What will the Solar Eclipse look like?

By Deborah Scherrer, Stanford Solar Center

Our Sun, and other stars, are surrounded by an atmosphere, a brightly glowing plasma that is usually overwhelmed by the Sun's radiance. Like a pearly aura, this atmosphere, or corona, will become visible during the total solar eclipse of 21 August 2017. Our Sun is a dynamic, constantly-changing, magnetic star. So the corona of each total solar eclipse has a unique and beautiful shape that is determined by the Sun's magnetic fields. About a month before the eclipse, solar scientists are able to predict that shape!

It's All About Magnetism

The Earth's magnetic field resembles that of a bar magnet, with its poles near the geographic poles of the Earth. The field is generated deep in the Earth's core, where the iron is as hot as the Sun's surface, but the crushing pressure caused by gravity prevents it from becoming liquid. Surrounding this core is a thick layer of primarily iron and nickel. Under less pressure than the inner core, these metals can liquefy. This flow of liquid iron generates electric currents, which in turn produce magnetic fields. The Earth's magnetic field remains fairly steady over thousands of years.

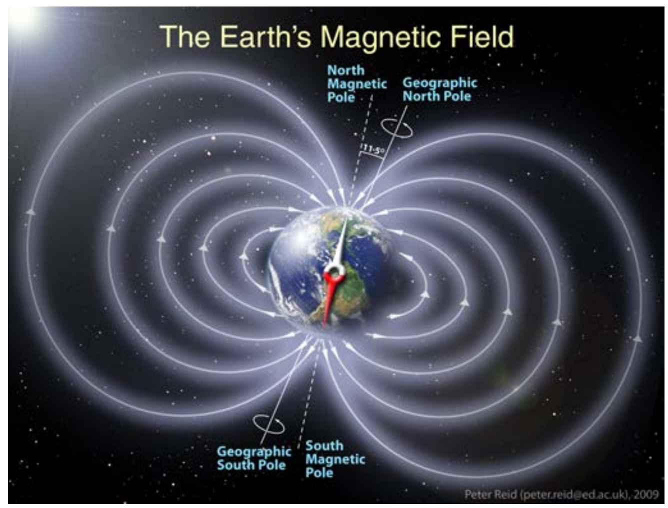

Figure 1: Earth's Magnetic Field

The Sun's magnetic field is quite different. There is a polar field somewhat similar to the Earth's, with lines of force that fan out into space from the north and south poles. But there are also equatorial fields generated by the bubbling and roiling gases. The Sun's magnetic fields are constantly changing on timescales ranging from a fraction of a second to billions of years.

How does this work?

The Sun is made of plasma, a gas-like state of matter in which electrons are stripped from their nuclei. Both the electrons and the stripped atoms now carry an electrical charge. The result is a super-hot mix of charged particles, and when charged particles move, they create magnetic fields. When these magnetic fields rise from the solar interior, they emerge through the Sun's surface and reach high into the corona.

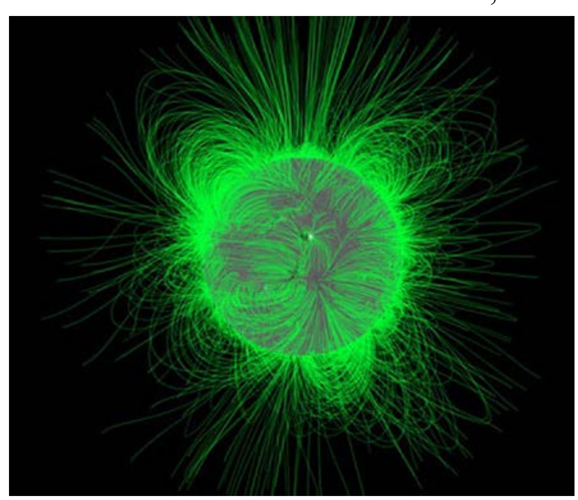

Figure 2: An example of the Sun's Magnetic Field

Magnetic fields, of course, are invisible. But plasma can be trapped in them, and hence show us the shape, just as we use iron filings to trace the field of a bar magnet. The Sun's magnetic fields are responsible for solar activity. Sunspots result from magnetic fields emerging through the solar surface. And, it is the breaking and reconnecting of these magnetic fields that cause solar flares and the resulting coronal mass ejections (plasma shot into space)!

