

# SUN'S MAGNETIC FIELD

A magnetic field is a vector field that describes the magnetic influence on magnetic materials, electric currents, and moving electric charges. Magnetic fields can be represented by continuous lines of force or magnetic flux, which is the flux of a magnetic field through a surface. In the SI, the magnetic flux is measured in weber (Wb) which is equivalent to the magnetic flux through a loop producing an electromotive force equal to 1 volt when uniformly reduced to zero in 1 second. An important derivative of weber is flux density measured in tesla (T).

## SOLAR MAGNETIC FIELD

The Sun is a **magnetic star** and its magnetic field is generated by the movement of **conductive plasma** in a part of the Sun called the convective zone. This motion is a result of convection, a form of energy transport that entails the physical movement of material. The convective motion of plasma works like a **dynamo** and is generated both a global and some localized magnetic fields. In addition the circulation of plasma creates the star's primordial magnetic field and generates a global magnetic field. As the star rotates with different velocities at various latitudes, the magnetism wraps itself around a toroidal field of **flux ropes** that surrounds the star.

On topography, a ridge is a surface and a valley, often contains a stream.

There are two different magnetic zones in the solar corona (which is an area of plasma that surrounds stars).

**Open field regions**, which connect the solar surface with the interplanetary field and are the source of the fast solar wind.

**Closed field regions**, which open up at higher altitudes and then connect to the heliosphere.

The sun's magnetic field **changes polarity about every 11 years**, which brings a diminished magnitude of the field for a number of years. During this, we have the maximum sunspot activity and massive eruptions of high energy plasma take place in the corona and in the interplanetary space. An important thing in the solar field reversal is the heliospheric **current sheet** which is the surface projecting outward from the sun's equator where a magnetic field (vector) differs from other parts of the surface produces an electrical current and where the polarity of the Sun's magnetic field varies from north to south, becoming very easy. The current sheet is small and thin, but extends billions of kilometers beyond Pluto, in the domains of interstellar space. The changing of polarity can cause stormy space weather around the Earth. In addition, the current sheet acts as a barrier to cosmic rays when they attempt to go inside the solar system.

The Sun's magnetic fields store a large amount of energy that can be released in a gradual or explosive way. Explosive energy release takes place through:

- Flares**, that are powerful eruptions of radiation at all wavelengths that happen in the sun's atmosphere.

- Coronal mass ejections (CMEs)**, which are the release of plasma and magnetic field from the Sun's outer layer (corona). They happen in active regions of the solar surface like groups of sunspots which have closed magnetic field lines. When these field lines are broken they suddenly release energy, which causes a CME, usually accompanying a solar flare. CMEs directed towards Earth cause geomagnetic storms.

Along the structure of the magnetic field line solar **prominences**, gaseous structures extending outward from the surface of the sun. The eruption of a prominence takes place when the structure gets unstable and bursts outward, making plasma that is more turbulent and dense than coronal plasma.

## EFFECTS ON EARTH

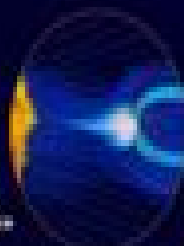
The sun's magnetic field is responsible for the solar eruptions that create **space weather** on Earth.

When the field breaks, it releases a small quantity of energy, shown as a flare. Many flares are felt the solar corona, resulting in the emission of X-ray and ultraviolet radiation that can change the state of satellites and disturb communications, navigation and surveillance systems.

The **solar wind** is generated in the solar corona. It is a continuous stream of charged particles accelerated to near the Sun. The solar wind carries the **interplanetary magnetic field (IMF)** while flowing through interplanetary space. When it comes Earth and other planet eruptions of radiation into a planet's magnetic field, it can cause the **magnetic reconnection** that is a process where the field on the back side goes together. Charged particles then stream back to the planet's magnetic poles causing the aurora borealis in the upper atmosphere.


When magnetic fields **emerge** through the photosphere, they form:

- Sunspots**, which are dark areas we can observe on the sun's surface. The reason why they are darker is that they are relatively cooler because there the magnetic fields are particularly intense and because they keep some of the heat within the Sun from reaching the surface.
- Coronal loops**, which are bright arc structures above the sun's surface made of hot plasma. They form around curving magnetic field lines and are usually associated with surfaces of opposite magnetic polarity.



