Size effects in microstructured superconductors and quantum materials

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We find ourselves in an era of transition, not just towards a more computing- and data-driven society but also away from unsustainable fossil fuels as an energy source. This leads to a rapidly increasing demand for computing power on an ever more tight energy budget. Therefore, it is imperative to investigate novel energy-efficient computing techniques, like superconducting spintronics or neuromorphic computing using correlated electron matter. Naturally, understanding the physics governing these processes at the sub-micrometer (i.e., device) scale is crucial for this development to succeed. This thesis examines the effects of size reduction and geometry on ferromagnetic Josephson junctions and highly correlated electron matter through transport experiments. Specifically, it describes how spin-polarized supercurrents can be generated using spin texture, stabilized by carefully tuning the geometry of planar Josephson junctions, and how the bistability of these spin textures can be employed to create non-volatile superconducting memory elements. Furthermore, it reports a strong size dependence of the current density that drives the Mott-insulating-to-metal transition in Ca_2RuO_4 and shows how various constricted geometries can be used to localize and examine the properties of superconducting chiral domain walls in Sr_2RuO_4.

ISBN 978-90-8593-538-4
Casimir PhD series 2022-27

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