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Dynamics of Self-Organized and Self-Assembled Structures by Rashmi C. Desai and Raymond Kapral, Cambridge University Press, 2009, pp. xi + 328. Scope: monograph. Level: professional physicists, researchers, PhD students, advanced undergraduates.

We all represent examples of self-organized and self-assembled structures. The natural world is full of them, and they are by no means exclusively biological in character. One can think of e.g. the process of crystallization from a melt or saturated solution, the hexagonal patterns that form in Rayleigh-Bénard convection when a fluid is heated from below, chemical waves, and patterns in Langmuir monolayers at water-air interfaces. Sometimes there is a fairly direct connection between the character and symmetry of the underlying intermolecular forces and the resultant macroscopic structure, and this will usually be true under equilibrium or quasi-equilibrium conditions. Such processes can be analyzed and modeled using free energy functionals and relaxational dynamics. Often, however, the structure arises under nonequilibrium conditions, where there is a continuous flow of energy and/or matter through the system, in which case more sophisticated approaches are needed.

Desai and Kapral point out that, during the second half of the twentieth century, the concept of universality came to the fore to play a major role in our understanding of structural correlations and dynamics in condensed matter systems. Although many physicists failed to realize what was happening at the time (and some still do not), it was the beginning of the end for reductionism – the assumption that all could be understood by analysis on smaller and smaller scales of length and time. There are, of course, many phenomena that simply cannot be predicted or understood in this way, so that a macroscopic analysis is essential: self-organization and pattern-formation provide good examples. Landau's unifying concept of an order parameter, coherent throughout the whole system under study, led eventually to the renormalization group theory of critical phenomena. Self-organized structures and their dynamics under far-from-equilibrium conditions can often be analysed within a similar context, as the authors discuss for many different examples.

The book grew in part from a 1-semester course on interface dynamics and pattern formation in nonequilibrium systems at the University of Toronto. It does not describe applications in fluid dynamics but, apart from that, the 31 chapters seem to cover practically everything one could imagine in relation to the dynamics of self-organized structures in terms of the equations of motion for order parameter fields. After introductory chapters covering self-organization, order parameters, and free energy functionals, the authors go on to discuss e.g. phase separation kinetics, Langevin models with and without conserved order parameters, domain growth, vector order parameters and topological defects, liquid crystals, the effect of long-range repulsive interactions, diffusively rough surfaces and curved interfaces, propagating chemical fronts, Turing patterns, excitable media, the complex Ginsburg-Landau equation, spiral waves and resonantly-forced oscillatory media – just to give a few examples of the diversity of phenomena being brought together and described analytically under the same conceptual umbrella.

The text is very well-written and grips the attention of the reader. It is pitched at a level that will be understandable to graduate students, and much of it will be accessible to final year undergraduates. There are numerous figures and illustrations to illuminate the text, an extensive list of references, and a good index. In my opinion it is an excellent book that can be recommended warmly both to libraries and for personal purchase by physicists and nonlinear dynamicists, especially those working or teaching in the area of self-organization.

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