Probing quantum materials with novel scanning tunneling microscopy techniques

Bastiaans, K.M.

Propositions

Accompanying the thesis

"Probing quantum materials with novel scanning tunneling microscopy techniques"

1. To measure the local noise associated with the local tunneling current, one can impedance match the tunnel junction at MHz frequencies using a superconducting tank circuit including a high electron mobility transistor.

Chapter 2 of this thesis.

2. The cuprate high-temperature superconductors can be viewed as a stacking of metallic CuO_2 planes separated by atomically thin polarizable insulating layers, forming a three-dimensional superconducting state.

Chapter 3 of this thesis.

3. When noise measurements are used to determine the effective charge of the carriers in a tunnel junction, the measured noise signal should be separated into the various noise components and the effective impedance of the electronic circuit.

Chapter 4 of this thesis.

4. The spatial correlation between the inhomogeneity of the superfluid and the sharpness of the quasiparticle peak suggests that superconductivity is needed for quasiparticles to be coherent in unconventional superconductors.

Chapter 5 of this thesis.

5. A direct measurement of the effective charge will help to verify the hypothesis of pre-formed Cooper pairing in the pseudogap phase of unconventional superconductors.

*Sacépé et al. Nature Physics **7**, 239 (2011)*
*Keimer et al. Nature **518**, 179 (2015)*

6. Based on the work by Burtzlaff *et al*. it is hard to conclude that shot noise can be used as a local probe for spin-polarized transport through a single Co atom, since the experimental data supporting this claim is orthogonal to the theoretical predictions.

*Burtzlaff et al. Phys. Rev. Lett. **114**, 016602 (2015)*

7. Combining the spin-noise spectrometer presented by Dusad *et al*. with a scanning tunneling microscope could be a promising platform to visualize the single magnetic monopoles in spin ice materials.

*Dusad et al. Nature **571**, 234 (2019)*

8. Although the radio-frequency technique by Kemiktarak *et al*. allows for shot noise measurements in the tunneling regime, it is not suitable for probing quantum materials, since it only works at a low junction resistance.

*Kemiktarak et al. Nature **450**, 85 (2007)*

9. Getting hands-on experience working in an experimental physics laboratory is an essential part of undergraduate physics education.

Koen Mathijs Bastiaans
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