Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

EARTH'S ELECTROMAGNETIC FIELD ITS PROTECTIVE SYSTEM

Kurbonov Jamshid
Toshpulatova Munisa
Usarova Aziza
Aliyorov Murod
Tashkent State Medical University, Tashkent Uzbekistan

Abstract
Space weather refers to the effects of solar activity – particularly solar storms – throughout the heliosphere, the vast region of space influenced by the Sun, extending out far beyond Pluto. Within this region, charged particles and radiation from the Sun interact with planetary magnetospheres, ionospheres and atmospheres. Conclusion.The Earth's electromagnetic field is an essential component of our planet's natural defense system. Understanding and preserving this invisible shield is crucial for the future of life and technology on Earth.

Keywords: Magnetic, magnetosphere, space weather, geomagnetic field, radiation, interplanetary.

Introduction:
The magnetosphere generally describes the area around a celestial body in which the behaviour of charged particles is mainly determined by its magnetic field. As such, Earth's magnetosphere is the area of influence of its magnetic field, which is generated by the geodynamo – a process driven by the convective flow of molten iron in Earth's outer core, combined with Earth's rotation.
The Earth is surrounded by an invisible magnetic field known as the electromagnetic field. This field protects our planet from harmful solar radiation and charged particles coming from space. It is created by the movement of molten metals in the Earth's outer core. Without this magnetic shield, life on Earth would be exposed to dangerous radiation from the Sun and other cosmic sources. Understanding how this field works helps scientists protect modern technology

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

and explore space safely. Earth's magnetic field corresponds approximately to a tilted magnetic dipole centred at the Earth's core. The magnetic field can be visualised as the field of a bar magnet with a north and south pole aligned along Earth's longitudinal, or rotational, axis. The magnetic field of such a magnet exerts its force along field lines, typically revealed by iron filings in school physics lessons. The strength of the field is proportional to the distance between these lines – where the field is stronger, the lines are closer together. Topical Issues on Earth's Electromagnetic Field as a Defense System

1. Weakening of the Magnetic Field.Scientists have observed that Earth's magnetic field has been gradually weakening over the past two centuries. This weakening could reduce the planet’s natural protection against harmful solar and cosmic radiation.
2. Magnetic Pole Shifts.The magnetic poles are not fixed and have been drifting at an accelerated rate. A sudden or complete magnetic pole reversal (geomagnetic reversal) could disrupt navigation systems, communication networks, and increase radiation exposure.
3. South Atlantic Anomaly (SAA).A region over South America and the South Atlantic where the magnetic field is significantly weaker, posing a risk to satellites and spacecraft due to higher radiation levels.
4. Space Weather Vulnerability.Strong solar storms and coronal mass ejections (CMEs) can temporarily disrupt or damage Earth’s magnetosphere, potentially affecting power grids, satellite operations, and aviation.
5. Impact on Human Technology.As reliance on satellites and electrical infrastructure grows, the importance of a stable and strong geomagnetic shield becomes more critical. Any disruption can affect GPS, telecommunications, and internet systems.
6. Inadequate Monitoring Systems.There are limited global systems for continuously monitoring the magnetic field and predicting sudden changes, making early warning difficult.
7. Climate and Atmospheric Interaction Uncertainties.Scientists are still researching how changes in the magnetic field may influence climate systems or atmospheric phenomena such as auroras and radiation belts.

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

8. Lack of Public Awareness.Despite its critical role, many people are unaware of the magnetic field's protective function and the consequences of its disturbance or weakening.

Earth's dipole field is currently tilted by approximately 9.2 degrees relative to its axis of rotation. This causes the deviation between geomagnetic and geographic poles. The strength of the field varies from around 60,000 nanoteslas at the poles to 30,000 nanoteslas at the equator. Compared to artificial electromagnets, which are in the range of a several teslas – many billion times higher – this is miniscule. Despite its relatively low strength, Earth's magnetic field plays a crucial role in shielding our planet by deflecting most of the solar wind. The magnetosphere can be seen as a kind of protective bubble in the Sun's particle stream that shields life and electronic equipment from harmful radiation. Due to the constant pressure from the solar wind, Earth's magnetic field is somewhat compressed on the dayside and stretched on the nightside. On average, the outer boundary of the magnetosphere on the dayside – the magnetopause – is about 63,000 kilometres from Earth's surface.

During solar storms (such as coronal mass ejections), the protective shield of the magnetosphere is weakened by the incoming plasma cloud. This weakening allows an above-average number of charged particles to penetrate the magnetosphere, which travel along the magnetic field lines into the polar atmosphere and create the auroras. At the same time, Earths magnetic field becomes particularly strong and is distorted in a distinctive way. Such disturbances are called geomagnetic storms and can last for several days.

