# Dancing Up A Solar Storm

"I hope that every dance I do reveals something of myself or some wonderful thing a human can be."
- Martha Graham, American modern dancer and choreographer

**ACTIVITY OVERVIEW:**

Many cultures around the world use dance as a way to express their connections to the natural world. In this field-tested activity, participants use their bodies and the elements of dance to represent key features of *solar activity* (sunspots, flares, coronal mass ejections, and solar wind) through movement.

After creating their own solar activity movements, participants demonstrate a solar cycle by dancing with low activity levels to high activity levels and back again. Participants then form a Sun Team and an Observation Team to play a dance-based game that represents the PUNCH spacecraft observing the level of the Sun's magnetic activity.

We have field tested this activity in different venues and with different audiences including Girl Scouts, families, and adults. This activity is best with 8-12 participants and an open space that allows sufficient room for movement. However, with some adjustment, we have successfully implemented this activity in the planetarium dome where participants essentially "dance" in place.

| | |
|---|---|
| **Venue(s)** | planetarium dome, indoors, outdoors |
| **Ages** | 5 - 8; 9 - 18 (depending on activity) |
| **Materials** | household objects, slideshow, printouts |
| **Participants** | 8 - 12 |
| **Time** | 20 - 30 minutes |
| **NGSS** | Appendix G: Cross-cutting Concept 5: Energy and matter: Flows, cycles, etc |

Dr. Heather Elliott is a scientist who studies spiral shapes in space, called "Parker Spirals." These are made by a combination of the Sun's outflow of magnetized solar wind and the Sun's rotation. She is also a dancer who uses interpretive dance to express ideas about these spiral shapes with scarves as she spins around.

**LEARNING GOALS:**

1. Provide an opportunity for personal expression of Sun-related science related to flows & cycles of matter and energy.
2. Compare and contrast different types of solar events and features known as "space weather"
3. Address misconceptions related to the dynamic nature of the Sun
4. Introduce Dr. Heather Elliott as a relatable role model for young people

**REQUIRED MATERIALS:**

1. Chair or another stationary object (except for ages 5-8)
2. Video slideshow (recommended) or printouts of the Sun's key solar activity features
3. Supporting visuals

**OPTIONAL MATERIALS:**

1. Materials to dance with (recommended for ages 9+), such as:
    a. Scarves or thule cut into wide strips (for solar wind or coronal mass ejections)
    b. Flashlights (for solar flares)
    c. Pom-poms (for sunspots)

**SETUP:**

1. We recommend cueing up this video slideshow of the Sun's solar activity. If you don't have access to a digital display, you can use printouts of the Sun's solar activity instead. Have the supporting visuals on hand as well.
2. Set a chair nearby that you can move into the space for the second half of the activity.
3. (Optional): Cue up one of the music recommendations (see **Appendix B**) on a phone or computer for the second half of the activity.
4. (Optional): Cue up one of the supporting videos about solar storm features (see **Appendix C**).

**ACTIVITY (for ages 5-8):**

1. Using the video slideshow or printouts, introduce the key features of solar activity. Be mindful to address misconceptions A & B. Information about solar activity can be found in the Background section of this document below.

2. Introduce Dr. Heather Elliott as a dancer and scientist who studies the Sun.

3. Return to each of the key features one-by-one and ask participants to create a movement to represent the solar wind / a sunspot / a flare / a CME. Use the video slideshow or printouts for participants to reference. Invite participants to think about **what** part of their body they might want to use and **how** they might move that body part. Introduce the Elements of Dance as appropriate (**Appendix A**) to help inspire participation and creativity.

4. Introduce participants to the element of level of activity. Demonstrate movements with high levels of activity and movements with low levels of activity. Explain that sometimes the Sun and all of its features have high levels of activity and sometimes low levels of activity.

5. Instruct dancers to listen for you to shout: "high activity" and "low activity" and to adjust their dancing as appropriate. Encourage them to use the dance moves they created earlier to represent the Sun's level of activity.

6. Explain that the PUNCH spacecraft will observe the solar wind, which is stuff that is emitted continuously from the Sun. Mention that you and any other adults (e.g. parents, other instructors, etc.) represent the PUNCH observers, and all of the participants represent the Sun going through different activity phases.

7. Begin playing music or otherwise indicate that dancers should begin to dance. Shout out "high activity" and "low activity" at regular intervals (about 15-20 seconds). *Optional: consider making a nonverbal 'secret signal' for the dancers to go to high or low activity, young participants enjoy being a part of the mystery, so to speak, and it can feel like the adults - the PUNCH observers - are more challenged to guess the activity level.

**ACTIVITY (for ages 9-18):**

1. Introduce the key features of solar activity. Be mindful to address misconceptions A-D. Information about the solar activity can be found in the Background Q & A section of this document below.

