

Fingerprinting arbitrary stackings of graphite, from perfect rhombohedral to mixed stackings by Electronic Raman Scattering

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In recent years, rhombohedral graphite gained prominence, because it can host a multitude of strongly correlated electronic phenomena in its surface flat electronic band [1-2]. However, the identification of rhombohedral graphite samples is getting more challenging as the layer number increases because the number of possible stacking configurations grows exponentially, thus the traditional Raman identification methods become unreliable. As an example, in 6-layer thick graphite 10 different layer configurations is possible from which only 1-1 is perfectly hexagonal, or rhombohedral. Recently, using a conventional confocal Raman spectrometer at room temperature, we were able to unambiguously identify the perfect rhombohedral stacks by measuring their Electronic Raman Scattering signal which directly fingerprints the flawless stacking [3]. In this presentation we extend this method for mixed stackings (partial rhombohedral and Bernal), and we show that the mixed stackings can be fingerprinted as well. These configurations are elemental weak ferroelectric materials and may host even denominator fractional quantum hall phases [4]. Furthermore, based on DFT and TB calculations, we give the full landscape of the ERS spectra of all possible stacking configurations to establish a solid background for their identification.

References

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- [2] Lu, Z., et al. (2025). Extended quantum anomalous Hall states in graphene/hBN moiré superlattices. *Nature*, 637, 1090–1095.
- [3] Pálinkás, A. et al. (2024) Identification of graphite with perfect rhombohedral stacking by electronic Raman scattering *Carbon* 230, 119608
- [4] Sha, Y. et al. Cascade of Even-Denominator Fractional Quantum Hall States in Mixed-Stacked Multilayer Graphene. ArXiv: 2507.20695 (2025).

Figures

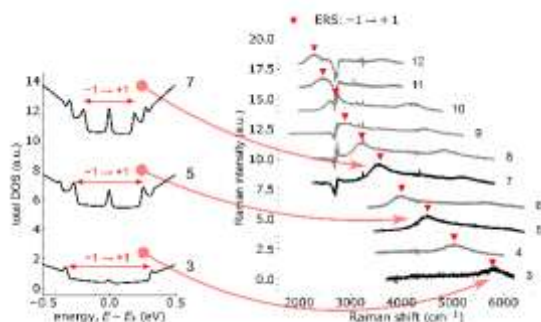


Figure 1: Layer number dependent density of states of perfect rhombohedral graphite. The peaks in the density of states at the edge of first dispersive subbands upper and below the Fermi energy marked with red dots. b) Experimental ERS spectra of perfect ABC graphite thin layers from 3-12 perfect layers. The position of the electronic Raman scattering peaks of each perfect stacking can be used as a fingerprint.