The degree of coupling between the solar wind and the magnetosphere depends primarily on the relative orientation of the interplanetary magnetic field – the magnetic field transported by the solar wind – and Earth's magnetic field at the magnetopause. When these fields point in opposite directions, the impact of a coronal mass ejection increases, transferring more momentum and energy into the magnetosphere and intensifying geomagnetic storms. During extreme events, the field strength can fluctuate by more than 1000 nanoteslas – only a few percent of the average total field strength.

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

EARTH'S MAGNETOSPHERE

The magnetosphere is the region of space surrounding Earth where the dominant magnetic field is the magnetic field of Earth, rather than the magnetic field of interplanetary space. The magnetosphere is formed by the interaction of the solar wind with Earth's magnetic field. This figure illustrates the shape and size of Earth's magnetic field that is continually changing as it is buffeted by the solar wind.

It has been several thousand years since the Chinese discovered that certain magnetic minerals, called lodestones, would align in roughly the north-south direction. The reason for this effect wasn't understood, though, until 1600, when William Gilbert published De Magnete and demonstrated that our Earth behaved like a giant magnet and loadstones were aligning with Earth's magnetic field.

After several more centuries of investigation, it is now known that Earth's magnetic field is quite complex, but still, to a great extent, can be viewed as a dipole, with north and south poles like a simple bar magnet. Earth's magnetic axis, the dipole, is inclined at about 11 degrees to Earth's spin axis. If space were a vacuum, Earth's magnetic field would extend to infinity, getting weaker with distance, but in 1951, while studying why comet tails always point away from the sun, Ludwig Biermann discovered that the sun emits what we now call the solar wind. This continuous flow of plasma, comprised of mostly electrons and protons, with an embedded magnetic field, interacts with Earth and other objects in the solar system.

The pressure of the solar wind on Earth's magnetic field compresses the field on the dayside of Earth and stretches the field into a long tail on the nightside. The shape of the resulting distorted field has been compared to the appearance of water flowing around a rock in a stream. On the dayside of Earth, rather than extending to infinity, the magnetic field is confined to within about 10 Earth radii from the center of Earth and on the nightside, the field is stretched out to hundreds of Earth radii, well beyond the orbit of the moon at 60 Earth radii.

The boundary between the solar wind and Earth's magnetic field is called the magnetopause. The boundary is constantly in motion as Earth is buffeted by the ever-changing solar wind. While the magnetopause shields us to some extent

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

from the solar wind, it is far from impenetrable, and energy, mass, and momentum are transferred from the solar wind to regions inside Earth's magnetosphere. The interaction between the solar wind and Earth's magnetic field, and the influence of the underlying atmosphere and ionosphere, creates various regions of fields, plasmas, and currents inside the magnetosphere such as the plasmasphere, the ring current, and radiation belts.

The consequence is that conditions inside the magnetosphere are highly dynamic and create what we call "space weather" that can affect technological systems and human activities. For example, the radiation belts can have impacts on the operations of satellites, and particles and currents from the magnetosphere can heat the upper atmosphere and result in satellite drag that can affect the orbits of low-altitude Earth orbiting satellites. Influences from the magnetosphere on the ionosphere can also affect communication and navigations systems. All of these effects are discussed elsewhere in more detail.

Earth's magnetic field, also known as the geomagnetic field, is the magnetic field that extends from Earth's interior out into space, where it interacts with the solar wind, a stream of charged particles emanating from the Sun. The magnetic field is generated by electric currents due to the motion of convection currents of a mixture of molten iron and nickel in Earth's outer core: these convection currents are caused by heat escaping from the core, a natural process called a geodynamo.

The magnitude of Earth's magnetic field at its surface ranges from 25 to 65 μT (0.25 to 0.65 G). As an approximation, it is represented by a field of a magnetic dipole currently tilted at an angle of about 11° with respect to Earth's rotational axis, as if there were an enormous bar magnet placed at that angle through the center of Earth. The North geomagnetic pole (Ellesmere Island, Nunavut, Canada) actually represents the South pole of Earth's magnetic field, and conversely the South geomagnetic pole corresponds to the north pole of Earth's magnetic field (because opposite magnetic poles attract and the north end of a magnet, like a compass needle, points toward Earth's South magnetic field.)

