MAFIA - the seminar you can't refuse

Computation and Verification of Spectra for Non-Hermitian Systems

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Abstract:
We establish a deep connection between quantum mechanics and computation, revealing fundamental limitations for algorithms computing spectra, especially in non-Hermitian settings. Introducing the concept of locally trivial pseudospectra (LTP), we show such assumptions are necessary for spectral computation. LTP adapts dynamically to system energies, enabling spectral analysis across a broad class of challenging non-Hermitian problems. Exploiting this framework, we overcome a longstanding obstacle by computing the eigenvalues and eigenfunctions of the imaginary cubic oscillator $H_B = p^2 + ix^3$ with rigorous error bounds and no spurious modes—yielding, to our knowledge, the first such error-controlled result. We confirm, for instance, the 100th eigenvalue as $627.69471224843651135267370290115 36\ldots$ Here, truncation-induced PT-symmetry breaking causes spurious eigenvalues—a pitfall our method avoids, highlighting the link between truncation and physics. Finally, we illustrate the approach's generality via spectral computations for a range of physically relevant operators. This talk provides a rigorous framework linking computational theory to quantum mechanics and offers a precise tool for spectral calculations with error bounds.