kasahara[1], Y. Takeuchi[2], R.H. Zadik[3], Y. Takabayashi[4], R.H. Colman[3], R.D. McDonald[5], M.J. Rosseinsky[6], K. Prassides[4,7] & Y. Iwasa[2,8]
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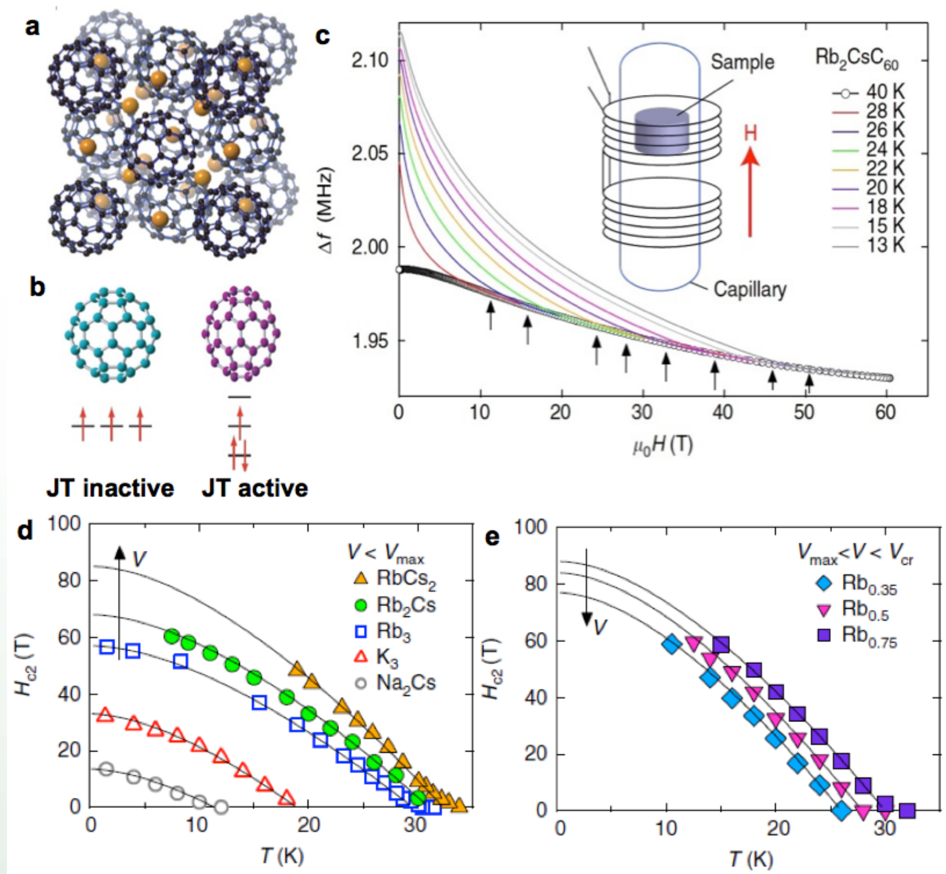
Intellectual Merit: The alkali-doped fullerides provide the first example of a transition from a three-dimensional Mott insulator to a superconductor, enabling the effects of both dimensionality and electron correlations on superconductivity to be explored. Chemically, the alkali species tunes the superconductivity in the vicinity of the Mott transition by varying the unit cell volume.

Measuring the relationship between the superconducting transition temperature (Tc) and upper critical magnetic field, (Hc2) revealed a crossover from weak- to strong-coupling as the Mott transition is approached, a crossover associated with the dynamical Jahn–Teller effect. The use of pulsed magnets is required because the upper critical field is enhanced in the vicinity of the Mott insulating phase, reaching 90 tesla for $Rb_xCs_{3-x}C_{60}$ — the highest-known Hc2 among all cubic crystals. This experiment required close collaboration among external users and MagLab scientists to design radio frequency (rf) measurements compatible with sample encapsulation in an inert atmosphere.

