How the sun gets its spots

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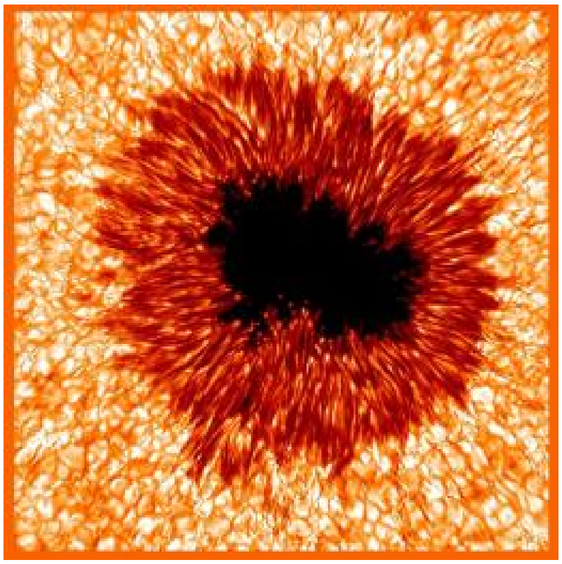

One of the leading researchers studying the sun reveals the origins and lifecycles of sunspots. This high-resolution image of a sunspot was taken at the Sacramento Peak Observatory of the National Solar Observatory in New Mexico. The direction of the fringes around the sunspot indicate the direction of the sun's magnetic field. Credit: National Solar Observatory

Sunspots are huge, dark, irregularly shaped--and yet, temporary--areas of intense magnetism on the sun that expand and contract as they move.

The diameters of sunspots are frequently on the order of 50,000 miles," said Frank Hill of the National Science Foundation's (NSF) National Solar Observatory. "By contrast, the Earth's diameter at the equator is about 8,000 miles. The intense magnetism of sunspots usually reaches about 3,000 Gauss. [The more intense a body's magnetic field is, the higher its Gauss number.] By contrast, refrigerator magnets average about 5 Gauss, the sun averages about 1.0 Gauss, and the Earth averages about .50 Gauss."

Most of the sun's surface is covered by convection cells--roiling and boiling gases that bring heat up to the sun's surface from the furnace in its core via convection. However, the intense magnetism of sunspots inhibits convection and the associated heat transport to them. Therefore, their temperatures range from about 5,000 to 7,600 degrees Fahrenheit (F), cooler than their surroundings, which hover around 10,000 degrees F.

It is only because of the "coolness" of sunspots that they appear black relative to their surroundings; if sunspots could be separated from their surroundings, they would appear brighter than electric arcs.

Sunspots are cyclic. The number of sunspots increases and decreases over a period of approximately 11 years. During solar maximums, when sunspot activity is high, areas near sunspot clusters experience particularly frequent explosive activity, such as Coronal Mass Ejections (CMEs), massive blasts of highly charged particles and gases hurled from the sun. CMEs can pose serious threats to people because they may damage satellites, increase the radiation exposure of astronauts, disrupt communication and navigation systems, and knock out power grids and other high-tech systems.

During solar minimums, when sunspot activity is low, CMEs occur less frequently than they do during maximums. Nevertheless, solar minimums are not necessarily CME-free periods; large CMEs have occurred during solar minimums.

"During the solar cycle, slow (20 to 30 mile per hour) flows of plasmas, known as jet streams, move from east to west across the sun and slowly south from the solar north pole and slowly north from the south pole to the equator," Hill said.

Jet streams reach depths of about 65,000 miles below the sun's surface. "Sunspots and the jet stream are closely associated with one another in terms of location and behavior," adds Hill. Sunspots initially appear during a solar cycle when the center of the jet stream reaches a latitude of about 25 degrees. Also, sunspots are born above the jet stream and reach deep inside the sun into the stream.

At the beginning of any given sunspot cycle, sunspots are usually born in clusters at high latitudes. But by the end of the cycle, the birthplace of sunspots has--like the jet stream--usually moved to the equator.

During the current sunspot cycle, the jet stream took a year and a half longer to reach a latitude of 25 degrees than during the previous cycle. Likewise, the solar minimum between the previous and current cycle lasted 1.5 years longer than the previous minimum. This observation suggests that "scientists might be able to use the jet stream to predict the timing of sunspot cycles," Hill said. "Nevertheless, we don't know yet whether the jet stream causes sunspots or sunspots cause the jet stream."

How can scientists possibly determine what's happening in the sun's depths from our vantage 93 million miles away? They observe the speed of waves travelling through the sun, which manifest on the sun's surface as observable up-and-down oscillations of gases. From those oscillations, scientists can deduce the temperatures, composition and movement of materials inside the sun.

The technique of "seeing" inside the sun by observing its oscillations--known as helioseismology--is analogous to techniques used in Earth seismology to "see" inside our planet by measuring how long it takes earthquake-generated waves to travel through the interior and reach the Earth's surface.

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