

Navigating the Night Sky – Teacher Guide
Argos Online

Subject

IPC, Physics, and Astronomy

Grade Levels: 9, 10, 11, 12

Introduction

Students participating in the Argos-Online project will collect and analyze data gathered during an actual astronomical observation from McDonald Observatory of a white dwarf star. A videoconference will help students feel as if they are inside the control room in one of the telescope domes. To follow what the astronomer is doing and how the astronomer uses the telescope as a tool to investigate white dwarf stars, students need to understand some basic astronomy. This activity provides a first-hand experience with astronomy and using a star map as both a tool and model.

Purpose

Students learn to use a star map to identify stars in the sky, predict rise, transit, and set times for celestial objects, and apply mathematical concepts such as coordinate systems.

Materials

Each pair of students needs:

- Two star maps for concurrent months (see **Preparation** section below)
 - If using online maps:
 - Two 8.5 x 11 sheets of regular paper per group for printing star maps.
- A planisphere or Star Wheel (see **Preparation** section below)
 - If using Star Wheels:
 - Three 8.5 x 11 sheets of 60# paper per group for printing the sky wheels
 - See <http://www.astronomyinyourhands.com/starwheel/starwheel.html>
 - or
 - See <http://www.lhs.berkeley.edu/starclock/skywheel.html> -This page is part of the Lawrence Hall of Science *Hands On Universe* website (<http://www.handsonuniverse.org/>).
- A small flashlight (a red bulb or filter will help students retain their night vision)

Whole class:

- Globe of Earth or a large World Map

Objectives

TEKS (General)

Scientific inquiry

- Collect data
- Organize, analyze, and interpret information to construct reasonable explanations from direct and indirect evidence
- Communicate valid conclusions

Critical Thinking and Problem Solving

- Represent the natural world using models and identify their limitations

Tools and Technology

- Collect, analyze, and record information using tools (planisphere)
- Identify patterns

TEKS (Specific)

IPC

- Scientific Inquiry: 2A, 2B, 2C, 2D

Geometry

- Dimensionality and the geometry of location
(2) The student understands that coordinate systems provide convenient and efficient ways of representing geometric figures and uses them accordingly.

Observing White Dwarfs with Argos Online: Star Maps

The student uses one- and two-dimensional coordinate systems to represent points, lines, line segments, and figures.

NSES standards covered: Position and motion of objects, Objects in the night sky, Changes in the Earth and Sky.

Preparation

Before the activity day:

1. Plan ahead! Clear skies (no clouds) and a location that offers a clear view of the horizon are necessary to do this activity. Include the students in this critical planning stage:

- Select a location.
- Monitor local and national weather forecasts online.
- Check the Moon's phase. You may decide to avoid nights of the nearly full Moon (waxing gibbous and waning gibbous). The full Moon is very bright and washes out fainter stars. Ideally, pick a night of a crescent Moon (2-4 days after a New Moon).

2. Purchase planispheres or download and print Star Wheels. (Note: Planispheres and Star Wheels are basically the same thing. Planispheres are more durable and are recommended, however Star Wheels are very inexpensive or free to download online and are sufficient if this is a one-time activity)

- Planispheres can be found online or at stores that sell astronomy supplies, with less expensive models around \$5-10 each. Be sure to get ones that are specific to your general latitude (Austin, TX ~ 30 °N, Denver, CO ~ 40°N).

or

- Very inexpensive (high quality) Star Wheels are available from the Astronomy In Your Hands website at <http://www.astronomyinyourhands.com/starwheel/starwheel.html>. Follow the instructions in the "Download and Assembly " section - (a one-time subscription is all that is required).

or

- Free Star Wheels are available to download from Lawrence Hall of Science *Uncle Al's Sky Wheels* (<http://www.lhs.berkeley.edu/starclock/skywheel.html>)

- Download and print the Sky Wheel Holder
- Download and print the two star wheels: Basic Constellations Star Wheel & Coordinates Star Wheel

3. Get star maps for concurrent (ideally the two most recent) months. These can be found in *Stardate Magazine*, or online at Skymaps.com <http://www.skymaps.com/downloads.html> - go to middle of webpage and download and print both PDFs for recent months in the Northern Hemisphere (only first page of each month is needed.)

