# Solar Dynamics Observatory

| Activity Name | Grades | Suggested Activity Time | Prep Time | Materials |
|---|---|---|---|---|
| **Change Pairs** | 5-12 | 10-15 min | 5-10 min | Sets 1 and 2 of SDO pictures (see pages 4-8) |

**Objectives-** Students will be able to:

- Analyze and compare images taken by Solar Dynamics Observatory (SDO) instruments
- Identify active regions and loops in SDO images
- Recognize that active regions on the Sun are in areas of high-level magnetic activity

**Description:**
Students will analyze and compare two sets of solar images taken by SDO instruments. With Set 1, they will observe the Sun in both a highly active and a minimally active state, and be able to detect active regions and loops on the Sun by comparing the two images. With Set 2, students will identify areas of high magnetic activity on a magnetogram image and recognize that these areas correspond to highly active regions on the Sun.

**How to Prepare:**
Print out Sets 1 and 2 of SDO images in color on 8 ½ x 11-inch paper or larger (see images on pages 4-8). One copy of each set of pictures should be printed out for each group. If you need to know how to identify active regions and loops on SDO images, view the "Identifying Sun Features" picture on page 6 before the activity. To familiarize yourself with how to read magnetograms, visit the Stanford Solar Center's Solar Magnetograms website (see Resources section).

**Background Information:**
The Solar Dynamics Observatory (SDO) was launched on February 11, 2010 from Cape Canaveral, Florida. It is the first mission to be launched for NASA's Living With a Star Program, a program designed to understand the causes of solar variability and its impacts on Earth. SDO studies how solar activity is created, how it affects space weather, and how it influences life on Earth and humanity's technological systems.

SDO hosts three scientific experiments: the Atmospheric Imaging Assembly (AIA), Helioseismic and Magnetic Imager (HMI), and EUV Variability Experiment (EVE). Each of these experiments perform several measurements that characterize how and why the Sun varies. These three instruments observe the Sun simultaneously, performing the entire range of measurements necessary to understand solar variations.

In this activity, students will analyze and compare two sets of solar images taken by SDO's AIA and HMI instruments. AIA images are taken in extreme ultraviolet (EUV) light and images taken by HMI, called magnetograms, show the strength of the Sun's magnetic field. Set 1 contains two images of the Sun that were taken on separate days; one image shows the Sun at a high activity level and the other shows it at a low activity level. Both images in Set 1 are shown in EUV light taken by SDO's AIA instrument (at the 171 Angstrom wavelength). These AIA images will allow participants to observe several features of the Sun including active regions and loops. It is important to note that the bright active regions on these images are places where solar storms and other space weather processes may potentially erupt. Loops are streams of charged particles that are following the magnetic field lines of the Sun.

Set 2 contains two images of the Sun that were taken simultaneously by SDO instruments. One is a composite image taken by AIA at several different wavelengths and the second is a magnetogram image taken by SDO's HMI instrument. Students will identify active regions on the Sun in the AIA image and compare those regions to the HMI image (a magnetogram). They will observe that the active regions on the AIA image overlap with areas that have a high level of magnetic activity (black/white areas) on the magnetogram. For more information, visit the Stanford Solar Center's Solar Magnetograms website (see link in Resources section).

**Vocabulary:**

- active region
- electromagnetic spectrum
- extreme ultraviolet (EUV) light
- loop
- magnetogram
- Solar Dynamics Observatory (SDO)
- space weather