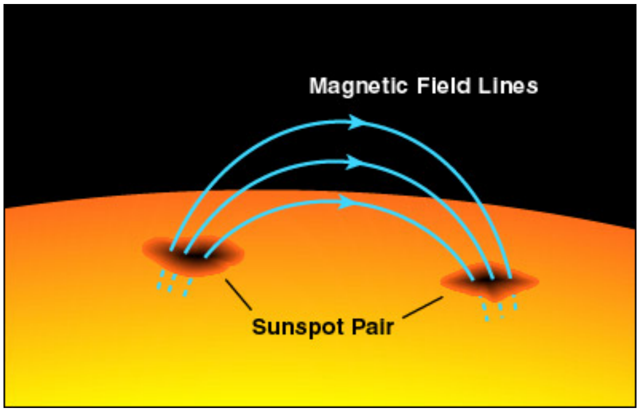

Figure 3: Sunspots generated by a magnetic field

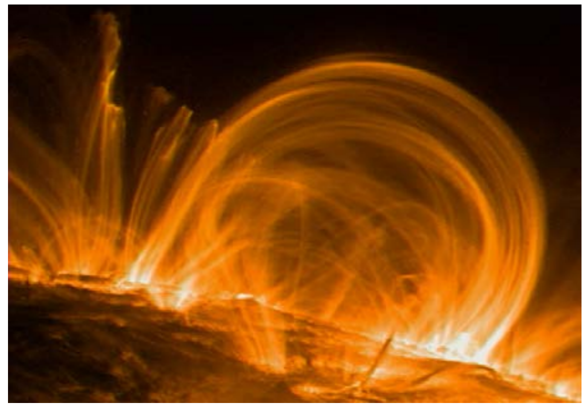

Figure 4: Coronal loops above a sunspot pair

It is the shape of the Sun's magnetic fields at the time of the eclipse that determine how the corona will appear.

The Solar Cycle Plays a Role

The shape of the corona is also determined by the solar cycle. Every 11 years or so, the Sun moves from a period of high solar activity (Solar Maximum), with lots of magnetic fields, sunspots, and flares, to a period of low solar activity (Solar Minimum), with few sunspots and less activity. During solar maximum, the ubiquitous magnetic fields hold the plasma in tightly, so the corona appears more circular. During solar minimum, with fewer magnetic fields, the plasma is freer to move out, especially in the equatorial regions, and the corona appears more elliptical. We are currently approaching solar minimum, so we expect to see more of an elliptical coronal pattern in our total eclipse.

The Predicted Shape

By observing the Sun's magnetic fields[1] solar scientists at Predictive Science, Inc. were able to predict the shape of the corona on July 25, one complete solar rotation (about 27 Earth days) before August 21 - the same side of the Sun will be facing us as on July 25. The fields may change a little, but the basic structure should remain fairly constant.

Streams of light protruding from the Sun's north and south pole will be visible, as well as concentrated bubbles of light close to the surface.

[1] Using HMI magnetograms from NASA's Solar Dynamics Observatory (SDO)

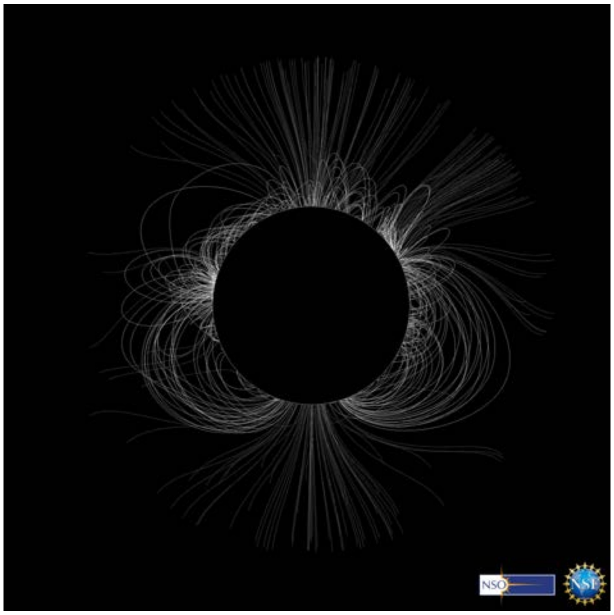

Figure 5: Diagram of solar magnetic fields on July 25

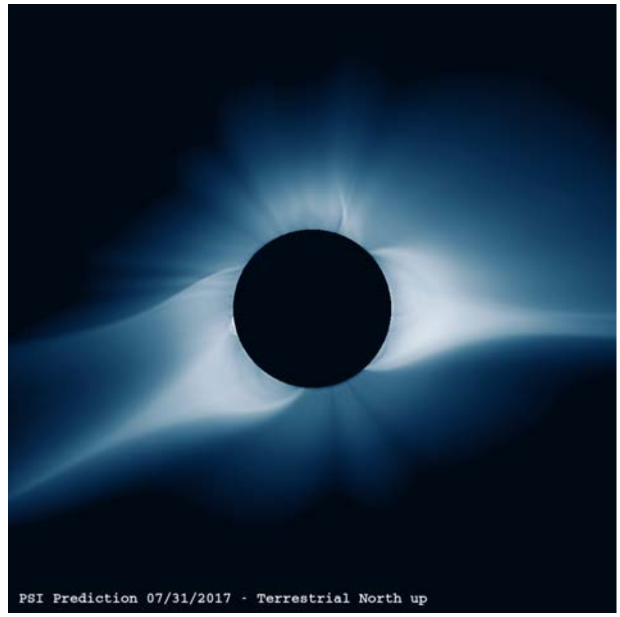

Figure 6: Prediction of coronal shape for August eclipse

Seeing for Yourself

As you observe the eclipse, try to imagine sketching the shapes you see. (Your camera will not be able to pick up these structures.) Look for the features below. Also, avert your gaze frequently, since each time your eyes return to the spectacle, your brain will (re)store the image!