4. Read through the student guide and this teacher guide thoroughly before presenting the activity.

On the activity day:

1. Organize students in teams of two or three. Each team will work with a pair of star maps and one planisphere or sky wheel.

2. Plan to begin the activity during or soon after sunset. The Sun and Moon will help students understand the significance critical features of their star maps such as the ecliptic. You will begin outside (**Engage**), then go inside (**Explore**), and then back outside to complete the **Explore** section.

Beginning the Activity

Engage (45 minutes) - outside

Begin at sunset. Go outside and view the night sky. Trace the ecliptic across the sky with a flashlight or laser pointer.

Confront notions of Earth's shape and rotation – why do stars and the Sun rise and set? (*Answer: Earth rotates on its axis.*)

We strongly recommend doing the remaining parts of the activity AFTER the **Engage** section.

Students need to critically view the actual night sky in order to use and understand the star map.

Explore

Part I: Getting to know the star map (30 minutes) - inside

Materials: Star maps

- Students compare two star maps for concurrent months:
 - What changes between the two maps?
-Positions of: stars and constellations (east/west? clockwise/counterclockwise?), ecliptic, planets (if present)
 - What remains constant?
-Position of Polaris (north star), zenith in middle
- Identify features of the star map:
 - How are constellations labeled? *- All capital letters*
 - How are stars labeled? *-Lowercase (except first letter)*
 - What do the symbols mean?
-Open clusters, globular clusters, galaxies, etc...(see legend)
 - Why are the stars different sizes on the map?
-Different magnitudes (brightness). Stars whose magnitudes are larger numbers are dimmer. The Greeks labeled the brightest stars they could see as magnitude 1 and the faintest as magnitude 6. We still use this system, but it often confuses people. The sun is -26 and the brighter planets are also often negative numbers.
- Identify limitations of the map:
 - Do the constellations near the horizon on the star map look like the constellations in the sky? If not, how do they look different?
-If you are using the star maps in Stardate Magazine, the answer is obviously No. If you are using the star maps from Starmaps.com, the distortion isn't as obvious, but it is there. The distortion is due to the problems of taking a half-sphere and projecting it onto a flat piece of paper. The constellations near the edges become misshapen.
 - How does the star map represent the apparent brightness of stars?
-The bigger the dot, the brighter the star. See the legend (the higher magnitudes are dimmer).
 - When does the star map most accurately represent the sky?
-Refer to the dates and times listed on the side of the map.

(NOTE: The cardinal directions (north, south, east, west) are listed around the edge of the circle so that you can hold the map up towards the corresponding horizon and see which stars would be visible at that particular horizon. So if you were looking east, you would hold the map on its side so that "EAST" is on the bottom – that would give the best representation of the sky along the eastern horizon.)

Class Discussion: How accurate are these star maps for an observer located in: (Choose from the list of locations below depending upon your interests and time available.)

-Refer to the globe (or world map). The latitude of each location is important here. The farther the location's latitude is from 40°N, the less accurate these star maps will be. For locations far down in the southern hemisphere (e.g. New Zealand or Antarctica), these star maps are basically useless – those locations see many different stars that we can't see.

-The Arctic Circle
-Quebec
-Montana
-Maine
-Costa Rica
-Sydney, Australia

-Kansas
-Tennessee
-New Zealand
-Southern Italy
-Turkey
-Northern China

-Hawaii
-North Korea
-Equator
-Brazil
-South Africa
-Antarctica

Part II: Making and Using the Star Wheels (20 minutes) - inside

A. Making the Star Wheel (omit this part if you use purchased planispheres)

Materials: Uncle Al's Sky Wheel

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- Make "Uncle Al's Sky Wheel." Allow students at least 20-minutes to complete their wheels.
- There are two wheels: one with constellations, and the other with constellations and coordinate lines. Students will use the constellation wheel when they go outside.

B. Using the Star Wheel or Planisphere

Compare the star wheel to the star maps. Note what is different between them.

