president Ronald Reagan, and for very different reasons by the researcher Robert Gallo. Has McKay's indignation over the unfair portrayal of Dugas allowed him to ignore some of the real groundbreaking achievements of *And the Band Played On* in sounding an alarm and raising awareness about AIDS from 'within' the community, so to speak? There is a tension in *Patient Zero* that I feel comes in part from the debt it owes to *And the Band Played On* – because without the earlier book the latter could not have been written – but also, I think, from the differences between the historical and journalistic perspectives. On the whole, however, I feel that McKay richly deserves the various accolades he has received for his book, including being shortlisted as a finalist – quite ironically – for the 2018 Randy Shilts Prize.

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Govert Schilling, **Ripples in Spacetime: Einstein, Gravitational Waves and the Future of Astronomy**. Cambridge, MA: Harvard University Press. Pp. 340. ISBN 978-0-6749-7166-0. £21.95 (hardcover).
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Ripples in Spacetime: Einstein, Gravitational Waves and the Future of Astronomy by journalist of astronomy Govert Schilling focuses on the historical events leading to the birth of multi-messenger astronomy, with a particular focus on the gravitational-wave field. Published shortly after the announcement of the first two black-hole merger detections (GW150914 and GW151226) and a third potential event (LVT151012) by the Laser Interferometer Gravitational-Wave Observatory (LIGO), Schilling provides a condensed history of detecting, observing and imaging cataclysmic events, such as supernovas and other binary system mergers, in our universe, including the initial direct detection of gravitational waves by LIGO alone. For those new to this field, this history is provided with simple explanations of the underlying physics needed to understand the observation methods and theories which multi-messenger astronomy seeks to explore.

Read in conjunction with Harry Collins's *Gravity's Shadow* (2004) and subsequent works, which focus on the growth of the gravitational-wave field, and Marcia's Bartusiak's *Einstein's Unfinished Symphony* (2017), which focuses on the same but also provides a history of the development of a related astronomy field, Schilling provides a deeper insight into the astronomy component of the new field of multi-messenger astronomy, or the coordinated observation of a single source through electromagnetic radiation, gravitational waves, neutrinos and cosmic rays, for example. In this regard, Schilling starts with the rise of radio astronomy, highlighting Jocelyn Bell's 1967 discovery of pulsars, which are rotating celestial objects generally maintaining a steady pulse able to keep time with the accuracy of an atomic clock. Schilling explains that her work led to the identification of numerous pulsar systems, including one identified by Russell Hulse in 1974 which was eventually classified as part of a stellar binary system. Hulse and his adviser, Joseph Tyler, realized that the period of this system was decaying, which ultimately resulted in Nobel Prizes for the first indirect detection of gravitational waves, which were causing the delay in this system.

Schilling then provides a concise history of the birth and growth of the field to directly detect gravitational waves, including the efforts made by Joseph Weber using bar detectors through the rise of laser interferometry. Although not as detailed as the account provided in Collins's work, Schilling's version provides an abridged version that will be helpful to those new to the history of gravitational-wave detection and the rise of multi-messenger astronomy and underlying science and theories. What is most beneficial in this compact history is how the interferometers in Germany (GEO600) and Italy (VIRGO) work as a collaborative network with LIGO, especially to locate sources of gravitational waves so that astronomers can turn their instruments to the correct

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location of a source to explore additional characteristics of the events producing gravitational waves.

Although published just ahead of the infamous detection of the collision of two neutron stars on 17 August 2017, which the wider astronomy field was able to observe through gamma ray detection and electromagnetic follow-on observations, resulting in a breakthrough for the field of multi-messenger astronomy, Schilling's work provides projections of the potential benefits and types of follow-on observation to a gravitational-wave detection by LIGO. In *Ripples in Spacetime*, Schilling expresses the need to better locate sources, which occurred with the 17 August 2017 detection because three interferometers were observing, with VIRGO now online instead of the two LIGO ones. As it turns out, projections provided by Schilling in the present work coincided with the momentous detection of the neutron star collision. These included observed gamma ray bursts, which are highly directional-dependent for observation, by the Fermi Gamma Burst-Ray Monitor, and X-ray afterglow by NASA's Chandra X-Ray Observatory.

Schilling's work also provides an overview of the history of, and current efforts to discern, gravitational waves from the cosmic microwave background (CMB), which could provide information about what might have happened during the period 380,000 years after the Big Bang, the nearest point in time to the Big Bang that we can study. Schilling explains that the most revolutionary work conducted thus far on the CMB was done by the Cosmic Background Explorer (COBE), which revealed hot and cold spots across the universe. From this work, scientists are now trying to detect B-mode patterns in the CMB, which may be caused by the propagation of primordial gravitational waves from the early period, through the Background Imaging of Cosmic Extragalactic Polarization (BICEP2) telescope, which is also a multinational effort through its collaboration with the European Space Agency's Planck space observatory.

Ripples in Spacetime also overviews the technical justification of projects currently in the works to boost the multi-messenger astronomy collective. These include the completion of the Japanese interferometer (KAGRA) and the Indian interferometer (IndIGO), which respectively claim to have greater sensitivity and greater source location ability. Further, Schilling details the efforts to launch the space-based Laser Interferometer Space Antenna (LISA). LISA will focus on low-frequency gravitational-wave detections that are not possible with the land-based interferometers due to earthly seismic noise, and LISA's role in providing land-based observatories with incoming gravitational waves will allow for an even quicker response time for follow-on observations.

In closing, Schilling's work will be of interest to those curious about the historic context of the birth of multi-messenger astronomy. For the historian of science seeking a concise history of the field of gravitational-wave physics along with an overview of the underlying physics, Schilling's work achieves this goal as its style is that of refined popular science. Lastly, Schilling work shows just how international the efforts of the growing field of multi-messenger astronomy are and provides insights into how the field may evolve moving forward in the quest to understand our universe and its origins.

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