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From Crystal Growth to Fermi Surface Mapping: Exploring $TaAs_2$ and NbP Semimetals

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Topological semimetals are a fascinating class of materials characterized by their unique electronic properties and potential for novel applications in quantum technologies. This study investigates the electronic behavior of two such semimetals: $TaAs_2$ and NbP, utilizing crystal growth techniques, electron transport measurements, and angle-resolved photoemission spectroscopy (ARPES) to probe their complex Fermi surface features and carrier dynamics [1, 2].

For $TaAs_2$ single crystals on the (201) surface, Shubnikov–de Haas oscillations revealed four distinct peaks, with angular dependence indicating elliptical Fermi surface cross-sections. Mobility spectrum analysis at 1.6 K identified four types of carriers—two electron and two hole species—contributing to conductance. ARPES spectra validated the elliptical bulk state pockets, with theoretical calculations incorporating weak n-doping aligning well with experimental observations. These findings offer crucial insights into the Dirac and Weyl points in this compound [3].

For NbP, Fermi surface modifications were investigated through in-situ deposition of ultra- thin Pb and Nb layers. Pristine (001) surfaces exhibited striking differences between P- and Nb-terminated surfaces: the P-termination displayed spoon- and bow-tie-shaped surface states, absent in the Nb-termination. Deposition of a single monolayer of Pb on the P- terminated surface induced a topological Lifshitz transition (TLT), dramatically reconfiguring the Fermi surface and shifting the Fermi energy. Deposition of approximately 0.8 ML of Nb brought the system near the critical point of a partial TLT, while retaining topological surface Fermi arcs [4].

These findings shed light on the tunability of topological states and Fermi surface dynamics in semimetals, advancing our understanding of their electronic behavior and paving the way for future research.

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References

1 Y. Luo, et al. Sci. Rep. 6 (2016) 27294.
2. H.F. Yang, et al. Nat. comm. 10 (2019) 3478.
3. A.S. Wadge, et al. J. Phys.: Condens. Matter 34 (2022) 125601.
4. A. S. Wadge, et al. Phys. Rev. B 105 (2022) 235304.