

Nonlinear stability and bifurcation analysis in prime number distributions

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Abstract: We propose a nonlinear dynamical framework for analyzing the distribution of prime numbers along the number line. Rigorous lower and upper bounds for the prime counting function are used to construct corresponding bounds on the prime density, yielding substantially improved accuracy over existing approximations and consistently enclosing the exact values. A single-particle wave function is formulated from the bounded prime density, and the associated interaction potential is derived using the Schrödinger equation. The resulting potentials are singular and intrinsically nonlinear, exhibiting distinct attractive and repulsive regimes. An equivalent classical Hamiltonian system governed by these potentials is then examined to study phase-space trajectories, equilibrium points, and their stability properties. The analysis reveals the occurrence of fold and blue-sky bifurcations, indicating the presence of an underlying nonlinear dynamical structure governing prime number distribution.