Astronomy 153 & 154
Telescope Lab (T-Lab) Make-Up – Planetarium Exercise

The University of Tennessee Planetarium, officially called The University of Tennessee Earth and Space Sciences Theatre, can provide students with an unobstructed view of the night sky that is related to the view seen by a naked eye observer. The Planetarium offers the additional abilities to turn off the Horizon, and the atmosphere, and then to go to any point in time and observe the sky. Make no mistake, the planetarium cannot and should not replace the Telescope Labs, T-Labs, but in cases where the weather is so poor that actual observations are prevented, then the planetarium is a very fair substitute.

This Make-Up exercise follows the Data Reduction Lab, and the grade for this exercise will be exactly translated to your cumulative T-Lab grade.

Identifying the objects in the night sky is the difference between stargazing and astronomy. It is the very first step to understanding the structure of our observable Universe. In this exercise, students will identify Constellations & Asterisms, Major Stars & Planets, and Deep Sky Objects. If students took TUTESST2 from the Fall 2013 semester, they will recognize this make-up as an extended version of that lab.

- With the projector on, turn off the horizon and the atmosphere. Make sure that star magnitude is set to 7 to simulate perfect viewing conditions. Turn on major star labels.

Part One – Constellation and Asterism Identification

The sky is divided into discrete regions, rather like the USA's state boundaries, known as constellations. The constellation boundaries as projected on the planetarium sky are blocked shapes whose boundaries are parallel and perpendicular to lines of Right Ascension and Declination that generally contain the asterism for which they are named. An asterism is a pattern of stars, like the Big Dipper. Although asterisms can be found in the constellation for which they are named, many of them cross constellation boundaries. Many different cultures on Earth found their own patterns and named their asterisms for different parts of their history and mythology. The system used here in the planetarium, and in most places around the USA, is nearly identical to the one used in England. An exception is that the British refer to the Dipper pattern as the Plow.

The instructor will turn on the constellation boundaries one by one, by focusing on a particular star within that boundary, starting with the circumpolar constellation. The star focused on will generally be the brightest star in the asterism for which the constellation is named. As the instructor brings up the asterisms and constellations, remember how to identify them, and how they fit together. The instructor will then point out the thirteen constellations of the zodiac, and the circumpolar constellations. For the exercises, you will need to remember how the constellations are laid out in the night sky!

- Turn on the ecliptic, and select a major star near the line. Then press the asterism key to show the asterism boundary, then the asterism name key to label it. Then shift+asterism line key to show the constellation boundary. Keep finding new label stars along the ecliptic outside of the constellation boundary and as you select it, all the lines for asterism, constellation boundary and the name will appear one by one.
- Put the cursor on Polaris and select the star. Then put Polaris at the center of the dome. Polaris will also bring up it's asterism, constellation, and constellation label. Then select all the neighboring stars to find all circumpolar constellations.
Part Two – Major Star and Planet Identification

In the Knoxville night sky, the only stars that you can see are major stars, the brightest in our view. In the planetarium, and in a clear sky location, you can see thousands, as has been previously mentioned. It's easier to memorize the brightest stars when they are the only ones that you see. However, it is considerably more important to know them in a clear sky, to reference for deep sky objects.

The instructor will go through some of the bright stars that can be seen on the roof of the Physics building. This should help reorient you to the new, abundantly starry sky. This is the time to turn on the equatorial coordinate system and take a minute to remember where the five brightest stars in the sky lay on that grid. This will help you identify the locations of dim deep sky objects later!

- For the current date, look at the brightest stars. If necessary go to Tools → 4. Stars → 4.3 Maximum Magnitude to Label, select the number, and press the down key once so that only the brightest few are labeled.
- After you're done going through the stars, be sure to press the arrow key up again to reset labeling to 2.6 before exiting Tools. Then turn off star labels.

All of the planets follow the ecliptic, so they are generally easier to identify. The instructor will put the Sun at the zenith and turn on the planet labels and orbits. Then one by one the instructor will turn off labels and zoom into the planets to identify. The images of the planets should be familiar!