**Directions:**

1. Break students into small groups. Give each group images from Sets 1 and 2.
2. Tell students they are looking at pictures taken by NASA's Solar Dynamics Observatory (SDO), which studies the Sun's activity so we can better predict space weather like solar storms, which can affect us on Earth (see Background Information and Resources for more information). Tell them the colorful pictures were taken by SDO's AIA instrument, which captures the Sun in extreme ultraviolet (EUV) light. Ask students: What do you know about ultraviolet (UV) light? Where does it come from? What do you think extreme ultraviolet (EUV) light means?
3. Discuss with students that ultraviolet light from the Sun comes in long and short waves. The long waves are closest to visible light in the electromagnetic spectrum and the short waves are furthest from it; the short waves make up what scientists refer to as EUV light. Explain that the colorful AIA images are pictures of EUV waves being given off by the Sun. *(Note: You may want to also explain to students that these are not the real colors of the Sun, which is actually white when viewed in space; it appears yellow to us because Earth's atmosphere removes shorter wavelength light—blue and violet. Filters on SDO's cameras create this "false color" which is different for each wavelength that it takes pictures in. See Resources for more information.)*
4. In groups, have students compare the images in Set 1. Ask them to describe what they see, and to identity similarities and differences in the pictures. Ask them: What is happening on the Sun in each picture? Which is more active? Which is more likely to be experiencing a solar storm? Where?
5. Introduce the terms active region and loop (see Background Information). Have them refer to the "Identifying Sun Features" handout and use it to identify solar features in the two Set 1 images they have in front of them. Walk around the class to see if they are able to identify these features. Have a student point out the features to the class before moving to the next step.
6. Have students put aside the Set 1 images and now compare the images in Set 2. Tell them these

images were taken at the exact same time by SDO, image 1 was taken by AIA and image 2 was taken by the HMI instrument. Explain that the HMI (gray) image is a magnetogram, which shows the levels of magnetic activity on the Sun. Ask them: What do you think the black and white areas on the magnetogram mean? What do you think the gray area represents—high or low magnetic activity?

7. Explain that the gray regions indicate no magnetic activity, while the black and white areas on the magnetogram indicate regions of high magnetic activity; the black and white spots represent the opposite poles of a magnetic field (see Stanford Solar Center link under Resources for more information). Have students visualize the pictures overlapped. Ask them if they recognize a connection between the two images: In the black and white areas on the magnetogram, what is happening on the colorful AIA image? Do you observe any Sun features (i.e. active regions, loops) in those areas? If so, why do you think that is? *(Note: The black/white areas on the magnetogram should match up with the bright active areas on the AIA image.)*

8. Discuss with students that active regions on the Sun are found in areas where there is high magnetic activity. By studying these active regions, scientists can learn more about what causes solar storms, which can affect us by interrupting our navigation and communication systems, power grids, and even interfere with satellites and harm astronauts in space.

9. (Optional) To help students better understand space weather and how it can affect them, show them the National Geographic video on Electromagnetic Sun Storms (see link under Resources below). To have them further explore and compare SDO images, visit the TeenSolarInvestigators.org's interactive Sun Slider website (see the Resources section for link). To see current images of the Sun, go to the SDO data page at http://sdo.gsfc.nasa.gov/data.

**Resources:**

- NASA—SOHO Glossary of solar terms: http://sohowww.nascom.nasa.gov/classroom/glossary.html
- NASA—Ultraviolet Waves: http://missionscience.nasa.gov/ems/10_ultravioletwaves.html
- NASA Space Place—Space Weather: http://spaceplace.nasa.gov/spaceweather/
- National Earth Science Teachers Association—What is Space Weather? http://www.windows2universe.org/space_weather/sw_intro/what_is_sw.html
- National Geographic—Electromagnetic Sun Storms (video): http://www.youtube.com/watch?v=W_cLSvP9qSU
- National Geographic—The Sun: Living with a Stormy Star: http://science.nationalgeographic.com/science/space/solar-system/Sun-stormy-star.html#page=1
- Stanford Solar Center—Solar Magnetograms: http://solar-center.stanford.edu/solar-images/magnetograms.html
- Teen Solar Investigators.org—Sun Slider: http://www.teensolarinvestigators.org/sun_slider
- Universe Today—Color of the Sun: http://www.universetoday.com/18689/color-of-the-sun/
- YouTube—SDO mission's channel: http://www.youtube.com/user/SDOmission2009

