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Investigating chaos through computing: Condensates, plasma, astronomy, biology and beyond

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Our research combines theoretical aspects of mathematics and physics with large-scale numerical investigations to understand characteristics of diverse multidimensional chaotic systems. By computing physical quantities as well as dynamical indicators, such as Lyapunov exponents, modern theoretical and numerical techniques and powerful computation resources enable us to quantify chaos and its importance in complex models with hard-to-predict behaviour. This includes investigations into the spreading of waves in 1D and 2D lattices describing solid-state materials and studying the role of chaos in wave propagation. Chaotic wave spreading is also relevant in granular chains, soft architected structures, and tight-binding models where optimised parallel computations enable novel findings. Apart from lattices, another aspect which attracted the attention of our group is the chaotic dynamics of charged particles in complex magnetic fields, which are central to the control of plasma in experiments. We also apply various numerical techniques to models from biology and chemistry, particularly related to the behaviour DNA and graphene, where we are able to probe physical and dynamical properties of these materials, as well as systems describing the motion of stars in galactic potentials. Furthermore, we develop and test efficient task-specific numerical techniques, while computationally we make use of OpenMP, CUDA, and effective task-splitting to use GNU Parallel and pbsdsh.

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