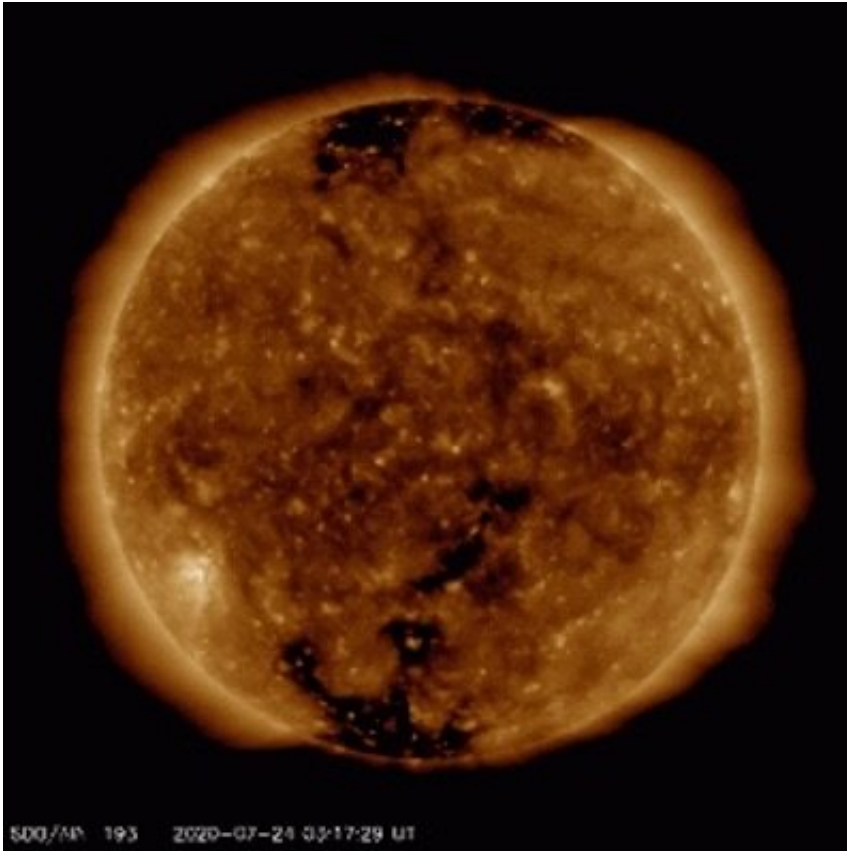


Coronal holes during the solar maximum

January 11 2021



An ultraviolet image of the Sun showing a coronal hole - a dark region, seen here at the north pole of the Sun with NASA's Solar Dynamics Observatory. Coronal holes are regions where the weakened magnetic field allows for a stronger solar wind to emerge. Astronomers have found correlations between coronal holes near the Sun's equator and the eleven and twenty-two year solar cycles. Credit: NASA, SDO

Sunspots were first seen by Galileo, and in the eighteenth century Rudolf

Wolf concluded from his study of previous observations that there was a roughly eleven-year solar cycle of activity. In 1919 the astronomer George Ellery Hale found a new solar periodicity, the twenty-two year solar magnetic cycle which is composed of two eleven-year cycles and today is referred to as the Hale cycle. The eleven-year cycle is a complex dynamo process in which the sun's twisted magnetic fields flip to the opposite direction as the result of the combination of the sun's differential rotation and the convection in its atmosphere. Then, after a second cycle, the original polarity is recovered.

The cycle is characterized by periodic changes in solar activity such as the number of sunspots and active regions (ensembles of looped magnetic structures); during the period of maximum activity the number of sunspots reaches a maximum. The number of coronal holes provides another measure of activity, a [coronal hole](#) being a darker appearing region of colder gas on the sun's surface. During maximum activity, coronal holes are found at low latitudes of the sun with fewer of them at the [polar regions](#).

Energetic events on the sun like eruptions, flares, and coronal mass ejections peak at or near times of solar maximum; at the same time some structures in the [magnetic field](#) weaken to zero strength and then increase but with the opposite sign. A particularly powerful solar wind can escape during these periods of weak magnetic fields and its charged particles can then travel into space and towards the Earth. Coronal holes are key structures that indicate these weakened fields. CfA astronomers Nishu Karna, Steven Saar, and Ed DeLuca and a team of colleagues performed a statistical study of the coronal holes near the equatorial region, and of active regions, during the maximum phase of the last four solar cycles spanning the years from 1979-2015.

The scientists found a strong negative correlation between the numbers of equatorial coronal holes and active regions as well as statistically

significant differences in the properties of the two eleven-year cycles of the Hale cycle. For example, they examined the changing distances ("pairings") between equatorial coronal holes and active regions and find more of the close pairings during the peak of activity in one half of the Hale cycle...but not in the other. Most significantly, during these active times the solar wind flow and wind pressure also increase significantly. The results lead to important insights into how [solar activity](#) impacts the Earth and highlight important processes that are still not understood like the different behaviors of the two halves of the Hale [cycle](#).

More information: Mahendra Lal Karna et al. A Study of Equatorial Coronal Holes during the Maximum Phase of Four Solar Cycles, *The Astrophysical Journal* (2020). [DOI: 10.3847/1538-4357/abafae](https://doi.org/10.3847/1538-4357/abafae)

Provided by Harvard-Smithsonian Center for Astrophysics

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