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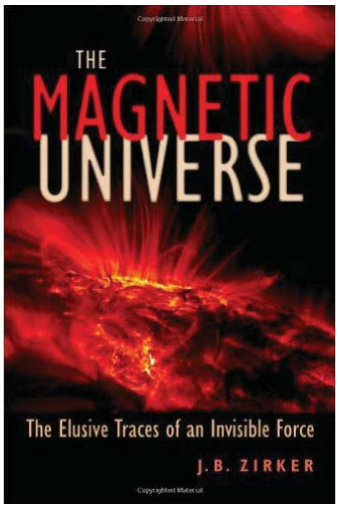
BOOK REVIEW

The Magnetic Universe: The Illusive Traces of an Invisible Force
by J. B. Zirker. Johns Hopkins University Press, 2009. 312 pp. $37 (paperback). ISBN 978-0801893025.

Magnetism is a complex concept to explain to the general public. The human eye cannot "see" a magnetic field; the human body cannot "feel" it even though all of us are constantly crossing Earth's magnetic field lines on a daily basis—going to work, to school, to the grocery store, to the park. Our home planet is surrounded by a magnetic "cocoon" called the magnetosphere, which plays an important role in shielding the Earth's atmosphere from the devastating effects of solar flares. Without it, solar flares could cause havoc in electrical power grids, damage communication satellites, and threaten astronauts in orbit. This explosive solar activity is fueled by the energy of solar magnetic fields.

How could something so weak and "invisible" be so devastating? What role does the magnetic field play in other astronomical objects? Where does the field come from and where does it go? There are many questions to consider about this topic, and as explorers throughout human history have shown us one of the best ways to answer these questions is to go on a discovery journey. Jack Zirker's book on *The Magnetic Universe: The Illusive Traces of an Invisible Force* takes the reader on such a journey through the magnetic Universe with stops at the Sun, the Earth, and the other planets in our solar system, the stars, the galaxies, the black holes, and other more exotic astronomical objects. As a true master of metaphor, Jack starts this journey by offering his readers a pair of imaginary glasses that enable them to see magnetic fields. Could you imagine what one would see if such glasses were really to exist?

Of course, a discovery journey must also account for time: the past, the present, the future. So, in his book, Zirker reviews the history behind the study of magnetic fields and connects it to currently known concepts. As he explains, researchers collected some of the first information about magnetic fields surrounding the Earth from the orientation of a magnetic compass needle and the patterns of the aurora displays. Then, during the Nineteenth Century, systematic measurements of the magnetic field were collected at magnetic stations, which were built in several locations around the globe.



Those measurements revealed that the orientation of the geomagnetic field slowly changes with time. As Zirker describes, Earth's magnetic field has its origin in the motions of material that occur in the core of our planet. Collectively, the action of these motions is called a dynamo. Zirker initially reviews the basic principles of a dynamo in his chapter on Earth magnetisms, and then utilizes those principles in later chapters to explain dynamo processes that take place in other planets and even stars.

Interestingly, the collected measurements of geomagnetic fields also revealed variations on shorter time scales (hours and days) that were later associated with space weather or the influence of solar activity on Earth's atmosphere and magnetosphere. In this book, Zirker introduces the concept of space weather, which originates in solar flares and coronal mass ejections—all powered by solar magnetism. He also briefly reviews sunspots, flares, coronal mass ejections, and other features of solar activity associated with solar magnetism, and describes how solar activity changes with the 10–11 year solar cycle. Next, he teaches about solar wind, a constant flow of material and magnetic field escaping the Sun. Subsequently, he guides the reader to "follow" solar wind into interplanetary space—to visit all major planets on its way to the outskirts of the solar system. The reader learns that space weather and aurorae are not limited to Earth, but are also present on some of the other planets.

Similarly, the magnetic field is also not limited to our neighboring part of the Universe. Its presence has been detected in other stars and galaxies. In his book, Zirker reviews the origin and the evolution of magnetic field in these various astronomical objects. He describes how in some cases, a magnetic field may help with formation of a star from the proto-stellar cloud material; yet in other cases, it may inhibit a star's formation. In addition, the author clarifies various similarities and differences between the Sun and other stars: how, similar to the Sun, many other stars have starspots, which may be much greater in size than the largest sunspots; how some of the other stars exhibit activity cycles similar to the solar cycle, while other stars appear magnetically inactive.

Yet, it is important to note that as stars and galaxies evolve, their

magnetic fields transform as well; so, the author then continues with the description of magnetic field topologies in peculiar stars, white dwarfs, pulsars, and neutron stars. In the final chapters of this book, Zirker ultimately explores the nature of weak magnetic fields that are present in our own and other galaxies. There, he specifically describes the concept of the so-called Biermann Battery, which is the separation of electric charges in the early Universe that could have created the seed magnetic field. Using popular and accessible language, the author describes some intricate physical processes such as ambipolar diffusion, Faraday rotation, and the duality of electricity and magnetism.

In summary, any astronomy enthusiast will enjoy reading this book. It could also be used as supplementary reading material in undergraduate-level astronomy courses. In fact, some of my colleagues already use this book in the undergraduate courses that they teach. One day, when I was talking to Professor James McAteer, my colleague who teaches at the New Mexico State University, he pulled out Zirker's *The Magnetic Universe* and asked if I had a chance to read it yet. I said that I have. "I am using it for my undergraduate astronomy class. I think this is an excellent book," he said. I replied that I could not agree more.

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