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Sunspot Cycle-Window to Our Galaxy's Past and Future

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Abstract:

The succession of day and night and the cycle of seasons are two acquainted natural cycles around which many human happenings are planned. But there is a third natural cycle also which is of great importance for humans. There was an event took place on 13 March 1989 where the electricity went out for many hours in Canada: a large detonation on the sun was exposed as the reason for this shutdown. In further researches, it was cleared the mystery that explosions occur above sunspots which is actually dark structures on the surface of the Sun that have been detected through telescopes since the period of Galileo. The first ever record that is found to be in written about sunspot sighting dates back to 28 B.C There's fascinating science behind the sunspot cycle. Astronomer S.H. Schwabe is regarded as the first scientist who describes the 11-year sunspot cycle. The sum of sunspots has been found to undergo alternate increases and decreases over a period of 11 years. This cycle was exposed less than two centuries ago, it is becoming progressively significant for us as human civilization becomes more reliant on technology. For nearly a century after its discovery, the root of the sunspot cycle stayed completely masked in unidentified situation. In 1908 strong magnetic fields were discovered which made that the 11-year cycle is actually the magnetic cycle of the sun. It is only throughout the last few eras that major growths in plasma physics have at last given us the linking evidence to the backgrounds of the cycle and also about how the large explosion is affecting the earth.

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Introduction

Sunspots

Sunspots are dark, about planet-sized areas that seem to be on the surface of the Sun. Sunspots are dark as they are colder than their surrounding areas. A large sunspot might have a temperature of about 4,000 K (about 3,700° C or 6,700° F) which is actually much lower than the 5,800 K (about 5,500° C or 10,000° F) temperature of the bright photosphere of the sun, the area that environs the sunspots.

Sunspots appear only dark in contrast to the sunny side of the Sun. If an average sunspot cut out of the Sun and place in the night sky, it will be approximately as bright as a full moon. Sunspots have a lighter periphery called the penumbra, and a darker middle region is named as the umbra.

Sunspots are produced by the Sun's magnetic field brimming up to the photosphere which is Sun's visible surface. Active regions on the Sun is produced because of the powerful magnetic fields, which eventually cause to generate solar flares and Coronal Mass Ejections (CMEs) and this solar activity of flares and CMEs are entitled as" solar storms".

Sunspots formed over periods lasting from days to weeks and can last for weeks or sometimes even for months. The average sum of spots that can be clearly visible on the brighter face of the Sun is not always the same but sometimes drives up and down in a cycle also. Historical records of counting of sunspot demonstrated that this sunspot cycle has a typical duration of about eleven years.

Sunspot Cycle

The sum of sunspots perceived on the surface of the Sun deviates from year to year. This increase and decrease in the count of a sunspot is a cycle. The span of the cycle is about eleven years on an average. This cycle was discovered in 1843 by the inexpert German astronomer Samuel Heinrich Schwabe. A peak in the sunspot count is called "solar maximum" (or "solar max"). The time when only a few sunspots are seemed, it is called as "solar minimum" (or "solar min"). An instance of a recent sunspot cycle spans the years from the solar min in 1986, when 13 sunspots were seen, through the solar max in 1989 when more than 157 sunspots appeared, on to the next solar min in 1996 (ten years after the 1986 solar min) when the sunspot count had fallen back down to fewer than 9. The length of the sunspot cycle is, on average, around eleven years. But the span of the cycle does fluctuate. Between 1700 and today, the sunspot cycle (from one solar min to the next solar min) has varied in length from as short as nine years to as long as fourteen years.

Sometimes it is tough to get a careful count of the figure of sunspots on the Sun. Some spots are much superior to others, many spots appear in groups and some sunspots cross unruffled at their edges. In 1848, a Swiss astronomer named Rudolf Wolf originated with the finest way to tally sunspots count. The sunspot count using Wolf's formula, now known as the Wolf sunspot number and is still in use today. Wolf used data from earlier astronomers to rebuild sunspot counts as far back as the 1755-1766 cycle, which he called "cycle 1". Since then, successive cycles have been totaled consecutively, so the cycle that began with the 1996 solar minimum is cycle 23. The Sun is usually very vigorous and energetic when sunspot counts are high. Sunspots demonstrated to us where the Sun's magnetic field might be twisted up plentiful to ground for solar flares and coronal mass ejections. The Sun radiates more radiation than usual during solar max, and this extra energy changes the uppermost layers of Earth's atmosphere extensively.

Size of Sunspots

Sunspots are very big structures. They impact small compared to the Sun but remember the Sun has a diameter of 1.4 million km (870 thousand miles).

Most sunspots might swallow a planet! Many sunspots, like the ones shown in the image on this page, are as large as Earth! Most spots range in size from about 1,500 km (932 miles) to around 50,000 km (31,068 miles) in diameter. Once in a while, huge sunspots the size of Jupiter show up on the Sun's surface.