- Find the Sun, select it and put it on dome center. Then turn on the ecliptic, planet labels, and go through the eight major planets one by one zooming in to show what each planet looks like.
- When you are done, turn off all the planet labels and ecliptic, reselect the Sun and zoom back out to reorient the dome.

Part Three – Deep Sky Object Identification

Most of the objects visible by naked eye in the night sky are stars in the Milky Way galaxy and planets in our Solar System. This is definitely not because the Universe is made of stars and planets inside of the Milky Way galaxy. It's a matter of perspective. We are in orbit around an absolutely average star (Sol) with seven other planets, which in turn is in an arm of a barred spiral galaxy that we call the Milky Way. Therefore we are surrounded by a field of stars, and our night sky shows that!

The first portion of identifying a deep sky object is determining that the object in question is not a star and not in our solar system. There have been many fuzzy regions in the sky that change rapidly which we now know to be comets. Comets and asteroids originate within our own Solar System. In fact the list of deep sky objects made by Charles Messier centuries ago was essentially a list of odd things in the sky that were not stars, planets, or comets. So the primary way for finding objects not within our own solar system is to observe them over time. Within our solar system, positions of objects generally change rapidly enough to be noticed. The background of stars and deep sky objects remains relatively fixed.

Star Clusters

The first deep sky objects to look at are Star Clusters. Star Clusters are groups of
gravitationally bound stars that collapsed from the same cloud of gas and dust and come in two basic
diversity. Globular Clusters, which can contain hundreds of thousands of older stars, and Open
Clusters which contain a few hundred to a few thousand younger stars.

The instructor will now highlight a cluster of each kind. Identify which object is Open or
Globular cluster, and then describe the cluster in detail. The goal of the description is to uniquely
identify the cluster you are seeing, or to at least separate it from other different clusters. For example:
the Globular Cluster Omega Centauri is a tightly packed spherical ball with hundreds of thousands of
red and orange stars. The cluster contains darker red stars at the outside, which fades to orange stars,
then yellow stars at the very center of the cluster.

- Select Open cluster M7 and zoom in to show the image, Open cluster the Pleiades (M45)
  and zoom in to show the picture, and Globular cluster M2 and zoom in to show the
  picture. Have students identify on the worksheet which kind of cluster each object is.

Nebulae

Nebulae are collections of gas, dust, and ionized particles in interstellar space. The major types
of nebulae are 1) Diffuse Nebulae: collections of gas and dust with no distinct boundaries (Show
Omega Nebula); 2) Planetary Nebulae – Clouds of former stellar atmosphere thrown off by a star dying
to a White Dwarf remnant (Show Cat’s Eye Nebula); 3) Supernova Remnant – The remains of a star that
underwent a supernova at the end of its' life (Show Crab Nebula); 4) Dark Nebula – A region of cloud
seen not by its' own emission, but by the light it blocks from the background stars (Show Horsehead
Nebula). Identifying the types of nebulae can be tricky, and it is worth mentioning that not all
interstellar cloud structures are classified as one of these nebulae. The instructor will now put up
nebulae to identify as Diffuse, Planetary, Supernova Remnant, or Dark Nebulae. Then describe the
nebulae observationally, as you did with the star clusters.

- Select M1 as a Supernova Remnant, M57 (The Ring Nebula) and M27 The Dumbell
  Nebula as Planetary Nebula, and M8 (The Lagoon) or M42 (the Orion Nebula) as star
  forming nebulae. Zoom in on each and help students identify each type of nebula.

Galaxies

Galaxies are larger collections of stars, gas, dust and dark matter like our own Milky Way
galaxy. Galaxies also come in a variety of shapes and sizes. The oldest and largest galaxies tend to be
massive elliptical galaxies at the center of galaxy groups. (Show ESO325-G004 on dome) Elliptical
galaxies are ellipsoidal in shape, and can range from nearly-circular from our perspective to thin disks.
Spiral Galaxies are the picturesque galaxies like the Andromeda Galaxy (shown on dome at this time)
with spiral arms branching from their core. Barred Spiral Galaxies, like the Milky Way have great bars
branching out the center from which their spiral arms generally originate. (Show Milky Way Map on
dome). There are further sub-classifications for each kind of galaxy depending on its shape, 154
students saw a more in-depth classification in Lab6. The Instructor will now bring up several objects
on the planetarium dome.

