The subject of the thesis is

In quest of a non-linear wave mechanics.

The linearity of the Schroedinger equation has the status of a postulate: it is usually postulated to be valid, always and everywhere.

Linearity is also congenitally linked to the vectorial space nature of the quantum state space (Hilbert space) as well as to the superposition principle.

The superposition principle is in turn at the origin of serious and fundamental problems (e.g. the Schroedinger cat paradox and the so-called measurement problem), and there were in the past several attempts to investigate non-linear generalisations of Schroedinger equation.

We are interested in studying deterministic non-linear modifications of the Schroedinger equation à la Diosi-Penrose*. This theory predicts that whenever coherent superpositions of macroscopically distinct localisations occur in nature, they will compete due to the non-local nature of the self-gravitational energy. We expect that, similar to optical rogue waves**, the non-linearity will act as a noise amplifier, which, combined with non-local energy transfer, results in the stochastic appearance of spontaneous localizations (quantum jumps***).

Our aim is to model this scenario, focusing on possible violations of the no-signaling condition, which was shown by Gisin**** to be a corollary of non-linearity.

We also plan to study the interplay between non-linear wave mechanics and de Broglie guidance relation*****.

Besides its interest concerning the foundations of the quantum theory, this work also presents applications in various fields of physics such as non-linear optics (optical rogue waves** and solitons***) and hydro-dynamics (bouncing oil droplets*****).

* [R. Penrose: On Gravity's Role in Quantum State Reduction. General Relativity and Gravitation, 28(5):581–600, 1996]

**[N. Akhmediev, A. Ankiewicz, and M. Taki. Waves that appear from nowhere and disappear without a trace. Physics Letters A, 373:675–678, 2009]

***[S. Colin, T. Durt, and R. Willox: Can quantum systems succumb to their own (gravitational) attraction? Classical and Quantum Gravity 31245003, 2014]

****[N. Gisin: Weinberg's non-linear quantum mechanics and superluminal communications. Phys. Lett. A, 143(1,2):1–2, 1990]

*****[T. Durt, Generalized guidance equation for peaked quantum solitons and effective gravity, Europhys. Lett. 114, 10004, 2016]

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