Sunspots and Magnetic Fields

Sunspots are initiated by very strong magnetic fields on the Sun. The best way to think about the very complicated process of sunspot construction is to think of magnetic "ropes" breaking through the visible surface (photosphere) of the Sun. Where the rope comes up from the solar surface is one sunspot and where the rope falls into photosphere is another sunspot. As you can see in the picture to the left, one sunspot has North magnetic polarity and one sunspot has south magnetic polarity. Scientists have faith in the differential rotation of the Sun is the underlying cause of the magnetic ropes on the Sun. Since the gaseous sphere of the Sun exchanges more quickly at its equator than at its poles, the Sun's whole magnetic field becomes distorted and twisted over time. The twisted field lines at the end of the day come through the photosphere, showing their presence as sunspots. When the tangled fields reach a "breaking point", like a rubber band that breaks when wound too tight, huge bursts of energy are released as the field lines recombine. This can lead to solar flares and Coronal Mass Ejections.

The Effect of Sunspots on the Earth's Climate Even still sunspots are darker, cooler regions on the look of the sun, periods of high sunspot activity are associated with a very minor increase in the total energy output of the sun. Dark sunspot areas are enclosed by areas of increased brightness, known as plages. Some parts of the solar spectrum, especially ultraviolet, increase a great deal during sunspot activity. Even though ultraviolet radiation marks very little contribution to the total energy that comes from the sun, fluctuations in this type of radiation can have a large effect on the earth's atmosphere, particularly the energy balance and chemistry of the outer atmosphere. Though the connection between sunspot activity and the earth's climate is still being debated, it is known that a period of unusually low sunspot activity from 1645-1715, called the Maunder Minimum, coincided with a period of long cold winters and severely cold temperatures in Western Europe, often called the "Little Ice Age."

According to Fisher, "It's controversial whether the solar cycle has an effect on the earth's climate. One thing that is known for sure is that solar activity, which is what we call the general feature of having magnetic fields on the sun, changes the sun's luminosity--that is, how much energy is coming out of the sun--on the level of a few tenths of a percent. That could conversion the earth's climate in this cyclical way, but it's controversial." The controversy is due to the intricacy of the earth's climate. It is tough to straighten out the many dynamics that subsidize climate change.

Dearborn is also thoughtful about ascribing climate effects to sunspot cycles: "People have speculated, but I don't think the fitting together is absolute yet, there is some assumption that sunspots result in climate effects, but that's a very, very hard area and one that requires much more research before we can be certain of climate effects."

Eccentricities in the sunspot cycle seem to have far less impact on the earth's climate than human actions for right now, such as burning fossil fuels or clear-cutting jungles, do. However, more research into sunspots needs to do. (Explotarium.edu)

Review of Literature

Hathaway, Wilson, and Reichmann (1993), studied that the temporal behavior of a sunspot cycle, as described by the International sunspot numbers, can be represented by a simple gathering with four parameters: starting time, amplitude, rise time, and asymmetry. Of these, the limitation that manages the irregularity between the rise to maximum and the fall to a minimum is found to vary little from cycle to cycle and can be fixed at a particular value for all cycles. A close relationship is found among rising time and amplitude which allows for an exemplification of each cycle by a function containing only two factors: the starting phase and the amplitude. These parameters are determined for the previous 22 sunspot cycles and examined for any predictable behavior. A weak correlation is found between the amplitude of a cycle and the length of the previous cycle. This allows for an estimate of the amplitude accurate to within about 30% right at the start of the cycle. As the cycle progresses, the amplitude can be better determined to within 20% at 30 months and to within 10% at 42 months into the cycle, thereby providing a good estimate both for the timing and size of sunspot maximum and for the behavior of the remaining 7-12 years of the cycle.

Hathaway, Wilson, and Reichmann (2002), examined the ‘Group’ sunspot numbers constructed by Hoyt and Schatten to determine their utility in characterizing the solar activity cycle. They compared smoothed monthly Group sunspot numbers to Zürich (International) sunspot numbers, 10.7-cm radio flux, and total sunspot area. They found that the Zürich numbers follow the 10.7-cm radio flux and total sunspot area measurements only a little better than the Group numbers. They examined numerous significant characteristics of the sunspot cycle using both Group numbers and Zürich numbers. It was found that the ‘Waldmeier Effect’ – the anti-correlation between cycle amplitude and the elapsed time between minimum and maximum of a cycle – is much more obvious in the Zürich numbers. The ‘Amplitude–Period Effect’ – the anti-correlation between cycle amplitude and the length of the previous cycle from minimum to minimum – is also much more apparent in the Zürich numbers. The ‘Amplitude–Minimum Effect’ – the correlation between cycle amplitude and the activity level at the previous (onset) minimum is equally apparent in both the Zürich numbers and the Group numbers. The ‘Even–Odd Effect’ – in which odd-numbered cycles are larger than their even-numbered precursors – is somewhat stronger in the Group numbers but with a tighter relationship in the Zürich numbers. The ‘Secular Trend’ – the increase in cycle amplitudes since the Maunder Minimum – is much stronger in Group numbers. They also found little evidence for a correlation between the amplitude of a cycle and its period or for a bimodal distribution of cycle periods. He concluded that the Group numbers were most useful for extending the sunspot cycle data further back in time and thereby adding more cycles and improving the statistics. However, the Zürich numbers were slightly more useful for characterizing the on-going levels of solar activity.