Answer:

- *The maps are only good for certain times/dates while the star wheel or planispheres can be adjusted for any date or time for the listed latitude*
- *The star maps show the position of the zenith, the point overhead. The objects near the zenith will change over time and thus zenith is not shown on star wheels or planispheres.*
- *Star maps often show the positions of planets since they are designed for one month's use. Star wheels and planispheres don't show the planetary positions.*
- *Some students may note that the Coordinate Sky Wheel shows coordinates, the maps don't.*
- *Although neither shows the local meridian, it is an important concept. The local meridian is the imaginary line that goes through the North Pole, the zenith, and the South Pole. Stars have their highest possible altitude when they rotate past the meridian (this is a star's transit).*

For practice, ask students to set up their instrument for midnight on their birthday.

Part III: Using the Star Wheels (45 minutes) - outside

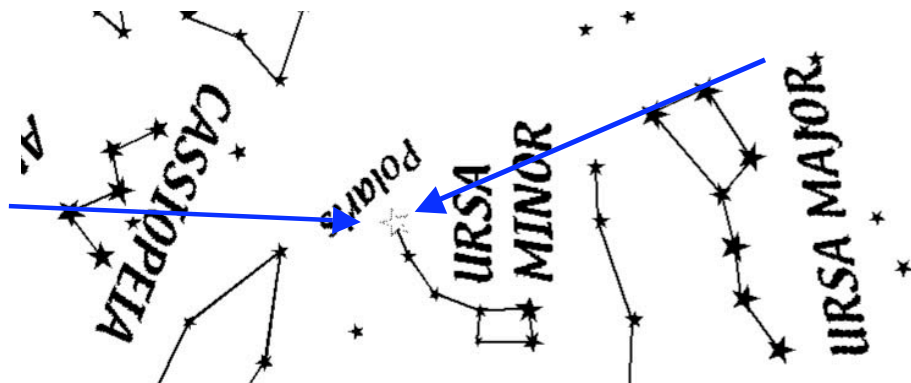
Materials: Uncle Al's Sky Wheel (constellation wheel) or Planispheres

- Students should observe in teams of two or three, with each student using a Star Wheel.
- Guide students to use the Star Wheel as a tool. Begin with the constellation wheel.
- Set the Star Wheel or planispheres to the present date and time of night.

First Challenge:

Find Polaris (North Star) in the sky.

Lead students to find Polaris in the sky.



Hints for finding Polaris in the sky:

Polaris's apparent brightness is about 2 – bright, but not blazing in the sky like Sirius (-1.4) or Venus (-4). Use Ursa Major or Cassiopeia to guide your eyes to Polaris.

Polaris: so what?

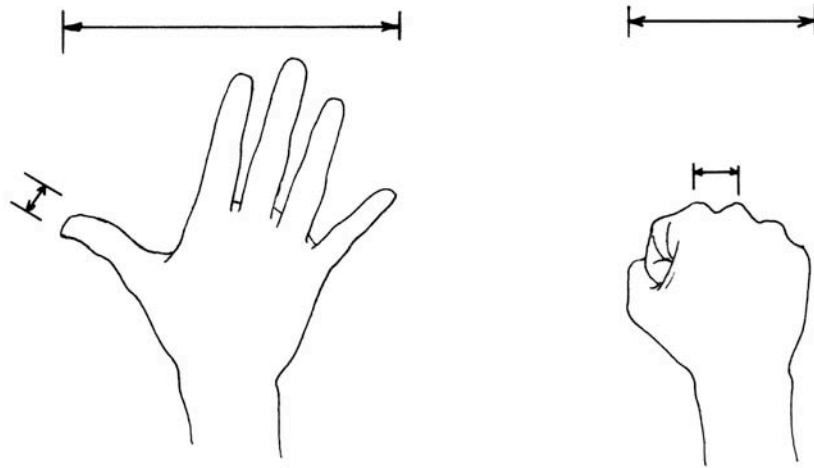
Polaris is special because at this time, Earth's rotation axis points toward it (within one degree). As a result, Polaris doesn't appear to move at all. The other stars appear to do circles around Polaris, and the stars in Polaris's vicinity do not set for observers in northern latitudes.

