Preface

Physical systems driven far from thermodynamic equilibrium can give rise to a variety of dissipative spatial structures through spontaneous breaking of symmetries. A fascinating feature of these pattern-forming systems is their tendency to originate spatially confined states. Such localized states can exist as wave packets or propagating entities through space and/or time. Observed in many different branches of science, localized states appear to be ubiquitous in nature and characterized by common macroscopic properties, independently of the specific physical laws governing the underlying field and/or matter interactions. Even though Localized States in Physics can be found in such different domains as hydrodynamics, optics, granular matter, reaction-diffusion systems, neural networks, plasmas, Bose-Einstein condensates etc., books on the topic are still very rare and often devoted to a particular type. This Book is based on a series of lectures given at a workshop on the subject: it reflects the spirit and the breadth of the meeting, held in 2008 at the University of los Andes, Santiago, Chile. Its main motivations stem from the need to bring together - coolate and compare - various approaches to the description of localized states in physics, offering a comprehensive panorama of confined states, from localized patterns to solitons, convectons, oscillons, pulses, etc., aimed at establishing a common - or at least shared - comprehension of these physical states. In fluids, for instance, convecting regions can coexist stably with non-convecting regions in uniformly heated cells. Localized hexagonal patterns have also been observed in a parametrically excited layer of fluid. In chemical systems, autocatalytic reactions on metallic surfaces can lead to solitary waves with partial and full annihilation after collision of pulses traveling in opposite directions. In granular matter, vertically driven layers of particles (sand, rice, stones, metal balls, etc.) reveal that, for peak acceleration exceeding a critical value, standing wave patterns spontaneously form and oscillate at half the excitation frequency. Square, stripe, hexagonal and spiral patterns can emerge, depending on the oscillation frequency and amplitude of the forcing, including coherent states such as localized standing waves or oscillons. Localized states are also relevant in neural systems, where action potentials propagate along axons or networks of thalamic neurons exhibit activity waves, just to mention two examples. In optics, the interplay between dispersion/diffraction

and the medium nonlinearity leads to light propagation in space/time self-confined beams, the so-called optical solitons. In the presence of feedback, optical localized structures such as cavity solitons have been identified as transverse solutions encompassing bistability; they have been observed in several media and controlled by suitable addressing protocols. Finally, coherence and interference properties of atomic clouds of Bose-Einstein condensates, as well as localized structures in population models, have been investigated. The book covers quite a few of the most active and interesting contemporary aspects of Localized States in Physics, providing both review elements and current information on the latest research in the field. It consists of thirteen chapters discussing localized objects in optics, fluids and neural networks. The first four chapters are mostly dedicated to fundamental research in light localization. Reports on the state-of-the-art in optical spatial solitons, self-confined light and optical turbulence are presented with particular emphasis on experimental observations. The related theoretical work is treated in a general way and recent nonlinear optical experiments are reported to support the various predictions. The next three chapters deal with localized structures as localized solutions of pattern-forming systems. Analogies are drawn between fluids and optics, with a chapter dedicated to confined convective states in fluids and another one to optical transverse structures in liquid crystal light-valves. The recent theoretical developments in pattern localization are treated in a dedicated chapter, where crystal-like hexagonal structures are shown to localize according to the symmetry of the underlying grid. In the second part of the book special attention is paid to the potentials of localized states towards applications. Four chapters are devoted to optical systems and their use for controllable light pixels. Finally, excitability and localized states are treated in the last two chapters, where pulse localization is illustrated with examples in a nonlinear optical cavity and in neural networks. The Book as a whole is intended for an audience of senior and junior researchers and graduate students working in the field of pattern formation, instabilities and spatio-temporal dynamics of macroscopic systems far from equilibrium. It provides an overview of the state-of-the-art in localized states to a readership of physicists, mathematicians, electrical/electronic engineers. We trust that a number of scientists from neighbouring areas, such as e.g. biology, sociology, environment science and meteorology, will find its contents stimulating and informative.

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