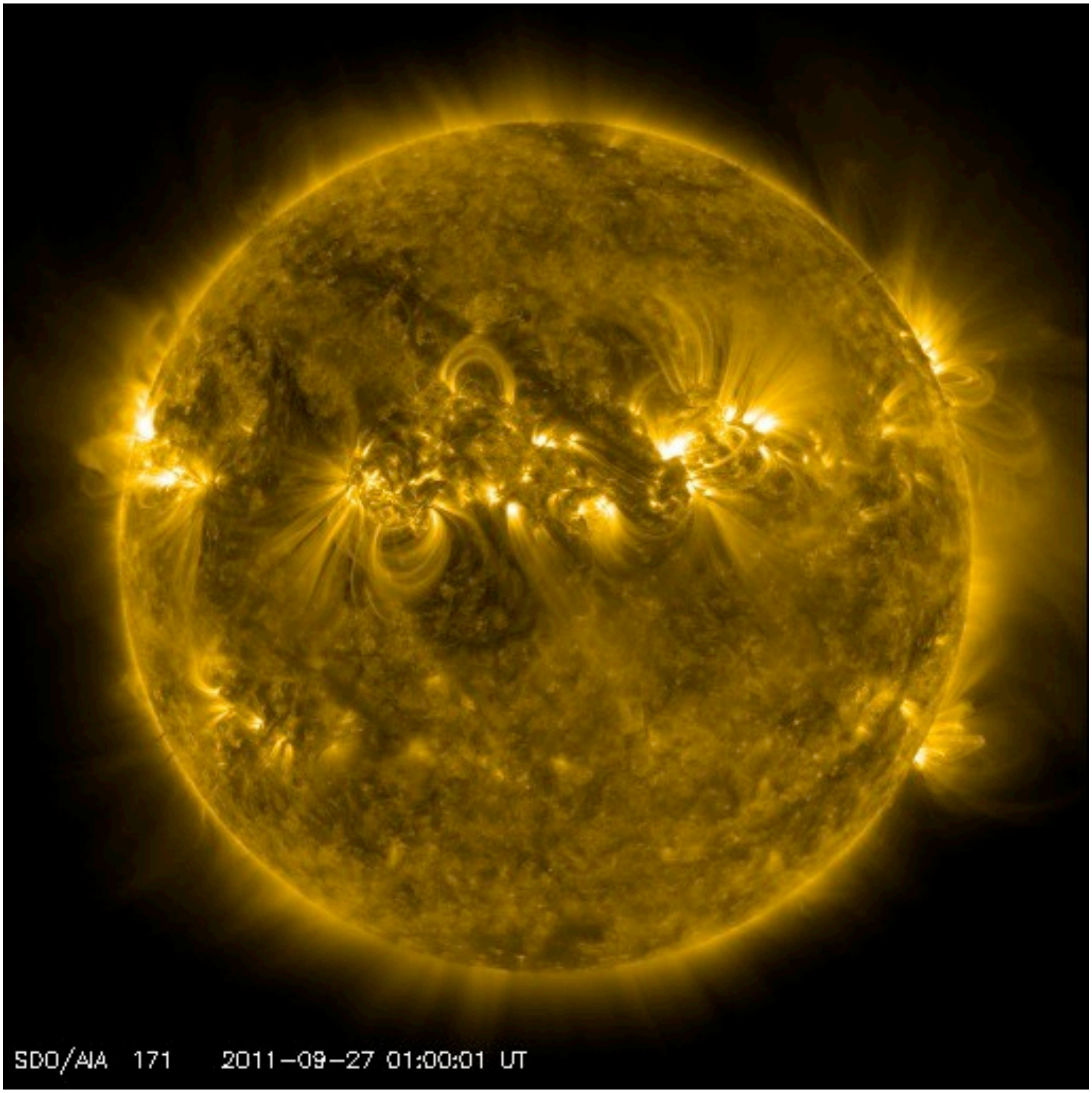
**National Science Education Standards addressed:**

5-8: *Content Standard B:* As a result of their activities in grades 5 – 8, all students should develop an understanding of transfer of energy, 6: The Sun is a major source of energy for changes on the Earth's surface. The Sun loses energy by emitting light. A tiny fraction of that light reaches the Earth, transferring energy from the Sun to the Earth. The Sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