Astronomy with your fingers:

After each group has located Polaris, ask them to measure its altitude with their hands and fingers (the altitude of Polaris is equal to your latitude):

Observing White Dwarfs with Argos Online: Star Maps

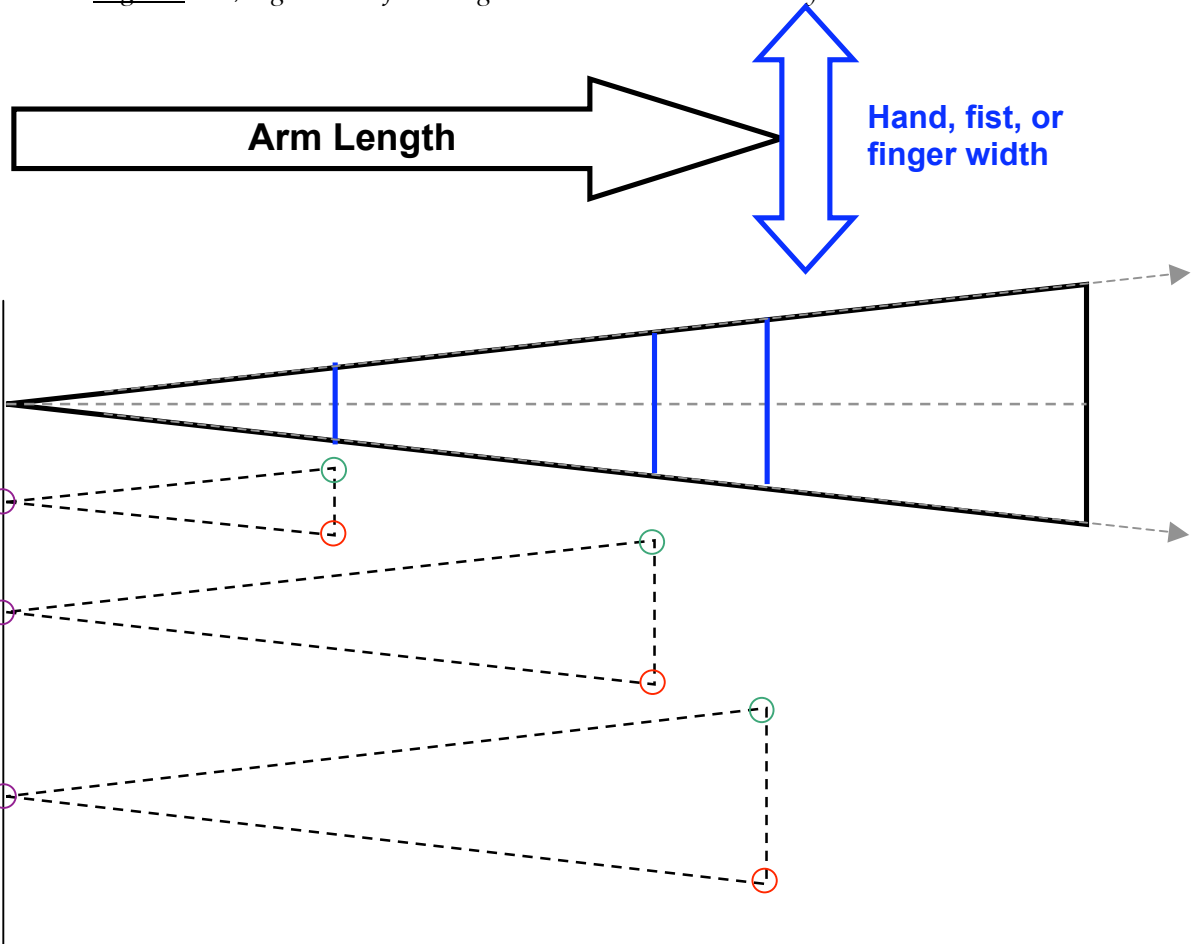
- Stretch your arm out.
- Spread your hand. From the pinky fingertip to the thumb tip is about 20 degrees in the sky.
- Each finger is about one degree.
- Make a fist – that's 10 degrees across, and the distance between adjacent knuckles is about 2 degrees.



Subtle geometry note:

Why does this work for everyone's hand?

-If a person has a bigger hand, then they probably also have a longer arm. A person with a smaller hand will have a shorter arm. So from each person's own point of view, their hand at arm's length will be about the same angular size, regardless of how big or small their hand actually is.



All the triangles are similar triangles: Each of the corresponding angles is the same.

