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Nanoscale Science and Engineering Graduate School of Research

Université de Toulouse

Spectrum and asymptotical freeness for block-modified random matrices

research project title

Internship supervisor	Ion NECHITA *name* Spectrum and asymptotical freeness for block-modified random matrices *title* nechita@irsamc.ups-tlse.fr *email* Quantware *group* http://www.lpt.ups-tlse.fr/?lang=en *laboratory's website*
Location	◉ Toulouse University ○ INSA ○ INP ○ Other *postal address:* Université Paul Sabatier, IRSAMC, LPT 118, route de Narbonne 31062 Toulouse, France

This research master's degree research project could be followed by a PhD: ◉ YES ○ NO

Abstract/work package/short bibliography/illustration:

By now, the theory of random matrices [AGZ10] is a well developed subfield of mathematics, having interactions with many many other research areas, such as theoretical physics, computer science and telecommunication, operator algebras, combinatorics, number theory, etc. In the recent years, the theory of quantum information [Wat18] has also benefited from random matrix models, both as a way to study the properties of typical objects (like states and channels) and also as a source of extremal examples [CN16]. In quantum theory, the tensor product of Hilbert spaces is a central operation, allowing to take into considerations systems composed of several components. Hence, the study of random operators acting on a tensor product is central to the theory. In particular, the study of the partial action of a linear map on such bipartite operators is very important in the study of quantum entanglement [HHHH09], one of the most important features of quantum theory. Such matrix models, called block-modified random matrices have been studied in [ANV16], where the asymptotic spectral distribution has been computed in some particular situations. The main technique used there was the notion of operator-valued freeness developed by Voiculescu and Speicher [Spe98].

The candidate will continue the development of the theory of block-modified random matrices in two directions. First, identify the most general cases where the asymptotical spectrum of the modified matrix can be computed from the initial data (distribution of the random matrix and the linear map acting on a tensor factor). Afterwards, study the joint distribution of two different modifications of a random matrix and eventually prove freeness results. The theoretical results will be applied to the study of entanglement in quantum information.

[AGZ10] Greg W Anderson, Alice Guionnet, and Ofer Zeitouni. An introduction to random matrices. Cambridge University Press, 2010.
[ANV16] Octavio Arizmendi, Ion Nechita, and Carlos Vargas. On the asymptotic distribution of block-modified random matrices. Journal of Mathematical Physics, 57(1):015216, 2016.
[CN16] Benoit Collins and Ion Nechita. Random matrix techniques in quantum information theory. Journal of Mathematical Physics, 57(1), 2016.
[HHHH09] Ryszard Horodecki, Pawel Horodecki, Michal Horodecki, and Karol Horodecki. Quantum entanglement. Reviews of Modern Physics, 81(2):865, 2009.
[Spe98] Roland Speicher. Combinatorial theory of the free product with amalgamation and operator-valued free probability theory, volume 627. American Mathematical Soc., 1998.
[Wat18] John Watrous. The Theory of Quantum Information. Cambridge University Press, 2018.

Keywords, areas of expertise (max 30 words)	quantum information theory, random matrices, free probability
Required skills for the internship (max 30 keywords)	basic linear algebra and probability, introductory quantum mechanics