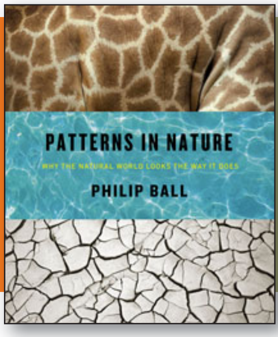


Patterns in Nature: Why the Natural World Looks the Way It Does

Philip Ball

The University of Chicago Press, 2016
288 pages, $35.00 (e-book $21.00)
ISBN 9780226332420

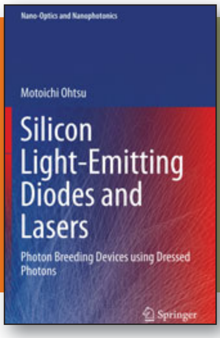
Reading this book is like going to an art gallery with a friend who is very learned. Ball presents a rich variety of patterns that exist in nature and the common principles that explain them, even when they appear in unrelated circumstances.

The Introduction sets the subject in context and shows the geometric designs in ancient architecture and in the natural world of the living and nonliving. Chapter 1 includes examples of bilateral symmetry exhibited by fish, mammals, insects, and birds. Snowflakes and honeycombs with hexagonal symmetry have long been admired, photographed, and studied. Sometimes patterns are obtained by breaking the symmetry. In chapter 2, fractals (hierarchical repetition of the same general form at decreasing scales) are illustrated with examples such as florets of broccoli, tree branches, and coastlines. Chapter 3 discusses logarithmic spirals, in which a cone rolls up, and Archimedean spirals, in which a rope rolls up. Spirals show up in chameleon tails, mollusk shells, and in swirling stars of galaxies. Flowing fluids often organize themselves into spiral vortices, with tornados being a dramatic example. Chapter 4 discusses patterns of flow and the emergence of chaotic behavior. Chapter 5 explains how wave patterns form, as in a plate sprinkled with sand and vibrated. Granules move away from vibrating places and fall onto nodal lines, where the plate is not vibrating, and form what is called a Chladni figure. Cracks due to electric discharge form a wavy pattern called Lichtenberg figures. Sand dunes show wave patterns.

Chapter 6 discusses bubbles and foams, where surface tension and pressure of the gas inside control the patterns to minimize the surface. Chapter 7 includes arrays and tilings, starting with wallpapers and flooring, and progresses to crystals and quasicrystals, which are five-sided and were once considered impossible. Chapter 8 covers how a pattern of cracks forms on dry mud, glazes, and paints on a coated surface. The top layer shrinks as it dries, while the bottom layer is still wet and swelling. As a result, there is a differential stress, released by forming a network of cracks with polygonal shapes. Chapter 9 explains the pattern of spots and stripes on animals, such as the zebra, using the reaction–diffusion model of Turing. In this model, ingredients called activators and inhibitors are present in cells. Depending on how they diffuse and react, chemical waves arise, and patterns are formed.

This book draws many examples from materials science: dendrite growth, crystallography, liquid crystals, quasicrystals, dielectrics, and naturally formed materials, which can inspire the creation of new materials and engineering designs. The book appeals to all scientists and to those who like to see art in science. There are 250 patterns in color pictures, juxtaposed thoughtfully, to bring out common themes. After you read this book, you will enjoy looking for patterns around you.

***Reviewer: N. Balasubramanian** is an independent research scholar and science writer working in Bangalore, India.*



Silicon Light-Emitting Diodes and Lasers: Photon Breeding Devices using Dressed Photons

Motoichi Ohtsu

Springer, 2016
192 pages, $129.00 (e-book $99.00)
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The topic of this book is very timely. Direct-bandgap semiconductors are used for conventional light-emitting diodes (LEDs) and lasers. Although there have been tremendous improvements in terms of efficiency, technical challenges remain in fabrication and in handling toxic and rare compounds, such as arsenic and indium. Silicon, being an indirect-bandgap semiconductor, exhibits poor efficiency because electrons must transition from the conduction band to the valence band to emit light spontaneously by electron–hole recombination. However, the momentum of the electron in the conduction band is different from that in the valence band, requiring a phonon in the process to satisfy the net momentum conservation. Modifications of silicon bulk density using porous Si, a superlattice structure of Si and SiO_2, or Er-doped Si have been employed to overcome this efficiency issue with little or no commercial success.

This brings us to the topic of this book: dressed photons (DPs) and dressed photon phonons (DPPs) and their utility to allow silicon bulk crystal into an efficient light-emitting material or device. A DP, unlike a conventional photon, provides a physical picture that illustrates the small size (quantum confinement), meaning that the quasiparticle is created in a nanomaterial or quantum dot material and has short duration, making the quasiparticle a virtual photon. Semiconductor materials have phonon-excited states within the bandgap. Since propagating far-field light cannot