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Quantum applications of harmonic analysis on the group of positive rationals

Harmonic analysis on the multiplicative group of positive rational numbers ($\mathbb{Q}_+$) has not been part of the common quantum-theoretic toolkit. In this talk, I will discuss how it lends itself to the analysis of operators in $\ell_2(\mathbb{N})$, in some cases leading to spectacular new insights into their spectral properties. I will also discuss its application in a study of the Bose-Hubbard model, i.e. a model of an array of bosons with the nearest-neighbour interactions. The Fourier transform on $\mathbb{Q}_+$ uncovers the model's unobvious symmetries and surprising connections with other structures. In addition, I will report a rigorous, albeit computer-assisted, proof of the existence of quantum phase transitions in finite quantum systems of this type. The study of the Bose-Hubbard model has been carried out in collaboration with Prof. Jonas Fransson (Department of Physics and Astronomy, University of Uppsala).