Identify the galaxies as either an elliptical, spiral, or barred spiral galaxy. After you have
identified each galaxy type and zoomed out, you should then describe a method for locating the galaxy
in the night sky. These descriptions should not include words such as up, down, left, right, north, or
south. These descriptors will change dramatically over the course of a night. Instead, use the asterisms
and brights stars around the galaxy to describe how to locate it. You can use words like “top” or
“bottom” if you are referring to an asterism's orientation. For example, the asterism Andromeda is
recognized as a woman, with stars that make up her feet and head. So if you need to refer to a galaxy
at her feet, you can say that the galaxy is at the bottom of Andromeda, since the asterism imposes its'
own top and bottom directions. But be warned, the top and bottom of each asterism is unique!
• Select Spiral Galaxies: M31, M51, M101, Elliptical galaxies M49 and M89. Zoom in on each until you can see the pictures and have students identify each galaxy.

Then there are Irregular and Peculiar Galaxies. These types do not fall into the original spiral, barred spiral, and elliptical groups. A peculiar galaxy is one that clearly had an identifiable shape, but was distorted by gravity in some way out of that shape. An Irregular galaxy, however, has no shape at all. Many dwarf galaxies are irregular in shape. The TA will show a simulation of two galaxies gravitationally colliding which will illustrate how galaxies can go from having a clearly defined classification to a Peculiar classification.

• Zoom back out to see the full dome sky.
• Press the Disc icon on the bottom right corner of the remote control to view the input source list. Choose 'Internal', scroll down to and select 'shorts', scroll to and select 'NASA Clips', scroll down to and select 'galactic_collision.full.mp4'.
• When that has finished playing, press the null key at the very bottom right of the remote to go back to the menu.

**Larger Scale Structures**

Galaxies are themselves gravitationally bound to each other in groups and clusters. These clusters are bound together to form super-clusters, and these super-clusters are gravitationally bound to create a great cosmic web, the largest structure in the Universe. The animation you are about to see is a computer generated fly through of the known Universe at the scale of this cosmic web. Remember that every bright dot in this animation is a galaxy, and the groups are great clusters of galaxies, each with hundreds, thousands, or millions of galaxies within them.

• Press the Disc icon on the remote control to view the input source list. Choose 'Internal', scroll down to select 'shorts', scroll to select 'NASA Clips', scroll down to select 'cosmic_cruise.full.mp4' and play to the end.
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Telescope Lab (T-Lab) Make-Up Worksheet

Part One
1. When we connect the stars with straight lines to make patterns in the sky, what do we call those patterns?
2. What is the difference between an asterism and a constellation?
3. How many constellations lie along the zodiac? Name 6. Name 5 constellations that are south of the zodiac.
4. Name the 5 circumpolar constellations.

Part Two
5. What are the five brightest stars in the night sky at the current date? What are their approximate RA and Dec?
   a. 
   b. 
   c. 
   d. 
   e. 
6. What planets are up at the time of the planetarium observation?

Part Three
Star Clusters:
7. Object Name______________________ Cluster Type?______________________
   Observational Description

8. Object Name______________________ Cluster Type?______________________
   Observational Description

9. Object Name______________________ Cluster Type?______________________
   Observational Description
Nebulae:
10. Object Name______________________ Nebula Type?_______________________
   Observational Description

11. Object Name______________________ Nebula Type?_______________________
   Observational Description

12. Object Name______________________ Nebula Type?_______________________
   Observational Description

13. Object Name______________________ Nebula Type?_______________________
   Observational Description

Galaxies:
14. Object Name______________________ Galaxy Type?_______________________
   Observational Location Method:

15. Object Name______________________ Galaxy Type?_______________________
   Observational Location Method:

16. Object Name______________________ Galaxy Type?_______________________
   Observational Location Method:

17. Object Name______________________ Galaxy Type?_______________________
   Observational Location Method:

18. Object Name______________________ Galaxy Type?_______________________
   Observational Location Method: