Using magnetism to understand superconductivity

Eurekalert!

Might it one day be possible to transmit electricity from an offshore wind turbine to land-based users without any loss of current? Materials known as "high temperature" superconductors (even though they must be maintained at -140°C!), which can conduct electricity without any losses, were supposed to make this dream a reality. But over the past twenty-five years, scientists have not been able to make any progress in this area. Research being done in EPFL's Laboratory for Quantum Magnetism (LQM) could change that. Their study of magnetism at extremely small scales could give physicists a tool to use in their search for new superconducting materials.

Studying a superthin layer

There are some ceramics that are excellent insulators at room temperature but that become perfect conductors when submersed in liquid nitrogen. However, this phenomenon, known as "high temperature" superconductivity, is not at all well understood by physicists. They theorize that at these temperatures, the collective quantum magnetic properties of the atoms in the material might come into play. But studying the magnetic properties of these materials at this minuscule scale would require years of effort.

Mark Dean, John Hill and Ivan Bozovic from Brookhaven National Laboratory (BNL), Thorsten Schmitt from Switzerland's Paul Scherrer Institut (PSI), and Bastien Dalla Piazza and Henrik Ronnow from EPFL have unveiled the phenomena at work at this atomic scale. Using a unique device, the Brookhaven team created a layer just a single atom thick. Then, despite the material's extreme thinness, the PSI scientists were able to use an ultrasensitive instrument to measure the magnetic dynamics of the atoms. And then EPFL provided the final piece of the puzzle, with mathematical models to analyze the measurements.

A long-awaited research tool

"We now have a kind of flashlight that will show us what direction we should take in our search," explains Ronnow. Without understanding how these superconducting properties occurred at these temperatures, researchers were probing in the dark, using trial and error, to explore promising new materials. By combining these results with other recent work done by LQM researcher Nikolai Tsyrulin, the EPFL team has provided a new method to help physicists in their search for new superconductors. It's a long-awaited step forward in the field; the Nobel Prize recognizing the discovery of high temperature superconductivity was awarded more than 25 years ago.

Promises for the future

Electrical resistance in traditional power lines leads to energy losses on the order of 3% in the electricity grid. At the scale of an entire country, this translates into several thousand gigawatts, which, in Switzerland's case, would be the equivalent of the electricity consumption of a city the size of Geneva. "The energy challenges we face are significant; being able to use superconductivity won't solve all of them, but it would nonetheless enable huge energy savings," Ronnow adds.

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