Connections

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Physics provides explanations of the world of matter and energy as a hierarchy of interlocking theories, each appropriate in different circumstances.

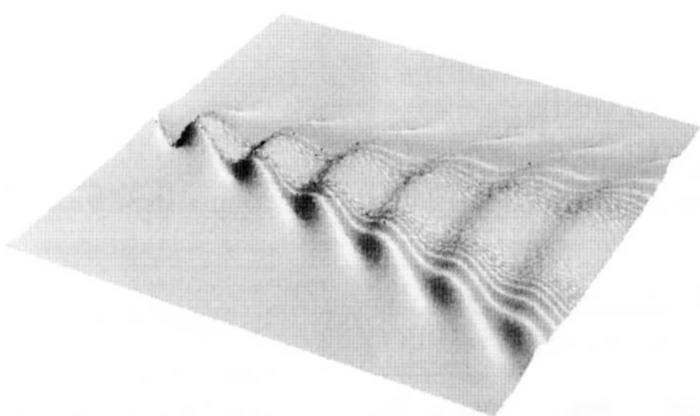
For the motion of planets and spacecraft, the 'classical' mechanics of Newton is accurate enough: these objects move in orbits under the action of forces. On the atomic scale, Newtonian mechanics fails; this is the quantum realm, where only the probability of an individual event can be known, and the probabilities are determined by the strengths of waves (a rough analogy is a crime wave). Quantum theory includes classical mechanics as a special case - a useful approximation on large scales. But because the two worlds look so different, connections between them are subtle and difficult to unravel. Much interesting and puzzling physics, and much of my research as a theoretical physicist, lies in the borderland between theories.

In the quantum-classical border, an area of much current interest is the study of quantum waves and energy levels when the classical orbits are unstable and hence unpredictable. 'Quantum chaology' is beginning to be probed experimentally, and there are surprising connections with a deep question in arithmetic, related to prime numbers.

Another - and mathematically similar - border is in optics. The operation of cameras and binoculars is well explained by thinking of light as rays, but to understand fine detail it is necessary to describe light using waves. Between rays and waves live beautiful natural phenomena, for example rainbows and twinkling starlight. New insight into the geometry of waves and their interference has been achieved with the modern mathematics of catastrophe theory.

Arising from this is another theme of my research: to find simple demonstrations of abstract ideas - the arcane in the mundane. Conjuring tricks with a belt illustrate the quantum physics of identical particles; a levitating-magnet toy illustrates a stability theorem in mechanics and is a model for devices used to trap microscopic particles; a top that only spins one way illustrates symmetry-breaking...

The passage from one theory to another is mathematical: the less general theory is a limiting case of the more general one - light can be thought of in terms of rays in the limit when the wavelength is negligibly small. The mathematics of limits, called asymptotics, involves representing physical quantities as the sum of infinite series of numbers of a peculiar kind that is hard even to define. Thinking about the associated physics has led to new insight into asymptotics, marking another stage in humanity's long struggle to understand infinity.



Waves behind a ship. The calculation uses the mathematical asymptotics of water waves near the limit of 'water rays', and is based on the V shape which is a focusing singularity of these rays - a watery equivalent of the rainbow.

Sir Michael Berry, normaliter als natuurkundige verbonden aan Bristol University, bekleedt dit jaar de positie van Lorentz-hoogleraar aan de Universiteit Leiden. Velen hebben hem al in actie gezien tijdens zijn zeer boeiende en druk bezochte college "The Seven Wonders of Physics", 8 november jl.