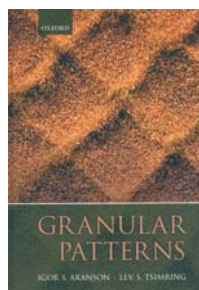


of discrete macroscopic particles. Not only are granular materials ubiquitous, they also display an incredibly rich set of behaviors. Whenever the particles are set in motion, nontrivial patterns are created. For example, shaken granular layers display surface patterns, gravity-driven flows yield avalanches and vortices, shaken or flowing granular mixtures show various types of segregation patterns, and a freely cooling granular gas forms clusters.

Over the past two decades, such phenomena have attracted the interest of physicists whose findings have been consolidated in review articles and monographs on granular media (see, for example, the article by Heinrich Jaeger, Sidney Nagel, and Robert Behringer in *PHYSICS TODAY*, April 1996, page 32). Of the few of those works that focus on pattern formation, the most notable are Gerald Ristow's *Pattern Formation in Granular Materials* (Springer, 2000), Igor Aranson and Lev Tsimring's article in *Reviews of Modern Physics* (April–June 2006, page 641), and Aranson and Tsimring's new book *Granular Patterns*. Ristow's book is, unfortunately, somewhat outdated and is narrower in scope and lacking the theoretical richness offered in *Granular Patterns*.

Aranson and Tsimring, highly esteemed in their field, are well placed to write about the subject. In *Granular Patterns*, they offer an informative and detailed overview of the field. As it stands, granular physics is missing a comprehensive theoretical foundation. The nonequilibrium nature of granular media and the lack of separation of scales lead to difficulties in developing an overarching theory akin to the kinetic theory of gases or the Navier–Stokes equations for Newtonian fluids. At present, we have a set of approaches covering different regimes of granular physics; those include the Boltzmann equation with a dissipative collision term, conservation equations (à la Navier–Stokes) completed with phenomenological constitutive equations, the Edwards theory, Ginzburg–Landau and phase-field descriptions, and many more. The techniques vary in breadth of applicability, and some are more phenomenological than others; *Granular Patterns* gives a good overview of how the techniques can be used to interpret different pattern formations.

An interesting—and for a book on granular media, unique—feature of the text is that it includes examples in biol-



ogy. Pattern formation in biological systems is a personal interest of the authors and an increasingly popular pursuit of other practitioners in the field. Although biological dynamics are generally considered complex, the interactions between organisms (modeled as particles) in a number of pattern-forming systems are simple—for example, they are often short-range interactions—and the resulting patterns can be understood with the same tools used for “dead” granular matter. The growth of bacterial colonies, self-organization of cellular microtubules by molecular motors, flocking, and collective swimming of bacteria are all relevant examples.

Included with the book is a CD-ROM containing about 70 movies contributed by various research groups of experiments and simulations. Although the quality and utility of those movies is uneven, some of them—particularly a number of experimental ones—are truly spectacular. Somewhat less spectacular is the style of writing: *Granular Patterns* reads in places like a review article, which makes sense given it is based in part on the authors' 2006 publication in *Reviews of Modern Physics*. Despite generally careful editing, a number of typos and even minor inconsistencies have remained, which I hope are weeded out before subsequent printings. Also, some of the figures are not print quality, which I find surprising from a reputable publisher such as Oxford University Press.

Those minor issues notwithstanding, I enthusiastically recommend *Granular Patterns* to graduate students and researchers working on pattern formation or with granular media. The book is very useful, and having it at hand will foster appreciation of granular patterns and help researchers push the boundaries of that truly rich and fascinating subject.

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