Imaging currents in two-dimensional quantum materials

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Magnetic imaging is uniquely suited to the non-invasive imaging of current densities, particularly in two-dimensional devices. In this talk, I will showcase this approach by discussing two examples: measurements on HgTe quantum well devices in the quantum spin Hall (QSH) regime and measurements on microstructures fabricated from the heavy fermion superconductor $CeIrIn_5$. In a nutshell, we scan a superconducting quantum interference device (SQUID) to obtain maps of the magnetic field produced by the current flowing in a device. From the magnetic image we reconstruct a two-dimensional current distribution with a spatial resolution on the micron scale. In the case of HgTe quantum wells this allows us to directly visualize that most of the current is carried by the edges of the quantum well devices when tuned into their insulating gaps - a key feature of the QSH state. In the case of $CeIrIn_5$ we visualize how superconductivity turns on in the microstructures in a non-uniform way. If time permits I will discuss routes towards improving the spatial resolution of our measurements to sub-micron length scales through a combination of improved image reconstruction and smaller sensor sizes.