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Spectral geometric aspects and applications to resonances and related themes

This work explores the spectral geometry of Laplace–Beltrami operators on compact and non-compact Riemann surfaces, emphasizing their role as quantum Hamiltonians. On compact manifolds, the Laplacian yields a discrete spectrum intimately tied to the geometry and energy distribution of the space. Through a modern geometric analytic viewpoint, we unravel how the chaotic geodesic flow on negatively curved surfaces imprints statistical patterns on eigenvalues, aligning with quantum chaos. The Selberg trace formula compares these spectral features to modular forms and arithmetic number theory, revealing deep algebraic structures. In contrast, non-compact arithmetic hyperbolic surfaces exhibit continuous spectra governed by scattering matrices, which connect to automorphic L-functions and analytic number theory. By applying various modern innovations involving geometric quantization, spectral invariants, and Hamiltonian dynamics, this study describes the interplay between classical trajectories, quantum states, and arithmetic symmetries thus offering new perspectives for integrable systems, topological field theories, and the spectral analysis of low-dimensional manifolds.

Key words: hyperbolic, spectra, scattering, GUE

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