Muslim Heritage, Vol.11, No.1, Juni 2026
E-ISSN 2502-5341
P-ISSN 2502-535X

INTEGRATING QUR'ANIC SCIENCE AND ASTRONOMY IN THE STUDY OF SUNSPOTS AND SOLAR STORMS

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DOI: https://doi.org/10.21154/muslimheritage.v11i1.13025
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Received: Jan 1, 2026 | *Revised: May 11, 2026* | *Approved: June 2, 2026*

Abstract
The sunspot and solar storm phenomena represent two crucial aspects of solar activity that significantly affect Earth's environmental systems. Increased solar activity, particularly during the peak of the 11year solar cycle, often causes major disturbances to space weather and modern technological infrastructures. This study aims to explore the relationship between sunspots and solar storms from both *tafsir ilmi* (scientific Qur'anic interpretation) and astronomical perspectives, and to analyze their impacts on Earth. The research employs a qualitative-descriptive approach through field observations using telescopic monitoring of sunspots from May 2022 to September 2023. Observational data were analyzed in light of relevant Qur'anic verses, including Surah Yasin [36]:38 and Surah At-Takwir [81]:1. Results indicate that Solar Cycle 25 reached its maximum phase at the end of 2023, marked by a substantial increase in sunspot frequency and the potential for severe geomagnetic storms affecting communications, satellites, and electrical systems. From a *tafsir ilmi* viewpoint, these events reflect the greatness and precision of divine creation, highlighting the harmony between natural laws and revelation. This study emphasizes the importance of integrating astronomical science with *tafsir ilmi* to achieve a holistic understanding of cosmic phenomena.

Abstrak
Fenomena sunspot dan badai matahari merupakan dua aspek penting dari dinamika aktivitas matahari yang memiliki pengaruh signifikan terhadap sistem kehidupan di Bumi. Aktivitas matahari yang meningkat, terutama pada fase puncak siklus 11 tahunan, sering kali menimbulkan perubahan besar terhadap cuaca antariksa dan kestabilan sistem teknologi modern. Penelitian ini bertujuan untuk mengkaji keterkaitan antara fenomena sunspot dan badai matahari dalam perspektif *tafsir ilmi* dan astronomi, serta menelaah dampaknya terhadap kehidupan di Bumi. Pendekatan yang digunakan ialah kualitatif-deskriptif dengan metode observasi lapangan menggunakan teleskop untuk memantau sunspot secara berkala sejak Mei 2022 hingga September 2023. Data lapangan tersebut kemudian dianalisis secara interdisipliner dengan pendekatan tafsir *ilmi* terhadap ayat-ayat Al-Qur'an yang relevan, seperti Q.S. Yasin (36):38 dan Q.S. At-Takwir (81):1. Hasil penelitian menunjukkan bahwa siklus matahari ke-25 mencapai fase maksimum pada akhir tahun 2023 dengan peningkatan jumlah sunspot yang signifikan, berpotensi memicu badai geomagnetik besar yang berdampak pada gangguan komunikasi, satelit, dan sistem kelistrikan. Dalam perspektif *tafsir ilmi*, fenomena ini menjadi bukti kebesaran dan keteraturan ciptaan Allah yang menunjukkan keterpaduan antara hukum-hukum alam dan wahyu. Kajian ini menegaskan pentingnya sinergi ilmu astronomi dan tafsir *ilmi* dalam memahami fenomena alam semesta secara holistik.
Keywords: Sunspot; Solar Storm; Qur'anic Exegesis; Astronomy; Solar Cycle

INTRODUCTION

The Sun is the central star of the solar system and the primary source of energy sustaining life on Earth. Through thermonuclear fusion processes occurring in its core, the Sun continuously emits electromagnetic radiation and charged particles that influence atmospheric stability, climate systems, and the balance of Earth's ecosystem. In addition to providing energy essential for life, the

Sun also exhibits dynamic activities such as sunspots, solar flares, solar winds, and Coronal Mass Ejections (CMEs). These activities are part of solar magnetic dynamics that periodically increase and decrease within an approximately eleven-year cycle known as the Solar Cycle.[1] In recent decades, studies concerning solar activity have become increasingly important because modern human civilization relies heavily on electrical systems, satellite technology, aviation navigation, telecommunications, and digital infrastructure vulnerable to space weather disturbances. Increased solar activity can trigger geomagnetic storms capable of disrupting radio communications, damaging satellites, affecting Global Positioning System (GPS) accuracy, and causing failures in electrical transmission systems.[2] The increasing dependence of modern society on electromagnetic technology has made the study of solar storms not only scientifically significant but also strategically important for global technological resilience.

One of the most visible indicators of solar activity is the appearance of sunspots on the Sun's photosphere. Sunspots are relatively dark regions caused by extremely strong magnetic field concentrations that inhibit convective heat transfer from the Sun's interior to its surface. As a result, these regions possess lower temperatures than the surrounding photosphere and appear darker when observed through telescopes equipped with solar filters.[3] The number, distribution, and complexity of sunspots are closely associated with the level of solar magnetic activity and frequently serve as early indicators of solar flares and CMEs. Therefore, observations of sunspots are widely utilized to predict space weather conditions and evaluate solar cycle development.[4] The phenomenon of sunspots has attracted the attention of astronomers since the seventeenth century when Galileo Galilei conducted direct observations using telescopes. His observations demonstrated that the Sun is not a static celestial object but undergoes rotational motion and dynamic magnetic changes.[5] Modern astronomy later confirmed that the Sun experiences differential rotation and possesses highly complex plasma magnetic interactions. Consequently, the study of sunspots became one of the primary foundations for understanding solar storms and space weather.

From the perspective of Islamic studies, astronomical phenomena such as sunspots and solar storms are categorized as ayat kauniyyah, namely signs of Allah's greatness manifested throughout the universe. The Qur'an repeatedly encourages humanity to observe and contemplate celestial phenomena as part of intellectual and spiritual reflection upon divine creation.[6] In this context, scientific exegesis (tafsir 'ilmi) serves as an approach seeking harmony between scientific discoveries and Qur'anic verses without subordinating revelation to empirical science.

One of the Qur'anic verses relevant to the discussion of solar dynamics is Surah Yasin (36):38:

وَالشَّمْسُ تَجْرِيْ لِمُسْتَقَرٍّ لَّهَا ۗذٰلِكَ تَقْدِيْرُ الْعَزِيْزِ الْعَلِيْمِ

"And the Sun runs on its fixed course; such is the decree of the Almighty, the All-Knowing."

