Using the IDATA Tool Umbrella Sky

RA and Dec

Purpose/Overview: The purpose of this tool is to act as a model that provides a platform for demonstrating many other concepts. With the basic lines of right ascension, declination, ecliptic, and celestial equator, you can demonstrate many additional concepts and facts about the position and motion of celestial bodies. The sense of touch is the dominant modality. Some possible directions for instruction are suggested by the guiding questions below while the remaining instructions primarily focus on the mechanics of the tool itself.

*Note: The activity, **1a) RA and Dec Umbrella Activity Simple Form** requires very little construction*

Standards Addressed:

Cross Cutting Concept: Systems and System Models
Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
(HS-PS4-3)

ESS1.A: The Universe and Its Stars
Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
(MS-ESS1-1)

ESS1.B: Earth and the Solar System
This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1)

Focus Questions:

1. What can you learn from the umbrella model about the motion of stars in the night sky?
2. What are some ways that you can describe the location of stars in the sky?
3. How are lines of right ascension and declination used to define the location of an object in the sky? When would you want to use this system?
4. If you choose a random point on the umbrella, how would you go about describing the position to someone else?

Materials: Well in advance of this lesson, you will need to acquire a good old fashioned bubble umbrella. You can choose the level of embellishment you would like to add to the umbrella. Directions for this can be found in the document **0)Construction - RA and Dec.** Although this makes a wonderful model, you may first want to use it for demonstration purposes and then allow students to create their own. This is described in the lesson **2)Umbrella Sky as a Model for Celestial Motion.**

The Tool: This model of the sky focuses on demonstrating the celestial coordinate system and the features of the celestial sphere that astronomers use to describe the motion of objects in the sky. Terms here are described in reference to a northern hemisphere point of view.

Celestial Coordinate System - a fixed system of numeric identifiers that define the location of objects in the sky, analogous to the longitude/latitude system on Earth.

Celestial Sphere - the imaginary dome of the sky that surrounds the Earth. The umbrella represents half of the celestial sphere.

Celestial Equator - the imaginary line in the sky that is reflective of the equator on Earth. This is designated as zero degrees declination. The lower edge of the umbrella is the celestial equator.

Ecliptic - the path the sun appears to track through the sky throughout the **year** relative to the stars. The ecliptic is also the imaginary line along which the planets can be located. The ecliptic must be marked with stitching, markers, or wax string as indicated in the instructions. Be careful to not confuse the path the sun appears to travel through the sky throughout one year with the path the sun takes across the sky on a particular day.

Celestial Pole - the point in the sky directly above the north or south pole on Earth. These points appear stationary as the rest of the sky rotates around it. The point of the umbrella is the celestial pole. It can be either the north or the south pole depending upon your needs. The instructions for this model are given assuming that a northern hemisphere sky is being modeled.

Declination - the name astronomers give to imaginary lines on the night sky similar to the lines of latitude on Earth. Moving from one line of declination in the sky to the next is how astronomers measure north/south positions on the sky The bottom edge of the umbrella is both the celestial equator and the zero line of declination. Each stitched line is 22.5 degrees further north in declination than the line before it. For younger students, you can use 20 degrees approximately for ease of communication.

Right Ascension - the designation astronomers give to imaginary lines on the sky that run from pole to pole through the celestial equator, like sections of an orange. Lines of right ascension allow astronomers to define east/west locations on the night sky and are measured in hours, minutes and seconds of arc. There are 24 hours of right ascension on the celestial sphere.

Procedures: (remember to discuss the above definitions as you are demonstrating)

1. **The Motion of the Sky** is modeled by you holding the umbrella in front of you and facing north. The center of the umbrella will represent the north pole of the celestial sphere, so you will need to hold it at some angle between directly overhead (which is where the celestial north pole would be if you were standing on the Earth's North Pole!), and the horizon (which is where the celestial north pole would be if you were standing on the equator). The angle you hold it should be the latitude of your location. Once in this position, turn the axis of the umbrella counterclockwise. This is how the sky appears to move when you are facing north. BUT, if you face south, and put the umbrella over your shoulder, the umbrella will need to be rotated clockwise. This is how it appears to move when facing south, and is similar to what would be observed in the northern United States.
2. **The Path of the Sun at Different Times of the Year** is shown by first placing a marker (either a brad or a sticky dot) on the point where the ecliptic crosses the celestial equator at the zero hours of right ascension. This is the location of the sun on the first day of spring (**vernal equinox**). With the umbrella positioned as described above, follow the arc the marker takes across the sky from the sunrise position in the east to the sunset position in the west. This model does not have a horizon line. Ask students to describe where the horizon line would be. Observe and describe the path.

As Earth continues its orbit, the position the sun appears in the sky changes. By the first day of summer in the northern hemisphere, the sun is at its highest point. Place a marker on the highest point of the ecliptic. Return the marker to the sunrise position in the east. Turn the umbrella slowly and observe the path of the "sun" from east to west.

Students should be able to observe that the sun rises at a point much further north than the one observed for the first day of spring. The point opposite the first day of spring, where the ecliptic crosses the celestial equator at 12 hours of right ascension, marks the position of the sun on the first day of fall. The model does not show the sun's position on the first day of winter. When students become confident with the model, they should be able to tell you that you would need a second umbrella joined to the first to complete the sphere in order to place the first day of winter opposite the first day of summer.

Accessibility Considerations:

1. Allow sufficient time to explore the umbrella sky before beginning whatever lesson you will be exploring.
2. Whether the student has low or no vision, you will need to explain that sighted individuals see the sky as a dome.

Credits: **Innovators Developing Accessible Tools for Astronomy (IDATA)**, officially known as *Research Supporting Multisensory Engagement by Blind, Visually Impaired,* and *Sighted Students to Advance Integrated Learning of Astronomy and Computer Science,* and the resulting curricular resources, Afterglow Access software, and project research were made possible with support from the U.S. National Science Foundation's STEM+C program (Award 1640131). IDATA institutional collaborators include AUI, GLAS Education, Linder Research & Development Inc., Logos Consulting Group, TERC, University of Nevada – Las Vegas, University of North Carolina at Chapel Hill, and Universidad Diego Portales. Individual consultants on the project include Kathy Gustavson and Alexandra Dean Grossi. IDATA Teacher collaborators in the U.S. include Amanda Allen, Jacqueline Barge, Holly Bensel, Neal Boys, Tim Fahlberg, Kristin Grender, David Lockett, Matthew McCutcheon, Caroline Odden, Michael Prokosch, Kara Rowbotham, Rick Sanchez, and Barbara Stachelski. IDATA Student collaborators in the U.S. include Evan Blad, Naleah Boys, Ellen Butler, Jayden Dimas, Riley Kappell, Joseph Murphy, Logan Ruby, Alex Scerba, Charlize Sentosa, Meg Sorensen, Remy Streichenberger, Trevor Warren, and others. IDATA Undergraduate Mentors include Tia Bertz, Katya Gozman, Chris Mathews, Kendall Mehling, Andrea Salazar, Ben Shafer, Alex Traub, and Sophia Vlahakis. Special thanks to the IDATA external advisors including Nic Bonne, Al Harper, Sue Ann Heatherly, Russ Laher, Luisa Rebull, Ed Summers, and Kathryn Williamson.