ORANGE COUNTY ASTRONOMERS

BEGINNERS CLASS NOTES

WHAT'S UP THERE

1. Introduction

Often times beginning amateur astronomers loose interest in the activity after a while, not because of lack of enthusiasm, but because of lack of direction on what to look up in the sky. Invariably the Moon is the first target of beginners, and observing the Moon can be fascinating. However, unless they become dedicated Moon observers, pretty soon they will start looking for something else to observe. Left to themselves many beginner astronomers loose interest and quit the hobby.

The purpose of these notes is to describe the astronomical objects that can be observed with a small telescope. The instruments required to observe these objects, and the tools and methods to find them in the sky are the subject of other beginners notes.

2. Distances

The first thing to realize is that the distances to stellar objects are enormous. Except for measuring the distance to the planets of the Solar system, using miles to measure distances to stars and galaxies is impractical. It would be like trying to measure the distance from Los Angeles to Peking in inches,

The unit used to measure interstellar distances is the light-year. A light year is the distance that the light can travel in a year and it equals to roughly six trillion miles. The enormity of this number can be only grasped by saying that if a human being starts counting non-stop from 0 to 1 trillion it would take him/her 325,000 years to complete the count.

It is also easy to depict a model of interstellar distances. Let's imagine the Solar system. The sun would be a pinpoint one inch away from the speck size Earth. In this model, Pluto would be 3 ½ feet from the Sun, and the nearest star, Proxima Centauri, would be almost 4 ½ miles away. We live in utter isolation.

The Milky Way, our galaxy, is approximately 100,000 light year across, and the Andromeda Galaxy, the closest galaxy to the Milky Way, is at a staggering 2.5 million light-years away. The Virgo cluster of galaxies is near 100 million light-years away, and the most remote quasars are 12 to 13 billion light-years away.

However, a modest amateur scope can probe the galaxies of the Virgo cluster and larger amateur scopes can show some of the closest quasars. In between lays a rich assortment of beautiful stellar objects that make this activity so interesting and fulfilling.

The objects we will describe fall into two different categories: Solar System and deep space.

3. Solar System

The Solar system consists of the Sun, the nine planets and their moons, the asteroid belt, the comets, and the small icy objects of the Kuiper Belt and the Oort Cloud. The objects of the Kuiper Belt and the Oort Cloud are beyond the capabilities of amateur scopes and we will not elaborate on them in these notes.

3.1. The Sun

The Sun is our star. The Sun supplies the Earth with the energy required to sustain life in our planet. The Sun, like all the stars, is a ball of highly compressed hydrogen gas undergoing thermonuclear fusion. The Sun converts 4.5 million metric tons of hydrogen into energy each second.

The Sun has a diameter of almost 850,000 miles and could fit 1.3 million Earths inside it. The Sun temperature at the photosphere is approximately 6,000 Kelvin while the temperature at the core is estimated at 15 million Kelvin.

The easiest features to observe in the Sun are the sun spots. The sun spots are areas on the Sun's surface that are cooler than the surrounding areas. This makes them look darker. The Sun spots are normally clustered in groups and their abundance increases and decreases in a 11 year cycle.

Another feature of the Sun is the corona. The corona can be seen easily during total eclipses, when the Sun's disk is covered by the Moon. Another features like prominences require special filters to be seen.

WARNING: Always use a solar filter when looking at the Sun.

3.2. The Planets.

All the planets revolve around the sun in the same direction, along almost the same orbital plane of Earth's. It is also instructive to know the planets' positions (configuration) as it relates to the sun's position. In order to do this it is necessary to separate the planets into two groups: the *inferior planets* which have their orbits inside the Earth's orbit (Mercury and Venus), and the *superior planets* which have an orbit outside the orbit of the Earth (Mars, Jupiter, Saturn, Uranus, Neptune and Pluto).

Figure 1 shows the positions of an inferior planet relative to the Sun and the Earth. When the planet is aligned with the Sun and the Earth, the planet is in conjunction. The angle that the planet makes with the Sun as seen from the earth is called elongation. The elongation can be East or West.