Observing White Dwarfs with Argos Online: Star Maps

Estimate the size of the bowl of the Big Dipper and Cassiopeia. –BD is $\sim 25^\circ$ long w/ handle, bowl is $\sim 10^\circ$ by 5° –Cassiopeia is $\sim 13^\circ$ by 5°

Second Challenge:

Find these stars in the sky and on your Star Wheel for the season you are observing.

Autumn: September 20:

Arcturus, Antares, Vega, Altair, and Deneb

Winter: December 21

Altair, Deneb, Aldebaran, and Capella,

Spring: March 20

Aldebaran, Capella, Rigel, Betelgeuse, **Sirius**, Procyon, and Regulus

Summer: June 21

Regulus, Spica, Arcturus, Antares, and Vega

Note: these stars are selected by the date about an hour past sunset. The stars are listed in order from east to west in the sky.

Part IV: Using the Star Wheels or Planispheres (20 minutes) – inside

Complete the following activity using your Star Wheel:

1. When is each star highest above the horizon in the sky?
 - o Note the direction of the star in the sky: over which horizon would you look for the star to be highest in the sky? (North, South, East, West...) _____
 - o Other questions to consider: Is this the same for every star? Is there a trend to where the stars are at their highest on the Star Wheel? ...on the night sky outside? (*The local meridian is the imaginary line that goes through the North Pole, the zenith, and the South Pole. Stars have their highest possible altitude the moment they rotate past the meridian. This is a star's transit.*)
 - o Label the blank column "Transit."
2. In the table below: For the current season, fill in the time of day when each star rises, transits, and sets. If the time cannot be determined because it is between 6 a.m. – 6 p.m. (daytime), write "N/A" (though you can figure it out if you think about it).

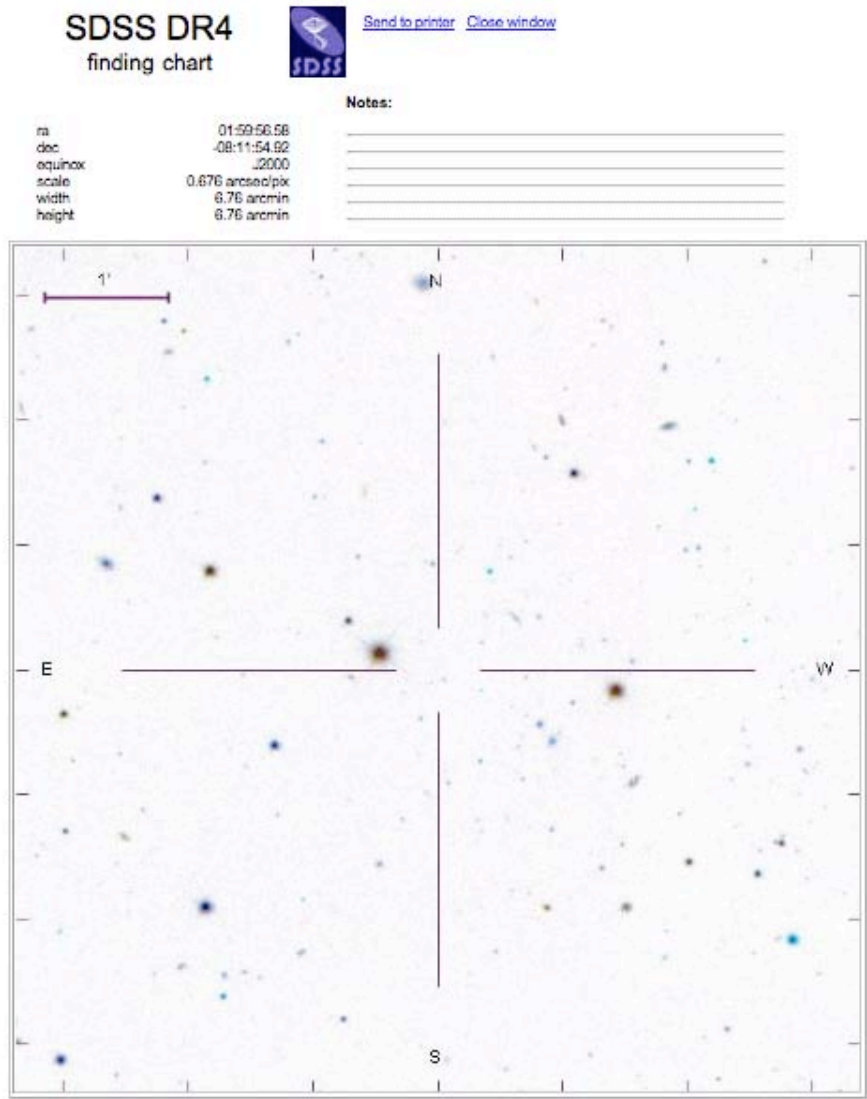
*(This answer sheet provides exact times for date listed for Austin, Texas [$\sim 30^\circ$ N latitude]. Student answers will not be precise and will vary depending on the planisphere or sky wheel they use. Student responses within 30 minutes are excellent. Times where students might put "N/A" are marked with a *)*