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1 Robin Kerrod, *Bengkel Ilmu Astronomi* (Penerbit Erlangga, 2005).
2 Dkk Dyah Rahayu Martiningrum, *Fenomena Cuaca Antariksa* (Puspa Swara bekerja sama dengan Pusfatsainsa, 2009).
3 A. Gunawan Admiranto, *Menjelajahi Tata Surya* (Penerbit Kanisius, 2000).
4 David H. Hathaway, "The Solar Cycle," *Living Reviews in Solar Physics* 12, no. 04 (2015): 1–87.
5 Danang Endarto, *Kosmografi* (Ombak, 2014).
6 Kementerian Agama RI, *Penciptaan Jagat Raya Dalam Perspektif Al-Qur'an Dan Sains* (PT Sinergi Pustaka Indonesia, 2012).

This verse indicates that the Sun continuously moves according to a precise cosmic order. Contemporary scientific interpretation understands the word tajrī not merely as solar rotation but also as the translational motion of the Sun within the Milky Way galaxy at extraordinary speed.[7] Such interpretation demonstrates the compatibility between Qur'anic cosmological descriptions and modern astronomical findings regarding celestial motion.

Another relevant verse is Surah Fushshilat (41):37, which emphasizes that the Sun and Moon are creations of Allah subjected entirely to divine laws. According to Quraish Shihab in Tafsir al-Misbah, celestial regularity reflects tawhid al-rububiyyah, namely recognition of Allah's sovereignty through the order of the universe.[8] Thus, solar phenomena such as sunspots and solar storms may also be understood as manifestations of cosmic balance (mīzān) established by Allah SWT. In this regard, tafsir ilmi (scientific exegesis) offers an interpretive framework that seeks to understand Qur'anic verses in light of scientific discoveries while maintaining the epistemological distinction between revelation and empirical science.[9] Despite the growing number of studies on astronomy and Islamic cosmology, research specifically integrating empirical observations of sunspots with scientific exegesis remains limited. Most previous studies concerning solar storms focus primarily on physical, astrophysical, or technological aspects. For example, Anwar Susanto examined geomagnetic disturbances and ionospheric responses over Indonesia caused by extreme space weather, but his research did not integrate Qur'anic interpretation perspectives.[10] Similarly, Thomas Djamaluddin discussed astronomy in relation to Islamic studies primarily within the context of hisab-rukyat and Islamic cosmology.[11]

Agus Purwanto, through his work Ayat-Ayat Semesta, attempted to connect scientific discoveries with Qur'anic verses concerning the universe. However, his discussion did not specifically analyze observational data related to sunspots and Solar Cycle 25.[12] In addition, several studies published in Muslim Heritage have discussed the integration of Islam and science from epistemological and educational perspectives. Ahmad Fauzan emphasized the importance of integrating Qur'anic values into scientific discourse in contemporary Islamic scholarship.[13] Similarly, Nur Kholis emphasizes that the integration paradigm encourages interdisciplinary approaches in contemporary Islamic scholarship.[14]

From the scientific perspective, numerous studies have examined solar activity and its consequences. Hathaway explains that sunspot cycles constitute fundamental indicators of solar magnetic dynamics and significantly influence space weather conditions.[15] Schrijver and Siscoe further demonstrate that solar storms generated by magnetic reconnection processes can affect Earth's magnetosphere and technological infrastructures.[16] Pulkkinen likewise confirms that extreme geomagnetic storms pose substantial risks to communication systems, navigation technol-

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7 Agus Purwanto, *Ayat-Ayat Semesta Sisi-Sisi al-Quran Yang Terlupakan* (PT.Mizan Pustaka, 2015).
8 Quraish Shihab, *M. Tafsir Al-Misbah Vol. 15* (Lentera Hati, 2002).
9 Mehdi Golshani, *The Holy Quran and the Sciences of Nature* (Global Scholarly Publications, 2011).
10 Anwar Susanto, *Respon Magnetosfer Dan Ionosfer Di Atas Indonesia Terhadap Cuaca Antariksa Ekstrim Dan Dampaknya Pada Satelit Lapan Tubsat* (CV. Andira, 2015).
11 Thomas Djamaluddin, *Semesta Pun Berthawaf: Astronomi Untuk Memahami Al-Qur'an* (Mizan Pustaka, 2018).
12 Agus Purwanto, *Ayat-Ayat Semesta Sisi-Sisi al-Quran Yang Terlupakan*.
13 Ahmad Fauzan, "Integrasi Islam Dan Sains Dalam Perspektif Pendidikan Islam," *Muslim Heritage* 5, no. 2 (2020): 115–20.
14 Nur Kholis, "Integrasi Keilmuan Dalam Pendidikan Islam Kontemporer," *Muslim Heritage* 7, no. 1 (2022): 45–63.
15 Hathaway, "The Solar Cycle."
16 C. J. Schrijver and G. L. Siscoe, *Heliophysics: Space Storms and Radiation* (Cambridge University Press, 2010).

ogies, and power grids.[17] Although these studies contribute significantly to solar physics, they primarily focus on astrophysical and technological dimensions without incorporating Islamic interpretive perspectives.

Based on these previous studies, there remains an analytical gap concerning interdisciplinary research that integrates direct observations of sunspots, modern astronomical analysis, and scientific Qur'anic interpretation simultaneously. Most astronomical studies remain purely empirical, while tafsir 'ilmi studies often remain normative without integrating observational scientific data. Therefore, this research seeks to bridge these two approaches through an integrative study of sunspots and solar storms from both scientific exegesis and astronomical perspectives.

This study aims to: 1. Analyze the phenomenon of sunspots based on direct astronomical observations conducted from May 2022 to September 2023, 2. Explain the relationship between sunspots and solar storms within the framework of modern astronomy, 3. Examine the impacts of solar storms on Earth's technological and environmental systems. 4. Interpret the phenomena of sunspots and solar activity through the perspective of scientific exegesis of the Qur'an.

The novelty of this research lies in several aspects. First, this study utilizes direct observational documentation of sunspots during the active phase of Solar Cycle 25 conducted using telescopic imaging techniques. Second, this research integrates modern astronomical analysis with scientific Qur'anic interpretation within a comprehensive interdisciplinary framework. Third, this study provides analytical explanations regarding the relationship between solar magnetic activity, geomagnetic storms, and their implications for contemporary technological civilization from both scientific and theological perspectives. Consequently, this research contributes not only to the development of astronomy studies but also to strengthening the integration of science and Islam in contemporary academic discourse.

