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NEWS | AUGUST 06 2021

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Aili McConnon

Scilight 2021, 321103 (2021)
https://doi.org/10.1063/10.0005714

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2 August 2021

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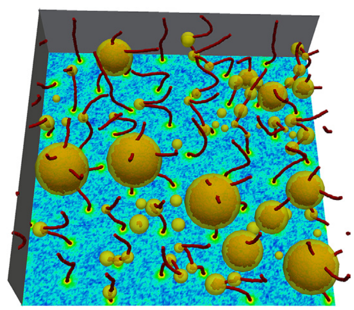
New advances in superconductor vortex physics from using simulations to predict the defect landscape and create optimal superconducting properties to designing advanced microscopy techniques that could image vortex-defect interactions



Superconductors are used in a wide range of applications including motors, generators, particle accelerator magnets, fault-current limiters, quantum computers and quantum sensors. Yet, these applications are often impaired by the motion of vortices – the discrete, nanoscale regions of quantized magnetic flux that penetrate type-II superconductors.

Consequently, researchers have been developing methods to tailor the disorder landscape in superconductors to increase the strength of vortex pinning.

Eley et al. present various opportunities in the field, including improving the understanding of thermally-activated vortex motion, reaching the theoretically-predicted maximum for the current carrying capacity, using simulations to predict the defect landscape that results in optimal superconducting properties, and designing advanced microscopy techniques that could image vortex-defect interactions.

Since researchers cannot reliably predict the electromagnetic properties of real (disordered) superconducting materials, designing superconductors for applications remains a largely inefficient process of trial and error. This is ultimately because of gaps in the understanding of vortex-vortex interactions, vortex-defect interactions, the impact of thermal energy on vortices, and the elastic properties of vortices.

“Our work expresses our opinion on areas that could make transformative advances in the field, which will have a direct impact on both our fundamental understanding of vortex physics and superconductor applications,” said author Serena Eley.

Looking forward, the researchers will explore introducing artificial intelligence techniques into the field of vortex pinning in superconducting materials, studying quantum tunneling, or quantum creep, of vortices through energy barriers defined by the disorder landscape, and studying microwave resonances in artificial vortex pinning configurations.

Source: “Challenges and transformative opportunities in superconductor vortex physics,” by Serena Eley, Andreas Glatz, and Roland Willa, *Journal of Applied Physics* (2021). The article can be accessed at https://doi.org/10.1063/5.0055611.