Portable superconductivity systems for small motors

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Superconductivity, where electrical currents course unhindered through a material, is one of modern physics' most intriguing scientific discoveries. It has many practical uses. Governments, industries, and health care and science centers all make use of superconductivity in applications extending from MRIs in hospitals to the cavities of particle accelerators, where scientists explore the fundamentals of matter. However, practical exploitation of superconductivity also presents many challenges.

The challenges are perhaps greatest for researchers trying to integrate superconductivity in small, portable systems. Cambridge University academic and superconductivity expert John Durrell and his team demonstrate this week in *Applied Physics Letters*, from AIP Publishing, that a portable superconducting magnetic system, which is, in essence, a high performance substitute for a conventional permanent magnet, can attain a 3-tesla level for the magnetic field. Durrell said his team's work in large part evolved from the innovative findings of University of Houston physicist Roy Weinstein, who has shown how conventional electromagnets and pulsed field magnetization can be used to activate superconducting magnetic fields which are "captured" and sustained as part of a superconductive arrangement. This avoids the requirement for large expensive superconducting magnets to "activate" such portable systems. Also key, Durrell pointed out, is that his team capitalized on other new and cheaper technologies, especially for cooling.

"For example, the leap with advances in cryogenics, allows you to do

interesting things in other areas, too," Durell explained. "There is a lot coming together to make this possible." While large industrial-size superconducting systems do generate a 20-tesla magnetic field, Durrell's 3-tesla magnetic field is new for a portable system.

Durrell and his team were curious about what they could do as they looked at Weinstein's work just a few years earlier. Weinstein demonstrated that with conventional external electromagnetic pulsing of a medium, it was possible to "capture" a magnetic field in a superconductor using a much smaller external magnetic field than previously thought possible. The Weinstein investigation used Yttrium Barium Cuprate doped with uranium and subject to an irradiation treatment. Durrell's team looked for a less expensive material and chose Gadolinium Barium Cuprate, without uranium doping. Difan Zhou, team investigator and lead author, came up with the idea of extending Weinstein's findings, Durrell said, and the research, which took just short of two years to do, has paid off.

"It was a surprise to us that we managed to see in a not-quite-so-cutting-edge-material the same giant flux leap effect as Roy Weinstein demonstrated," Durrell said. "The key thing that made this possible is that we have looked at what Roy has done to get it to work but for this kind of portable system. Before we were using conventional superconducting magnets to charge our bulks. This will make access to these high fields cheaper and more practical."

Advances in cheaper, more efficient cooling—the cryogenic system—were also key for Durrell and team's research. For both the magnetic field charging and sustaining phases, it is necessary to keep the superconducting sample cool or else the superconductivity gives out. Recently, the private sector has come up with cryogenic systems that are cheap and light, and Durrell used a cooling system from Sunpower Inc., a U.S. firm. According to Durrell, this lightness and relative low-cost

could make portable superconductivity in various products a real possibility.

The total effect of bringing together these new technological opportunities, Durrell pointed out, is "essentially a better, portable permanent magnet—one with a 3-tesla rather than 1-tesla magnetic field. The obvious interest in that is that you could use that to make a smaller and lighter motor."

Low cost NMR and MRI systems for hospitals are also a strong possibility for use, Durrell explained, as these systems often use large superconducting magnets. Magnetically targeted drug delivery systems in human and veterinary applications may also be enabled.

Durrell and his team are planning for more testing for more magnetic power and overall efficiency. They have received significant support from The Boeing Company for this investigation, and Durrell feels it is a strong example of what a company and an academic lab can do when they team up for basic research.

More information: Difan Zhou et al, A portable magnetic field of >3 T generated by the flux jump assisted, pulsed field magnetization of bulk superconductors, *Applied Physics Letters* (2017). DOI: 10.1063/1.4973991

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