THE PHENOMENA SOLAR STORM AND THE SOLAR CYCLE

In addition to emitting electromagnetic waves, the Sun also emits high-energy particles. One example of a stream of high-energy particles from the Sun that spreads throughout the universe is the wind that blows across the Earth. Therefore, the flow of particles from the Sun is called the solar wind. This solar wind, which contains charged particles, is capable of altering the structure of the magnetic field in interplanetary space.[18] During periods of peak solar activity, the solar wind blows faster than usual, carrying particles with greater energy.

History records that an extremely powerful and massive solar storm occurred in 1859. The storm had an energy output nearly equivalent to 10 billion atomic bombs detonated in Hiroshima and Nagasaki, Japan, with an impact speed of 3,000 km/s. When the storm struck, telegraph lines in the United States and Europe experienced voltage surges, and many telegraph operators were electrocuted. Solar storms are also known as solar flares, which interact with Earth's magnetic field. This interaction causes a stronger transfer of energy[19]. Meanwhile,

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17 Antti Pulkkinen, "Space Weather: Terrestrial Perspective," *Living Reviews in Solar Physics* 4, no. 1 (2007): 1–60.

18 David A. King, *Astronomy in the Service of Islam* (Taylor & Francis, 2024), https://books.google.com/books?hl=id&lr=&id=_ME0EQAAQBAJ&oi=fnd&pg=PP1&dq=islamic+astronomy&ots=z4pzGbj9Bf&sig=w5WbBGwoSDP2r7uCBcTXGadgWdE.

19 David A. King, *Islamic Astronomy and Geography* (Routledge, 2022), https://books.google.com/books?hl=id&lr=&id=mV9cEAAAQBAJ&oi=fnd&pg=PT11&dq=islamic+astronomy&ots=tGvbueldAN&sig=PaPVm-6LIwKXKmD5au2HYqcGL4k.

geomagnetic storms are solar storms or temporary disturbances in Earth's magnetosphere; these are caused by shock waves from the solar wind and solar magnetic field clouds that interact with Earth's magnetic field.[20]

The 24th solar cycle is recorded to have peaked in 2012–2013, while the 25th cycle is expected to reach its maximum phase during the 2023–2024 period. The appearance of sunspots plays a crucial role not only in determining the Sun's rotation period but also serves as a key indicator of solar activity levels. The more sunspots that appear on the Sun's surface, the higher the activity level, and vice versa. Based on centuries of observations, scientists have found that the appearance of sunspots follows a regular periodic pattern, not random variations. Thus, fluctuations in the number of sunspots serve as the primary marker for the Sun's activity cycle.

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Therefore, the magnetosphere, satellites, the atmosphere, and the ionosphere all respond to increased solar activity. However, each of these environments reacts differently depending on the magnetic field and the energy of the solar particles. Extreme solar activity leads to extreme space weather and extreme reactions in the magnetosphere, ionosphere, and atmosphere.[21]

SUNSPOT OBSERVATION RESULTS FROM MAY 2022 TO SEPTEMBER 2023

Sunspots are areas on the Sun's surface that have lower temperatures than the average, with a highly complex arrangement. Another crucial finding from Galileo's in-depth observations of these sunspots is their constantly shifting positions, similar to what researchers do in sunspot studies, which yield various results regarding the appearance of sunspots on the Sun's surface, as shown in the image below:

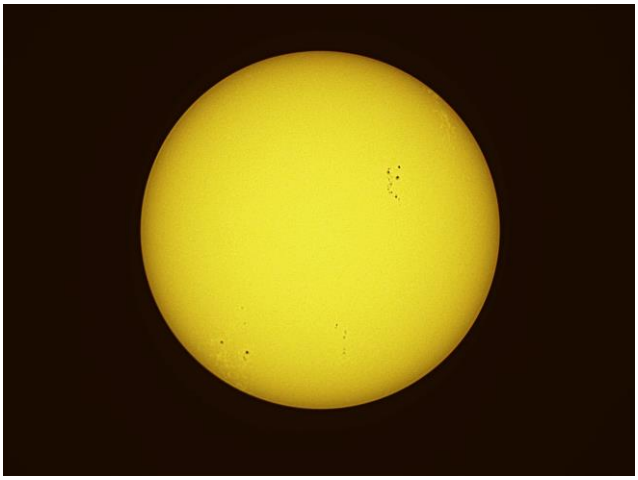

Figure 1: Sunspot On May 16, 2022

[20] Ilmu Geografi.com, "Bagian-Bagian Matahari Dan Gambarnya," preprint, n.d.

[21] Susanto, *Respon Magnetosfer Dan Ionosfer Di Atas Indonesia Terhadap Cuaca Antariksa Ekstrim Dan Dampaknya Pada Satelit Lapan Tubsat*.

Imaging Time	May 16, 2022, at 9:30 a.m. WIB.
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)
Imaging Device	Kamera : ZWO asi 224mc
	Lens : SV Bony 80ed f/7
	Mounting : Skywatcher EQ 3 Automated with Onstep
	Filter : ND 5, IR cut
Image Capture software	Sharpcap
Image Recording Format	AV1 (Video non-kompresi)
Number of Frames	200 frame
Image Processing Software	Stacked with Registax 6, Enhanced with Light-room Mobile
Image output Format	JPG color

Based on observations on May 16, 2022, several groups of sunspots were observed beginning to appear on the Sun's photosphere. The emergence of sunspots during this period indicates that solar activity is beginning to increase as we approach the active phase of Solar Cycle 25. The relatively limited distribution of sunspots suggests that the Sun's magnetic field has not yet reached its maximum strength, but has already shown signs of magnetic instability. From an astronomical perspective, this phase marks the beginning of increased flare activity and the release of electromagnetic energy that can affect space weather conditions.

