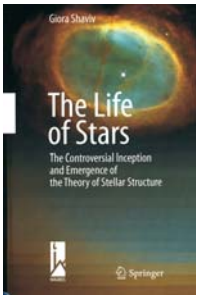
The Life of Stars

The Controversial Inception and Emergence of the Theory of Stellar Structure

Giora Shaviv
Springer, New York, 2009. $129.00 (504 pp.). ISBN 978-3-642-02087-2

Progress in scientific research is often presented in undergraduate courses as straightforward, perhaps inevitable. In actuality, the path is considerably messier, strewn with the misconceptions and prejudices of individual researchers.



In *The Life of Stars: The Controversial Inception and Emergence of the Theory of Stellar Structure*, Giora Shaviv, an astrophysicist with a career spanning more than 40 years, traces the path that led us to our current understanding of stellar structure. Covering the critical period of the field's development—the latter part of the 19th century and the first half of the 20th—Shaviv demonstrates how science eventually triumphs over scientists' errors.

The story of stellar structure is interwoven with the development of quantum mechanics and the determination that nuclear fusion reactions produce the energy emitted by stars. The author provides excellent coverage of those two developments. He also effectively notes that stellar theorists often had access, in principle, to information that would have allowed them to take giant leaps toward a solution. But although the information was available, many researchers at the time were insufficiently acquainted with the emerging literature.

Early theorists still made progress, but the path to understanding had more in common with a random walk, slightly weighted toward progress, than with a direct march. On more than one occasion, personality clashes impeded progress; however, the author does not give the reader enough detail to assess the personalities of those involved. Nonetheless, he thoroughly explores the researchers' views in light of what their peers were thinking and finding at the time.

In addition to the early controversies, the author discusses specific stellar-structure issues—including nuclear astrophysics and supernovae explosions—that he himself has researched. He also summarizes several more contemporary puzzles, such as the solar neutrino problem and what to make of helioseismology and SN1987A, the supernova observed in 1987. Their coverage may be adequate for astronomers who are not experts in those topics, but the principal researchers will probably feel short-changed. I thought the book should have discussed how the rise of computers in the 1950s and 1960s enabled both the solution of the appropriate equations—with realistic physics—and the ability to make credible comparisons with observations and modeled stellar evolutions. I also think that asteroseismology deserved a mention, although I appreciate the difficulty of summarizing in one book every unsolved problem in stellar astrophysics.

The author could have been better served by his editors. Sometimes a technical concept is introduced, but an explanation does not appear until several pages later. I also question the need to present as figures the front pages of old articles, as is done several times. The most remarkable mistake is figure 7.8, in which the entirely missing left half leaves an open space on the page. Also, the book contains a number of incomplete sentences and a few obvious scientific errors, such as a relationship, presented twice, that requires the astronomical unit to be about 20 000 solar radii; that value is high by a factor of 100.

Despite the occasional mistake, *The Life of Stars*, presented at a level that requires at least an undergraduate education in physics and an introduction to astronomy, delivers on showing budding professionals a realistic picture of how science gets done.

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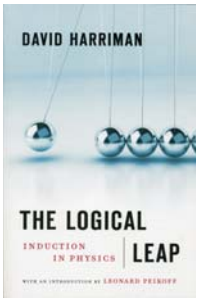
The Logical Leap

Induction in Physics

David Harriman
New American Library, New York, 2010. $16.00 paper (266 pp.). ISBN 978-0-451-23005-8

Is philosophy relevant to physics? Do physicists need to understand philosophy and its consequences? Most people would say no. Physicists, if not offended, would raise their eyebrows for even having the second question put to them. Indeed, they and others point out, and correctly so, that physics is the most universal of the natural sciences. It teaches us the basic laws of the material world and serves as a paradigm of rational thought. Thus, many a physicist's view on the matter is, Philosophy? Who needs it!



Such a viewpoint has become so widely accepted that when physicist David Harriman tells people his field is philosophy of physics, "they often react as if I told them that I study the mating habits of rocks or the migratory flights of pigs. Even in today's world, they insist, there are a few things one can rely upon—namely, rocks don't mate, pigs don't fly, and a 'hard' science like physics doesn't have anything to do with philosophy" ("The 19th-Century Atomic War," *Objective Standard*, volume 1, number 2, page 83, 2006). The last point, however, is dead wrong; in *The Logical Leap: Induction in Physics*, Harriman shows us that not only is the existence of physics influenced by philosophy, but its success and progress are utterly dependent on it.

Harriman starts out by noticing a peculiar and unstable situation: "As our knowledge of the physical world has advanced, our understanding of knowledge itself has lagged behind.'' At the beginning of *The Logical Leap*, Harriman discusses how he witnessed that gap between physics and epistemology during his college years at the University of California, Berkeley:

> In my physics lab course, I learned how to determine the atomic structure of crystals by means of x-ray diffraction and how to identify subatomic particles by analyzing bubble-chamber photographs. In my philosophy of science course, on the other hand, I was taught by a world-renowned professor (Paul Feyerabend) that there is no such thing as a scientific method and that physicists have no better claim to knowledge than voodoo priests. I knew little about epistemology at the time, but I could not help noticing that it was the physicists, not the voodoo priests, who made possible the life-promoting technology we enjoy today.

Sharpening that paradoxical gap with the observation that "the triumphs of science stand as a . . . clear refutation of the skepticism that is endemic in contemporary philosophy of science," Harriman goes on to ask, "Why does this situation persist in universities around the world? How did we arrive at this bizarre contradiction—with scientists

developing technology that exploits our detailed knowledge of atomic structure, while philosophers bewail or revel in the alleged impotence of reason to grasp even relatively simple facts?"

And so he arrives at the crux of the matter: the failure of philosophers to offer a solution to what has been called "the problem of induction." Induction is the process of inferring generalizations from particular instances. The problem—how does one know the truth of a generalization?

Harriman shows that a generalization, to be true, must be the statement of a causal relationship. Furthermore, a set of generalizations forms a hierarchical pyramid: At its base, the starting point of induction, are first-order generalizations consisting of elementary causal relationships such as "pushing a ball causes it to roll." Subsequent higher-order generalizations eventually culminate in scientific theories. Along the way to presenting his fascinating solution to the "problem of induction," Harriman addresses several key questions: What is the structure of inductive reasoning (chapter 1)? Why is mathematics the language of physics (chapters 2, 3, and 7)? How does proper interpretation of an experiment depend on a scientist's context of knowledge (chapters 1, 2, and 5)?

That scientists *should* employ the inductive method is not the main theme of *The Logical Leap*; rather, the book makes the stronger claim and demonstrates that scientists *must* use this method in order to make progress. And many scientists are indeed making progress even now, particularly in the applied fields. But what happens when the inductive method is misapplied, or worse, abandoned? String theory is a 20th century case in point: Some physicists accept it because it is "beautiful," not because it was induced from observational evidence. That sort of reasoning has caused many fundamental theories of contemporary physics to stagnate for more than a generation. Indeed, Harriman quotes the late Harvard University chemist E. Bright Wilson, who said, "It is very unsatisfactory that no generally acceptable theory of scientific inference has yet been put forward. Mistakes are often made which would presumably not have been made if a consistent and satisfactory basic philosophy had been followed."

The Logical Leap is the most satisfying resolution of the "problem of induction" that I've come across. It not only shows how inductive reasoning comes about but also demonstrates that it is the sine qua non of progress and success in physics and, more generally, in science. Harriman's brilliant work is destined to be the fountainhead of future studies in the philosophy of science.

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