The multiple faces of spatial complexity: From galaxies to cities and to nanostructures

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Nonequilibrium statistical processes usually derive spatiotemporal complex behaviour where multiple factors activated in different degrees of freedom are involved in a nonlinear but coordinated fashion to output emergent and self-organized patterns. Recently, a bunch of methods inspired by various fields of science has been applied to model and characterize the complex spatiotemporal behaviour comprising what is usually called complexity science. To get better understanding of spatiotemporal complexity, one can decompose it to the time and space domain. Time complexity is related to the nonlinear and chaotic dynamics observed even in low-dimensional systems and has been largely investigated during last decades in both Hamiltonian and dissipative systems [1]. On the other hand, spatial complexity though close to the notions of pattern formation and surface growth studied in the past, has not been accepted a unified view and a systematic report of the methods for its characterization and modelling is still missing. The aim of this talk is to fill this gap and provide a review of the methods used to reveal patterns and information enclosed in complex spatial morphologies when they considered frozen in time. The examples will range multiple scales starting from the spatial arrangement of stars in galaxies then moving to the scale of cities and looking for the spatial patterns of city features and finally going to even smaller scales of technological structures at micro and nanoscale devices [2]. Special emphasis will be given to the mathematical and statistical characterization of nanostructure complex morphologies since they largely dictate the properties and functionalities of nanostructures in the nanodevices and nanosystems and therefore have attracted a lot of interest during the last years [3]. The critical impact of these mathematical and statistical methods on the development of nanometrology of complex nanostructures will be demonstrated along with their potential industrial relevance in nanotechnology applications.

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