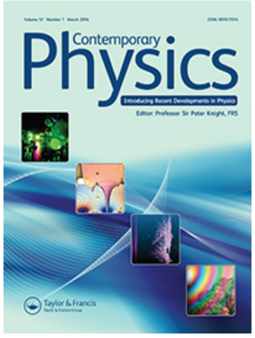

Contemporary Physics

ISSN: 0010-7514 (Print) 1366-5812 (Online) Journal homepage: http://www.tandfonline.com/loi/tcph20

Nature's third cycle: a story of sunspots, by A. R. Choudhuri

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To cite this article: Miguel A. F. Sanjuán (2017): Nature's third cycle: a story of sunspots, by A. R. Choudhuri, Contemporary Physics, DOI: 10.1080/00107514.2017.1408688

To link to this article: https://doi.org/10.1080/00107514.2017.1408688

Published online: 11 Dec 2017.

CONTEMPORARY PHYSICS, 2017
https://doi.org/10.1080/00107514.2017.1408688

BOOK REVIEW

Nature's third cycle: a story of sunspots, by A. R. Choudhuri, Oxford, Oxford University Press, 2017, 304 pp., £14.99 (paperback), ISBN 9780198807643. Scope: general interest. Level: general readership, undergraduate, postgraduate, early career researcher, teacher, scientist.

This is a fascinating, engaging and enjoyable book where readers can learn about the sunspot story, solar activity and its effects on the Earth. Cycles and periodicities abound in Nature, the most well-known being the diurnal cycle of the full rotation of the Earth on its axis with respect to the Sun, and the annual cycle as the Earth rotates around the Sun. The third cycle to which this book refers concerns the sunspot cycle that has a cyclic behaviour of an average period of 11 years. Furthermore, sunspots are sites of strong magnetic fields generated in the solar interior.

The scientific study of the Sun based on the principles of physics, which constitutes the field of solar physics, began as modern science with Galileo. From observations of the sunspots with telescopes, it was found that a sunspot keeps changing its position. Galileo concluded that sunspots must be marks on the solar surface that seem to change their positions because the Sun is rotating about its own axis, just like the Earth. He also gave an estimation of the rotation period of the Sun about 27 days. The rotation of the Sun actually plays a central part in the story of how the 11-year sunspot cycle is produced, including the idea of differential rotation that means that regions near the equator move faster. I have found of special interest the description of the work done by so many important scientists who contributed to the early development of what we know today as the physics of the Sun. Among them are the stories of Richard Carrington, who discovered the solar flares for the first time and the differential rotation of the Sun; Heinrich Schwabe, who discovered the 11-year sunspot cycle; and George Hale, the discoverer of magnetic fields in sunspots. In fact, solar astronomers refer to this 11-year cycle as the Schwabe cycle. However, the time a magnetic cycle takes to return to the same configuration is 22 years, which is called the Hale cycle.

One of the main goals of the book is to explain what the author calls the central dogma of solar dynamo theory, which is at the foundation of the 11-year solar cycle. The main idea is that the Sun's magnetic field is made up of a toroidal magnetic field part and a poloidal part. Sunspots are formed out of the toroidal magnetic field, whereas the polar magnetic field of the Sun is a manifestation of the poloidal magnetic field. Basically, the sunspot cycle is produced by an oscillation between these two kinds of magnetic fields.

The book is very well written and designed, containing nine chapters, where the reader can get an excellent overview of the current understanding of solar physics. The first two chapters explain the early historical developments of solar physics, such as sunspots, solar flares, solar wind, solar corona, the differential rotation of the Sun, the solar magnetic field and sunspots as regions of strong magnetic fields. The rest of the chapters attempt to provide explanations for many of the phenomena introduced in the first two chapters. The sunspot cycle is produced by magnetohydrodynamic processes in the Sun's interior so that both issues are discussed in Chapters 3 and 4. The explanations of the sunspot cycle and the central dogma of the solar dynamo are given in Chapters 5–7. The discussion about the origin of the oscillations of the magnetic fields that give rise to the solar cycle at the heart of the dynamo theory appears in Chapters 6 and 7. The important question of solar flares associated with the sunspot cycle, and how this might strongly affect the Earth, is the subject of Chapter 8. It is well-known that the cycle is only 11 years on average so that there are irregularities in the period of the cycle. Different theories have been used to explain these irregularities, including the speculation that irregularities of the sunspot cycle are chaotic, originating from the nonlinearities of the dynamo equations. All this is considered in Chapter 9, besides a discussion on the different strengths of the cycles and their possible prediction. The author indicates that these last chapters contain the more controversial material on these issues, and points out the disagreements and alternative viewpoints. There is a very rich and useful list of key references included at the end of the book.

I am convinced that the author has succeeded in writing a very interesting book, from which one can obtain a broad overview of what we know about the Sun. He shares with the reader the excitement of the current understanding of the sunspot cycle, including many autobiographical reminiscences, of joys and difficulties, since he has played an important role in the story. It constitutes an excellent account that might be appealing to a broad range of readers, from high school and college students to professional scientists. Most graduates in physics from universities all over the world have never had a course on astronomy or astrophysics, so that I presume that a big part of what one can learn from this book is unknown even by many physicists. I strongly recommend this book to a broad audience.

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https://doi.org/10.1080/00107514.2017.1408688