Stars, Clusters Nebulae and Galaxies
ASTR 102

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1 Objective

The objective of this lab report is not to outline a scientific process, but rather to inform of the information learned during this lab section using the tool Google Earth. I will describe different types of objects which were viewed and what was learned about them.

2 Astronomical Objects

All astronomical objects in this report were viewed using Google Earth. Google Earth has an astronomy feature that allows you user to view the sky and images taken in a number of astronomical surveys (including one done by the famous Edwin Hubble). Here, I will group objects by there type (even though specific objects were looked at) and talk about what was learned in general about the types as well as any specific instances which have unique properties.

2.1 Stars

Stars, when viewed from the Earth's surface or from Google Earth, appear to have some size dimensions associated with them. However, this is untrue and is actually caused by air turbulence in the Earth's atmosphere. This condition is known as the "seeing", and since Google Earth's images were taken from Earth's surface, the condition is present here as well. Stars also appear to be different colours in the sky. This is due to their temperature, or wavelength of peak emission emitted from the star. When looking at Cygni 30 and 31, 30 appears blue which is associated with a shorter wavelength meaning higher energy. Higher energy in a star means higher temperature. These stars also have the property of appearing close together in the sky. This is however not true as the stars are actually many many light years apart and only appear close together

due to the angle of view. When viewing stars in Google Earth, there can also be slight artefacts caused by the camera which are known as ghosts. This was seen viewing Vega.

Google Earth was also used to find a lower bound and upper bound on the number of stars in our Milky Way Galaxy. If you take the least dense region of stars, count the stars, and multiply it by the relative size of the galaxy you find the lower bound for the number of stars in the Milky Way. Similarly, if you take the densest region, the centre, and count stars and multiply, you get an upper bound. It is thought that there are between 100 and 400 billion stars in the Milky Way.

2.2 Clusters

Two types of clusters were examined in this lab: open, and globular. Open clusters are large groups of stars in the sky, however there is usually space between the stars and not a nuclei of the cluster. Globular clusters on the other hand tend to have a nuclei which the concentration of stars is at a peak. Globular clusters appear to be more concentrated and have less visible space between the stars. You can determine the general age of a cluster based on the average colour of stars inside it. If the stars are blue then the cluster is younger while if the stars are red then the cluster is older.

2.3 Nebulae

Three types of nebulae were examined: reflection, emission, and dark. These three types of nebulae are all present in the North American nebula which has a shape similar to that of North America. Reflection nebulas occur due to a scattering of light particles from the emitting stars which are present. The other wavelengths of light are less prone to scattering so they pass through the gas. This is the same reason why our sky appears blue during the day (the scattering of the Sun's light). Reflection nebulas are mainly composed of HI (temperature not hot enough to ionize the hydrogen). The emission nebula has a red colour to it and is composed of HII (ionized hydrogen). The dark nebula is composed of H_2 and is the most dense of the nebulae. Dark nebulas are where stars are formed. Here the condensed gas begins to compress in on itself and form the starting of a brown dwarf. The starting the evolutionary process of a star is know as the nebular theory. The dark nebulas are so dense that they absorb any star light that is behind them, making them appear as black holes in the sky.

2.4 Galaxies

Four types of galaxies were examined using Google Earth. These type of galaxies are: elliptical, spiral, barred, and peculiar galaxies. It is worth noting that these galaxies are so far away that no particular star can be seen inside of them. Any

