Principles of Space–Time–Matter: Cosmology, Particles and Waves in Five Dimensions, by Paul S. Wesson & James M. Overduin (World Scientific), 2019. Pp. 274, 23·5 × 15 cm. Price £85 (hardbound; ISBN 978 981 3235 77 9).

Paul S. Wesson, whose obituary (written by the second author) appeared in these pages[1] a while back, is the posthumous co-author of a new book which summarizes the main topic of his life's work. The first eight chapters had been essentially completed by Wesson before his death; the second author wrote a concluding chapter, which is a short summary, and a biographical appendix. Wesson was certainly an interesting character: from a working-class Nottingham background, he became a doctoral student of Martin Rees at Cambridge (after Hoyle, Narlikar, and Wikramasinghe had left due to a dispute with Ryle; Wesson had approached all four as potential supervisors), and had published 50 papers and a book by the time he was 30. After research trips to Canada before and after obtaining his doctorate, he spent some time in Norway, where, together with Rolf Stabell, he concentrated on another important topic in his career, namely extragalactic background light (*i.e.*, a quantitative investigation of Olbers's paradox, arriving at the correct conclusion — still not appreciated by many — that the resolution is due mainly to the finite age of the Universe and not to its expansion), married a Norwegian woman, and became so proficient in Norwegian that he used it for his annotations of books and articles. In 1980, he became assistant professor at the University of Alberta; he was to stay in Canada for the rest of his life, moving to Waterloo in 1984. Until the end, he focussed on science while retaining a serious interest in a wide range of other topics.

Wesson's science is, for most, probably more difficult to understand than his life. Although he wrote on many topics, a five-dimensional extension to General Relativity (with a non-compact fourth spatial dimension) was the main topic of his career. The first eight chapters of the book, starting with an overview of standard GR, describe the extended theory and its applications to cosmology, astrophysics, electromagnetism, and so on. The main idea is that a 4-dimensional (three of space and one of time) universe with matter and energy can be explained as a consequence of a 5-dimensional universe with neither. Easier said than done: the description here, though thorough and well written, is very mathematical, and takes appreciable effort to digest. Rather than a geometrization of physics or a physicalization of matter, the goals are a unification of fields with their sources and of gravitation with electromagnetism, similar to the goals of Einstein in his search for a unified field theory.

Space–Time–Matter theory hasn't taken the community by storm. Although there are some experimental tests, such as a predicted violation of Lorentz invariance*, the magnitude cannot be predicted from first principles, and observations indicate that any deviation must be very small, enhancing the feeling that a possible violation is probably not 'just around the corner'. (It also would not immediately follow from observed Lorentz invariance that Space–Time–Matter theory, rather than some other explanation, were correct.) It is also not clear whether, as usually assumed, the fifth dimension is a spatial dimension; it could also be a dimension of time, or associated with spin, or mass (*i.e.*, displacement along the fifth dimension could give rise to mass in a geometrical analogue of the Higgs mechanism). In addition, even enthusiasts admit that there are problems: the nature and role of a new scalar field is not clear; there is no theory of fermionic matter, particle spins, *etc.*; descriptions of induced 4-D matter sources are macroscopic. As such, Space–Time–Matter is perhaps similar to string theory, MOND[2], shape dynamics[3], and loop quantum gravity[4] in that, while there might be something to it, it is clear that it is not yet a complete theory. (Also, apart from MOND, those ideas all suffer from a lack of easily testable predictions.)

While the editing is above average, there are still a few typos and so on. The main text contains a handful of black-and-white diagrams while the biographical appendix contains many photos, most in colour. Each chapter (except the last, which is a summary) begins with an introduction and ends with a conclusion followed by references. The references in the appendix are to all of Wesson's work. There are neither footnotes nor endnotes and the book ends with a six-page index. The only factual mistake I noticed is a wrong parenthetical description of the Hubble law, a common mistake[5–8].

According to the second author[9], there are two target readerships. One is those who are already interested in Space–Time–Matter; for those, the book is a good and well-written overview of the work of Wesson and his collaborators. The other is those with a general interest in extensions of standard physics; for these, accessibility is strongly dependent on the reader's technical background, though the good structure of the book and copious references (including many to work by more-mainstream physicists on related topics) make that possible for those willing to invest some time. — PHILLIP HELBIG.

References

(1) J. Overduin, *The Observatory*, **136**, 102, 2016.
(2) P. Helbig, *The Observatory*, **137**, 91, 2017.
(3) P. Helbig, *The Observatory*, **138**, 327, 2018.
(4) P. Helbig, *The Observatory*, **139**, 128, 2019.
(5) E. R. Harrison, *ApJ*, **403**, 28, 1993.
(6) P. Helbig, *The Observatory*, **132**, 183, 2012.
(7) P. Helbig, *The Observatory*, **133**, 294, 2013.
(8) P. Helbig, *The Observatory*, **138**, 22, 2018.
(9) J. Overduin, personal communication.

*No deviations are expected from Solar System tests or from inflation. In principle, the $m - z$ relation might be able to distinguish a 5-D-inspired dark energy from other forms, and more accurate experiments in the style of *Gravity Probe-B* could perhaps detect a predicted anomalous precession. Also, at some level, there should be a violation of the equivalence principle. None of those tests are likely to be performed in the foreseeable future, so while the theory is testable in principle, it isn't in practice, at least not yet.