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**Pattern formation in reaction-diffusion systems: From spiral waves to turbulence**

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Almost all systems we encounter in nature possess some sort of form or structure. In many cases, the structures arise from an initially unstructured state without the action of an agent that predetermines the pattern. Such self-organized structures emerge from cooperative interactions among the constituents of the system and often exhibit properties that are distinct from those of their constituent elements or molecules. For example, chemical waves in reaction-diffusion systems are at the core of a huge variety of physical, chemical, and biological processes. In (quasi) two-dimensional situations, spiral wave patterns are especially prevalent and determine the characteristics of processes such as surface catalytic oxidation reactions, contraction of the heart muscle, and various signaling mechanisms in biological systems. In this talk, I will review and discuss recent theoretical and experimental results regarding the dynamics, properties and stability of spiral waves and their three-dimensional analog (scroll waves). Special emphasis will be given to synchronization defect lines which generically arise in complex-oscillatory media, and the phenomenon of defect-mediated turbulence or filament turbulence where the dynamics of a pattern is dominated by the rapid motion, nucleation, and annihilation of spirals or scroll waves, respectively. The latter is of direct relevance in the context of ventricular fibrillation - a turbulent electrical wave activity that destroys the coherent contraction of the ventricular muscle and its main pumping function leading to sudden cardiac death.