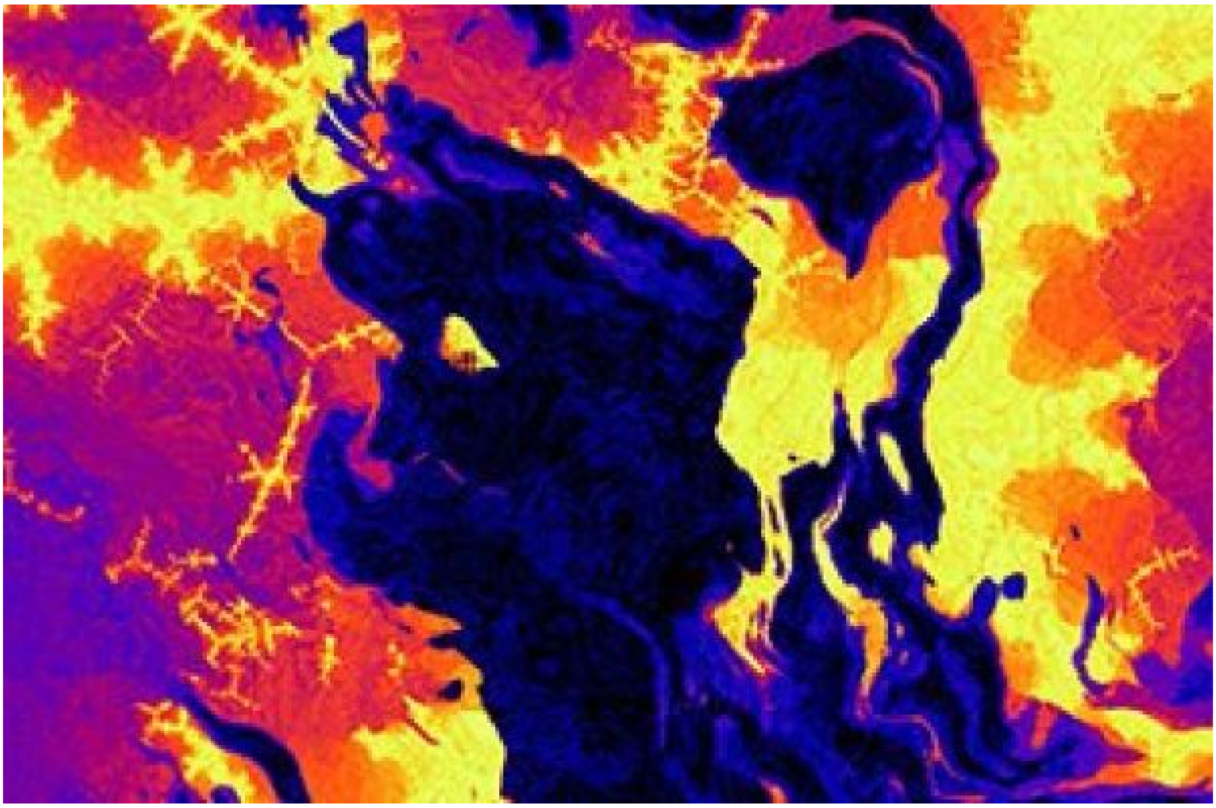

PhD THESIS DEFENSE: Anomalous diffusion: from life to machines

GORKA MUNOZ GIL

November 09, 2020
17:00
ICFO Auditorium and Online (Teams)

Diffusion refers to numerous phenomena, by which particles and bodies of all kinds move throughout any kind of material, has emerged as one of the most prominent subjects in the study of complex systems. Motivated by the recent developments in experimental techniques, the field had an important burst in theoretical research, particularly in the study of the motion of particles in biological environments. Just with the information retrieved from the trajectories of particles we are now able to characterize many properties of the system with astonishing accuracy. For instance, when Einstein introduced the diffusion theory back in 1905, he used the motion of microscopic particles to calculate the size of the atoms of the liquid these were suspended. Initially, most of the experimental evidence showed that such systems follow Brownian-like dynamics, i.e. the homogeneous interaction between the particles and the environment led to its stochastic, but uncorrelated motion. However, we know now that such a simple explanation lacks crucial phenomena that have been shown to arise in a plethora of physical systems. The divergence from Brownian dynamics led to the theory of anomalous diffusion, in which the particles are affected in a way or another by their interactions with the environment such that their diffusion changes drastically. For instance features such as ergodicity, Gaussianity, or ageing are now crucial for in the understanding of diffusion processes, well beyond Brownian motion.

In theoretical terms, anomalous diffusion has a well-developed framework, able to explain most of the current experimental observations. However, it has been usually focused in describing the systems in terms of its macroscopic behaviour. This means that the processes are described by means of general models, able to predict the average or collective features. Even though such an approach leads to a correct description of the system and hints on the actual underlying phenomena, it lacks the understanding of the particular microscopic interactions leading to anomalous diffusion.

The work presented in this Thesis has two main goals. First, we will explore how one may use microscopical (or phenomenological) models to understand anomalous diffusion. By microscopical model we refer to a model in which we will set exactly how the interactions between the various components of a system are. Then, we will explore how these interactions may be tuned in order to recover and control anomalous diffusion and how its features depend on the properties of the system. We will explore crucial topics arising in recent experimental observations, such as weak-ergodicity breaking or liquid-liquid phase separation. Second, we will survey the topic of trajectory characterization. Even if our theories are extremely well developed, without an accurate tool for studying the trajectories observed in experiments, we will be unable to correctly make any faithful prediction. In particular, we will introduce one of the first machine learning techniques that can be used for such purpose, even in systems where previous techniques failed largely.

Monday November 9, 17:00, MsTeams - Auditorium

Thesis Advisor: Prof Dr Maciej Lewenstein

Thesis Co-advisor: Dr Miguel Angel Garcia-March

Due to recommendations in place to contribute containing the spreading of COVID-19, th defence will be carried out semi presencial with a maximum of 66 Icfonians in t e Auditorium, and partly remotely via MS Teams.

If you are interested in attending in person, please address your request to mery.gil@icfo.eu

Hosted by: Maciej Lewenstein

Gorka Munoz Gil's Thesi Cover