# Solar Magnetic Fields

**International Astronomical Union.  
Symposium**



## **Solar Magnetic Fields:**

**Magnetic Fields in the Solar System** Hermann Lühr, Johannes Wicht, Stuart A. Gilder, Matthias Holschneider, 2018-01-10 This book addresses and reviews many of the still little understood questions related to the processes underlying planetary magnetic fields and their interaction with the solar wind With focus on research carried out within the German Priority Program PlanetMag it also provides an overview of the most recent research in the field Magnetic fields play an important role in making a planet habitable by protecting the environment from the solar wind Without the geomagnetic field for example life on Earth as we know it would not be possible And results from recent space missions to Mars and Venus strongly indicate that planetary magnetic fields play a vital role in preventing atmospheric erosion by the solar wind However very little is known about the underlying interaction between the solar wind and a planet's magnetic field The book takes a synergistic interdisciplinary approach that combines newly developed tools for data acquisition and analysis computer simulations of planetary interiors and dynamos models of solar wind interaction measurement of ancient terrestrial rocks and meteorites and laboratory investigations Solar Magnetic Fields Jan Olof Stenflo, 1994-03-31 Magnetic fields are responsible for much of the variability and structuring in the universe but only on the Sun can the basic magnetic field related processes be explored in detail While several excellent textbooks have established a diagnostic foundation for exploring the physics of unmagnetized stellar atmospheres through spectral analysis no corresponding treatise for magnetized stellar atmospheres has been available The present monograph fills this gap The theoretical foundation for the diagnostics of stellar magnetism is developed from first principles in a comprehensive way both within the frameworks of classical physics and quantum field theory together with a presentation of the various solar applications This textbook can serve as an introduction to solar and stellar magnetism for astronomers and physicists at the graduate or advanced undergraduate level and will also become a resource book for more senior scientists with a general interest in cosmic magnetic fields **Magnetic Fields in the Solar Atmosphere** Jacques Maurice Beckers, 1976 This paper describes the magnetic field configurations observed in the solar atmosphere including the corona and the solar wind The techniques for observing solar magnetic fields are briefly reviewed The significance of Alfvén waves in transporting energy is stressed Author **Solar Magnetic Fields** R.F. Howard, 2012-12-06 This symposium was held at the Collège de France in Paris from August 31 to September 4 1970 The Organizing Committee consisted of V Bumba R Howard Chairman K O Kiepenheuer R Michard E N Parker A B Severny V E Stepanov and T Takakura The Local Organizing Committee consisted of Miss G Drouin Secretary R Michard Chairman J C Pecker and J Rayrole We are indebted to the Collège de France for their kind hospitality I wish to express my gratitude to members of the Organizing Committee for advice and assistance and to R Michard and the Local Organizing Committee who were responsible for the smooth running of the sessions the distribution and collection of the discussion sheets and for a delightful Wednesday afternoon excursion to Meudon It is a pleasure to thank J W Evans V E

Stepanov K O Kiepenheuer R G Giovanelli T G Cowling V Bumba W C Livingston and J M Wilcox who kindly served as session chairmen I also wish to thank Miss Judy Harstine and John M Adkins of the Hale Observatories for invaluable assistance in editing the proceedings This Symposium has been supported financially by the International Astronomical Union

**Magnetic Fields in the Solar Atmosphere** Jacques Maurice Beckers, 1976 This paper describes the magnetic field configurations observed in the solar atmosphere including the corona and the solar wind The techniques for observing solar magnetic fields are briefly reviewed The significance of Alfvén waves in transporting energy is stressed Author

**Studies of Solar Magnetic Fields During the Rise of Solar Cycle 22**, 1991 New information about the solar cycle and the changing magnetic fields includes 1 Every solar cycle has a duration of 18-22 years even though the peak between successive cycles is approximately 11 years This means that there are two solar cycles on the sun nearly all of the time the exception is the few years preceding solar maximum 2 a large scale velocity field was discovered around the perimeter of one of the major active regions that developed during the rise of the current solar cycle If averaged over a several month interval the velocity would be of the same order of magnitude as the velocity pattern of the torsional oscillation signal that varies systematically over the solar cycle The newly discovered velocity pattern can be interpreted as either a severe contamination to the torsional oscillation signal or another way of observing the torsional oscillation velocity field 3 Our analyses of small scale magnetic fields on the quiet sun has shown that network magnetic fields are continuously being replaced by intranetwork magnetic fields The replacement occurs when intranetwork magnetic fields collide with network magnetic fields both polarities are observed to cancel each other at a mean rates of 10 to the 18th power Maxwells hour The non cancelling components of the intranetwork magnetic field replace the cancelled components of the network No net long term increases or decreases in magnetic flux occur as a consequence of these processes

