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Daniel H. Rothman, Stiphane Zaleski

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The text is a self-contained, comprehensive introduction to the theory of hydrodynamic lattice gases. Lattice-gas cellular automata are discrete models of fluids. Identical particles hop from site to site on a regular lattice, obeying simple conservative scattering rules when they collide. Remarkably, at a scale larger than the lattice spacing, these discrete models simulate the Navier-Stokes equations of fluid mechanics. This book addresses three important aspects of lattice gases. First, it shows how such simple idealised microscopic dynamics give rise to isotropic macroscopic hydrodynamics. Second, it details how the simplicity of the lattice gas provides for equally simple models of fluid phase separation, hydrodynamic interfaces, and multiphase flow. Lastly, it illustrates how lattice-gas models and related lattice-Boltzmann methods have been used to solve problems in applications as diverse as flow through porous media, phase separation, and interface dynamics. Many exercises and references are included.

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