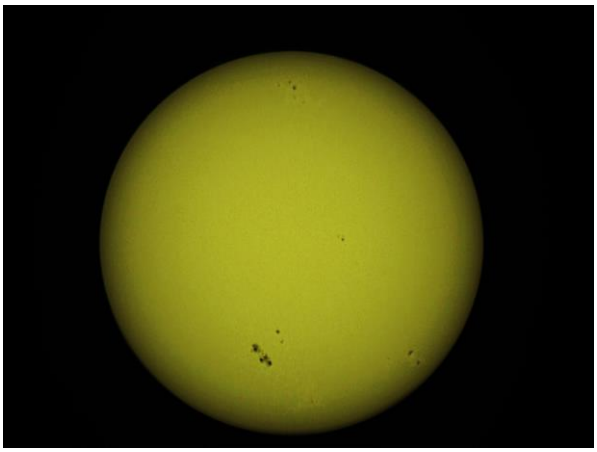

Figure 2: Sunspot On May 18, 2022

Imaging Time	May 18, 2022

Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	
Image Recording Format	AV1 (Video non-kompresi)	
Number of Frames	200 frame	
Image Processing Soft-ware	Stacked with Registax 6, Enhanced with Lightroom Mobile	
Image output Format	JPG color	

Observations on May 18, 2022, show changes in the position and number of sunspots compared to previous observations. The shift in sunspot positions indicates the Sun's rotation on its axis. Additionally, the increase in the number of sunspots reflects the development of increasingly complex magnetic activity. This phenomenon supports the theory that solar activity is dynamic and undergoes periodic changes in accordance with the 11 year cycle. Scientifically, these changes serve as early indicators of an increased probability of solar flares and Coronal Mass Ejections (CMEs).

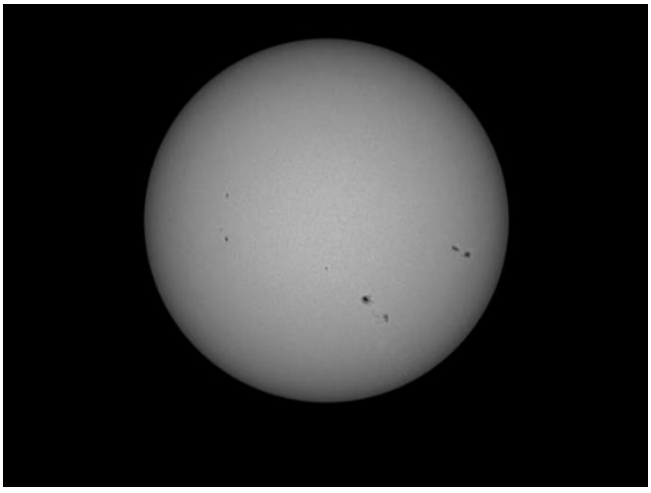

Figure 3: Sunspot On July 09, 2022

Imaging Time	July 09, 2022 at 10:28 am. WIB.
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)

Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	
Image Recording Format	AV1 (Video non-kompresi)	
Number of Frames	200 frame	
Image Processing Soft-ware	Stacked with Registax 6, Enhanced with Lightroom Mobile	
Image output Format	JPG monochrome	

During observations on July 9, 2022, a group of sunspots was observed that were larger than those in the previous period. This indicates an increase in the intensity of the Sun's magnetic activity. Enlarged sunspots are typically associated with an increased concentration of magnetic fields in the photosphere, which inhibits the process of heat convection from the Sun's interior. This condition causes certain areas to appear darker than their surroundings. In the context of modern astronomy, an increase in sunspot size is often associated with the potential for medium- to high-class solar flares.

Figure 4: Sunspot On September 25, 2022

Imaging Time	September 25, 2022 at 15:15 am. WIB.
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)
Imaging Device	Kamera : ZWO asi 224mc

	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	
Image Recording Format	AV1 (Video non-kompresi)	
Number of Frames	200 frame	
Image Processing Software	Stacked with Registax 6, Enhanced with Lightroom Mobile	
Image output Format	JPG color	

Observations show that sunspot distribution is beginning to spread across parts of the Sun's surface. This pattern indicates that Solar Cycle 25 is entering a phase of greater activity compared to mid-2022. The complexity of the sunspot structure indicates increased magnetic field interactions that could trigger instability in the Sun's plasma. In space weather studies, such conditions often serve as an indicator of an increased potential for geomagnetic storms that impact communication and navigation systems on Earth.

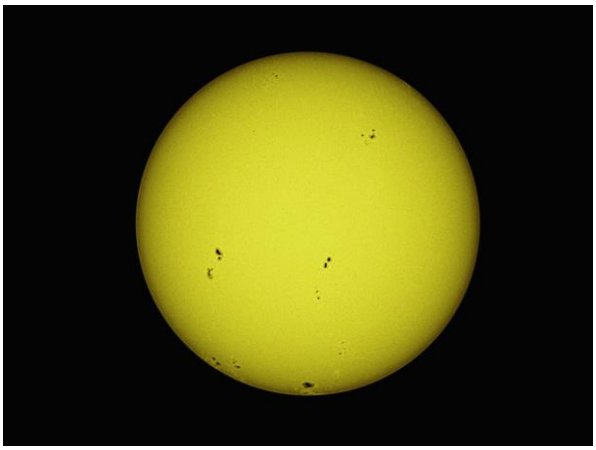

Figure 5: Sunspot On January 14, 2023

Imaging Time	January 14, 2023 at 09:30 am.WIB.	
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step

	Filter : ND 5, IR cut
Image Capture software	Sharpcap
Image Recording Format	AV1 (Video non-kompresi)
Number of Frames	200 frame
Image Processing Software	Stacked with Registax 6, Enhanced with Lightroom Mobile
Image output Format	JPG color

In early 2023, the number of observed sunspots increased significantly. This indicates that the Sun is approaching the peak of Solar Cycle 25. Increased sunspot activity correlates with high levels of solar flares and the release of high-energy charged particles into space. From a solar physics perspective, this increase reflects increasingly complex magnetohydrodynamic dynamics within the Sun's photosphere and chromosphere.

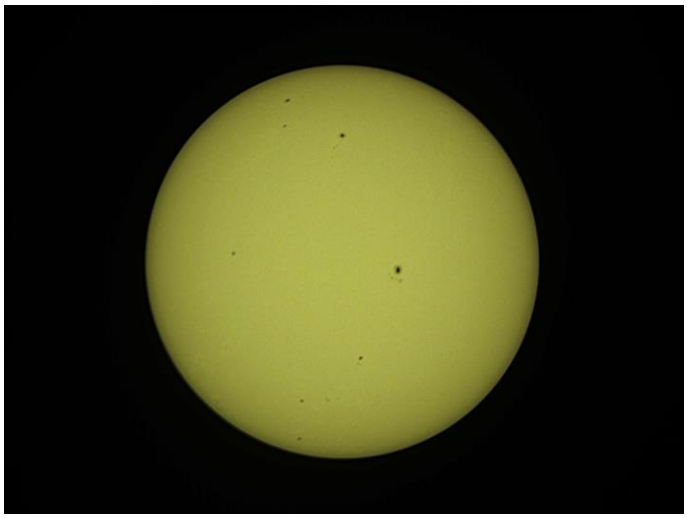

Figure 6: Sunspot On March 10, 2023

Imaging Time	March 10, 2023 at 09:51 am.WIB.	
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step

	Filter : ND 5, IR cut
Image Capture software	Sharpcap
Image Recording Format	AV1 (Video non-kompresi)
Number of Frames	200 frame
Image Processing Soft-ware	Stacked with Registax 6, Enhanced with Lightroom Mobile
Image output Format	JPG color

Observations on March 10, 2023, revealed a denser and more active sunspot structure. This pattern indicates that the Sun's magnetic activity is experiencing a fairly steady increase. The presence of several sunspot groups at the same time suggests a significant accumulation of magnetic energy on the Sun's surface. Astronomically, these conditions have the potential to produce high-class solar flares that could trigger geomagnetic disturbances if the plasma energy is directed toward Earth.