**Cosmic Magnetic Fields** Jorge Sánchez Almeida, María Jesús Martínez González, 2018-04-12 Magnetic fields pervade the universe and play an important role in many astrophysical processes However they require specialised observational tools and are challenging to model and understand This volume provides a unified view of magnetic fields across astrophysical and cosmological contexts drawing together disparate topics that are rarely covered together Written by the lecturers of the XXV Canary Islands Winter School it offers a self contained introduction to cosmic magnetic fields on a range of scales The connections between the behaviours of magnetic fields in these varying contexts are particularly emphasised from the relatively small and close ranges of the Sun planets and stars to galaxies and clusters of galaxies as well as on cosmological scales Aimed at young researchers and graduate students this up to date review uniquely brings together a subject often tackled by disconnected communities conveying the latest advances as well as highlighting the limits of our current understanding

**Cosmic Magnetic Fields (IAU S259)** International Astronomical Union. Symposium, 2009-06-11 IAU Symposium 259 presents the first interdisciplinary comprehensive review of the role of cosmic magnetic fields involving astronomers and physicists from

across the community Offering both theoretical and observational topics ranging from Earth's habitability to the origin of the universe this is an invaluable summary for researchers and graduate students *Solar System Magnetic Fields* E.R.

Priest, 2012-12-06 In September 1984 a Summer School on Solar System Plasmas was held at Imperial College with the support of the Science and Engineering Research Council An excellent group of lecturers was assembled to give a series of basic talks on the various aspects of the subject aimed at Ph.D. students or researchers from related areas wanting to learn about the plasma physics of the solar system The students were so appreciative of the lectures that it was decided to write them up as the present book Traditionally different areas of solar system science such as solar and magnetospheric physics have been studied by separate communities with little contact However it has become clear that many common themes cut right across these distinct topics such as magnetohydrodynamic instabilities and waves magnetic reconnection convection dynamo activity and particle acceleration The plasma parameters may well be quite different in the Sun's atmosphere a cometary tail Jupiter's magnetosphere but many of the basic processes are similar and it is by studying them in different environments that we come to understand them more deeply Furthermore direct in situ measurements of plasma properties at one point in the solar wind or the magnetosphere complement the more global view by remote sensing of a similar phenomenon at the Sun **Solar Magnetic Fields** André Balogh, Edward Cliver, Gordon Petrie, Sami Solanki, Michael

Thompson, Rudolf von Steiger, 2018-06-06 This volume provides an in depth review of all aspects of solar magnetic fields Written by world leading experts these thirteen papers cover all regions of the subject from the solar interior photosphere chromosphere active regions and corona out to the solar wind The history of solar magnetic fields as well as the necessary instrumentation are also covered The volume serves as both a reference for researchers and a starting point for graduate students Originally published in Space Science Reviews Volume 210 Issue 1-4 September 2017 **Magnetic Fields of**

**Celestial Bodies** Ye Shi-hui, 2012-12-06 Magnetism is one of the basic properties of matter Mankind has travelled a long road in discovering and utilizing magnetism and in this respect the ancient Chinese people have made outstanding contributions In the book Lu's Spring and Autumn written near the end of the Warring States Period i.e. in the third century B.C. there is a statement on the attraction of iron by lodestones So at that time it was known that magnets can attract ferromagnetic material At the beginning of the first century A.D. viz. in the early years of the East Han Dynasty the famous scholar Wang Chong wrote in his masterpiece *Len Hien* that the handle of a magnetic dipper pointed to the south It was thus discovered at the time that magnets can point to the poles of the geomagnetic field At the beginning of the twelfth century during the reign of Emperor Hui of the Sung Dynasty in the two books written by Zhu Yu and Xu Jin respectively there are descriptions of the compass used in navigation This tells us that the application of compasses was rather widespread at that time The distinguished scientist Shen Kuo 1031-1095 discovered the declination of the terrestrial magnetic field This is four hundred and more years earlier than its discovery by Christopher Columbus in 1492 during his voyage across the Atlantic Ocean Such

