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Mathematics of incompressible turbulence

Author: Theo Rivas

Abstract: We will discuss some foundational aspects of three-dimensional incompressible fluid turbulence, including guiding experimental observations, Kolmogorov's 1941 theory on the structure of a turbulent flow, Onsager's 1949 conjecture on anomalous dissipation and weak Euler solutions, and Landau's Kazan remark concerning intermittency. Mathematical constraints on, as well as constructions that exhibit features of turbulent behavior will be discussed.

Quantum Computing

Author: Aram Harrow

Abstract: This class is an introduction to the theory of quantum computing and quantum information. We will begin with a brief review of classical computing before defining qubits and describing the basic laws of quantum mechanics. Then we will describe problems which quantum computers can solve asymptotically more quickly than classical computers, such as search and factoring. Finally, we will introduce quantum error correcting codes and explain how they can be used to build a fault-tolerant quantum computer.

At the roots of pattern formation: from competing interactions to nonlocal curvatures

Author: Sara Daneri

Abstract: Patterns, meant as periodically repeated geometric structures, emerge in several physical and biological systems both at small and very large scales. Such patterns are often rather simple and common to diverse physical systems: stripes/lamellae, checkerboards, periodically ordered spherical droplets, etc. It is universally believed that in many of such systems the emergence of patterns is due to the competition between short range attractive forces (which would prefer to form large droplets and aggregate the mass together) and long range repulsive forces (which would prefer to split the mass in smaller and smaller droplets). The emergence of spontaneous periodicity is very important both from the theoretical and the applied point of view, because it allows microstructures to form without the aid of external forces (self-assembly).

In mathematical terms, such systems can be represented by variational models in which the energy functionals contain competing attractive/repulsive interactions.

In this series of lectures we are going to present a recent approach which has proved efficient to give a first rigorous characterization of the global minimizers (i.e. the ground states) of such energies, showing that they are indeed given by patterns. The focus will be on the role played by newly found intrinsic nonlocal curvatures, which provide the link between the energy of admissible configurations and their spatial organization into periodic geometric structures.