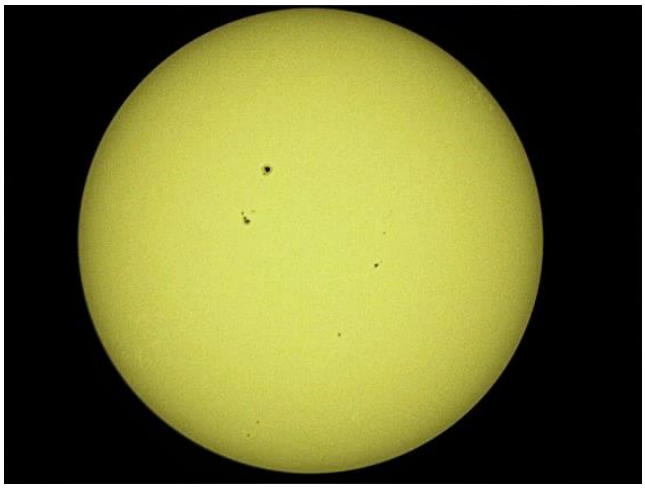

Figure 7: Sunspot On April 19, 2023

Imaging Time	April 19, 2023 at 09:37 am. WIB.	
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	

Image Recording Format	AV1 (Video non-kompresi)
Number of Frames	200 frame
Image Processing Software	Stacked with Registax 6, Enhanced with Lightroom Mobile
Image output Format	JPG color

Observations from April 2023 reveal increasingly complex sunspot activity. The rising number of sunspots indicates that the peak of Solar Cycle 25 is drawing nearer. The complexity of the magnetic structures within sunspot regions suggests the possibility of magnetic reconnection, which could trigger solar flares. From a modern astronomical perspective, this phenomenon is one of the primary indicators of increasing global space weather activity.

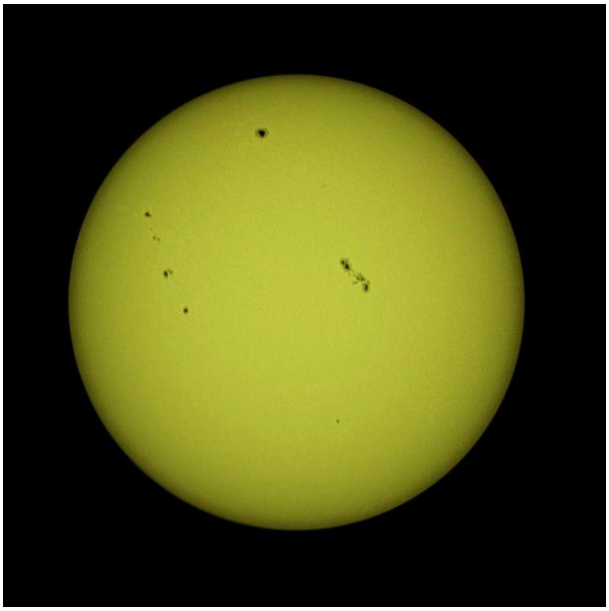

Figure 8: Sunspot On May 23, 2023

Imaging Time	May 23, 2023 at 11:01 am. WIB	
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	

Image Recording Format	AV1 (Video non-kompresi)
Number of Frames	200 frame
Image Processing Software	Stacked with Registax 6, Enhanced with Lightroom Mobile
Image output Format	JPG color

Observations on May 23, 2023, showed that sunspot activity was expanding and spreading across several regions of the Sun's photosphere. This indicates high solar activity during the middle of 2023. Physically, the distribution of sunspots is influenced by the interaction of the Sun's internal magnetic field, which is constantly changing due to the Sun's differential rotation. This activity also increases the likelihood of Coronal Mass Ejections (CMEs), which can impact Earth's magnetosphere.

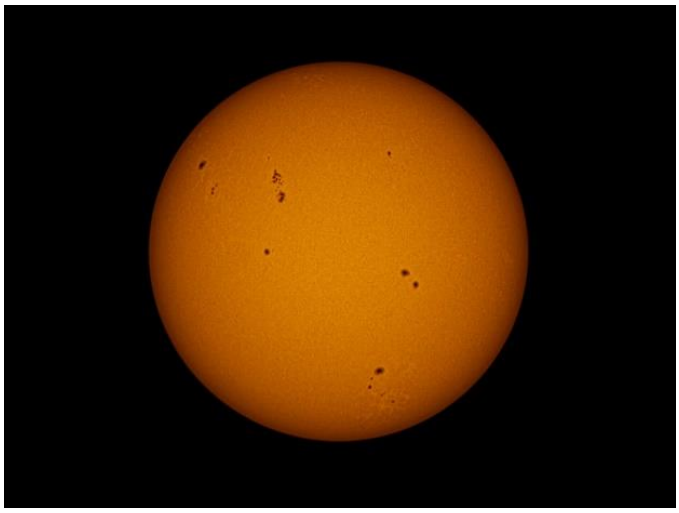

Figure 9: Sunspot On July 22, 2023

Imaging Time	July 22, 2023 at 09:44 am. WIB.	
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with Onstep
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	
Image Recording Format	AV1 (Video non-kompresi)	

Number of Frames	200 frame
Image Processing Soft-ware	Stacked with Registax 6, Enhanced with Lightroom Mobile
Image output Format	JPG color

Observations from July 2023 show a higher intensity of sunspot activity compared to observations from the previous year. Sunspots appear more prominent and active on the Sun's surface. This phenomenon indicates that Solar Cycle 25 is in a phase of high activity. In the context of space weather, these conditions are closely linked to an increased risk of disruptions to satellite communication systems, GPS, and power grids due to geomagnetic storms.

