fortunately only rarely—terrible airplane accidents with dozens of fatalities. Lightning strikes result in forest fires, ignite explosives, lead to transmission line and power system failures, and disturb the operations of electronic devices that control important systems. The annual cost in the US of the power failures alone is more than $1 billion. Clearly, humankind's interest in lightning and its effects will never disappear. So the publication of a new book with a great deal of information on lightning and lightning protection is an event. *Lightning: Physics and Effects*, by Vladimir A. Rakov and Martin A. Uman, is such a book.

The modern scientific study of lightning and its effects began about 100 years ago, and the field has developed exponentially since. Scientists now have available an immense quantity of facts that need to be collected, systematized, generalized, and presented in a convenient package. Probably the first steps in this direction were taken by Uman in his book *Lightning* (McGraw-Hill, 1969). Uman's *The Lightning Discharge* (Academic Press, 1987) updated his earlier work. The new book by Rakov and Uman, who have both made numerous contributions to the field, represents the current state of the art. It has much greater topic coverage and much more information than other books on lightning, including Uman's previous two efforts. In view of the rapid pace of progress in the field, even the two-volume collection *Lightning* edited by Rudolf H. Golde (Academic Press, 1977)—a standout among serious books treating the topic—can't compete with Rakov and Uman's offering. The more than 6000 references indicate the scope and completeness of the new book. All of those references have article titles, which significantly increases the value of the reference lists.

A short review cannot possibly address every topic that is discussed in the book. Among other things, the authors cover thundercloud formation and discuss hypotheses on lightning inception inside a cloud. They also consider upward-directed lightning emitted from high grounded structures, such as towers, skyscrapers, and so forth, that lie under thunderclouds. Rakov and Uman present numerous streak photographs of lightning leaders, the faint discharges that, after they touch Earth, are followed by the main stage of a lightning discharge—the so-called return stroke. The authors offer experimental data on electric fields generated by thunderclouds and leaders as well as data on return-stroke currents. Those currents, which grow at a rate of about 10^{11} A/s and can reach an impressive 100 kA, are responsible for lightning's damages and disturbances.

The book includes a chapter devoted to triggered lightning. Such lightning is excited by a small rocket that, while flying under a thundercloud, pulls a thin grounded wire. Lightning initiates when the rocket reaches an altitude of 200–300 m. Such experiments give especially valuable information because one can prepare them with an exact knowledge of where and when the lightning will strike. That kind of foreknowledge is impossible in natural conditions.

Lightning: Physics and Effects considers the influence of lightning on electromagnetic wave propagation and on broadcasting, the hazards lightning poses to people and animals, and the generation of nitrogen oxide during thunderstorms. The book also discusses some topics, not mentioned in other books, that have recently attracted attention. Those include lightning in the middle and upper atmosphere and on other planets. Aviation specialists will find much of value on interactions of lightning with aircraft and spacecraft, and engineers will find a great amount of data on the protection of terrestrial objects.

As extensive as its coverage is, the book does leave out some things I would like to have seen. It includes very little data concerning corona ion clouds above tall structures or corona ion layers above Earth's surface: Both coronas are excited by a thundercloud's electric field. Coronas can influence whether upward-directed lightning is initiated and can effect the location of downward-directed flashes.

Lightning: Physics and Effects tells the reader what was done and by whom rather than focusing on physical phenomena. Another relatively recent book, *Lightning Physics and Lightning Protection*, by E. M. Bazelyan and me (IOP, 2000), concentrates on physical mechanisms. Rakov and Uman's encyclopedic work will be extremely useful for specialists as a rich source of factual and bibliographic information, but it won't serve as a textbook. Students and others looking for a guide to help them become acquainted with the subject should look for a book that emphasizes the physics and clearly distinguishes what we understand from what we don't.

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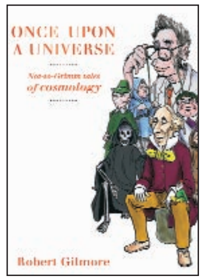
Once Upon a Universe: Not-so-Grimm Tales of Cosmology

Robert Gilmore
Copernicus Books/Springer-Verlag, New York, 2003. $25.00 (228 pp.). ISBN 0-387-95566-6

Breathes there a physicist with soul so dead,

Who never to himself has said

How can I show the public the marvels of comprehending scientific reality?



The above revision of Sir Walter Scott's 1805 patriotic verse summarizes scientists' ambitions to share the wonders they understand, and the remaining mysteries of the physical world, with those who have supported—often unknowingly—their research.

For most physicists, the desire to show the public the joys of understanding scientific reality remains unslaked—at least as far as reaching a wider audience goes. Robert Gilmore has acted upon that desire. *Once Upon a Universe: Not-so-Grimm Tales of Cosmology* is the fourth in a series of his books using fairy-tale approaches to communicate important points about physics.

In his latest book, Gilmore presents six tales. Two deal with basic physics: "The Prince and p" and "Snow White and the Particularly Little People"; two with relatively conventional astronomy: "Ali Gori and the Cave of Night" and "Cinderenda and the Death of Stars"; and two with cosmology: "Jack and the Starstalk" and "Waking Beauty." Each tale features one or more initially naive characters whose adventures bring them into contact with a wise entity—a wizard, a philosopher, a dominie, a surveyor, an artificer, or an astrogator—who explains one or more of the amazing phenomena of physics. The explanations read well, and the stories invariably end with the formerly naive character better informed.

