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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 measurements on HgTe quantum well devices in the quantum spin Hall (QSH) regime. 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 of several microns. 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. I will discuss routes towards improving the spatial resolution of the current images to sub-micron length scales through a combination of improved image reconstruction and smaller sensor sizes and outline opportunities for current imaging in a range of materials including graphene and magnetically doped topological insulators.