

Moon Lab – Two Weeks

OPEN/GALACTIC AND GLOBULAR CLUSTERS

Purpose: The purpose of this lab is to learn how to find faint objects not visible to the naked eye and sometimes not visible in the finder telescope. You will also develop an understanding and appreciation of the two primary types of clusters, and how they lead to an understanding of star formation and galactic structure.

Introduction

Forming Clusters When giant clouds of dust and gas form, the dust becomes thick enough to block visible and ultraviolet light (short wavelengths) from stars outside the cloud. Therefore, clouds cannot cool except by radiating away energy in other forms, such as infrared and radio radiation (long wavelengths) that the dust doesn't block. As the cloud cools, atoms unite to form molecules (which are also good at blocking short wavelengths and radiating away energy in the form of infrared and radio waves) and a "molecular cloud" is born. The molecular cloud continues to cool and collapse under the weak force of gravity. From the outside, these molecular clouds look like large blank areas from which no radiation (except IR and radio) is emitted.

Parts of the cloud become very dense, and the force of gravity becomes very strong. These small pieces of the cloud collapse very rapidly and their interiors become so condensed and hot from the collapse that nuclear fusion of hydrogen into helium is triggered, and they begin to shine as stars. The radiation from the stars starts to heat the cloud from the inside (because the dust is preventing the starlight from escaping!) and it starts to break the molecules back into the atoms again. The hottest and most luminous stars (the O and B supergiants) even ionize the cloud around them to form ionized hydrogen. These hot stars and ionized hydrogen (called HII regions "light up" the cloud and often provide spectacular views of it. We then see them as diffuse nebulae.

Open Clusters Eventually, the hot, luminous stars breakup, ionize, and disperse the cloud of dust and gas, leaving a group, or cluster of stars behind which formed from the cloud. These are called "open clusters" (or "Galactic clusters" – though this is a bit of a misnomer now as discussed below). Open clusters usually don't contain enough stars to hold on to each other gravitationally (most of the mass of the cloud was dispersed by the light from luminous stars). They contain a few dozen to a few thousand stars (usually a hundred or so). Most open clusters then break up over a hundred million years or so and the individual stars slowly orbit the Milky Way galaxy as loners, each in their own orbit (like our Sun is). Since open clusters don't contain a lot of stars, they become inconspicuous at distances beyond about a thousand light-years. Most of the naked-eye stars in the Big Dipper are actually part of an open cluster! Open clusters usually appear in the telescope as a coarse collection of stars of all luminosities and colors. Open clusters appear only to have a few extras stars in their region of the sky, compared to globular clusters (below).

Globular Clusters Globular clusters are very different from open clusters. For starters, each globular cluster contains between 100,000 to ten million stars! The stars are mostly old (>10 billion years), which means that the clusters date back to the formation of the Milky Way when the Universe was much younger than today. The clusters orbit the center of the Milky Way in randomly oriented elliptical orbits. This makes them look like a spherical "swarm" of clusters surrounding our galaxy. There are a little over a hundred known globular clusters that orbit our Milky Way. In each cluster, the stars remain bound to the cluster because there are so many stars crammed in so little space that they cannot escape their collective gravity. Since the clusters are so old, there are no supergiant stars left, and the brightest stars left are stars like our Sun in their red giant phase, at the end of their 10-billion year lifespan. The distances to these clusters range from a "nearby" one only 9,000 light-years away to the other side of the Milky Way about 80,000 light-years away! Because they are so far away, they appear as fuzzy blobs in small telescopes (like the ones we're using), with a sprinkling of the brightest stars just visible as tiny pinpoints of light.

Objectives

1. To observe and sketch the appearances of open and globular clusters, and understand their differences.
2. To familiarize yourself with your star atlas.
3. To familiarize yourself with observing faint objects and the magnitude system.
4. To practice finding faint objects with a telescope.
5. To learn about cluster types and begin to develop a sense of galactic structure

Requirements

Three (or more) detailed sketches of open clusters and two (or more) of globular clusters. Observe a total of five clusters [3 pts per observation]. In your sketches and notes, include comments about their total brightness, number of stars, the brightness and color of the individual stars, shape of the cluster, etc. Don't just randomly sprinkle stars in your sketch! Try to accurately sketch the brightest 30-50 stars in each cluster.