2. Introduce Dr. Heather Elliott as a dancer and scientist who studies the Sun and something called "Parker Spirals." Explain that because the Sun rotates or spins, the solar wind can look like a spiral. Demonstrate with your body what a spiral movement would look like.

3. Return to each of the key features one-by-one and ask participants to create a movement to represent the solar wind / a sunspot / a flare / a CME. Use the video slideshow or printouts for participants to reference. Invite participants to think about what part of their body they might want to use and how they might move that body part.

    a. **For ages 11+:** to help inspire participation and creativity, introduce participants to the five elements of dance (see **Appendix A**) and provide examples of each.

4. Introduce participants to the idea of higher and lower activity levels. Explain that sometimes the Sun can have higher activity levels and sometimes lower activity levels. Demonstrate movements with higher and lower activity levels.

5. Have all participants demonstrate a solar cycle. Describe how participants will dance from low activity level (1) to high a high activity level (10) and then back to a low activity level (1). Explain that this represents the 11-year cycle of magnetic activity. Invite participants to do a dance move they created in step 3 and change how much energy they're dancing with as you call out activity levels starting at 1, going to 10, then going back down to 1. Then start calling out numbers randomly between 1-10 and have everyone match that activity level with their solar dance moves.

6. Choose four participants to be observers. You may reserve this role for any participant who does not want to dance, or you may make your selection from all the participants. Remember to mention that roles will rotate after two rounds. *(Note: you can select two observers if you have a smaller group.)*

7. Separate the four observers from the rest of the participants and have them circle around a chair or other stationary object that represents the Earth. Mention that these observers will be the Observing Team and will represent the four PUNCH spacecraft. Instruct the Observing Team that they must be touching Earth at all times. This is because the PUNCH spacecraft are bound in orbit around Earth.

8. Have the remaining participants group close together. Mention that these participants are the Sun Team and will represent the Sun. Instruct the Sun Team to work together and decide secretly, on a scale of 1 - 10, at what activity level they will dance when the music starts.

9. Instruct the Observing Team that they will guess at what activity level the dancers are dancing, on a scale of 1 - 10. Observers have until the music stops or until you shout "Snapshot!" to make their observations and decide together what their guess is. They *must* work together to decide what their guess is.

10. Start the music. The Sun Team will dance their movements at their decided activity level. Stop the music after 5-8 seconds and shout "Snapshot!" All dancers should freeze.

11. Encourage the Observing Team to talk together to agree on an activity level. After giving their guess, ask the Sun Team if they are correct. Give the Observing Team a second guess if their first guess was wrong, otherwise have the Sun Team reveal what the activity level was.

12. Complete round 2 with the same teams.

13. Select new observers and repeat until all participants have the opportunity to participate in both roles.

14. **For ages 11+**: Ask participants to share with each other how their movements were representing different aspects of solar activity.

## BACKGROUND Q&A:

### What misconceptions should I try to address during this activity?

Related to this activity are several common misconceptions about the Sun and its features including:

A: Space is empty
B: Solar wind is wind on the Earth caused by the Sun
C: The Sun just sits still in space
D: Solar maximum is a single episode of high activity
E: The Sun is a featureless smooth ball that remains constant
F: A solar storm is a storm on Earth caused by the Sun
G: Space weather means weather on Earth caused by something in space
H: A solar flare is the same thing as a coronal mass ejection (CME)

You will likely choose to address misconceptions as they come up or at a time you feel would be appropriate during the context of the activity. The number of misconceptions you should try to address will depend on the age of the participants. At a basic level, you might try addressing misconceptions A & B. For older participants, all misconceptions could potentially be addressed. The Q & A below will help.

### What is the solar wind?

Space is not empty. Every second, over 300,000 tons of material leave the Sun and streak outward into space in all directions. This “solar wind” impacts everything in the Solar System, including Earth. It causes the beautiful northern lights, the glow of comets’ tails, and it also carries the “space weather” that can threaten satellites and astronauts in space. The solar wind fills the interplanetary space in our Solar System and defines the heliosphere - the region of space influenced by the Sun. The heliosphere extends out to more than twice the distance to Pluto, before the solar wind slows to a halt at the so-called heliopause.

### What is meant by “space weather”?

When used without qualification, the word "weather" is generally understood to mean the weather in Earth’s atmosphere. “Space weather” is a term used to refer to “weather” in space, including the dynamic changes in the solar wind caused by storms from the Sun such as coronal mass ejections (CMEs). Severe “space weather” can be harmful to astronauts and spacecraft. Learn more about “space weather” at: https://scied.ucar.edu/learning-zone/sun-space-weather

### What are sunspots?

*Sunspots* are dark spots on the Sun’s surface and can be greater than the size of the entire Earth. Sunspots are places on the Sun where magnetic energy is incredibly strong. They appear dark because the magnetic forces are blocking some of the heat flow from the inside of the Sun, making them a bit cooler than the surrounding areas. Even though they are cooler than the surrounding areas, they are still really really hot! Sunspots are important because they are the places where there is lots of magnetic energy and the churning motions of the Sun can tangle up the magnetic fields and so they become the places where “solar storms” can start. As the Sun moves towards Solar Maximum, more sunspots and solar storms appear. Solar Minimum is a period of fewer sunspots.