9-12: *Content Standard B:* As a result of their activities in grades 9-12, all students should develop an understanding of interactions of energy and matter: 2: Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

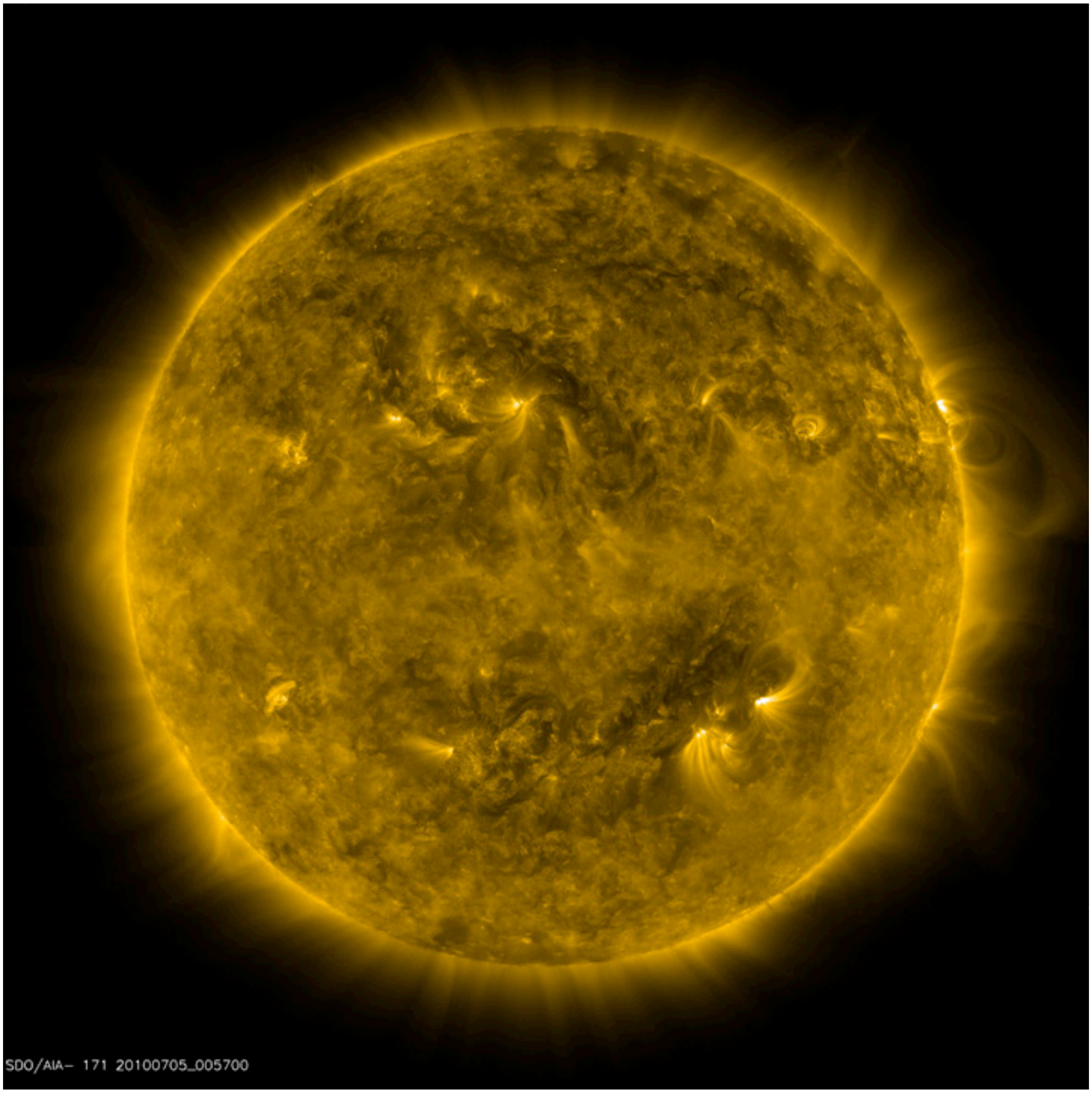
# Set 1 – image 1

AIA image from 9/27/2011

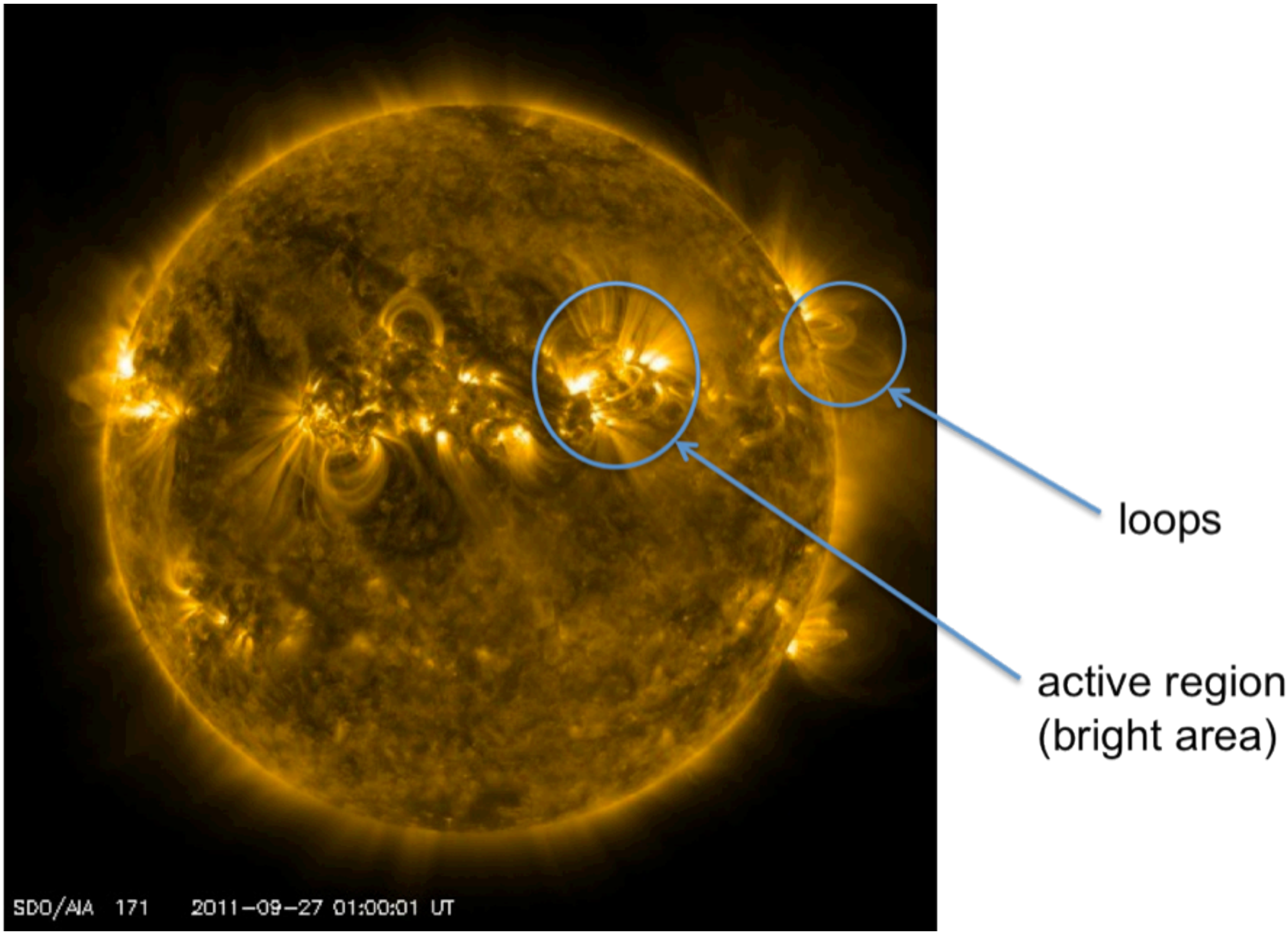


# Set 1 – image 2

AIA image from 7/5/2010