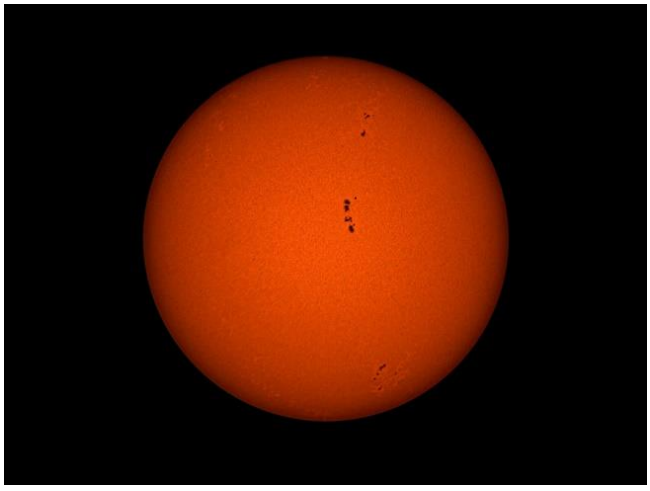

Figure 10: Sunspot On September 09, 2023

Imaging Time	September 09, 2023 at 15:37 am. WIB.	
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)	
Imaging Device	Kamera	: ZWO asi 224mc
	Lens	: SV Bony 80ed f/7
	Mounting	: Skywatcher EQ 3 Automated with On-step
	Filter	: ND 5, IR cut
Image Capture software	Sharpcap	
Image Recording Format	AV1 (Video non-kompresi)	
Number of Frames	200 frame	
Image Processing Software	Stacked with Registax 6, Enhanced with Lightroom	

	Mobile
Image output Format	JPG color

Observations from September 2023 show highly active sunspot activity with an increasingly widespread distribution. This indicates that the Sun is very close to the peak of its cycle. High magnetic activity increases the potential for Class X solar flares and large-scale CMEs. From an astronomical perspective, this phenomenon demonstrates that the Sun is an active plasma system that is constantly undergoing dynamic energy changes.

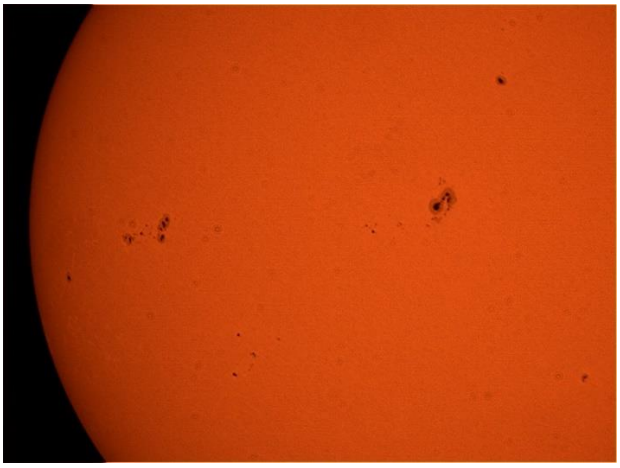

Figure 11: Sunspot On September 23, 2023

Imaging Time	September 23, 2023 at 09:55 am. WIB.
Imaging Location	Songgolangit Institute (111° 30' BT, 07° 55' S)
Imaging Device	Kamera : ZWO asi 224mc
	Lens : SV Bony 80ed f/7
	Mounting : Mounting Skywatcher AZEQ 6 Pro
	Filter : ND 5, IR cut, Teleskop 102 mm F/7
Image Capture software	Sharpcap
Image Recording Format	AV1 (Video non-kompresi)
Number of Frames	200 frame
Image Processing Software	Stacked with Registax 6, Enhanced with Lightroom Mobile
Image output Format	JPG color

The latest observations on September 23, 2023, show that the number and complexity of sunspots have reached a very significant level. This reinforces indications that Solar Cycle 25 is entering its peak phase. The complex structure of the sunspots indicates a large and unstable accumulation of magnetic energy. In astronomical analysis, such conditions have a high potential to trigger major solar storms that could affect Earth's magnetosphere, global communication systems, and modern satellite technology. Furthermore, these observations also demonstrate that solar activity is dynamic and follows a regular cyclical pattern in accordance with cosmic laws (sunnatullah).

SUNSPOTS AND SOLAR STORMS FROM THE PERSPECTIVES OF SCIENTIFIC EXEGESIS AND ASTRONOMY

Based on the results of sunspot observations presented by researchers through photographs of the Sun, it can be explained that the position of sunspots is constantly changing; sometimes these sunspots appear sparse, and at other times they appear numerous on the Sun's surface. These changes in the position of sunspots can occur and are interpreted as a result of the Sun's rotation around its axis. Thus, the sun also has an 11 year cycle in its activity; as per the cycle theory, at the beginning and end of the cycle, the sun exhibits little activity or, more accurately, is in a quiet phase but at the peak of the cycle, the sun exhibits significant activity, one of which is sunspots, marked by the frequent appearance of sunspots on the sun's surface, indicating that its activity is increasing. Then, regarding the sun being rolled up, the sun rotating, and its center translating. As per the verse below:

وَالشَّمْسُ تَجْرِيْ لِمُسْتَقَرٍّ لَّهَا ۗذٰلِكَ تَقْدِيْرُ الْعَزِيْزِ الْعَلِيْمِ

Meaning:

"And the sun runs its course to a place of rest. Such is the decree of the Almighty, the All-Knowing." (Q.S. Yasin ayat:38)

The word tajrī in this verse refers to continuous motion not merely rotation, but also the Sun's translation through the Milky Way at a speed of approximately 220 km/s. In Tafsir al-Marāghī, this verse explains that every celestial body, including the Sun, travels precisely along its orbit without colliding with one another. This aligns with the principles of celestial mechanics developed by Kepler and Newton regarding the regularity of planetary orbits.