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

While the North and South magnetic poles are usually located near the geographic poles, they slowly and continuously move over geological time scales, but sufficiently slowly for ordinary compasses to remain useful for navigation. However, at irregular intervals averaging several hundred thousand years, Earth's field reverses and the North and South Magnetic Poles abruptly switch places. These reversals of the geomagnetic poles leave a record in rocks that are of value to paleomagnetists in calculating geomagnetic fields in the past. Such information in turn is helpful in studying the motions of continents and ocean floors. The magnetosphere is defined by the extent of Earth's magnetic field in space or geospace. It extends above the ionosphere, several tens of thousands of kilometres into space, protecting Earth from the charged particles of the solar wind and cosmic rays that would otherwise strip away the upper atmosphere, including the ozone layer that protects Earth from harmful ultraviolet radiation.

1. What is Earth's Electromagnetic Field

Earth's electromagnetic field (also called the geomagnetic field) is an invisible force field that extends from the planet's core out into space. It is mainly generated by electric currents caused by the movement of molten iron in the outer core. These movements create what is called a dynamo effect, which produces the magnetic field.

2. The Magnetosphere: A Giant Protective Bubble

The magnetosphere is the region around Earth where the magnetic field interacts with solar wind (a stream of charged particles from the Sun). The magnetosphere deflects most of these harmful particles, preventing them from hitting Earth directly.

The outer layer of the magnetosphere is called the magnetopause.

Inside it, there are radiation belts called the Van Allen Belts, which trap charged particles.

3. Why is the Magnetic Field Important?

a. Protection from Solar Radiation

Without the magnetic field, the solar wind would strip away the Earth's atmosphere over time, making life impossible.

b. Protection of Technology

It shields satellites, airplanes, and electrical systems from geomagnetic storms.

c. Navigation

The field allows compasses to work and helps animals (like birds, whales, and sea turtles) navigate using Earth's natural magnetic field.

4. Changes in the Magnetic Field

Earth's magnetic field is not fixed; it changes over time.

The magnetic poles (north and south) slowly shift.

Sometimes, they even reverse (called a geomagnetic reversal), which has happened many times in Earth's history.

5. South Atlantic Anomaly (SAA)

This is a region over South America and the Atlantic Ocean where Earth's magnetic field is especially weak.

Satellites passing through this zone often experience malfunctions.

Scientists are carefully monitoring this area because it might signal bigger chinges

6. Artificial Magnetospheres (Future Technology)

Scientists are exploring artificial mini-magnetospheres to protect astronauts during space missions to Mars or the Moon. These would act like Earth's magnetic field, shielding them from solar radiation.

7. Interesting Facts

Earth is not the only planet with a magnetic field — Jupiter has the strongest magnetic field in the solar system.

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

The auroras (Northern and Southern Lights) are caused by charged particles from the Sun interacting with the magnetic field and the atmosphere.
Earth's magnetic field deflects most of the solar wind, whose charged particles would otherwise strip away the ozone layer that protects the Earth from harmful ultraviolet radiation. One stripping mechanism is for gas to be caught in bubbles of the magnetic field, which are ripped off by solar winds.
The study of the past magnetic field of the Earth is known as paleomagnetism. The polarity of the Earth's magnetic field is recorded in igneous rocks, and reversals of the field are thus detectable as "stripes" centered on mid-ocean ridges where the sea floor is spreading, while the stability of the geomagnetic poles between reversals has allowed paleomagnetism to track the past motion of continents. Reversals also provide the basis for magnetostratigraphy, a way of dating rocks and sediments. The field also magnetizes the crust, and magnetic anomalies can be used to search for deposits of metal ores.
Humans have used compasses for direction finding since the 11th century A.D. and for navigation since the 12th century. Although the magnetic declination does shift with time, this wandering is slow enough that a simple compass can remain useful for navigation. Using magnetoreception, various other organisms, ranging from some types of bacteria to pigeons, use the Earth's magnetic field for orientation and navigation.
Unlike the geographic poles, Earth's magnetic poles are not fixed and tend to wander over time. British polar explorer James Clark Ross first identified the Magnetic North Pole on the Boothis Peninsula in Canada's Nunavut territory in 1831, according to the Antarctic travel site Antarctic Logistics. Since its discovery, the magnetic north pole moves about 25 miles (40 kilometers) a year in a northwest direction according to the Royal Museums Greenwich. Whatsmore, Earth's magnetic poles have also 'flipped' whereby north becomes south and south becomes north. These magnetic reversals occur at irregular intervals every 200,000 years or so.
According to NASA, the magnetosphere also protects Earth from large quantities of particle radiation emitted during coronal mass ejection (CME) events and also

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

from cosmic rays — atom fragments — raining down on Earth from deep space. The magnetosphere repels harmful energy away from Earth and traps it in zones called the Van Allen radiation belts. These donut-shaped belts of radiation can swell when the sun's activity increases.

