

## A polka-dot pattern appears in superfluid helium-3 in a thin cell when exposed to a magnetic field

March 1 2019, by Bob Yirka



(Left) A sketch of the one-dimensional order-parameter modulation in the FFLO state of organic superconductors, where the stripes correspond to different superconducting phases separated by magnetically ordered regions (blue). (Right) The two-dimensional polka-dot pattern proposed by Saunders, Parpia, and colleagues to explain nuclear magnetic resonance observations of superfluid helium-3. The domains here correspond to different superfluid phases (B<sub>+</sub> and B<sub>-</sub>), which are separated by nonsuperfluid domain walls (blue). Credit: APS/Alan Stonebraker



A team of researchers from Royal Holloway University of London and Cornell University has found that a polka-dot pattern emerges in superfluid helium-3 when it is placed in a thin cavity and subjected to a magnetic field. They have published their findings in the journal *Physical Review Letters*.

A lot of work over the past several years has shown that superconductivity is quite common in metals subjected to very cold temperatures. Scientists have found that the zero-resistance state arises due to electrons forming a condensate of Cooper pairs that carry electrical current without losing any of it. Less well known is that similar pairings happen in <u>neutron stars</u>, quark matter, some gases at very low temperatures and neutral helium-3 atoms. In this new effort, the researchers were studying the behavior of such atoms under varying conditions, and in so doing, discovered that a 2-D pattern appeared in superfluid helium-3 when it was confined using a magnetic field.

In their work, the researchers pumped helium-3 into a silicon-glass cell with an inner cavity that had a height of just 1.1um—they increased the pressure inside to 30 mbar. Next, they took pulsed nuclear magnetic resonance measurements in an applied <u>magnetic field</u> of 31 mT. They report that doing so allowed them to identify two B phases in the cavity. They note that they were expecting to see single-dimensional modulation in both B+ and B- phases, and stripes would form with walls between them made of non-superfluid material. Instead, they found that the area of the B+ domain was four times bigger than the B- domain. They noted that this meant that their stripe assumptions were incorrect. To explain the difference, they suggest a 2-D modulation in superfluid order in which the B-domains are patterned like polka-dots within a B+ domain.

The researchers note that their findings open the door to more questions, such as the size of the polka-dots and the distance between them. Additionally, the nature of the boundaries is unknown as yet. Because



the pattern was unexpected, new theories are required to explain it.

**More information:** Lev V. Levitin et al. Evidence for a Spatially Modulated Superfluid Phase of He3 under Confinement, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.122.085301, arxiv.org/abs/1805.02053

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