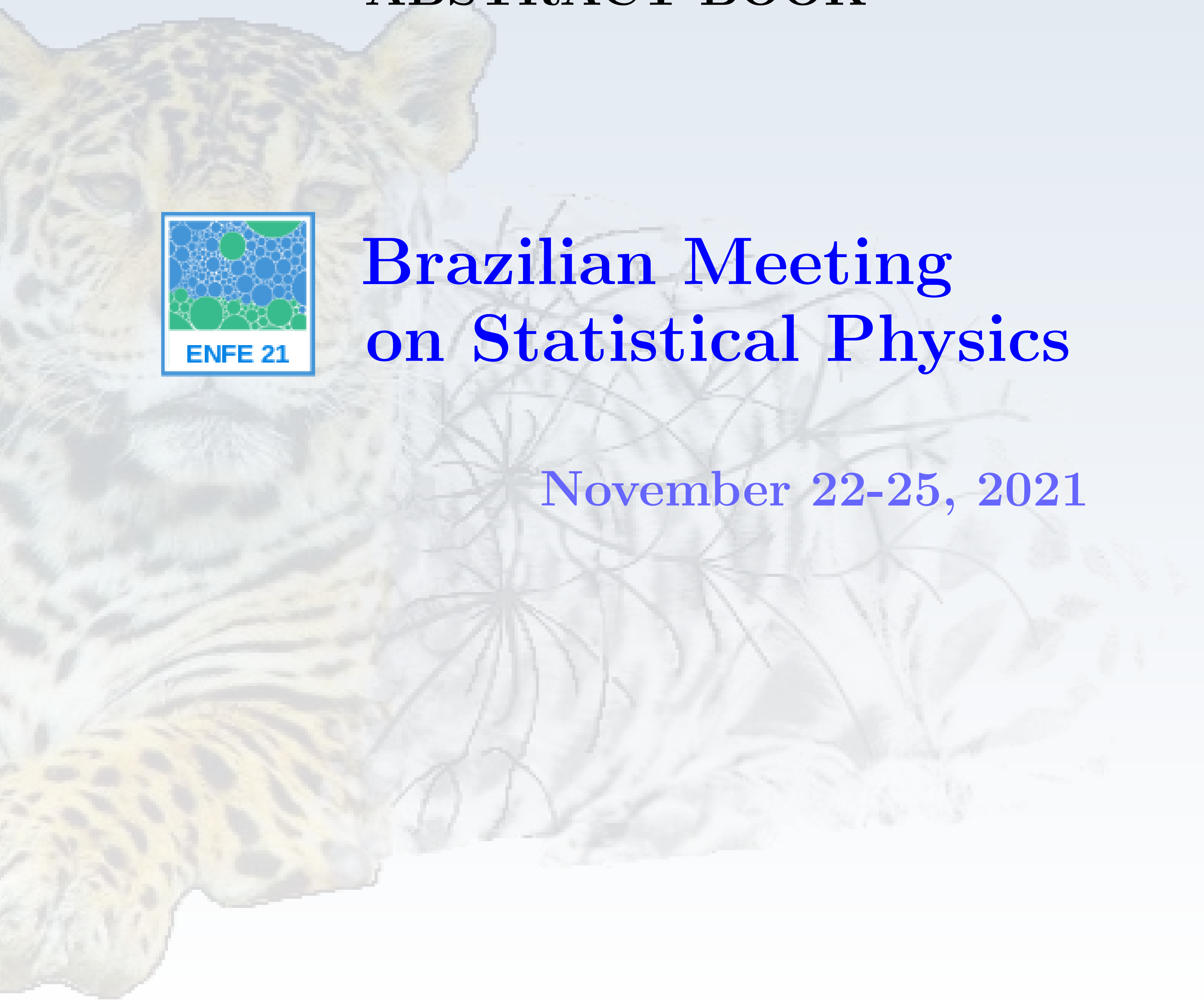
ABSTRACT BOOK



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Black swan events are rare and drastic events that received this name by the mathematician and economist N. Taleb in analogy to the late discovery of black swans: until the Oceania colonization all the swans were expected to be white. Thus, Taleb states that even within well established theories exists the possibility of occurrence of hardly predictable events which can cause great impact. We can cite as examples: earthquakes, super energetic astronomical events and financial crises. We wish to describe the concept of black swan events in the probabilistic point of view of random motion described by the stochastic least action principle (SAP). We conceive this principle, in analogy with the least action principle, stating that the average of the action variation shall be minimum on a system with aleatory trajectories. Mathematically, it provides the necessary constraints to, by the maximization of the Shannon entropy as stated by the Jaynes principle, obtain the path probability distribution, being it proportional to the exponential of the action path. By means of computational simulations using random paths, constructed by the Langevin formalism with Gaussian noise, we verify that the path probability is correct. Moreover, when we are interested in the black swan events we must modify the noise distribution to a heavy tailed distribution, in such a way that the occurrence of extreme events become possible. We choose the stable distribution which possesses a parameter to control the tails heaviness, $\alpha =]0, 2]$, as smaller the parameter as heavier the tails, being the Gaussian distribution the case with $\alpha = 2$. By this modification, the system switches from a process of normal diffusion to an anomalous diffusion, since the Gaussian distribution is the solution to the diffusion equation and the stable distribution is the solution of the fractional diffusion equation. In this context, due to the presence of a fractional differential operator on the diffusion equation, we have long range interactions, therefore, the Shannon entropy is not adequate to describe the system. In long range interactions scenarios it is necessary to use a modified entropy which is capable of capturing the low probability events. One of these modifications, which possesses a relation with the anomalous diffusion, is the Tsallis entropy. If we maximize the Tsallis entropy using the constraints of the SAP, we find a path probability distribution which is proportional to the q-exponential of the action. Using this new path probability, we verified by using computational simulations its validity and that the parameters α and q are related by $q = \sqrt{3 - \alpha}$, recovering the Gaussian behavior to $\alpha \to 2$ just as the Shannon entropy to $q \to 1$.

References

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Studies of Stochastic Thermodynamics with Optical Tweezers