But our protective shield is not completely invincible.

— Wild solar weather is causing satellites to plummet from orbit

— Solar storms can destroy satellites with ease — a space weather expert explains the science

— Is the electric grid ready for extreme space weather?

During particularly strong space weather events such as high solar winds or large CMEs, Earth's magnetic field is disturbed and geomagnetic storms can penetrate the magnetosphere and lead to widespread radio and power blackouts as well as endangering astronauts and Earth-orbiting satellites.

The degree of magnetic disturbance from a CME depends on the CME's magnetic field and Earth's. If the CME's magnetic field is aligned with Earth's, pointing from south to north the CME will pass on by with little effect. However, if the CME is aligned in the opposite direction it can cause Earth's magnetic field to be reorganized, triggering large geomagnetic storms.

A less destructive and far prettier side effect of magnetosphere disturbances is the aurora above Earth's polar regions. The phenomenon is known as the northern lights (aurora borealis) in the Northern Hemisphere and the southern lights (aurora australis) in the Southern Hemisphere.

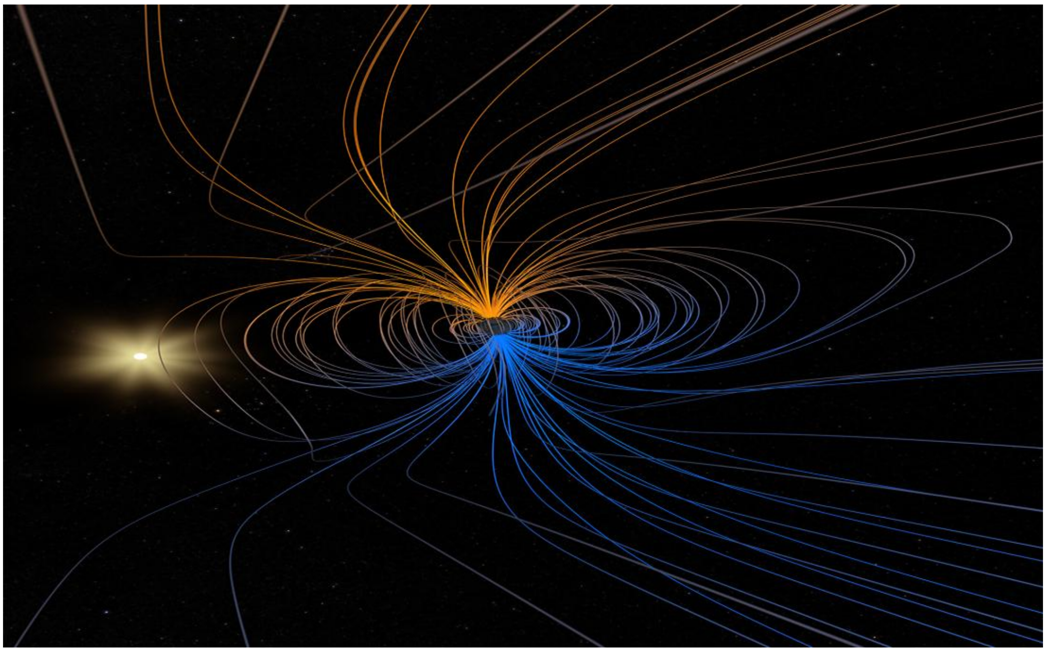
The disturbances in Earth's magnetic field funnel ions down towards Earth's poles where they collide with atoms of oxygen and nitrogen in Earth's atmosphere, creating dazzling aurora light shows.

Schematic illustration of the invisible magnetic field lines generated by the Earth, represented as a dipole magnet field. In actuality, our magnetic shield is squeezed in closer to Earth on the Sun-facing side and extremely elongated on the night-side due to the solar wind.

Earth's polarity is not a constant. Unlike a classic bar magnet, the matter governing Earth's magnetic field moves around. Geophysicists are pretty sure that the reason Earth has a magnetic field is because its solid iron core is surrounded

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

by a fluid ocean of hot, liquid metal. The flow of liquid iron in Earth's core creates electric currents, which in turn creates the magnetic field.



References

1. Kivelson, M. G., & Russell, C. T. (1995). Introduction to Space Physics. Cambridge University Press. A comprehensive guide on magnetospheres, space plasma, and the Earth's electromagnetic environment.
2. Merrill, R. T., McElhinny, M. W., & McFadden, P. L. (1998). The Magnetic Field of the Earth: Paleomagnetism, the Core, and the Deep Mantle. Academic Press.Covers the generation and variation of Earth's magnetic field.
3. NASA. (2023). Earth's Magnetosphere. Retrieved from https://www.nasa.gov NASA's official explanation of the Earth's magnetosphere and its protective function.
4. ESA (European Space Agency). (2023). Swarm Mission: Studying Earth's Magnetic Field. Retrieved from https://www.esa.int Real-time data and studies about Earth's magnetic field and how it changes.
5. Valet, J.-P. (2003). Time variations in Earth's magnetic field: From daily to secular changes. Reviews of Geophysics, 41(1). Discusses the variability and behavior of the geomagnetic field over different timescales.