Why then do I doubt the book's ability to secure readers among the general public? My own inclinations and experience have led to the conclusion that the public does not care for physics (or astrophysics or cosmology) packaged in the form of a fable. This disinterest is doubled when the fable includes, as it must, a great deal of straightforward exposition. Whether one is a Richard Feynman, George W. Bush, or royal chamberlain, he will eventually end up using sentences like "the upper cone that you see there is bounded by all the possible paths that light may take as it moves from you into the future. . . . Along the [present light] cone lie all those events where someone or something might look back and see you as you are now. . . . Within this [past light] cone will lie all the events of your actual past, which must be separated by movements slower than light. . . ." Thus I cannot see why Gilmore thought that bringing Hendrik Lorentz briefly into the picture would make much of a difference in how readers would absorb the scientifically significant parts of his book. A fair number of general readers might find the author's approach condescending and unhelpful. I salute Gilmore for his desire to connect with the public, but I believe he has little chance of doing so with cosmic fairy tales.

But all is not lost. A segment of the market does exist that might find deep pleasure in such cosmic quests. I can well imagine that someone who has mastered the material, at least in part, could take delight in revisiting topics recast into a fairy-tale format. Small jokes, such as "The Prince and p," could resonate in a mind primed to understand scientific matters written in a style that might leave others with a diffident, suspicious, or even hostile attitude.

As its inside cover states, *Once Upon a Universe* demonstrates more than one way to shed light on the strange profundities of modern physics and cosmology. The problem is that Gilmore's way probably won't fly with those who fear the worst about physical science, and even those with a positive attitude are likely to find his approach of little merit. But give the book to your scientist friends. They will thank you for it—and mean it.

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Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves

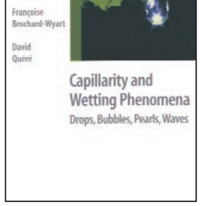
Pierre-Gilles de Gennes, Françoise Brochard-Wyart, and David Quéré (translated from French by Axel Reisinger)
Springer-Verlag, New York, 2004, $69.95 (291 pp.).
ISBN 0-387-00592-7

Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves is a translation of the earlier French *Gouttes, Bulles, Perles et Ondes* by the same authors, which was published in 2002 by Éditions Belin-Herscher (Paris) as part of the series Collection Échelles. It has been wonderfully translated by Axel Reisinger. The English is fully fluent and idiomatic, with a style and wit that are undoubtedly faithful to the original.

What we now call capillarity and wetting manifest themselves constantly in everyday life. Their origin had long been the object of much philosophical speculation. As one may read in chapter 2 of this book, or in John S. Rowlinson's *Cohesion: A Scientific History of Intermolecular Forces* (Cambridge U. Press, 2002; reviewed in PHYSICS TODAY, November 2003, page 68), the subject became quantitative science in the early 18th century with the experiments on capillarity by Francis Hauksbee. He showed that the rise of liquid between parallel glass plates is inversely proportional to their separation. (Shortly afterward, James Jurin showed that the rise in a glass capillary is inversely proportional to the capillary's radius.) Hauksbee also showed that the rise in a capillary is independent of the thickness of the tube's walls and that it occurs as well in vacuum as in air. That the rise between parallel plates is inversely proportional to their spacing means that when the plates are joined at a vertical edge, forming a wedge, the shape of the resulting meniscus, as viewed from the side through either of the plates, is a hyperbola. The hyperbolic shape of the meniscus was soon confirmed.

The authors are great admirers of Henri Bouasse, the French scientist and author of *Capillarité et Phénomènes Superficiels* (Delagrave, 1924). They state that their intention was to write a book "in the Bouasse tradition, that is to say, by aiming at an audience of students. What we offer here is not a comprehensive account of the latest research but rather a compendium of principles." In this, they have been eminently successful.

With its many homely examples, references to everyday observation, and invitations to readers to check the principles with "kitchen" experiments, which the authors carefully describe and illustrate, *Capillarity and Wetting Phenomena* is also like another great classic of the subject—Charles Vernon Boys's *Soap-Bubbles, Their Colours and the Forces Which Mould Them* (Society for Promoting Christian Knowledge, 1912; Dover, 1959). Indeed, on page 2 of *Capillarity and Wetting Phenomena*, we find a charming sketch of a luxuriant head of hair becoming compact and drooping when wet and exposed to the air, which illustrates an effect of the surface tension of water. One may then instantly recall the same idea in Boys's book illustrated by an artist's paint brush, first dry and then fully immersed in water—in both cases the bristles are free from one another and the brush is full—and then removed from the water and exposed to the air, as a result of which the brush becomes compact and pointed. That is not because the brush is now wet—it could not have been wetter than when immersed in the water—but because of water's surface tension against air.



The captivating drawing in *Capillarity and Wetting Phenomena* of the head of hair above a pert, curvilinear-triangular face is signed with a discreet "PG." It is the only such sketch in the book, which is a pity: Pierre-Gilles de Gennes is an accomplished amateur artist, as well as a renowned scientist. Still, the book has many (177, by the publisher's count) illuminating diagrams and photographs. One example among many is a striking photograph of liquid drops hanging under a horizontal panel (as one might observe with wet paint on a ceiling), which illustrates the Rayleigh–Taylor instability.

Although the mathematics and technicalities have been confined to the minimum necessary, they are nevertheless here and are often quite sophisticated. The book can be read with pleasure and profit by the uninitiated, but it is also a valuable—and even an indispensable—reference work for the expert. Still, the mathematics is always motivated and explained in physical terms, never without numerical estimates, and with profuse reference to commonly observable effects. Ever since reading chapter 7 on dewetting, I have been unable to view the hydraulic jump at the edge of the outward-flowing film of water at the bottom of the kitchen sink below the stream from the faucet as anything other than a shock front. In that same flow from the faucet, we learn (in chapter 5 on the hydrodynamics of interfaces), you can feel with your hands the Rayleigh instability in the discrete drops near the bottom of the stream, which are in contrast to the laminar flow near the top. Are you curious to know what weight of water covers you when, as the