# JORNADA PCI/CBPF
# APRESENTAÇÃO DE PÔSTER – 2019/2020



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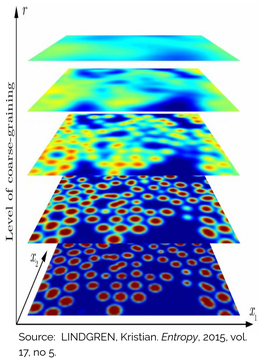
| **TÍTULO DO PROJETO:** | **Dinâmicas quânticas efetivas induzidas por canais de *coarse-graining*** |



## Research project




Source: LINDGREN, Kristian. *Entropy*, 2015, vol. 17, no 5.

**A notable feature of our physical world is the ample time intervals, energy or size scales in which the deterministic laws of classical physics give excellent approximations. In fact, our everyday life experience heavily relies on effective descriptions which are far less complex than their underlying intricate quantum characterization [1-3].**

**The main idea of coarse-grained models is to simulate the behaviour of complex systems through a simplified representation. Quantum effective systems theory studies the kinds of dynamics that may emerge from a full quantum description when one does not have access to, or is not interested in, all the degrees of freedom of a given system. This formalism generalizes the theory of open quantum systems, as it also works for closed systems [1].**

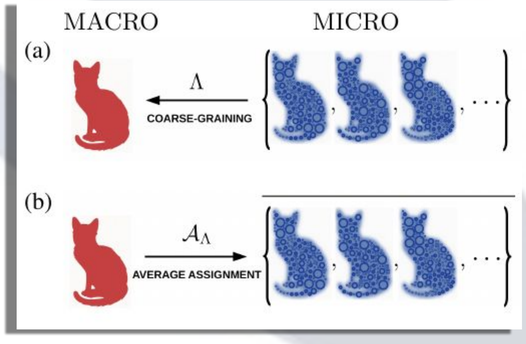
**This research project has as principal aim to use techniques of quantum information to build effective descriptions of complex quantum systems.**

**This project is included in the research line of theoretical quantum information at CBPF, with a focus on quantum effective systems, in charge of the researchers Fernando de Melo and Raul Vallejos, and the doctoral student Pedro Silva Correia.**

## Macro-to-micro quantum mapping and the emergence of nonlinearity [4]

**As a universal theory of physics, quantum mechanics must assign states to every level of description of a system, and also describe the interconnections among them. Assuming that we only have a coarse-grained access to a macroscopic system, in this work we show how to assign to it a microscopic description that abides by all macroscopic constraints. As a by-product, we show how effective nonlinear dynamics can emerge from the linear quantum evolution, and we readily apply it to a state discrimination task.**

FIG. 1. (a) Micro-to-macro assignment. In the right side, we pictorially represent in blue the set all microscopic states that are mapped through the coarse-graining operation $\Lambda$ to a unique effective macroscopic state represented by the red cat in the left. (b) Macro to micro assignment. The map $\mathcal{A}_\Lambda$ assigns to a macroscopic system a microscopic state given by the average over the ensemble of all microscopic states that comply with the macroscopic observations.




## Coarse-graining maps

**A coarse-graining operation is a completely positive trace preserving (CPTP) map that preserves only the accessible degrees of freedom**

$$\Lambda : \mathcal{L}(\mathcal{H}_D) \to \mathcal{L}(\mathcal{H}_d)$$

Effective description

Full description

**where** $\dim(\mathcal{H}_D) > \dim(\mathcal{H}_d)$

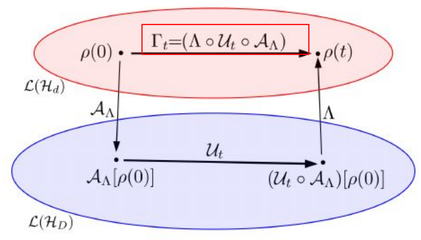
## Averaging assignment maps

**Considering an arbitrary set of macroscopic observations, our method gives an ensemble of microscopic states which the underlying physical system could be in. Thus, for a given set of micro-states that satisfies the macroscopic constraints we find an averaging map $\mathcal{A}_\Lambda : \mathcal{O} \to \{\psi\}$ that assigns the appropriate description to the microscopic ensemble:**

$$\mathcal{A}_\Lambda[\mathcal{O}] \equiv \int d\mu_\psi \mathrm{Pr}_\Lambda(\psi|\mathcal{O})\,\psi$$

## Effective state dynamics

**The effective dynamical map $\Gamma_t : \mathcal{L}(\mathcal{H}_d) \to \mathcal{L}(\mathcal{H}_d)$ is given by:**




## Conclusions

- **We formalized and generalized the canonical ensemble assignment fixed a set of macroscopic constraints.**
- **Stochastic nonlinear effective dynamics may emerge from the deterministic linear quantum evolution. The level of description, and thus the ability to prepare a macroscopic system, is the key.**

## References


**[1] C. Duarte, et. Al, PRA 96, 032113 (2017).**
**[2] P. S. Correia and F. de Melo, PRA 100, 022334 (2019)**
**[3] G. D. Carvalho and P. S. Correia PRA 102, 032217 (2020)**
**[4] Correia, P. S., Obando, P. C., Vallejos, R. O., & de Melo, F. *arXiv preprint arXiv:2007.14370* (2020).**