Volobuev (2009), described empirically the shape of the sunspot cycle as one of the oldest problems of solar physics. They demonstrated that accurate two-parameter fit is achievable where the parameters are correlated (r = 0.88) for 23 solar cycle correlation between the factors of our fit provides the possibility of a one-parameter fit if the times of the minima are known a priori. A one-parameter fit can also be derived from truncated dynamo models, but the goodness of the fit is not better than as achieved for the empirical fit. They suggested that the goodness of a one-parameter fit can serve as a criterion to compare different dynamo models. A one-parameter fit provides the possibility to forecast the shape of the coming cycle via a forecast of one parameter which changes synchronously with the secular variation. A previous estimation of the coming decadal average sunspot number is converted into the forecast of the shape of the 24th cycle with a maximum of 118±26 W. The accuracy is limited mostly by the uncertainties of the predicted secular variation and the uncertainty of the time of the minimum.

UCAR (2012), discussed that the number of sunspots observed on the "surface" of the Sun varies from year to year. This rise and fall in sunspot counts vary in a cyclical way; the length of the cycle is around eleven years on average. The cyclical variation in sunspot counts, discovered in 1843 by the amateur German astronomer Samuel Heinrich Schwabe, is called "the Sunspot Cycle". A peak in the sunspot count is referred to as a time of "solar maximum" (or "solar max"), whereas a period when few sunspots appear is called a "solar minimum" (or "solar min"). An example of a recent sunspot cycle spans the years from the solar min in 1986, when 13 sunspots were seen, through the solar max in 1989 when more than 157 sunspots appeared, on to the next solar min in 1996 (ten years after the 1986 solar min) when the sunspot count had fallen back down to fewer than 9. The 11-year sunspot cycle is actually half of a longer, 22-year cycle of solar activity. Each time the sunspot count rises and falls, the magnetic field of the Sun associated with sunspots reverses polarity; the positioning of magnetic fields in the Sun's northern and southern hemispheres switch. Thus, in terms of magnetic fields, the solar cycle is only complete (with the fields back the way they were at the start of the cycle) after two 11-year sunspot cycles. This solar cycle is, on average, about 22 years long - twice the duration of the sunspot cycle.

Choudhuri (2015), studied that in his book Nature's Third Cycle: A Story of Sunspot, he has described the whole series behind sunspot phenomena. From its origin to its cycle and various other phenomenon related directly to solar cycles. He explained that how sunspots reveal about the sun's rotation. In his book he explained the role of differential rotation of Earth and sun and also about that how can dis parameter can affect other phenomena that holds everything in its correct timing and place and what could be the possible changes may occur if there arise any turbulence in the natural process. Further, in included The Little Ice Age, it's the duration when there is no visible sunspot because of which there are various kinds of changes on the sun like changes in temperature, magnetic field etc. which eventually leads to changes on Earth as well. It was considered an an epoch in which auroral sighting was rare and also the corona also had gone missing in total solar eclipse falling during the epoch. In his book, he confirmed that Maunder minima were undoubtedly a reality. His book further investigates that whether the unusual climate changes on Earth and disappearance of sunspots was merely coincidence or related phenomenon.

Conclusion: Discovery of the sunspot cycle was a phenomenal event of the history in itself. Sunspot cycle does not only cause changes on the sun but eventually is the source of changes on the Earth as well. Phenomena taking place on the sun reveals about the sun and more we are getting to know the sun, our solar star, more we get to know about past of humankind and its existence into the solar system. It's a window to our past and future as well. Studying the sun and phenomena occurring on it like-sunspots, will not only teach us about formation of the sun but might also tell us the formation of our galaxy and there might be the chances that if we once get to know about how our galaxy came into existence, we might get to know the other galaxies and the world also. Though this will take bulks of decades to resolve the mystery we must not stop and feel content with our knowledge. Scientists have already used a collection of apparatuses including giant solar telescopes that were specifically ventilated and chilled to perceive the sun's light without any distortion of the sun's its heat so that we can learn more about the physics of sunspots. It's the tedious work and consistent effort of researchers and scientists in this field that recently spots on other stars have also been discovered. With the help of researches that have already been done, considering it as guidance, we can progress every day into this journey towards a better knowledge because better we know, better we would survive.

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