Gaps and high multiplicities in the spectrum of finitely ramified fractals

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July 19th, 2012, 13:30

For many symmetric finitely ramified fractals it is possible to develop a theoretical matrix analysis, including analysis of singularities, which allows to compute eigenvalues, eigenfunctions and their multiplicities. Generically we have an abundance of localized eigenvalues of high multiplicity and large gaps in the spectrum. This fact precludes the possibility that a Weyl-type ratio can have a limit and is also a key ingredient in proving that the Fourier series on such fractals can have better convergence results than in the classical setting. The existence of gaps is equivalent to the total disconnectedness of the Julia set of the spectral decimation function.

One can also obtain these results for fractafolds, the fractal equivalent of a manifolds, spaces that are locally modeled on a specified fractal. On periodic Sierpinski fractafolds and 3-regular tree fractafolds, there is a mixture of point spectrum and absolutely continuous spectrum (this is a joint work with Strichartz).

Vector calculus on fractals

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July 20th, 2012, 10:30

A Laplacian on fractals can be defined either as the generator of a diffusion process (Kusuoka, Barlow, Bass, Perkins, Lindstrom, Kumagai, Hambly et al) or as a re-normalized limit of graph Laplacians (Kigami, Strichartz et al). However, it is less clear how to de fine the first order derivatives (different approaches were introduced earlier by Kusuoka, Kigami, Strichartz and the presenter). In the talk, based on joint works with Michael Hinz, Michael Roeckner, Marius Ionecu, Luke Rogers and Dan Kelleher, I will describe recent progress toward better understanding of the derivatives and related notions of differential and Riemannian geometries on fractals.