

Uncertainty Has a Geometry

New math reveals how quantum variance adds across observables—via pseudospectral methods.

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the square of the smallest singular value of the associated localizer

Minimum Singular Value (Localizer)

This term emerges as a lower bound in the additive variance relation for d Hermitian observables.

The paper establishes a rigorous lower bound on the sum of variances for any finite set of quantum observables, where the bound includes both commutator expectations and the geometric structure of the system's localizer matrix. This is not a heuristic—it's a provable inequality rooted in operator algebra and pseudospectral theory.



01

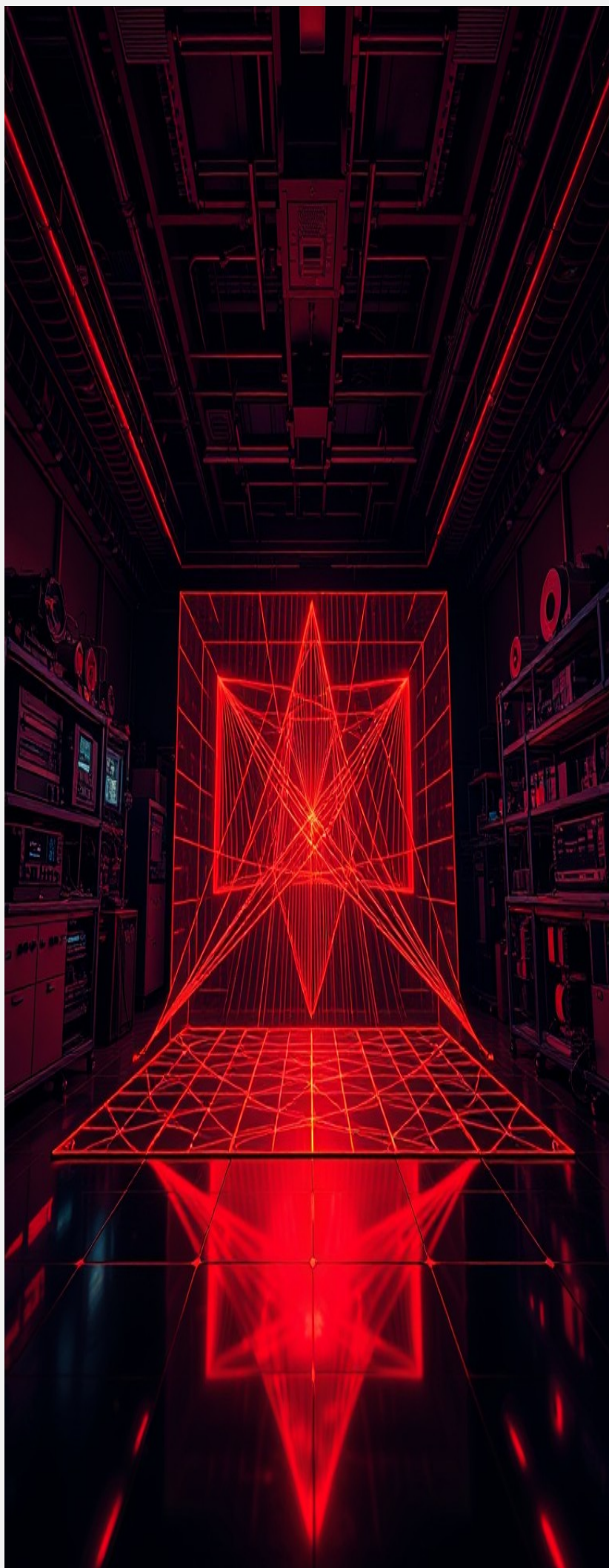
Uncertainty Is a Constructible Landscape

The paper demonstrates that the sum of variances across observables isn't just bounded—it's geometrically encoded. The smallest singular value of the localizer matrix acts as a spectral anchor, meaning quantum uncertainty is not abstract but tied to measurable, computational features of the system's operator structure. This implies that error estimation in quantum algorithms can be refined by analyzing this singular value, not just by sampling.

02

Commutators Are Not Enough

While the expectation of commutators $\langle i[A_j, A_k] \rangle$ contributes to the lower bound, it is not sufficient on its own. The pseudospectral containment between Clifford and quadratic pseudospectra shows that the full uncertainty relation depends on the non-commutative geometry of the operator set. This reveals a deeper layer: uncertainty isn't just about non-commutativity—it's about how those non-commutative relations embed in the system's spectral landscape.



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