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Sekimoto has shown in the late 90s that work and heat can be associated with individual trajectories of a Brownian particle [1]. Work becomes a stochastic quantity and is done when the control parameter (the variable that the experimentalist has control) is changed. The average work is larger or equal to the free energy difference of the system, being equal for infinitely long processes. The optimal protocol is defined as the protocol that has the lower average work for a finite time process. Optimal protocols are hard to find out, in general. However, there is a linear response theory method that allows one to construct such protocols [2]. We have numerically determined that the protocols generated by this method have good performance even outside the linear response regime for the variation of the trap stiffness of an optical tweezer.

References

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Critical Dynamics of Multiplicative Systems

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In this study we analyze the critical dynamics of a real scalar field in 2D near a continuos phase transition. We have computed and solved Dynamical Renormalization Group (DRG) equations to two loops order. We have found that, different from the case $d < 4$, characterized by a Wilson-Fisher fixed point with $z = 2 + O(\epsilon^2)$, the critical dynamics is dominated by a novel multiplicative fixed point.

The interest in critical dynamics is rapidly growing up in part due to the wide range of multidisciplinary applications deeply impacted by the use of criticality. For instance, the collective behavior of biological systems displays critical behavior with space-time correlation functions with non-trivial scaling laws[1].

The standart approach to deal with dynamics is the Dynamical Renormalization Group[2]. We assume that the evolution of the system near the critical point is governed by a dissipative process. Then we use the *Martin-Siggia-Rose-Janssen-DeDominicis* formalism[3] to transform the dynamical equation in to a functional generator. On top of that, one can add two Grassmann fields $\bar{\xi}, \xi$ in the functional generator in order to increase the supersymmetric formulation for the dynamics[4,5]. This supersymmetric formalism enables the choice of a specific stochastic evolution.

In this work, we begin with the dynamical ϕ^4. We adopted the so called Generalized Stratonovich prescription parametrized by a real number $0 \leq \alpha \leq 1$ and present here the calculations for the Itô ($\alpha = 0$) prescription. We use the functional generator to compute the dynamical correlation functions. We perform a diagrammatic pertubation theory up to 2-loops and obtain the DRG equations. We fully calculated up to 2-loop corrections for the flux equations using an "Wilsonionan approach". Here we are presenting only the 1-loop corrections since the analysis for the 2-loop equations is still ongoing. The 1-loop DRG equations has fixed points, depending essentially on dimensionality. For $d > 4$, the Gaussian fixed point, with $z = 2$ correctly describes the phase transitions. However, for $d < 4$, a Wilson-Fisher fixed point[6] shows up. At this level of approximation, g is an irrelevant variable and the dynamics is driven by a usual additive noise stochastic process recovering the results from Ref. [2]. However, at d = 2 the dynamical behavior changes and the former Wilson-Fischer point is transfered to a relevant multiplicative fix point with $g \neq 0$. Thus creating a critical plane for the transition. We also notice, in 1-loop, the appearance of an anomalous dimension originatad from the multiplicative interaction.

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Optimal protocols in linear response theory

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