From a scientific perspective, the Sun's rotation causes the phenomenon of sunspots. Changes in the position and number of sunspots correspond to the Sun's rotation around its axis. Thus, this verse can be understood as an indication that the Qur'an had already hinted at the dynamic nature of the Sun long before modern astronomy developed.[22]

The topic of sunspots is also related to Surah Fushilat, verse 37, which reads:

وَمِنْ اٰيٰتِهِ الَّيْلُ وَالنَّهَارُ وَالشَّمْسُ وَالْقَمَرُۗ لَا تَسْجُدُوْا لِلشَّمْسِ وَلَا لِلْقَمَرِ وَاسْجُدُوْا لِلّٰهِ الَّذِيْ خَلَقَهُنَّ اِنْ كُنْتُمْ اِيَّاهُ تَعْبُدُوْنَ

Meaning: "And among His signs are the night, the day, the sun, and the moon. Do not worship the sun or the moon, but worship God, who created them, if it is Him you wish to worship.". (Q.S. Fushilat ayat 37)

This verse affirms that although the Sun is a vital source of energy for life, it is merely a creation of God, not an entity worthy of worship. In his commentary "al-Misbah", Quraish Shihab interprets this verse as an affirmation of "tawhid al-rububiyah", that is, the recognition

[22] Purwanto, *Ayat-Ayat Semesta Sisi-Sisi al-Quran Yang Terlupakan*.

that the order of the cosmos reflects the majesty of God and the obedience of His creatures to divine law.[23]

The phenomenon of sunspots appearing and disappearing periodically can be interpreted as a form of "nature's obedience" to the system established by God. The Sun's 11year cycle demonstrates a balance between activity and calm, which, from a scientific interpretive perspective, can be understood as a manifestation of the principle of balance (mīzān) in the cosmos, as mentioned in Q.S. *Al-Rahman* (55):7–9.

Next is verse 1 of Surah al-Takwir, which reads

اِذَا الشَّمْسُ كُوِّرَتْۚ

Meaning: "When the Sun is rolled up." (Q.S. al-Takwir ayat:1)

he sun is rolled up? The sun is not like a piece of cloth, so how could it possibly be rolled up? We have accepted the sun as a celestial body, just like the earth, which is spherical, but what does a spherical object look like when it is rolled up?. Classical exegetes such as al-Qurtubi interpret the phrase kuwwirat (rolled up) as a symbol of the sun's light being extinguished on the Day of Judgment.[24] However, contemporary exegetes such as Agus Purwanto also interpret this verse scientifically as a possible "collapse" or "decrease in energy intensity" associated with the phases of stellar evolution.

From an astronomical perspective, the term "rolled up" can be likened to the decline in solar activity during the minimum phase of its cycle, when the number of sunspots drops dramatically and electromagnetic radiation remains relatively stable. In this context, the Qur'an seems to suggest that the Sun's light is not constant, but rather undergoes fluctuating dynamics in accordance with Allah's will[25].

Physically, the formation of sunspots is explained by the concept of magnetohydrodynamics (MHD), which describes the interaction between magnetic fields and plasma within the Sun. When convective currents carry hot plasma from the interior to the surface, some of the magnetic fields become trapped in the photosphere, creating regions of high magnetic pressure. This pressure inhibits the transfer of convective energy, causing the local temperature to drop, and a sunspot is formed.[26]

Sunspots typically appear in pairs, each with opposite magnetic polarities (bipolar). The direction of these polarities reverses every 11 years, so the Sun's entire magnetic cycle lasts 22 years. This cycle is known as the Hale Cycle, which explains the reversal of the Sun's global magnetic field polarity. Observations using the Solar Dynamics Observatory (SDO) show that the magnetic field in large sunspots can reach intensities of up to 4,000 Gauss, equivalent to 10,000 times the Earth's magnetic field. When these magnetic field lines become entangled and then break apart (magnetic reconnection), a large amount of energy is released in the form of electromagnetic radiation a phenomenon observed as a flare or CME.

The relationship between sunspots and solar storms is direct and causal. Statistics from the NOAA Space Weather Prediction Center show that more than 80% of major solar flares (M- and X-class) occur near active sunspot groups with complex magnetic configurations (βγδ type

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[23] Shihab, *M. Tafsir Al-Misbah Vol. 15*.

[24] A. Al-Qurtubi, *Al-Jami' Li Ahkām al-Qur'an* (Dar al-Kutub al-'Ilmiyyah, 1964).

[25] David A. King, "Astronomy and Islamic Society: Qibla, Gnomonics and Timekeeping," in *Encyclopedia of the History of Arabic Science* (Routledge, 2019), https://www.taylorfrancis.com/chapters/edit/10.4324/9780203403600-4/astronomy-islamic-society-qibla-gnomonics-timekeeping-david-king.

[26] Fransiska Viola Gina, "Akan Terjadi Lebih Cepat, Apa Saja Dampak Badai Matahari Bagi Bumi?," preprint, n.d.

according to the Mount Wilson classification). During the peak of the solar cycle, the number of sunspots increases and the magnetic field configuration becomes unstable. Consequently, the frequency of flares and CMEs also increases. When a CME reaches Earth, charged particles interact with Earth's magnetic field (the magnetosphere), causing geomagnetic storm phenomena. The intensity of these storms is measured by the Kp index, where a value of ≥5 indicates strong activity.

Sunspots are characterized by eruptions that spew out jets of plasma. This phenomenon is often referred to as a solar flare, which triggers a solar storm with temperatures reaching 5 million Kelvin. The form of a solar storm can be seen in the image below:

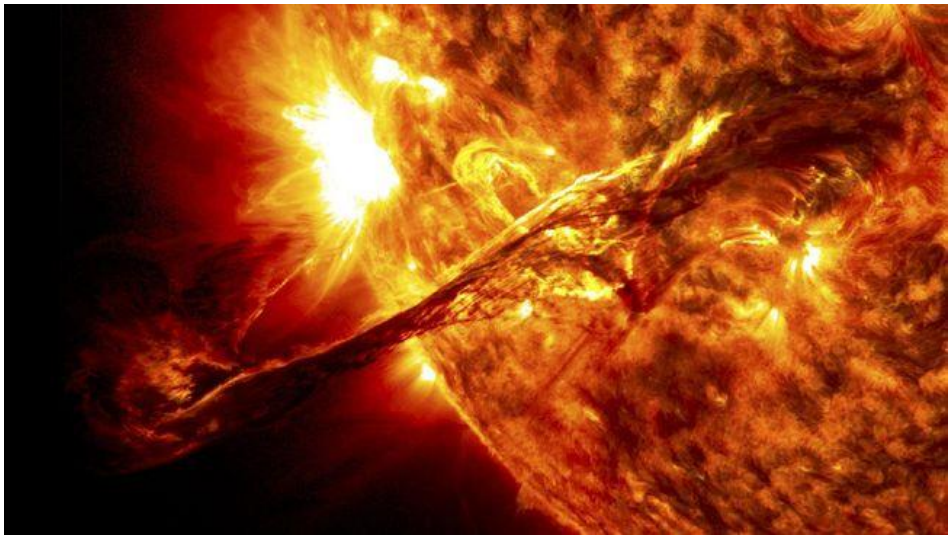

Figure: 12

THE IMPACT OF SUNSPOTS AND SOLAR STORMS

Solar activity plays a fundamental role in shaping the near-Earth space environment. During periods of increased solar activity, particularly around the maximum phase of the solar cycle, the frequency of solar flares and Coronal Mass Ejections (CMEs) rises significantly. These phenomena release enormous amounts of electromagnetic radiation and charged particles into interplanetary space, which can interact with Earth's magnetosphere and ionosphere.[27]

One of the most significant consequences of solar storms is the occurrence of geomagnetic disturbances. When CMEs reach Earth, they compress the magnetosphere and generate geomagnetically induced currents (GICs) in long conductive infrastructures such as electrical transmission networks, pipelines, and communication cables[28]. Studies have shown that intense geomagnetic storms can disrupt power systems and even cause widespread blackouts[29]. A notable

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27 Hugh S. Hudson, "Solar Flares, Microflares, Nanoflares, and Coronal Heating," *Solar Physics* 133, no. 02 (1991): 357–69.