### What is a solar flare?

Solar flares are one type of solar storm, visible as a bright flash. When magnetic fields in sunspot regions are tangled by vigorous convective motions, they can snap like a giant invisible rubber band. When they do, a huge amount of energy can be released in a bright solar flare. When a flare happens, it creates a really bright flash of light in lots of different wavelengths, from the visible light that we see with our eyes to x-rays. One flare can produce the same amount of energy needed to power the entire Earth for a million years! This flash of light can then be seen from the Earth 8 minutes after it happens, because it takes the light 8 minutes to cross space from the Sun to the Earth.

### What is a Coronal Mass Ejection (CME)?

Coronal Mass Ejections (CMEs) are powerful explosions above the Sun where particles are violently ejected from the Sun's outermost atmosphere called the *corona*. Like solar flares, CMEs tend to happen in areas above sunspots where there is high magnetic energy. A billion tons of tiny particles can be thrown out into space at very high speeds in a short time. Fortunately, most CMEs do not head directly toward the Earth. However, when they do, those particles interact with the Earth's magnetic field, leading to beautiful Northern and Southern lights, and/or harmful effects like disrupting our satellites or our power grid.

### What is the difference between a CME and a solar flare?

Solar flares and Coronal Mass Ejections (CMEs) are fundamentally different. They can occur together or independently. Flares emit high energy electromagnetic *light* especially in the ultraviolet and x-ray. In contrast, Coronal Mass Ejections emit high energy *particles* with mass, especially electrons and protons. Another difference is the time it takes each event to "reach" the Earth. Solar flares travel at the speed of light, reaching Earth in a matter of minutes. Coronal Mass Ejections can take 1-3 days to reach Earth, depending on their speed. We have summarized the major differences in the table below.

| | Solar Flare | Coronal Mass Ejection |
|---|---|---|
| Type of Radiation | High Energy Light | High Energy Particles |
| What Protects Us | Earth's Atmosphere | Earth's Magnetic Field |
| Aurora Causing | No | Yes |
| Time to Reach Earth | Minutes | 1-3 Days |

### What is a solar cycle and how long is it?

The Sun is a rotating sphere of plasma ("electrified gas") with ever changing features. Over a period of 11 years, the Sun goes from low levels of magnetic activity (Solar Minimum) to high levels of magnetic activity (Solar Maximum) and back to Solar Minimum again in what's called the solar activity cycle. We can observe this change in the state of the Sun by looking for key features of solar magnetic activity, including sunspots, solar flares, and coronal mass ejections (or CMEs).

### What is the NASA PUNCH mission?

The NASA PUNCH mission is composed of four Earth-orbiting, suitcase-sized spacecraft designed to make 3-D images of the solar wind continuously in the *inner* heliosphere from the Sun's corona (outermost atmosphere) all the way to Earth orbit. We expect to see how solar storms from the Sun and other key features of "space weather" influence the patterns and structures we see in the solar wind. PUNCH science is intended to help us better understand how the Sun's corona (outermost atmosphere) becomes the solar wind and also how "space weather" affects humanity.

## APPENDIX A: Elements of Dance

Modern dancers, like Martha Graham, have developed a framework known as the elements of dance to assist in the creation of unique movements that represent natural phenomena. The five elements are:

**BODY:** The part of your body that you use (examples include hips, head, arms)

**ACTION:** The action that the body part takes (examples include extending, contracting, shaking)

**SPACE:** How the action relates to the space around you (examples include high, low, using objects)

**TIME:** How the action relates to time (examples include fast, slow, variable)

**ENERGY:** How much effort is given to the action (examples include sharp, heavy, flowing)

## APPENDIX B: Music Recommendations

1. Walking On Sunshine – Katrina and the Waves
2. The Sound of Sunshine – Michael Franti and Spearhead
3. Brighter than the Sun – Colbie Caillat
4. Soak up the Sun – Sheryl Crow

## APPENDIX C: Videos and Articles about Solar Storm Features

Want to learn more about the key features of solar storms or see more video footage of these amazing phenomena? Check out some of the video and article links below!

NOVA: Solar Wind and Storms (Video)
No Jargon Presentation about how the Sun causes the Northern and Southern Lights (Video)
Two Weeks in the Life of a Sunspot (Video)
Butterfly-shaped Coronal Mass Ejection (Article)
NASA: Video of Magnificent Solar Eruption in Full HD
The Difference Between CMEs and Solar Flares