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Spectral properties of structured graphs: theory and numerical applications

The study of spectral properties of structured graphs constitutes a recent and fast growing research field, useful in various branches of applied mathematics.
Spectral properties of the graph-Laplacian turn out to be useful in the discretization and in the computation of solutions of partial differential equations (PDEs), in the study of spectral gaps, clustering, etc. ([1],[2],[3]). In particular, we will focus on the study of sequences of graphs with a uniform local structure (Toeplitz graphs and their generalizations) and the spectral properties of such graphs and of the associated graph-Laplacians. Such graphs often appear when modeling real-world problems, particularly when dealing with the discretization of PDEs. The knowledge of the spectral properties of these graphs and of their associated graph-Laplacian can give valuable insights for various numerical applications, ranging from the study of spectral gaps and clustering to the construction of optimal preconditioners ([1],[2],[3],[4]). Our main theoretical result is giving the spectral distribution for the sequence of graph-Laplacians associated with a sequence of d-level diamond Toeplitz graphs ([1],[3]). After this, we will show some numerical applications related to the solutions of linear systems involving graph-Laplacians of structured graphs which confirm the usefulness of the developed theory ([1],[2]).

[1] A. Adriani, "Geometric, Stochastic and Spectral properties of Graphs: theory and numerical applications", PhD Thesis, 2022.

[2] A. Adriani, D. Bianchi, P. Ferrari, S. Serra-Capizzano, "Asymptotic spectra of large (grid) graphs with a uniform local structure (part II): numerical applications", Submitted, 2021.

[3] A. Adriani, D. Bianchi, S. Serra-Capizzano, "Asymptotic spectra of large (grid) graphs with a uniform local structure (part I): theory", Milan J. Math. 88: 409–454, 2020.

[4] C. Garoni, S. Serra-Capizzano, "The theory of Generalized Locally Toeplitz sequences: theory and applications - Vol I", Springer - Springer Monographs in Mathematics, New York, 2017.

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