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Qubits, wavelets, fractals, bands

The traditional focus of Quantum Information Theory is structures comprising a finite number of qubits. However, it is also rewarding to study transfinite objects, such as infinite arrays of qubits. Most research on the physics of such structures relies upon one approximate technique or another. At the same time, it is desirable to collect examples of exactly solvable models, which rigorously capture how the functional properties of arrays (e.g. how they interact with modes of light) depend on their quantum state.

In the first part of my talk, I will discuss such a model (joint work with A. Zagoskin, ref.1). Our analysis directly involves multiresolution analysis, specifically the Haar basis. While applications of the Fourier transform in studies of spin systems are already classical, a quantum application of the Haar transform is, to our best knowledge, unprecedented. Also intriguing is an unexpected emergence of fractals in this very context. In the time remaining I will discuss some other connections between classical harmonic analysis and modern quantum theory, ref.2, and implications. In particular, I will demonstrate that band gaps can arise in a qubit-array Hamiltonian via a mechanism that does not involve a periodic potential.

References:

1. A. Sowa and A. Zagoskin, An exactly solvable quantum-metamaterial type model, Preprint, available via https://arxiv.org/abs/1902.05324
2. A. Sowa, Encoding spatial data into quantum observables, Preprint, available via http://arxiv.org/abs/1609.01712