

Opening Space Research

Dreams, Technology, and Scientific Discovery

George H. Ludwig
American Geophysical Union,
Washington, DC, 2011. \$60.00
(478 pp.). ISBN 978-0-87590-733-8

Fifty years ago, I uprooted George Ludwig and his family from Iowa. I had recruited him to work at the Jet Propulsion Laboratory (JPL) in Pasadena, California, integrating the Geiger-Müller cosmic-ray detector into the first Explorer satellites. Ludwig was a key participant in early US Earth satellite and space exploration efforts. He was involved in the development of the cosmic-ray research program at the State University of Iowa (SUI, now better known as the University of Iowa), where he was a PhD student under James Van Allen and later became a full-time researcher. He kept detailed logs and journals of all his research activities at SUI and at JPL; he was probably influenced in that by Van Allen, who had a similar practice.

Those personal journals form the basis for *Opening Space Research: Dreams, Technology, and Scientific Discovery*, a detailed, informative, personal, and entertaining narrative of Ludwig's professional development and involvement in the space program. The chronology and some details of the early unmanned space program found in this book do not exist elsewhere. The text is semitechnical, with 500 endnotes and references, a directory of 395 names cited, and a comprehensive bibliography of 84 works for further reading—these are available to the casual follower of early space-exploration history.

Opening Space Research highlights the development of SUI's cosmic-ray research program. Ludwig traces the history of instrumental and experimental technology in the field, starting with the observation of cosmic rays with balloon-launched detectors and radio-telemetry equipment. Researchers subsequently gained higher altitudes by attaching a small rocket to a balloon and igniting the rocket in the upper atmosphere. That low-budget technology, called the "rockoon," eventually led to the cosmic-ray-detector satellite instrument.

The central focus of the book is on

Ludwig's role in designing and integrating the instrument that discovered the Van Allen radiation belts; it flew aboard *Explorer 1*, the first Earth satellite launched by a noncommunist state. The cold war, interservice military rivalries, and other political activity took place during the 1950s, the era in which the satellite was launched. Among the many fine books that have been written about that time period are Walter McDougall's *The Heavens and the Earth: A Political History of the Space Age* (Johns Hopkins University Press, 1985) and Clayton Koppes's *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* (Yale University Press, 1982). Ludwig's account offers a novel first-person perspective.

Ludwig spends several chapters describing the design of the satellite flight hardware, first at SUI and then at JPL. He warns readers that the discussion may get tedious and gives them permission to skip ahead. But for anyone who has been involved in the design and development process, Ludwig's detailed account is an excellent manual

on how to work out difficulties to produce an instrument—and particularly valuable if an instrument needing repair is inaccessible. The author also discusses the second generation of satellite instruments and how a cadre of early investigators branched out to different institutions to furnish the flight instruments and to analyze the data. That was after 1958, when NASA was formed, and after the development of other new laboratories and centers, such as NASA's Goddard Space Flight Center.

The last portion of the book contains an insider's view of the examination of the *Explorer 1* and *Explorer 3* data; cosmic-ray researchers spotted anomalies in the particle-counting results and realized that something strange was happening. That "something" was detector saturation by unexpectedly high radiation—the Van Allen belts. It took several weeks and several sets of data from the satellites to confirm what was happening. Ludwig relates how the public announcement of the radiation belts occurred and follows up with inside details of the *Explorer 4* results, particularly the measuring of the 1958 Operation Argus high-altitude nuclear blasts, which loaded more particles into the radiation belts.

Among the book's nontechnical gems are Ludwig's short personal histories of many of his SUI research



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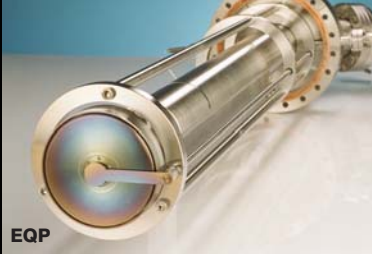
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colleagues. He also recounts instances of his attendance at key meetings where crucial decisions were made. On the evening of 4 October 1957, he was present at the Soviet Union's embassy in Washington, DC, when the electrifying news of the *Sputnik* launch was shouted out. He was a graduate student then, but attended as the designated alternate to Van Allen, who was out of the country at the time.

It was a pleasure to work with George and to review *Opening Space Research*, a welcome addition to the historical literature documenting the genesis of US space exploration.

