# Quantum Geometry of Electrons in 2D Materials: Proposals of GQuES Spectroscopies and Anomalous Hall Transistor

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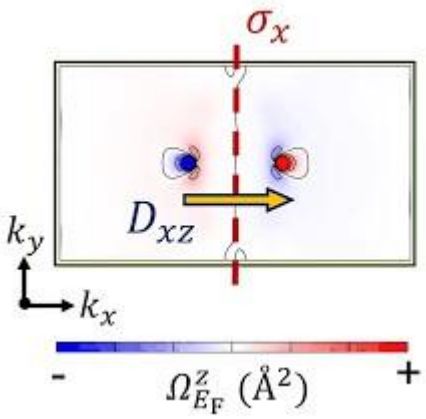
We will first present an introduction to quantum geometry of electrons in periodic structures in terms of Berry phases and curvature. We show that the coupling of dynamical excitations like phonons with electrons can have nontrivial consequences to quantum geometry of electronic structure, which manifest as oscillations in the Berry curvature dipole and hence have observable nonlinear Hall signatures. Using these, we introduce a vibrational spectroscopy[1] based on Geometry of Quantum Electronic Structure (GQuES) making specific predictions for the transport and radiative GQuES spectra of 2D materials. We demonstrate that a quantum material like graphene can be used as a substrate in GQuES spectroscopic analysis of other materials with trivial quantum geometry, significantly expanding the domain of applications of quantum materilas. Combining this with the idea of borken symmeties in 2D hetero-structures, we demonstrate emergence of nontrivial electric and Berry curvature dipoles in the heterostructure of graphene and monolayer of $CrTe_2$, and propose an Anomalous Hall Transistor [2] enabling electrically and magnetically readable memory.




Berry Curvature Dipole in $WTe_2$.

## References

1. R Bhuvaneswari, Deshmukh M M and Waghmare U V, *Phys. Rev. B* 2024, **110**, 014305.
2. Menon Surabhi and Waghmare U V, *Nanoscale* 2025, 17, 896.