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Numerical Treatment of Quantum Mechanical Problems

The one dimensional anharmonic oscillator is of great interest to field theoreticians; it models complicated fields in one-dimensional space-time. The study of quantum anharmonic oscillators as potentials in the Schrödinger equation has been on the edge of thrilling and exciting research during the past three decades. Numerous approaches have been proposed to solve this problem and while several of them yield excellent results for specific cases, it would be favourable to have one general method that could handle efficiently and accurately any anharmonic potential.

The Sinc collocation method (SCM) has been used extensively to solve many problems in numerical analysis. Their applications include numerical integration, linear and non-linear ordinary differential equations. The double exponential transformation yields optimal accuracy for a given number of function evaluations when using the trapezoidal rule in numerical integration. Recently, combination of the SCM with the double exponential (DE) transformation has sparked great interest.

In this talk, we present a method based on the double exponential Sinc collocation method (DESCM) for solving anharmonic oscillator eigenvalue problems to unprecedented accuracies. The DESCM approximates the wave function as a series of weighted Sinc functions and by evaluating the expression at several collocation points, we obtain a generalized eigensystem which can be transformed into a regular eigenvalue problem. The method is successfully applied to Coulombic anharmonic oscillator potentials that describe the interaction between charged particles and consistently arises in physical applications. These applications include interactions in atomic, molecular and particle physics, and between nuclei in plasma.