Directions

1. Set up a telescope and *accurately* align it with the north celestial pole.
2. Select a cluster from the list below, find it in your star atlas, and find it with your telescope.
3. Select the best magnification to observe the cluster (usually low or medium power).
4. Observe and sketch the cluster. Try to appreciate what it is and why it looks the way it does.
5. Draw a dotted circle around what you believe to be the edge of the cluster. Then use the drift-time method (only once per cluster) to compute the angular size of the cluster. However, multiply each of your angular calculations by the cosine of the declination. (Example: if you got 254 arcsec for an object at $\delta = 60^\circ$, the true answer is $254'' * \cos(60^\circ) = 127''$. Also estimate the angular size of the cluster by using the circle on your drawing. (See pages **Error! Bookmark not defined.** and **Error! Bookmark not defined.** for more on both of these methods.)

Spring Sem	<u>Open Clusters</u> (before April)	<u>Globular Clusters</u> (Late May)
Cluster	M 45 (Pleiades, Taurus, Finder only) – try 1 st	M 12 (Ophiuchus) – try last
(constellation they're in)	Hyades (Taurus, Finder only) – try early M 44 (Cancer)* NGC 2264 (Monoceros) M 41 (Canis Major) – try early M 35 (Gemini) NGC 869 & 884 (Perseus-sets early) -- try early M 37 (Auriga) M 36 (Auriga) M 46 (Canis Major) M 38 (Auriga) ^o M 67 (Cancer - faint)	M 92 (Hercules) – try late M 13 (Hercules) M 5 (Serpens Caput) M 3 (Canes Venatici) – try first M 10 (Ophiuchus – low, tough!) 12 ^o
		For both spring and fall semesters, You will be given the option to view 1+ globulars through the 16".
		* also named "Praesepe" or "Beehive"

For spring and fall semesters, you'll be given the option to view 1+ globulars through the 16" telescope.

Fall Sem	<u>Open Clusters</u> (late Nov/Dec)	<u>Globular Clusters</u> (before October)
Cluster	M 34 (Perseus)	M 12 (Ophiuchus) – try early
(constellation they're in)	NGC 869 & 884 (h & γ Perseus) M 37 (Auriga) M 11 (Scutum) – probably down M 36 (Auriga) M 38 (Auriga) M 29 (Cygnus) – try early NGC 7789 (Cassiopeia) M 52 (Cassiopeia)	M 92 (Hercules) – try early-ish M 30 (Capricornus) M 13 (Hercules) M 5 (Serpens Caput) – probably down M 15 (Pegasus) – save for late M 2 (Aquarius) – save for late M 22 (Sagittarius) – try early M 10 (Ophiuchus) – try early

NGC 752 (Andromeda, huge!) OR NGC 457

Questions

1. [1 pt] List all of the differences that you observed between open and globular clusters. (size, appearance, brightness in both finder and eyepiece, etc.)
2. [1 pt] A) Using your star atlas, determine which kind(s) of the two types of clusters is found in the plane of the Milky Way and which is found away from the Milky Way. B) Why would the locations be different?
3. [1 pt] Looking at the star atlas, do you see open clusters in most directions, or are they all concentrated in one general area of the sky (i.e. on 1-2 maps)? [If one area, which area?]
4. [1 pt] Looking at the star atlas, do you see globular clusters in most directions, or are they all concentrated in one general area of the sky (i.e. on 1-2 maps)? [If one area, which area?]
5. [1 pts] Which items from the list in questions 1 and 2 are clues to the differences in age between the clusters? Briefly explain why. (You may want to do some research on this.)
6. [1 pts] What kind of cluster did the Sun come from? Where are the other stars in that cluster now? (You will have to reason these out for yourself, most likely.)
7. [1 pt] Based on what you've seen, which type of cluster do you think has more stars? Why?
8. [1 pt] Based on what you've seen, which type of cluster do you think is further, on average? Why?
9. [1 pt] You determined the angular size using two methods: drift times and drawing-based using a scale. Which method do you think is more reliable?
10. [1 pt] The sky atlas has estimates of the cluster sizes listed. A) How many times was the drift method closer to the atlas' estimate? B) How many times was the drawing method closer? C) Were your angular estimates reasonably close to those listed in the atlas? Why do you think that is?

What to submit

- A) The answer to the above questions
- B) All drawings of clusters, including the dotted circle that estimates the size of the cluster. In the notes, you should **drift-time each cluster once** (and multiply by the correction factor given above) as well as **estimate the angular size of the cluster using your drawing** and the image scale method discussed on page **Error! Bookmark not defined..**