Ripples in Spacetime

Einstein, Gravitational Waves, and the Future of Astronomy

Govert Schilling

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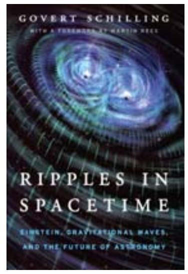

Govert Schilling's book *Ripples in Spacetime: Einstein, Gravitational Waves, and the Future of Astronomy* is a succinct, accessible, and remarkably timely survey of gravitational-wave astronomy as it developed over the past century. Published shortly after gravitational waves were observed from the coalescence of two black holes and just before both gravitational waves and light were detected from the merger of two neutron stars (see the stories on pages 16 and 19 of this issue), the book brings casual readers and experts alike up to date on the quest to discover gravitational waves and employ them as a tool for astronomical discovery.

This book is a rare find. As I reached the end, I was astonished to realize just how efficiently and effectively the author had captured the essence of so many projects and people over such a long period. Schilling, an accomplished popular-science writer, discusses interferometry, cosmology, pulsars, black holes, and the life and death of stars. He covers a century of experimental tests of gravitation, and he captivates readers with his description of the ongoing efforts to capture gravitational waves and observe other phenomena from coalescing black holes and neutron stars.

But I don't merely recommend *Ripples in Spacetime* for students and colleagues seeking an overview of the past, present, and future of the field. Schilling somehow anchors the scientific achievements in a relatable and human world. He describes the passion, excitement, and humanity of the cast of characters in a prolonged quest—the way they dealt with setbacks, their satisfaction with their success, and their hopes for the future as gravitational waves open a new window on the universe.

This ambitious volume's expansive and loosely chronological content touches on the essential developments in the history of Einstein's general theory of relativity. In chapter 1, after a brief tour through the history of astronomy, the author introduces general relativity and includes a few simple but quantitative examples of spacetime curvature in our solar system. Chapters 2 and 3 contain a lively historical account of the genesis of general relativity and tests of the theory over the past century, from Arthur Eddington's expedition to observe the bending of light by the Sun during an eclipse to *Gravity Probe B*'s test of frame dragging.

In chapter 4, Schilling introduces gravitational waves both conceptually and historically, beginning with Albert Einstein and Nathan Rosen's famous clash with the peer-review process at *Physical Review* (see the article by Daniel Kennefick, Physics Today, September 2005, page 43) through the unsuccessful but inspiring attempts by Joseph Weber to detect them. Two chapters on stars follow, with information on the life and death of stars, how neutron stars form, and how one famous binary pulsar was used to demonstrate that gravitational waves exist.

The Laser Interferometer Gravitational-Wave Observatory (LIGO) enters the story in chapter 7, which covers some of the technology that makes possible the experiment's remarkable sensitivity. Chapter 8 is a brief account of the genesis of LIGO, from Rainer Weiss's first design through several eventful years of development and management changes. In part to provide contrast with LIGO's approach, chapters 9 and 10 focus on cosmology, the cosmic microwave background, primordial gravitational waves, and the BICEP2 experiment's premature claims to have detected those primordial signals.

The detection of gravitational waves occupies chapters 11 and 12. The author provides a human-driven account of LIGO's initial discovery, and he conveys both the team's growing excitement and its determination to learn lessons from the field's history and to avoid Weber's and BICEP2's mistakes. I am a member of the LIGO collaboration, and Schilling's countdown to the press conference announcing the first gravitational-wave detection captures the building tension we felt as we raced to finish our work and prepare a paper and presentation for the ages. He deftly explains what LIGO found—a merger of two black holes—and what we learned from finding it.

The next three chapters look to the future; they describe methods to use pulsars to detect gravitational waves, to search for bursts of light produced when two neutron stars merge, and to build a gravitational-wave detector in space. Chapter 16 concludes the book with a bang. It describes the ongoing worldwide quest to build more instruments and some of the science they'd enable, and emphasizes how gravitational waves can be used to measure the expansion of the universe.

In short, the book's remarkable breadth and accessibility should make it the first piece of reading material for anyone—from high school students to policymakers—with an interest in gravitational waves. Experts will find a surprisingly comprehensive history of the field for such a short work, with only a handful of reasons for complaints (for example, the author's occasional use of "Einstein waves" instead of gravitational waves).

Readers interested in the history of and personalities behind LIGO might also be interested in Janna Levin's *Black Hole Blues and Other Songs from Outer Space* (2016), while *Gravity's Kiss: The Detection of Gravitational Waves* by Harry Collins (2017) covers the discovery of gravitational waves itself (see the review on the next page). But *Ripples in Spacetime* sets itself apart by putting the entire field into perspective—past, present, and future. It conveys a sense of awe about a century of scientific investment and achievement and a sense of excitement for what's to come.

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ON THE WEB: Q&A WITH GOVERT SCHILLING
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