

here on Earth, there are either immediately more moons than before or the same number. That seems like a real physical difference of macroscopic significance. More to the point, it seems like it should matter for the issue of whether Everett's many worlds really resolves the tension of Bell's theorem.

The middle section ends with a chapter on alternative interpretations, such as de Broglie-Bohm theory, spontaneous collapse theories, and quantum Bayesianism. Although Carroll charitably says he is glad others are studying those approaches, it comes off as disingenuous because he gives all of those theories bad reviews. For example, he makes a big deal of the alleged difficulties coming up with a Bohmian version of quantum field theory, but he later argues that QFT should emerge from a more fundamental discrete theory, whereas stochastic Bohm-like models for such discrete theories are known. Not that I want to advocate Bohmian theories myself, but the alternatives to Everett are not as hopeless as Carroll makes them out to be.

In the third part of the book, Carroll

describes recent work by himself and others that aims to derive spacetime as emergent from quantum theory. If we look at the vacuum state of a QFT, it tends to have entanglement correlations between regions of space that decrease with the distance between those regions. The idea is to invert that relation and define space in terms of the entanglement entropy between systems in a substrate of finite-dimensional quantum systems. More ambitiously, Carroll envisages defining the areas of surfaces in spacetime in terms of entanglement and using those areas to construct a metric. That is one version of the "it from qubit" approach, which has become popular in recent years.

Noticing that two quantities are always the same and then trying to construct a theory in which they are identical has been a route to progress in the past. The fact that inertial and gravitational masses are always the same is just a coincidence in Newtonian mechanics, but their necessary identities played a part in constructing general relativity.

Correlation, however, does not al-

ways imply identity. Often, a numerical correlation between two quantities is explained by the laws of a theory rather than by a literal identity of concepts. In the case of entanglement and metric, it seems that we have a perfectly good explanation in terms of laws: The locality of the Hamiltonians of QFT, combined with the fact that the initial state is close to the vacuum state, means that entanglement will drop off with distance. If a credible quantum theory of gravity grew out of that approach, I would change my tune, but I do not see strong evidence of that.

Although I am skeptical of many of the ideas described in this book, I still think it is an excellent one. A great deal of uncertainty about the foundations of quantum theory remain—more than most physicists are willing to admit—so naturally we all disagree. This is a masterful popular account of one approach, but for true balance, you are going to have to read a lot of other books alongside it.

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STARS OF THE SOUTHERN SKIES

BY
M. A. ORR
(MRS. JOHN EVERSHED)

AUTHOR OF "OUR FIRST GUIDE TO MODERN STARS"
AND "DANTE AND THE EARLY ASTRONOMER"

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We glimpse the untravell'd world whose margin fades
Poet and forever."

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Astronomer's biography skimps on the science

Although the lives of select female astronomers, such as Caroline Herschel, have been well documented, books about women who conducted astronomical studies before the 20th century are

generally few and far between. In *The Hidden Giants* (2006), Sethanne Howard reported on the lives and contributions of women scientists, including astronomers, throughout 4000 years of history. More re-

Dante and the Early Astronomer

Science, Adventure, and a Victorian Woman Who Opened the Heavens

Tracy Daugherty

Yale U. Press, 2019. \$26.00



cently, Dava Sobel told the story of Harvard computers in *The Glass Universe: How the Ladies of the Harvard Observatory Took the Measure of the Stars* (2016).

When I first heard about Tracy Daugherty's new book, *Dante and the Early Astronomer: Science, Adventure, and a Victorian Woman Who Opened the Heavens*, what most piqued my interest was the subtitle. I was expecting to read about the scientific contributions of yet another female astronomer whose story has been hidden or relegated to footnotes. I also expected to learn more about Dante and how Mary Acworth Evershed (née Orr), the Victorian woman in the title, interpreted his astronomy as written in his poetry.

The title, however, is misleading.