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

6. Lühr, H., & Maus, S. (2010). Solar wind driven magnetosphere-ionosphere interaction. Space Science Reviews, 152(1–4), 123–150. Describes how solar wind interacts with the Earth's magnetic field and upper atmosphere.
7. Jacobs, J. A. (1987). Geomagnetism Volume 1: Geomagnetic and Related Phenomena. Academic Press. Foundational text on Earth's magnetic field generation and behavior.
8. Sharma, A., Sreedhar, J., Haidari, M., & Rinawa, M. (2023, February). Control of Hydrothermal Power System Development of Hybrid Controller for Load Frequency. In 2023 IEEE International Conference on Integrated Circuits and Communication Systems (ICICACS) (pp. 1-6). IEEE.
9. Каримов, М. М., Зуфаров, П. С., Собирова, Г. Н., Каримова, Д. К., & Хайруллаева, С. С. (2023). Комбинированная терапия гастроэзоф агеальной рефлюксной болезни при коморбидности с функциональной диспепсией. Экспериментальная и клиническая гастроэнтерология, (3 (211)), 41-45.
10. Каримов, М. М., Рустамова, М. Т., Собирова, Г. Н., Зуфаров, П. С., & Хайруллаева, С. С. (2023). Оценка эффективности К-КБК вонопразана в комплексе эрадикационной терапии у больных с хроническими Hp-ассоциированными гастритами. Экспериментальная и клиническая гастроэнтерология, (12 (220)), 54-58.
11. Саидова, Ш. А., Якубов, А. В., Зуфаров, П. С., Пулатова, Н. И., & Пулатова, Д. Б. (2024). ВЫБОР АНТАГОНИСТОВ МИНЕРАЛОКОРТИКОИДНЫХ РЕЦЕПТОРОВ ПРИ РАЗЛИЧНЫХ ПАТОЛОГИЯХ.
12. Зуфаров, П. С., Якубов, А. В., & Салаева, Д. Т. (2009). Сравнительная оценка эффективности омепразола и пантопразола при лечении гастропатии, вызванной нестероидными противовоспалительными средствами у больных ревматоидным артритом. Лікарська справа, (3-4), 44-49.
13. Karimov, M. M., Zufarov, P. S., Go'zal, N. S., Pulatova, N. I., & Aripdjanova, S. S. (2022). Ulinastatin in the conservative therapy of chronic pancreatitis. Central Asian Journal of Medicine, (3), 54-61.

Modern American Journal of Medical and Health Sciences
ISSN (E): 3067-803X
Volume 01, Issue 02, May, 2025
Website: usajournals.org

14. Салаева, Д. Т., Зуфаров, П. С., & Якубов, А. В. (2008). Сравнительная оценка влияния ингибиторов протонной помпы на некоторые механизмы цитозащиты при экспериментальной гастропатии. Современные наукоемкие технологии, (3), 63-63.
15. Mustafakulov, A. A., & Arzikulov, F. (2020). Current State Of Wind Power Industry. American Journal of Engineering And Technology.(ISSN–2689-0984). Published: September, 14, 32-36.
16. Solidjonov, D., & Arzikulov, F. (2021). WHAT IS THE MOBILE LEARNING? AND HOW CAN WE CREATE IT IN OUR STUDYING?. Интернаука, (22-4), 19-21.
17. Mustafakulov, A. A., Arzikulov, F. F., & Dzhumanov, A. (2020). Use of Alternative Energy Sources in the Mountainous Areas of the Jizzakh Region of Uzbekistan. Internauka: electron. scientific. zhurn,(41 (170)).
18. Arzikulov, F., & Tolibjonov, L. (2025). THE INTRODUCTION OF BLOCKCHAIN TECHNOLOGIES TO OUR COUNTRY AND THEIR IMPACT ON THE ECONOMY. Web of Discoveries: Journal of Analysis and Inventions, 3(4), 108-111.
19. Islomjon, I., & Fazliddin, A. (2025). EFFICIENCY OF MOBILE APPS IN HEALTHCARE: A CASE STUDY OF MED-UZ AI. Modern American Journal of Medical and Health Sciences, 1(2), 19-24.