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Physics of the Future

How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100

Michio Kaku
Doubleday, New York, 2011. \$28.95
(389 pp.). ISBN 978-0-385-53080-4

Michio Kaku's latest book, *Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100*, is based on an appealing premise: Since the laws of physics are not likely to change between now and 2100, they can provide insight into how our world will. Kaku explores this observation through interviews with "more than 300 of the world's top scientists, thinkers, and dreamers," who are asked to base their forecasts on technologies that exist at least in prototype form today.

The result, alas, is a kind of future by committee. We're told that in the future there will be real-time spoken language translators; in the present there's an app for that. The book ends with a scenario of a day in the life in 2100 that features such science-fiction staples as magnetically levitating (maglev) cars, wrist-watch videos, space elevators, and artificial-intelligence avatars. Such a forecast could have been accomplished with less effort by collating covers from popular science magazines.

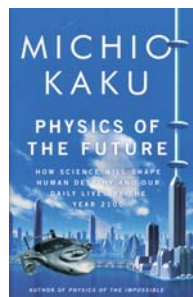
This future also appears to ignore important ideas introduced earlier in the book. A city dump overflows with electronic chips and robot parts, but research on digital materials argues strongly for a future in which functional systems are disassembled and reused rather than disposed. In 2100 one regularly shops for robot models,

but current research on programmable matter suggests that actuation will be distributed, reconfigurable, and integrated with computation rather than embodied in discrete devices. Worse, there are some surprising physics errors. The maglev driver observes that "you rarely need to fuel [the maglev vehicle] up, since there is almost no friction to slow it down." Unless the atmosphere is also superfluid in the future, air friction will be a significant loss mechanism at the velocities that would be hoped for a maglev vehicle.

Another problem with a future found from interviews is oversights based on who was interviewed for the book. Printed organic LEDs are introduced for electronic paper displays, but not the microencapsulated electrophoretic displays widely used in e-book readers. Electronic inks have the great virtue of modulating light as paper does, rather than having to generate light. Another section describes quantum computing in terms of superposition, which applies equally well to classical waves, but makes no mention of the essential roles of entanglement and projective measurement. Further on, the author describes the goal of creating life, but does not note the spectacular *ab initio* synthesis of a self-replicating bacterial cell, *Mycoplasma mycoides*. Metamaterials are not mentioned at all.

Asking technical evangelists about the future can also lead in *Physics of the Future* to uncritical reporting of what could be called "aspirational technologies" that are based on their descriptions rather than their physics. An "internet" contact lens is glowingly described for augmented reality, without discussion of the daunting challenge of controlling the phase or angle of light for the eye to be able to focus a source in such close proximity. The discussion of DNA computing omits explanations of the very limited scaling of brute-force combinatorial search or the slow diffusional time scales; the field has largely moved from universal computation to molecular programming for nanoassembly and medical applications.

The real strength of the book lies in its margins. The author makes an interesting observation that entropy would become the scarce resource in a world that can meet all of its energy needs with some combination of fusion and solar power: What happens if affluence buys order, and actions are judged by the disorder they create? Similarly,



what would life be like if a network of quantum repeaters allows entanglement to be shared as easily as we now share classical information? What if metamaterials succeed in decoupling our sensory experience from external reality? Such profound questions deserve a depth of attention to match. It would have been

more relevant to learn the author's perspective on these questions than to find out where and to whom he's presented lectures. Also, a few calculations, even in words, would have been welcome to illustrate how the physics works, as would some examples of the role of data-driven inference as a guide to forecasting.

Physics of the Future observes that "our destiny is to become like the gods we once worshiped." This follows from the evidence presented, if "god" is taken to mean "science fiction character." Although that's not such a bad fate, it's a projection with a great deal of prior art in science fiction. Perhaps the conclusion to draw about the future is that good storytelling remains a good way to do scenario planning for it.

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Single-Ion Solvation

Experimental and Theoretical Approaches to Elusive Thermodynamic Quantities

Philippe Hünenberger and Maria Reif
RSC, Cambridge, UK, 2011. \$144.99
(664 pp.). ISBN 978-1-84755-187-0

Classical thermodynamics is a beautiful subject. Albert Einstein famously said that it "is the only physical theory of universal content which I am convinced will never be overthrown." Indeed, scientists are confident that we will not observe any violation of the first and second laws of Rudolf Clausius's thermodynamics, even after we admit the post-Clausius realities of relativity, atomic structure, and quantum mechanics.

But other firm prescriptions of classical thermodynamics are not on such solid ground. For example, it is possible in the context of classical thermodynamics to measure the free energy of a solution containing sodium chloride, but because electroneutrality must be attained in bulk matter, it is impossible