Although Daugherty includes some information about Mary Evershed and her work, how she “opened the heavens” is not the primary focus. The author, a distinguished professor of English and creative writing emeritus at Oregon State University, has penned an imaginative account that focuses instead on Mary’s husband, John, and other male astronomers with whom the couple interacted, including E. Walter Maunder. I found this read to be less the story of a woman astronomer and more the story

of John (mostly) and Mary (sometimes). The science is scarce, and the adventure consists of travelogues and descriptions of everyday life at an observatory in India at the start of the 20th century.

Mary made two major contributions to astronomy. Based on her own observations, she created the first thorough atlas of southern stars, which was published in 1897. She also documented the history of the named lunar craters in a 1938 publication. Both contributions indeed “opened the heavens,” but the author spends just

a few paragraphs describing them and glosses over the scientific details. In contrast, Daugherty uses a little over four pages to describe what we currently know about the Sun.

Dante and the Early Astronomer also spends a great deal of time describing John’s struggles as director of the observatory in Kodaikanal, India. We read details about its less-than-modern infrastructure and its poor-quality and poorly maintained equipment. We also learn, multiple times, about John’s own dissatisfaction with his place in history and his potential legacy as a solar astronomer.

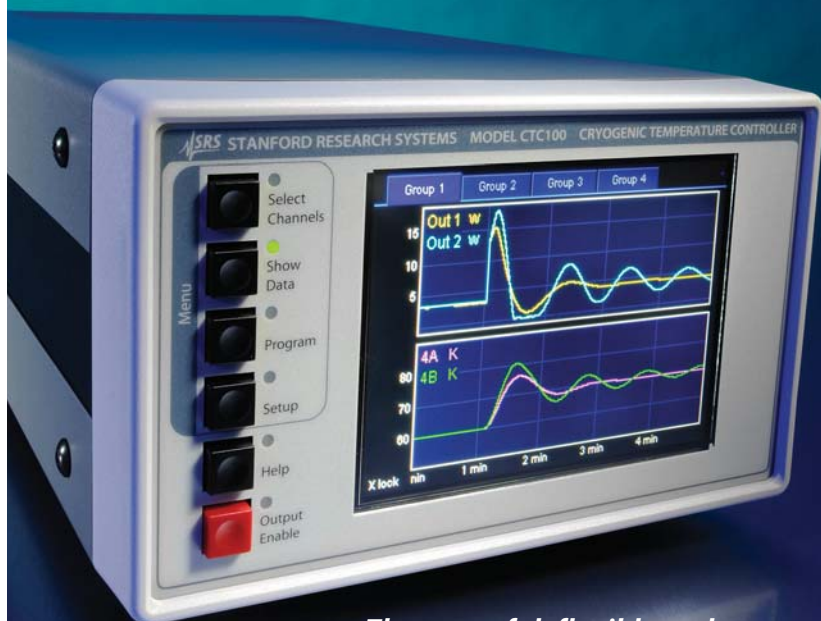
The title of the book is borrowed from Mary herself, who published the original *Dante and the Early Astronomers* in 1913. But Daugherty provides us with few references to her interpretations of Dante’s publications. The author tells us—often, and without citation—that Mary ruminated on the accuracy of Dante’s cosmography in *The Divine Comedy* but does not clearly relay the importance of her contributions. The frequent mentions of Mary’s doting attention to John’s mental and physical health overshadow the science and adventure I was promised in the subtitle.

As stated on the jacket, the book is a “creative tale” written by an author who brings “keen skill as a fiction writer.” But Daugherty takes too much artistic license when telling the story of Mary and John as a couple. He provides a great deal of speculation without much support. For example, based on a casually draped arm in one photo, Daugherty suggests that John had an adulterous affair with a family friend who cared for Mary while she was ill; he eventually married the woman after Mary’s death. Furthermore, the author’s description of astronomer Annie Maunder as “frumpy,” Mary as “gaunt,” and John as “handsome and distinguished” in a photo from one of their last excursions together reminded me of recent conversations about journalists’ tendency to describe women in ways in which they do not describe men.

