Van der Waals Materials and Quantum Information Technologies

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Abstract

In this talk, we present recent work at the intersection of van der Waals materials research and quantum information science and technology. We present recent results that use cavity quantum electrodynamics (cQED) – the standard microwave readout method for superconducting qubits [1-3] – to probe the kinetic inductance and thereby the superfluid stiffness of magic angle twisted bilayer graphene [4] and NbSe2 [5]. In turn, we also present our results applying van der Waals materials to build qubits involving NbSe2 and hBN with coherence times as high as 50 us [6].

References

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[2] A. Wallraff, et al., Nature 431 (2004) 162-167
[3] A. Blais, S. Girvin, W.D. Oliver, Nature Physics 16 (2020) 247-256
[4] M. Tanaka, J. I-j. Wang, et al., Nature 638 (2025) 99-105
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[6] S. Park, et al., in preparation

Figures

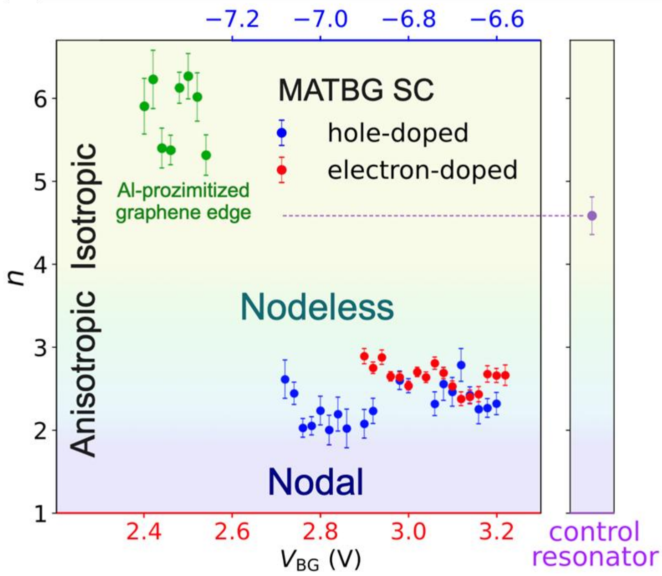

Figure 1: Evidence for anisotropic superconducting gap in magic-angle twisted bilayer graphene. Power-law exponent *n* extracted from temperature-dependent shift of resonance frequency due to varying superfluid stiffness with backgate voltage for electron-doped (red) and hole-doped (blue) regimes. Aluminum proximitized graphene and aluminum control resonator indicate an isotropic gap, as expected. See Ref. [4] for more details.

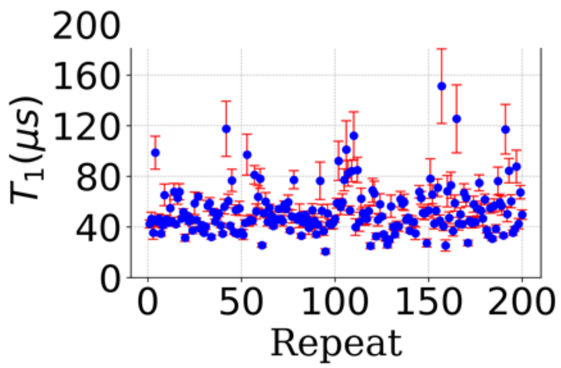

Figure 2: T_1 time measured repeatedly over 8 hours for a mergemon-style, all-vdW superconducting qubit comprising $NbSe_2$ and hBN [3]. The mean T_1 is 52 (+/- 18) µs. The Hahn echo T_{2E} (not shown) is 35 (+/- 0.6) µs. See Ref. [3] for more details.