Star	Date	Rise	Transit	Set
Autumn Bright Stars (Sep 22 – Dec 20) (example: October 1 - Central Standard Time for Austin)				
Aldebaran	10/1	9:41 pm	4:23 am-10/2	*11:05 am-10/2
Altair	10/1	*1:16 pm	7:39 pm	2:02 am-10/2
Rigel	10/1	11:19 pm	5:02 am-10/2	*10:44 am-10/2
Sirius	10/1	1:10 am-10/2	6:32 am-10/2	*11:53 am-10/2
Winter Bright Stars (Dec 21 – Mar 20) (example: January 1 - CST for Austin)				
Regulus	1/1	9:23 pm	3:53 am	*10:23 am-1/2
Sirius	1/1	7:08 pm	12:30 am-1/2	5:52 am-1/2
Rigel	1/1	*5:17 pm	11:00 pm	4:42 am-1/2
Aldebaran	1/1	*3:40 pm	10:21 pm	5:03 am-1/2
Procyon	1/1	7:10 pm	1:24 am-1/2	*7:38 am-1/2
Spring Bright Stars (Mar 21 – Jun 20) (example: April 1 - CST for Austin)				
Arcturus	4/1	7:17 pm	2:06 am-4/2	*8:54 am-4/2
Procyon	4/1	*1:16 pm	7:30 pm	1:44 am-4/2
Sirius	4/1	*1:15 pm	6:36 pm	*11:58 pm
Spica	4/1	7:40 pm	1:15 am	*6:51 am-4/2
Regulus	4/1	*3:29 pm	9:59 pm	4:29 am-4/2
Summer Bright Stars (Jun 21 – Sep 21) (example: July 1 - CST for Austin)				
Spica	7/1	*2:42 pm	8:17 pm	1:53 am-7/2
Altair	7/1	7:20 pm	1:42 am-7/2	*8:05 am-7/2
Arcturus	7/1	*2:19 pm	9:08 pm	3:56 am-7/2
Antares	7/1	6:27 pm	11:21 pm	4:16 am-7/2

Note: We have not taken Daylight Saving Time (commonly mispronounced “Savings”) into account here. During Daylight Saving Time (mid March through early November), we would add one hour to the times on this table. While using the Star Wheels (or planispheres) outside, we would subtract one hour from our watch to set the wheel to be the most accurate representation of the stars we actually see (i.e. At 10 pm we would set the wheel to 9 pm).

Part V: Flat star maps and narrow fields of view

This is a real astronomical star chart from the Sloan Digital Sky Survey



Although you can see 180 degrees of sky when you stand outside, a telescope captures only a very small piece of the sky. Each degree has 60 minutes of arc. The scale in the upper left of the image shows the size of 1' - one minute of arc (also called an arcminute).

- How big is the entire field that is shown? Answer: ~36 arcminutes squared
- The bowl of the Big Dipper has about 55 square degrees. How many of these Sloan fields would you need to study the entire of the entire bowl? Answer: 5,500

Explain

- Students explain why the stars and the Sun appear to rise and set
- Students explain how they would locate white dwarf objects in the night sky.

Elaborate

Plan your own observing run for a star.

- When could they acquire that star?
- How long could they observe that star?
- Which star would be best to observe tonight? (Hint: You want to observe it for the longest possible amount of time.)