

# Geometry of Reason: Spectral Signatures of Valid Mathematical Reasoning

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We present a training-free method for detecting valid mathematical reasoning in LLMs through spectral analysis of attention patterns. By treating attention matrices as adjacency matrices of dynamic graphs, we extract diagnostics, such as the Fiedler value and high-frequency energy ratio (HFER), that exhibit significant differences between valid and invalid proofs. Our findings demonstrate cross-architecture universality and reveal that these spectral signatures track 'Platonic validity', logical coherence, rather than simple compiler acceptance.

Our work establishes spectral graph analysis as a principled framework for reasoning verification.