The increase of pairing strength with lattice volume near the Mott transition suggests that a cooperative interplay between molecular electronic structure and strong electron correlations reinforces the robust superconductivity (high-Tc and high-Hc2) found in the alkali-doped fullerides.



a) the crystal structure, b) Jahn-Teller (JT) distortion, and c) the upper critical field, Hc2, measured via the rf-frequency shift. d) and e) Hc2 versus Tc for all alkali metal doping compositions studied.

DMR DIVISION OF MATERIALS RESEARCH
DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES

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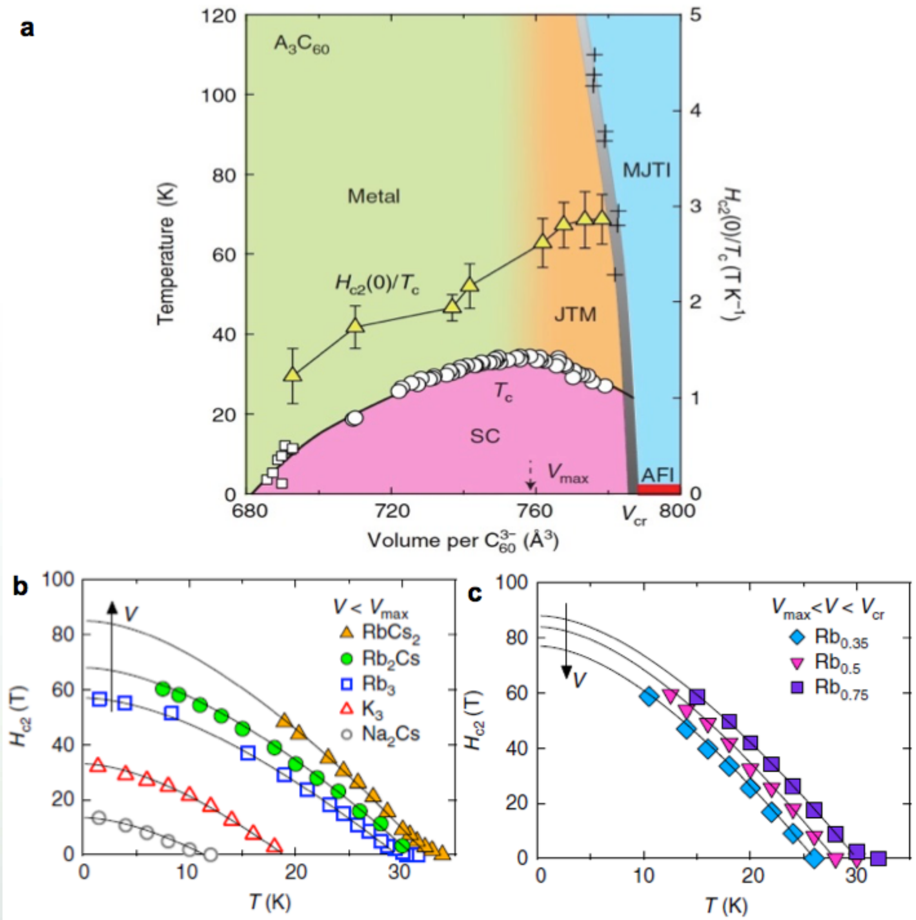
Broader Impacts: Materials that exhibit a high transition temperature into a superconducting state are of great potential interest for a multitude of electrical and magnetic applications, potentially revolutionizing technologies as diverse as electrical transmission and magnetic resonance imaging (MRI).

Higher transition temperature materials and materials that resist the deleterious effects of magnetic field on the superconducting state are broadly sought after. Many of today's highest temperature superconductors are brittle, easily breaking apart into layers, and are thus difficult to shape into electrical conductors. A three dimensional material like the one studied here with a high transition temperature (Tc) and a high resistance to magnetic field (Hc2) is of great interest to the community that develops technology that needs superconductors.



a) Phase diagram, including the superconducting (pink) and Mott insulator (blue) phases. b) and c) Hc2 versus Tc for all alkali metal doping compositions.

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