MATHEMATICAL PHYSICS WEEK
NEDELJA MATEMATICKE FIZIKE

MISANU, July 8-12, 2019

The goal of this informal meeting is to introduce audience to some recent developments in the field of mathematical physics. The expositions will be pedagogical and focusing in part on open problems and new research directions in this actively developing area. The format of the meeting is one 1 hour talk per day followed by discussions.

SPEAKERS.

Monday, July 8, 10:30–11:30. **Vojkan Jaksic**, McGill University.

Time and Entropy. This talk concerns mathematical theory of the so-called Fluctuation Relation (FR) and Fluctuation Theorem (FT) in context of dynamical systems relevant to physics. The FR refers to a certain universal identity linked to statistics of entropy production generated by a reversal operation and FT to the related mathematical large deviations result. The discovery of FR goes back to numerical experiments and Evans, Cohen and Morris (1993) and theoretical works of Evans and Searles (1994), Gallavotti and Cohen (1995). These discoveries generated an enormous body of numerical, theoretical and experimental works which have fundamentally altered our understanding of non-equilibrium physics, with applications extending to chemistry and biology. In this talk I will introduce modern theory of FR and FT on an example and comment on a current research program on this topic.

Tuesday, July 9, 10:30–11:30, **Noé Cuneo**, Université Paris Diderot (Paris 7).

Nonequilibrium steady states for chains of oscillators and rotors. I will talk about chains of oscillators and rotors interacting with stochastic heat baths at different temperatures. I will introduce these very simple models in the framework of the (yet unsolved!) problem of heat conduction. Then, we will focus on a much more elementary question: the existence of an invariant measure (called non-equilibrium steady state), which has been proved only in some specific cases over the past 20 years. I will explain how distinct models lead to distinct difficulties, and sketch some of the ideas used to overcome them.

Wednesday, July 10, 10:30–11:30. **Annalisa Panati**, University of Toulon and CPT, Luminy

Entropy and heat fluctuations in the two-time measurement framework. In this talk, I will introduce the two-time measurement framework in quantum mechanics. I will review important some results about entropy in classical and quantum in non-equilibrium statistical mechanics known as fluctuation relations, and some recent results on heat fluctuations.

Thursday, July 11, 10:30–11:30. **Tristan Benoist**, Toulouse Mathematics Institute.

Introduction to repeated measurements and quantum trajectories. In this talk I will present stochastic processes modeling the dynamic of a quantum system subject to repeated measurement. They model recent experiments in quantum optics. Assuming no prior background in quantum mechanics, I will first introduce the matrix formalization

of quantum mechanics and deterministic dynamics using completely positive maps. I will then introduce the effect of measurements and define the associated stochastic processes. I will finally review some important recent results in the field and highlight the key points of the different proofs. If there is time left I will sketch some open questions.

Friday, July 12, 10:30–11:30. **Angelina Ilic Stepic**, MISANU.

A probability logic for reasoning about quantum observations. In this talk we present the logic QLP suitable for reasoning about quantum observations. The notion of measurement can be expressed using the modal operator Δ, so that, instead of non-distributive structures (i.e., non-distributive lattices), it is possible to relay on classical logic extended with the corresponding modal laws for the modal logic **B**. Using formulas of the form $\Delta\varphi$, it is possible to overcome the well known "non distributivity problem" of quantum mechanics. QLP extends the modal logic **B** with probability formulas of the form $CS_{z_1,\rho_1;\ldots;z_m,\rho_m}\Delta\alpha$. The meaning of the formula $CS_{z_1,\rho_1;\ldots;z_m,\rho_m}\Delta\alpha$ is related to some observable O and some world (vector) w. If Δ is a subspace related to measuring the observable O, a is an eigenvalue of O, and $w_1,\ldots,w_m$ is the chosen base of eigenvectors that correspond to the eigenvalue a, then $\Delta\alpha$ means "It is measured that $O=a$", while $CS_{z_1,\rho_1;\ldots;z_m,\rho_m}\Delta\alpha$ means "$w=c_1\cdot w_1+\ldots+c_m\cdot w_m$ for some $c_i\in\mathbf{C}$ such that $\|c_1-z_1\|\leq\rho_1,\ldots,\|c_m-z_m\|\leq\rho_m$, and the probability of obtaining a while measuring O in the state w is equal to $\Sigma_{i=1}^m\|c_i\|^2$". Formulas are interpreted in reflexive and symmetric Kripke models equipped with probability distributions over families of subsets of possible worlds satisfying the ortomodularity. We give an infinitary axiom system which contains axioms and rules for probabilistic reasoning, and prove the corresponding soundness and strong completeness theorems. We show that the logic QLP is decidable.