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$\mathcal{PT}$-Symmetric Hamiltonians: Fundamental Concepts and Applications

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Conventional quantum mechanics relies on Hermitian Hamiltonians, which guarantee real and positive energy spectra while ensuring probability conservation through the Dirac inner product. However, $\mathcal{PT}$-symmetric Hamiltonians, which are invariant under parity $\mathcal{P}$ and time-reversal $\mathcal{T}$ transformations, naturally ensure a real and positive energy spectrum. By adopting a pseudo-Hermitian inner product in the system, it is also possible to guarantee probability conservation for $\mathcal{PT}$-symmetric Hamiltonians. These Hamiltonians are referred to as pseudo-Hermitian, preserving the essence of 'hermiticity' in inner products beyond the conventional Dirac framework. This work aims to provide a simplified introduction to the concept of $\mathcal{PT}$-symmetric Hamiltonians, emphasizing their properties, mathematical structure, and potential applications.

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