facts as these manifest the important contributions of ancient China to global civilization      Solar Flare Magnetic Fields and Plasmas Yuhong Fan, George Fisher, 2012-03-28 This volume is devoted to the dynamics and diagnostics of solar magnetic fields and plasmas in the Sun's atmosphere Five broad areas of current research in Solar Physics are presented 1 New techniques for incorporating radiation transfer effects into three dimensional magnetohydrodynamic models of the solar interior and atmosphere 2 The connection between observed radiation processes occurring during flares and the underlying flare energy release and transport mechanisms 3 The global balance of forces and momenta that occur during flares 4 The data analysis and theoretical tools needed to understand and assimilate vector magnetogram observations and 5 Connecting flare and CME phenomena to the topological properties of the magnetic field in the Solar Atmosphere The role of the Sun's magnetic field is a major emphasis of this book which was inspired by a workshop honoring Richard C Dick Canfield Dick has been making profound contributions to these areas of research over a long and productive scientific career Many of the articles in this topical issue were first presented as talks during this workshop and represent substantial original work The workshop was held 9-11 August 2010 at the Center Green campus of the National Center for Atmospheric Research NCAR in Boulder Colorado This volume is aimed at researchers and graduate students active in solar physics solar terrestrial physics and magneto hydrodynamics Previously published in Solar Physics journal Vol 277 1 2012      **Measurements of Solar Magnetic Fields** N. R. Sheeley, California Institute of Technology. Division of Physics, Mathematics and Astronomy, 1965

**The Earth's Magnetic Field : Its History, Origin, and Planetary Perspective** McElhinny, 1984-01-04 The Earth's Magnetic Field Its History Origin and Planetary Perspective      The Strongest Magnetic Fields in the Universe Vasily S. Beskin, A. Balogh, Maurizio Falanga, Maxim Lyutikov, Sandro Mereghetti, Tsvi Piran, R.A. Treumann, 2016-01-29 This volume extends the ISSI series on magnetic fields in the Universe into the domain of what are by far the strongest fields in the Universe and stronger than any field that could be produced on Earth The chapters describe the magnetic fields in non degenerate strongly magnetized stars in degenerate stars such as white dwarfs and neutron stars exotic members called magnetars and in their environments as well as magnetic fields in the environments of black holes These strong fields have a profound effect on the behavior of matter visible in particular in highly variable processes like radiation in all known wavelengths including Gamma Ray bursts The generation and structure of such strong magnetic fields and effects on the environment are also described      **A Study on the Evolution of Solar Magnetic Field in the Heliosphere** Iren Sobia A, 2023-01-08 The closest star to the Earth the Sun is a large ball of ionized gas called plasma The Sun has intense variable magnetic elds which are the drivers of most solar mag netic activity An overview of the solar magnetic eld its most important properties along with a description of the solar wind and solar transient events are presented in this chapter The solar wind represents the medium by which the Sun extends its atmosphere swiftly into the vastness of the solar system The solar wind in change carves out a region of interstellar space several times the orbit of the most distant planet in dimension known as

the heliosphere The heliosphere is the region of space that is dominated by the solar magnetic field which is drawn out into space by the solar wind its a bubble in the space Solar maximum and solar minimum are phases through which the Sun s magnetic field has been found to ip roughly every 11 years      *Nuclear Science Abstracts* ,1975      **Solar Magnetic Fields** Jan Stenflo,2014-01-15      Solar Magnetic Fields and Activities Jack Ireland,Brigitte Schmieder,2007      **Literature 1992, Part 1** Astronomisches Recheninstitut,2013-11-11 Astronomy and Astrophysics Abstracts appearing twice a year has become oneof the fundamental publications in the fields of astronomy astrophysics andneighbouring sciences It is the most important English language abstracting journal in the mentioned branches The abstracts are classified under more than a hundred subject categories thus permitting a quick survey of the whole extended material The AAA is a valuable and important publication for all students and scientists working in the fields of astronomy and related sciences As such it represents a necessary ingredient of any astronomical library all over the world

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