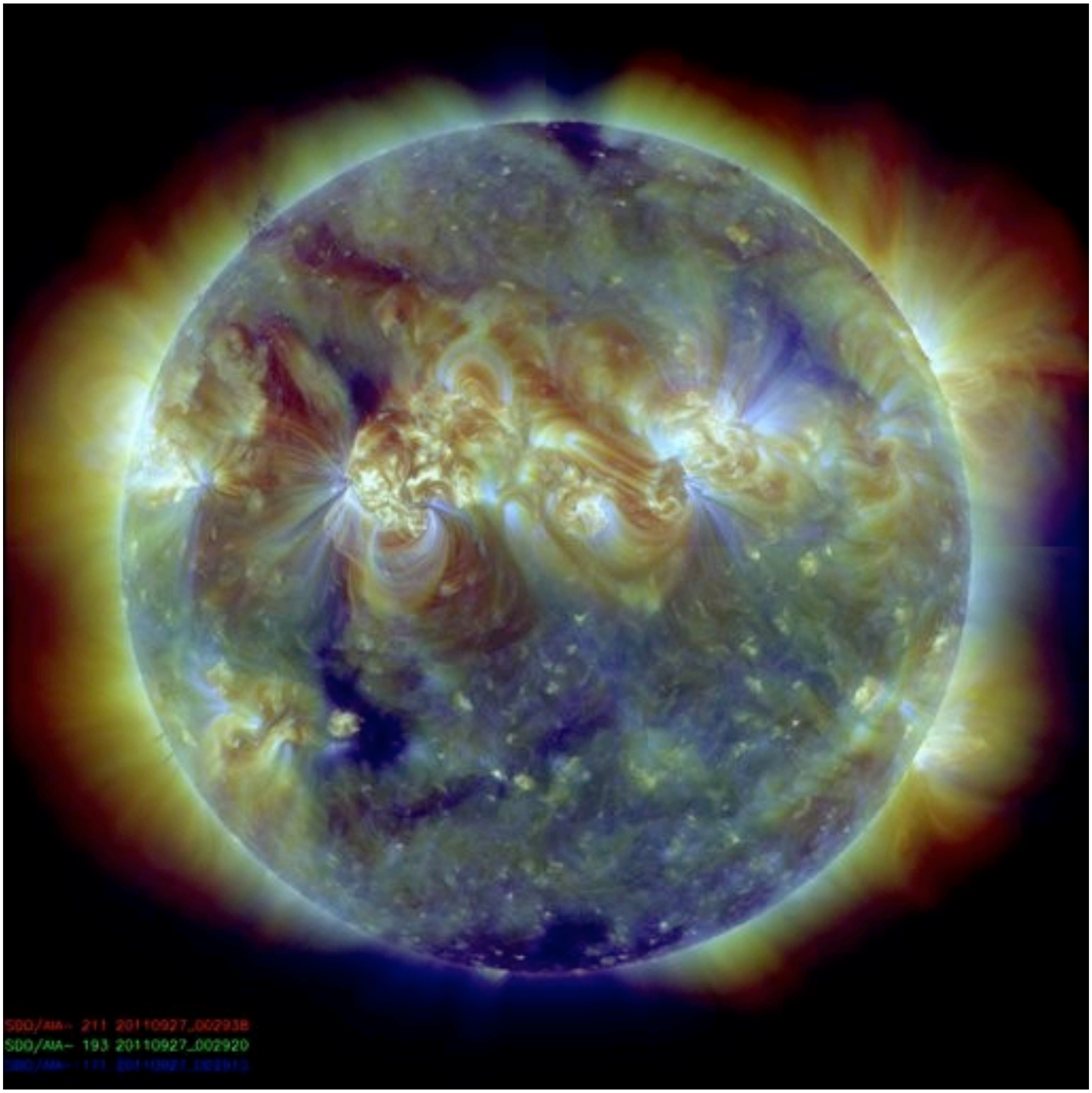


## Identifying Sun Features



## Set 2 – image 1

AIA composite image taken on 9/27/2011



# Set 2 – image 2

Magnetogram image taken on 9/27/2011