Even with those flaws, Daugherty’s material on the operations of the observatory, including the focus on obtaining solar data and the lifestyle of its astronomers, is enlightening. Descendants of John’s employees carry on the work at Kodaikanal today. I also appreciated the interwoven story of the Eversheds’ reac-

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tions to astronomical observations that changed our views of the heavens and the challenges they faced chasing solar eclipses to prove the theory of general relativity. Mary's persistence and self-direction in teaching herself about astronomy was also well described.

If you can read *Dante and the Early Astronomer* as a work of creative history, then you may gain some insight into the

life of Mary Orr Evershed. The bibliography is extensive, and I surmise that readers can learn more about Mary from the historical primary sources. However, as a stand-alone read, the title's promise of "science" from a "woman who opened the heavens" goes unfulfilled.

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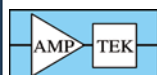
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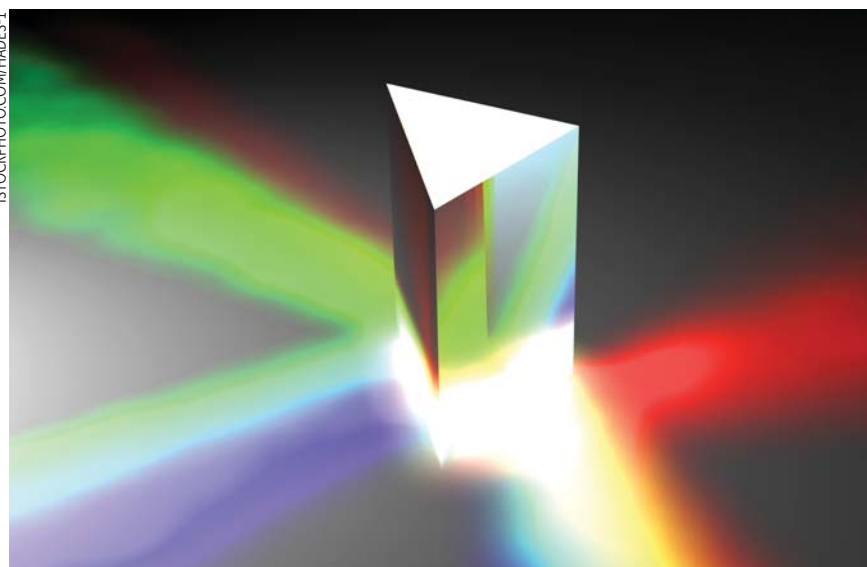
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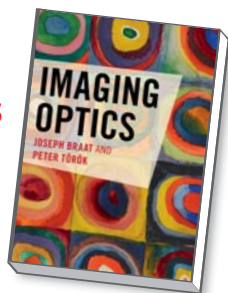
Connecting optical theory to practical applications

My first reaction upon receiving a copy of *Imaging Optics* by Joseph Braat and Peter Török could have been, "Do we really need a new book on optical imaging?" But after reading their work, I am convinced that we do. *Imaging Optics* brilliantly complements an already well-supplied field that includes such classics as *Principles of Optics* by Max Born and Emil Wolf (7th edition, 1999).

Imaging Optics establishes a clear connection among the electrodynamic theory of optical propagation, the various approaches to diffraction theory, and the practical methods used in the design and optimization of imaging systems. The book's way of linking those topics is original, as is the way the text moves from the conceptual aspects of optics to immediately usable practical results. The ability to transition smoothly between theoretical foundations and practical methods is

Imaging Optics

**Joseph Braat and
Peter Török**
Cambridge U. Press,
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one of the book's best features. Examples include the transition from Maxwell's equations to geometrical optics and lens design and the combined use of vector diffraction and coherence theories to describe recent imaging approaches that utilize light polarization. The depth of the content and great coherence in the presentation reflect the extensive teaching experience of both authors. In addition, each of the book's three parts begins with a historical discussion that provides illuminating context for their topics.