Social Dynamics and Emergence of Collective Behaviour
(Dr Mauro Mobilia, 2018)

Approaches relying on nonlinear dynamics and statistical mechanics have provided compelling models and crucial insights to understand interdisciplinary problems and emergent phenomena in complex systems. In the realm of social dynamics, one paradigmatic example is the "voter model", where individuals in a population can be in one of two opinion states. The voter model is also closely related to evolutionary games used to model social and cooperation dilemmas. In this class of models, an individual is selected at random and adopts (with some probability) the state of its randomly-chosen neighbour; this update step is applied repeatedly. In this project, we propose to develop equally simple and paradigmatic individual-based models to investigate social behaviour like the emergence of conformity, polarization, or of multicultural states. For this, the dynamics will be implemented on various types of graphs and we will study a series of nonlinear (deterministic and stochastic) problems using a well-rounded combination of mathematical methods, notably the theory of dynamical systems and differential equations, stochastic processes, and tools from statistical mechanics. Examples of problems of interest are:

(i) Consensus, group pressure and fanaticism: we will study the formation of consensus and the role of group pressure on conformism in voter-like models when the population is heterogeneous. As an example of population heterogeneity, we will consider the influence of fanatical individuals (zealots) favouring a specific "opinion" on the system's fate for various types of dynamics (update rules). The models will be first studied on static graphs where nodes represent individuals with random connections that are random but do not evolve in time. Another question of considerable interest concerns opinion dynamics on adaptive networks, on which the opinion of individuals and the connections between are coupled and change in time.

(ii) Similar type of questions can be asked in the framework of evolutionary game theory for models, such as the prisoner's dilemma, that metaphorically describe social dilemmas and aim at studying the emergence of cooperative behaviour. We will be particularly interested in studying evolutionary games on adaptive networks.

(iii) Dynamics of polarization: In many democracies, like in the UK, there are some major parties that trade governing roles every election and a number of other parties that access governing roles only very rarely. These can typically are prone to make compromise and alliances with parties of more extreme opinions, possibly leading to either societal polarization or fragmentation. We shall devise voter-like models to describe how polarization and marginalization emerge. We will typically study the probability for minority parties to reach the majority and the average time for such events to occur, and aim at characterizing the composition of the polarized states.