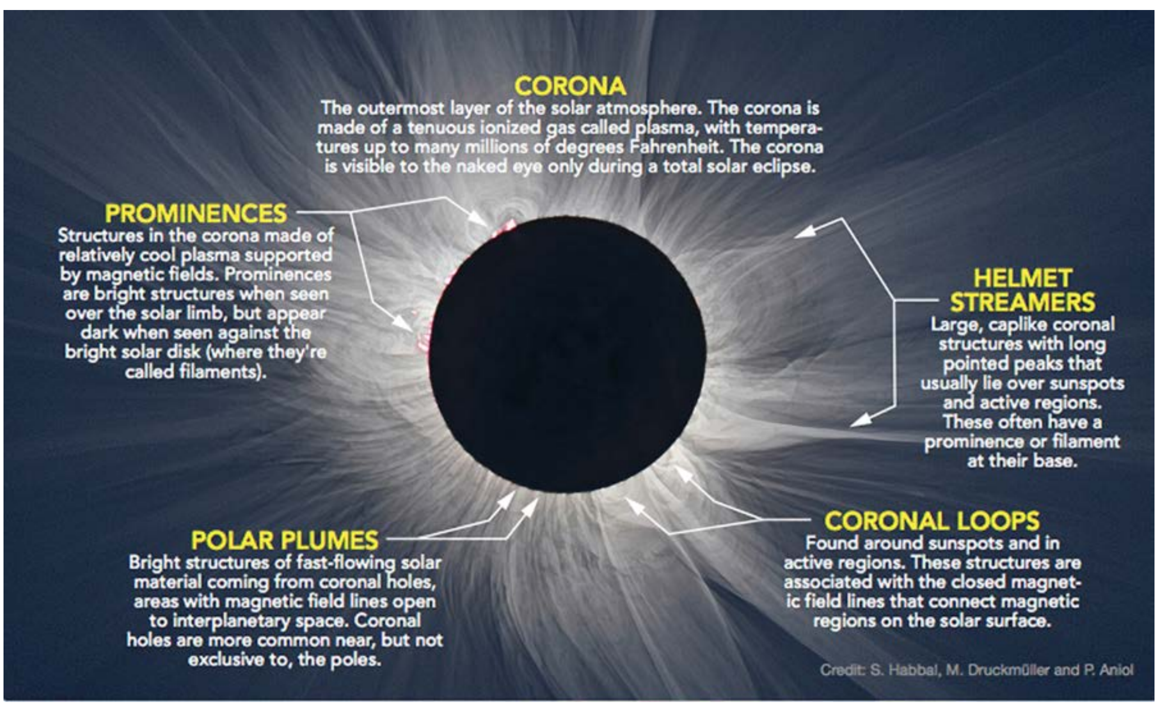

Figure 7: What to look for during a total eclipse

Additional Resources:

- Newsweek article on corona prediction http://www.newsweek.com/total-solar-eclipse-2017-sun-corona-646528
- Understanding the Magnetic Sun https://www.nasa.gov/feature/goddard/2016/understanding-the-magnetic-sun
- National Solar Observatory predicts shape of solar corona for August eclipse https://phys.org/news/2017-07-national-solar-observatory-corona-august.html
- Coronal Prediction (technical description) http://www.predsci.com/corona/aug2017eclipse/aug2017eclipse.html
- Magnetograms from the HMI instrument (Stanford University) on NASA's Solar Dynamics Observatory spacecraft https://www.nasa.gov/content/goddard/sdo-hmi-magnetogram/
- Solar activities and resources for educators and students http://solar-center.stanford.edu
- Solar Storms and Space Weather: https://www.nasa.gov/mission_pages/sunearth/spaceweather/index.html

Image credits:

- Figure 1: Peter Reid, The University of Edinburgh via NASA (https://www.nasa.gov/mission_pages/sunearth/news/gallery/Earths-magneticfieldlines-dipole.html)
- Figure 2: NASA
- Figure 3: Nature of the Universe (http://lifeng.lamost.org/courses/Hongkong/Hongkong_En/lecture/ch11/ch11.html)
- Figure 4: TRACE mission/NASA
- Figure 5: National Solar Observatory/NSF
- Figure 6: Predictive Science, Inc.
- Figure 7: NASA