star seen in images or on Google Earth which appears to be inside the galaxy is actually in front of the galaxy in space. Elliptical galaxies when viewed in images have a more round and elliptical shape while appearing almost all red and being similar to that of a globular cluster. These galaxies are the oldest of the known galaxies. M67 was examined and can be seen to be ejecting some blue material (in the visible) from its centre. This turns out to be a black hole ejecting gas primarily in the X-ray part of the spectrum. I will come back to black holes and quasars later on in this report. Spiral galaxies are those like our own Milky Way. They tend to be blue in colour and thus younger with spiral arms coming from their centre. These are are filled with nebulas, especially dark nebulas which are used in the forming of stars. These galaxies also tend to have a slight bulge in their centre. Barred galaxies are spiral galaxies with an apparent "bar" running through their centre and extending out on either side of the galaxy. Galaxies such as the "Mice" galaxies which do not fit into the three types of galaxies already listed are labelled as peculiar galaxies. Here, I looked at the "Mice" galaxy which is actually two galaxies colliding and ejecting stars from one another. An interesting note about galaxy collisions is that stars are so relatively small compared to the galaxies that start on star collisions are estimated to only occur once between the billions of stars in each galaxy in a collision. This is good new considering Andromeda is on a collision course with the Milky Way. Although we will probably be ejected out into space and never to return.

The final item to note in this report about galaxies was the viewing of the Hubble Ultra- Deep Field image. Here, the Hubble Space Telescope was pointed at an area of sky which looked as if it had little activity and took a many month exposure image. The resulting image returned a view littered with galaxies. From a view of 20 arc seconds, I counted 66 galaxies. which means the image contains 66 billion galaxies! These galaxies were formed around 13 billion years ago which is right near the formation of the universe which is 14 billion years old. These galaxies would have formed after the big bang, inflation, the dark ages, and then stars forming. It is interesting to note that when we see these galaxies, we are actually looking back in time 13 billion years as it took the light 13 billion years to reach our cameras.

2.5 Miscellaneous

Here I will discuss some of the miscellaneous objects viewed using Google Earth as they do not fit in with any previous category.

2.5.1 Planetary Nebula

At the end of a star's life, a couple things can happen which depend on its mass. One of those is to become a black hole (will come back to), but more importantly one is cause a planetary nebula. A planetary nebula is caused by a star ejecting its atmosphere at the end of its life. This causes a large ring to form around

the star. The ring is coloured from inside to out of short wavelengths to long because the star is still radiating in its new state of a white dwarf. Planetary nebula's were given their name because early astronomers believed that what they were seeing was similar to the look of planets. It is now know however that planets are not involved.

2.5.2 Asteroid Track

Asteroid are commonly discovered, and here in Google Earth, we can see how imaging can be used to find asteroids by accident. If an image is taken of the stars, with proper star tracking equipment, no streaks will be visible as the stars move due to the rotation of the Earth. However, asteroid move independently of the stars. Therefore, when a large streak is seen in an image, it usually mean that it is an asteroid in the field of view of the camera. Google Earth shows a red, green, and blue streak all corresponding to the same asteroid. Asteroids are commonly found accidentally using this technique.

2.5.3 Supernova Remnant

Here, I looked at what is know as the Crab nebula. This nebula (also know as M1) was formed by an exploding star in its last stages of life. Charles Messier discovered this nebula which he recorded in his astronomy catalogue while looking for comets. (The objects he found however were not moving and thus could not be comets.) At the centre of this nebula is what is known as a pulsar or a neutron star. This star (composed of neutrons) spins at a very rapid and constant rate which produces pulses of radiation from gamma to radio waves. Some of the first SETI astronomers mistook pulsars for alien life as the radio waves seemed to be emitted with intelligent thought. The neutron star is so dense that it is believed that a single tablespoon of neutrons has the same mass as Mt. Everest.

2.5.4 Quasar

Some galaxies, although recent research suggests all, have a supermassive black hole at their centre. This black hole is surround by gas and dust which get thrown about and heated. This heated gas is similar in appearance to a star and is actually called a quasar. These quasars are know to eject gas high into the space of the galaxy and can be seen often as a blue jet of gas coming from the centre.

2.5.5 Black Hole

Although we can not directly view black holes, we can see their effects. As previously stated, black holes are often found at the centre of galaxies witch super heated gas around them often forming quasars. The Milky Way's black hole can be seen indirectly from released surveys. In these surveys, objects are seen travelling very quickly around a central point in the galaxy and being

quickly ejected once they come to perigee. The point at which they orbit is thought to be the black hole.

References

[1] Smith, J. M. and Jones, A. B. (2012). *Chemistry.* Publisher, City, 7th edition.