ception of *Vestiges* in more ephemeral venues such as exhibitions, diaries, and conversations at fashionable soirées. He also details the financial problems confronting anyone who anticipated a life in science. Science was not totally a province of gentleman of independent means, but making a living from one's work as a scientist was far from easy.

I have only one significant criticism of Secord's book: the author occasionally lets his own morals and social commitments show through. Although he carefully refrains from denigrating earlier scientists for not holding present-day scientific views, he is willing to castigate them for not holding present-day moral views. I thought, however, that judging the past from the perspective of one's own present-day views is the worst sin that any historian can commit. I, too, find the social life of the upper crust in Victorian England supercilious, and I can only shake my head when I read about all the barriers that women confronted at the time, but should I allow these present-day convictions inform my reading of the past? Presentism is as pernicious as it is difficult to avoid. This minor objection to one side, Secord documents the genesis and reception of one of the most popular books of the Victorian era in as great a sweep and depth as anyone could wish.

BOOKS: PHYSICS

Music of the Spheres

Matt Visser

Gravitational waves—oscillations in the very fabric of space and time—are one of the key effects predicted by Einstein's theory of gravity: general relativity. We currently have good indirect tests for the existence of such waves, but to date none have unambiguously been directly observed (although there are numerous other direct tests of Einstein's general relativity). In her book *Einstein's Unfinished Symphony*, science journalist Marcia Bartusiak describes the present status of interferometry-based experiments designed to detect gravitational waves and examines the prospects for using the soon-to-be-functional detectors as observatories for exotic astrophysical events.

First, a matter of language: The relativity community now typically speaks of "gravity waves" rather than the more proper "gravitational waves." This is much to the annoyance of the fluid dynamics community, for whom the term "gravity wave" is reserved for any wave in which buoyancy acts as a restoring force. (Since Archimedes's cry of "Eureka!" scientists have realized that buoyancy was related to gravity.) In Einstein's gravity, a "gravity wave" is an oscillation of the gravitational field itself; because gravity is the curvature of space-time, a general-relativity gravity wave is an oscillation, a periodic squeezing and stretching, of both space and time.

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Heavy lens. The galaxy cluster Abell 2218 amplifies and bends light from more distant galaxies into concentric arcs, as predicted by general relativity.

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Although there is no real doubt that gravity waves are out there waiting to be discovered, it is also clear that direct detection will be very difficult. (There is also always a small knee-jerk anti-Einstein fringe out there, but let's quietly ignore them.) The current generation of gravity wave detectors is relatively expensive, with the U.S. detector, the Laser Interferometry Gravitational-Wave Observatory (LIGO) estimated to cost about $300 million. (Four other detectors of various sensitivities are coming online in Australia, Germany, Italy, and Japan, establishing a truly international network.) By the standards of the relativity community, $300 million is a lot of money but not by those of many other major research efforts (for example, in particle physics or biology). Nevertheless, when such quantities of money are at issue there is always some heated discussion. On the brighter side, the various interferomety-based detectors are close to completion and the prospects for direct gravity wave detection look extremely promising—with a tremendous amount of detailed slog-work still in progress.

As Bartisuak reports, the relativity community has also been at pains to point out that historically every time the astrophysicists and astronomers have developed a new type of detector there have been surprises—new and unexpected powerful signals coming to us from the deep cosmos. To date, astrophysics has only explored the electromagnetic and cosmic-ray spectra. Gravity waves will add a whole new spectrum of opportunity, not merely widening the window but providing a whole new perspective on the cosmos. Estimates of the signals anticipated in interferometry-based gravity wave detectors have been based on conservative physics, the systems and objects we already know are out there. The really exciting possibility is that we might find something completely unexpected. (Gravity wave quasars, anyone?)

The field of gravity wave detection is not free from controversy, and Bartusiak provides a sympathetic and careful discussion of the late Joseph Weber's claims to have detected gravity waves with his resonant bar antennas as early as the 1970s. The current consensus is that Weber's bar detectors were picking up noise, not signal, and that his filtering algorithm did not suppress the noise as much as he thought it did. This issue of signal-to-noise is the paramount problem that needs to be addressed with the current interferometry-based generation of detectors, and it is where the greatest theoretical and experimetal challenges to gravity wave detection still lie.

Einstein's Unfinished Symphony Listening to the Sounds of Space-Time
by Marcia Bartusiak
Joseph Henry, Washington, DC, 2000. 263 pp. $24.95. ISBN 0-309-06987-4.

Why is the whole subject referred to as an "unfinished symphony"? Consider the gravity wave sources that we know are out there (for example, tight-orbit coalescing-binary neutron star systems) and calculate the frequency of the expected signal. If we then convert the gravity wave to acoustic energy, the interesting parts of the signal would be in the audible range. Although this would not be the way the actual search is carried out, one can envision a graduate student hooking up the output of the gravity wave detector to the input of a loudspeaker and really "listening to the sounds of space-time".

All in all, *Einstein's Unfinished Symphony* provides a delightful and clearly written survey of the physics, the hopes, and the fears of the gravity wave community. You do not need to be an expert in general relativity to appreciate Bartusiak's account, which anyone with a basic grounding in science will benefit from, and enjoy, reading.