Forcing a metal to be a superconductor via rapid chilling

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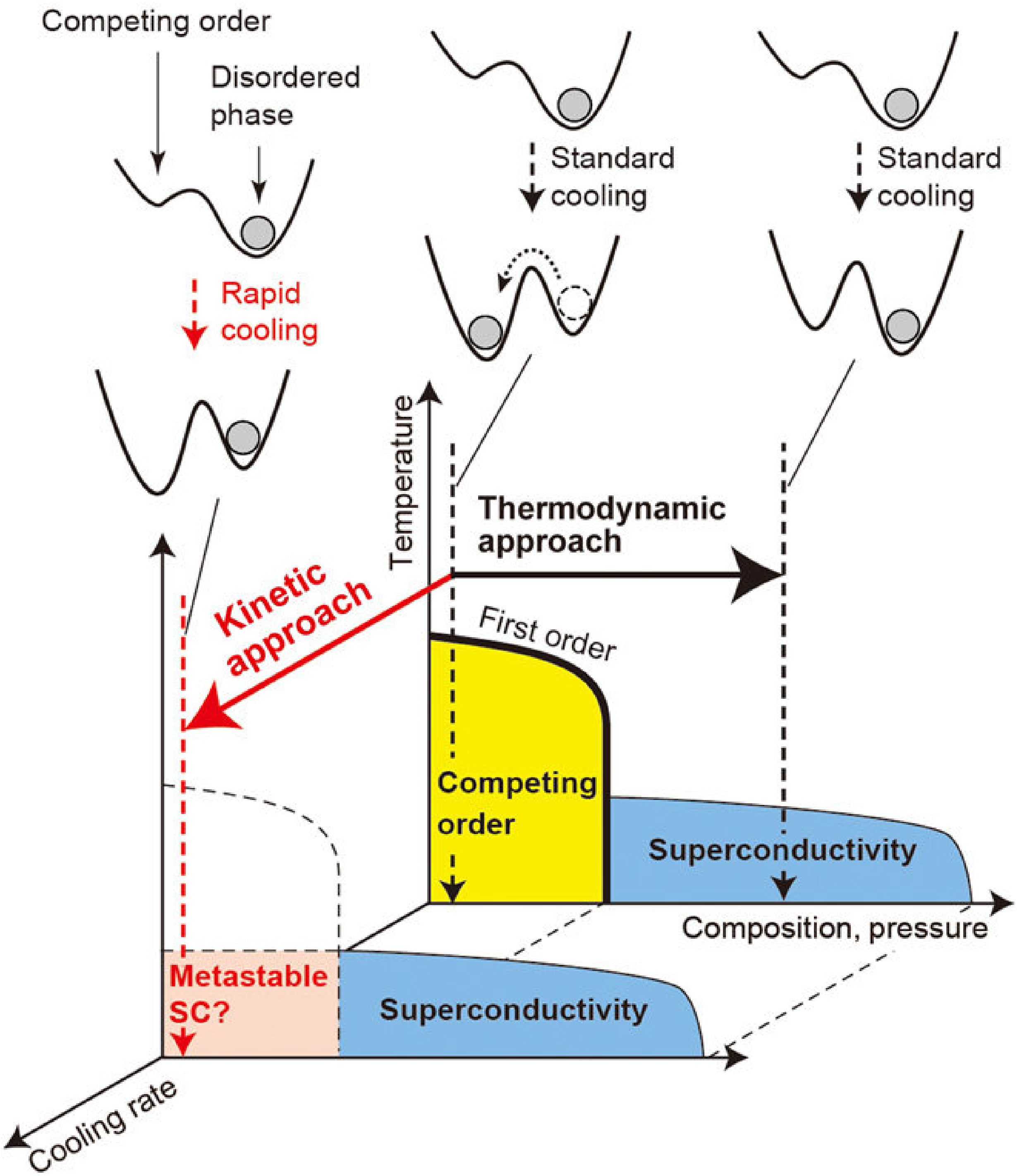

Scheme for thermodynamic and kinetic approaches to realizing superconductivity in certain strongly correlated electron systems. The conceptual electronic phase diagram considered in this study is displayed with pressure/carrier doping as a control parameter. The double well and ball represent temperature-dependent schematic free-energy landscapes and realized electronic states in each cooling process, respectively. The thermodynamic approach, which can be advanced by increasing pressure or carrier doping, results in a change in the lowest free-energy state, from a certain competing order to a superconducting (SC) state. By contrast, the kinetic approach, which can be advanced by rapid cooling, allows the system to kinetically avoid the first-order phase transition to the competing order and thus to remain in a metastable supercooled state, which is expected to eventually turn into superconducting at low temperatures. Credit: *Science Advances* (2018). DOI: 10.1126/sciadv.aau3489

A team of researchers with the RIKEN Center for Emergent Matter Science and The University of Tokyo, both in Japan, has found a way to force a metal to be a superconductor by cooling it very quickly. In their paper published on the open access site, *Science Advances*, the group describes their process and how well it worked.

Scientists around the world continue to seek a material that behaves as a superconductor at room temperature—such a material would be extremely valuable because it would have zero electrical resistance. Because of that, it would not increase in heat as electricity passed through it, nor lose energy. Scientists have known that cooling some materials to very cold temperatures causes them to be superconductive. They have also known that some metals fail to do so because they enter a "competing state." In this new effort, the researchers in Japan have found a way to get one such non-cooperative metal to enter a superconductive state anyway—and to stay that way for over a week.

Noting that there is a very small delay between the moment when a metal reaches a temperature cold enough to enter a superconductive state and the onset of the competing state, the researchers came up with an idea—if the metal was cooled rapidly, it might not have a chance to enter a competing state. They liken the idea to metal forgers plunging their work into cold water after fashioning to prevent it from weakening.

To find out if their idea worked, they made a metal sample out of iridium and tellurium. They connected electrodes and gave it a jolt of electricity. The jolt initially caused the metal to heat to over 27°C, but then it cooled very rapidly to -269°C, in under ten microseconds. The researchers found that via quick-freeze technique, the metal changed into a superconducting state for over a week.

More information: Hiroshi Oike et al. Kinetic approach to superconductivity hidden behind a competing order, *Science Advances* (2018). DOI: 10.1126/sciadv.aau3489