28 David A. King, "Universal Solutions in Islamic Astronomy," in *Astronomy in the Service of Islam* (Routledge, 2024), https://api.taylorfrancis.com/content/chapters/edit/download?identifierName=doi&identifierValue=10.4324/9781003557166-6&type=chapterpdf.

29 Zulkarnain Muhammad Ali and Eneng Musfiroh, "Astronomy in The Quran: Comparative Study of Geocentric and Heliocentric," *Darul Hikmah: Jurnal Penelitian Tafsir dan Hadits* 10, no. 2 (2024): 177–91.

example is the March 1989 geomagnetic storm that led to the collapse of the Hydro-Québec power grid in Canada, leaving millions without electricity.[30]

Solar storms also have substantial impacts on satellite operations and global navigation systems. Enhanced solar radiation increases ionospheric electron density, causing signal scintillation and propagation delays that reduce the accuracy of Global Positioning System (GPS) measurements. Such disturbances can negatively affect aviation, maritime navigation, military operations, and satellite-based communication systems.[31] Furthermore, increased thermospheric heating during periods of strong solar activity expands the upper atmosphere, resulting in greater atmospheric drag on Low Earth Orbit (LEO) satellites and accelerating orbital decay.[32]

Another important consequence concerns space radiation hazards. Solar Energetic Particle (SEP) events associated with major solar eruptions can expose astronauts and spacecraft electronics to high levels of ionizing radiation. Such exposure may damage electronic components, disrupt onboard systems, and increase long-term health risks for astronauts, including DNA damage, cancer development, and neurological disorders.[33] Therefore, continuous monitoring of solar activity has become a critical component of modern space mission planning and space weather forecasting.

From an environmental perspective, solar storms are also associated with spectacular auroral displays produced when energetic charged particles collide with atmospheric atoms and molecules in the polar regions[34]. Although auroras represent the visible manifestation of geomagnetic activity, extreme space weather events can simultaneously create adverse technological consequences[35]. Consequently, understanding the relationship between sunspots, solar flares, and geomagnetic storms is essential for mitigating the vulnerability of contemporary technological civilization to solar-induced disturbances. The observations conducted in this study indicate that the increasing number and complexity of sunspots during Solar Cycle 25 correspond with a heightened probability of solar flares and CMEs. This finding is consistent with contemporary heliophysics research demonstrating that active sunspot regions with complex magnetic configurations serve as primary sources of major solar eruptions.[36]

CONCLUSION

Sunspots and solar storms are astronomical phenomena that demonstrate the dynamics and complexity of the Sun's magnetic activity. Based on observations and a review of the literature from May 2022 to September 2023, increased solar activity marks the peak phase of the 25th Solar Cycle, characterized by a rise in the number of sunspots and the occurrence of Class X and

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30 Pulkkinen, "Space Weather: Terrestrial Perspective."

31 Cathryn N. Mitchell and Paul S. J. Spencer, "Ionospheric Effects on GPS," *Space Weather* 1, no. 2 (2003): 1019–28.

32 Delores J. Knipp et Al, "The May 2024 Extreme Space Weather Event and Atmospheric Drag Effects," *Space Weather* 22, no. 8 (2024).

33 Cary Zeitlin et Al, "Overview of Solar Energetic Particle Events and Radiation Hazards," *Life Sciences in Space Research* 21 (2019): 73–82.

34 Belay Sitotaw Goshu, "Mapping Solar Variability of Equatorial Sunspots and Plasma Flows," *Brazilian Journal of Science* 3, no. 9 (2024): 49–64.

35 Muna Zahriya and Faisal Abdullah, "The Movement of The Sun In Qs. Yasin Verse 38: Analysis of The Meaning of Tajrī Li Mustaqarrin Lahā from The Perspective Of The Qur'an and Astronomical Science," *Interdisciplinary Journal of Global and Multidisciplinary* 2, no. 1 (2026): 686–93; Goshu, "Mapping Solar Variability of Equatorial Sunspots and Plasma Flows."

36 Dibyendu Nandy, "The Sun's Magnetic Cycle and Space Weather," *Progress in Earth and Planetary Science* 8, no. 1 (2021): 1–23.

CME flares. These phenomena demonstrate that the Sun is not a static object, but rather an active plasma system that moves in accordance with the laws of the universe (sunnatullah).

From an astronomical perspective, research shows that there is a significant correlation between the number of sunspots and geomagnetic storms: the higher the sunspot activity, the greater the likelihood of solar storms that affect communication, navigation, and electrical systems on Earth. However, the Earth's magnetosphere and atmosphere act as natural shields, preventing high-energy radiation from the Sun from endangering life on the surface.

From a scientific interpretation, this phenomenon aligns with Allah's words in Surah Yasin (36:38) and Surah Fushshilat (41:37), which demonstrate the order and obedience of celestial bodies to the laws of His creation. Sunspots and solar storms are forms of signs of His greatness (ayat kauniyyah) that contain spiritual lessons for humanity: that all cosmic systems are subject to the decrees of Allah SWT. This study demonstrates that the integration of scientific exegesis and modern astronomy can provide a comprehensive understanding of natural phenomena, both scientifically and theologically. Science helps humanity understand the mechanisms of God's creation, while revelation provides ethical guidance and moral values in utilizing it. Thus, this research not only expands scientific horizons but also strengthens humanity's spiritual and ecological awareness as stewards of the earth.

Finally, the phenomena of sunspots and solar storms symbolize the harmony between science and faith between the order of celestial physics and the beauty of the Divine order. Both teach us that understanding the universe is not merely a matter of science, but also an effort to uncover the signs of God's greatness in every pulse of cosmic energy.

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