Magnetically Controllable Two-Dimensional Spin Transport in a Three-Dimensional Crystal

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Two-dimensional (2D) phases of matter have become a new paradigm in condensed matter physics, bringing in an abundance of novel quantum phenomena with promising device applications.

However, realizing such quantum phases has its own challenges, stimulating research into non-traditional methods to create them. One such attempt is presented here[1], where computational and theoretical techniques are used to show that the intrinsic crystal anisotropy in a ``fractional" perovskite, Eu_xTaO_3 ($x=1/3 \sim 1/2$), leads to the formation of stacked layers of quasi-2D electron gases (2DEG), Fig.1A, despite being a three-dimensional bulk system. Quantum oscillations in charge conductivity and thermoelectric properties, Fig.1B and C, are examined and proposed as routes to experimentally demonstrate the quasi-2D behavior.

Furthermore, these carriers possess topologically non-trivial spin textures, owing to a coupling of two component Rashba fields, Fig.2. These textures are indirectly controllable by an external magnetic field via proximity effect, in a manner analogous to $EuTiO_3$[2], making it an ideal system for spintronics. Lastly, an anomalous Hall effect with a non-monotonic dependence on carrier density is shown to exist, signifying a shift in band topology with carrier doping.

References

[1] Dowinton et al. Submitted (2023)
[2] Dowinton et al. Phys. Rev. B, 105 23, 235142, (2022)

Figures

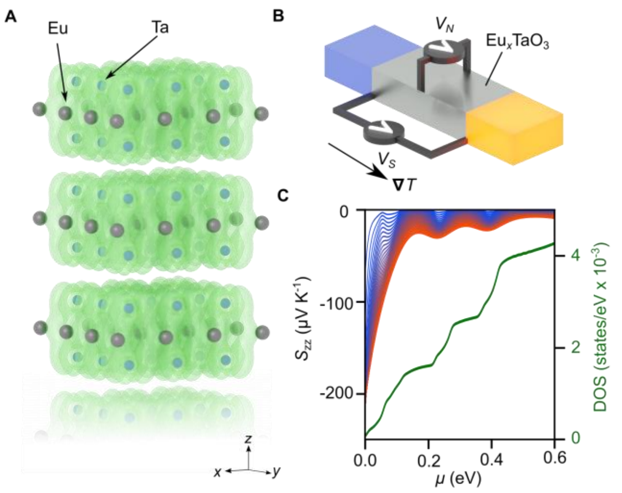

Figure 1: A Confinement of charge density to layers of quasi-2DEGs. **B** Schematic of Seebeck measurement to probe this quasi-2D phase experimentally. **C** Non-monotonic Seebeck effect that arises from quasi-2D behavior.

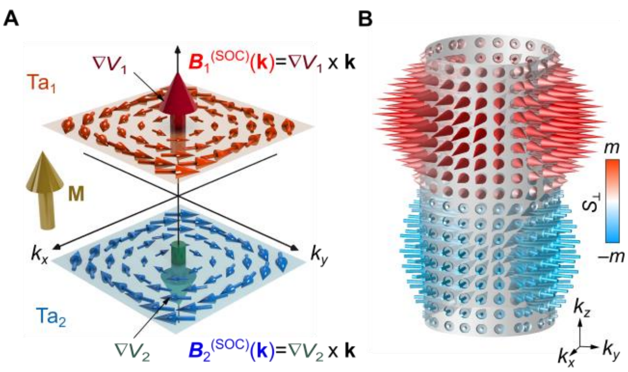

Figure 2: A local Rashba spin orbit fields on Ta sites, with opposite chirality. **B** Example of *k*-space in-plane spin texture, taken from lowest energy band, that arises from non-trivial coupling of Ta sites.