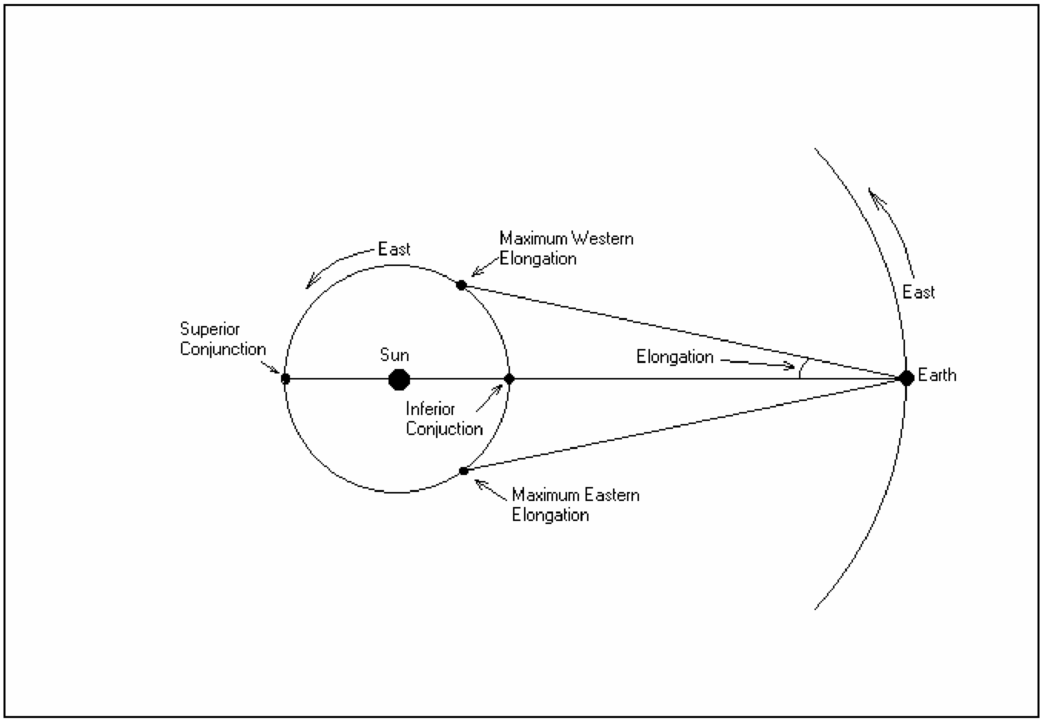

Figure 1. - Configuration of the inferior planets

Figure 2 in next page shows the positions of a superior planet relative to the Sun and the Earth. The planet is in conjunction when it is on the opposite side of the Sun as seen from the Earth. The planet is in opposition when The Earth is between the Sun and the planet. Opposition is the best time to observe a planet since it is closest to earth, is fully illuminated by the Sun, and stays visible from sunset to sunrise.

The planets fit into two categories: those that are earthlike (Mercury, Venus, Earth and Mars), called the *terrestrial planets*, and those that are Jupiterlike (Jupiter, Saturn, Uranus and Neptune) called *jovian planets*. The *jovian planets* are also referred to as *gas giants* because they composed mainly of gas. Pluto fits the terrestrial group, but some consider it as a Kuiper belt object.

In the following pages we will be referring to the Astronomical Unit (AU) to describe the distance from the planets to the Sun. The AU is the distance from the Earth to the Sun and it is equivalent to 93 million miles.

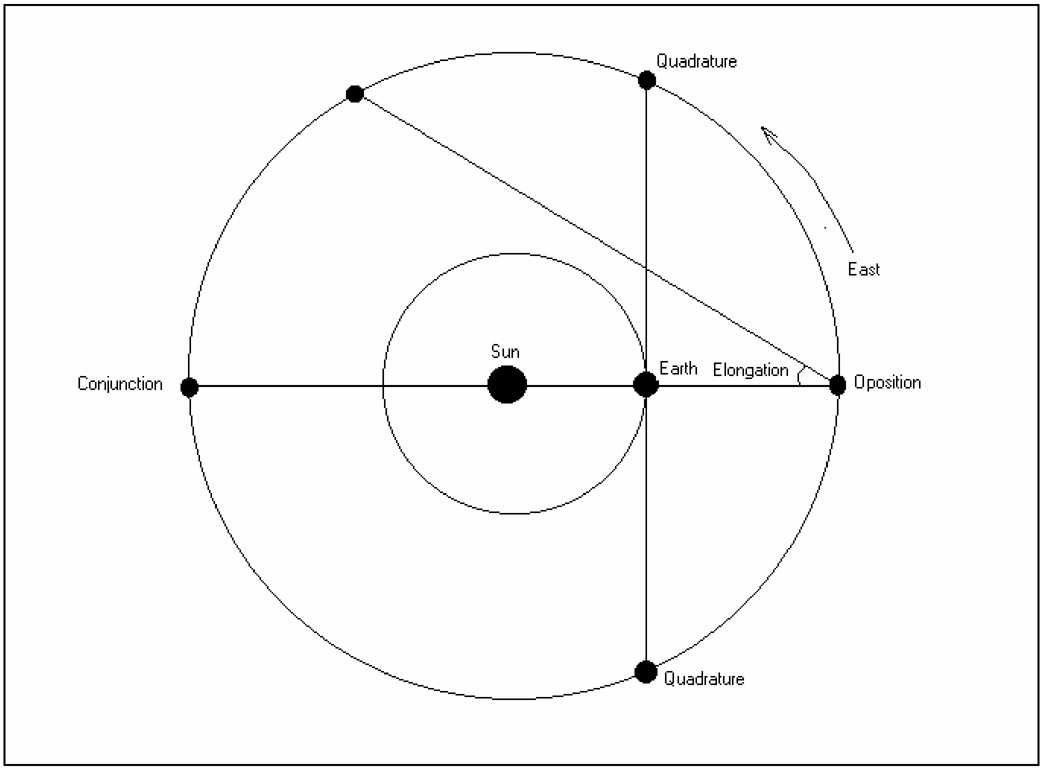

Figure 2. Configuration of the superior planets

3.2.1. Mercury

Mercury is the closest planet to the Sun. Its diameter is around 3,000 miles (Earth diameter = 7,718 miles), its mass is about 5% of Earth's and circles the Sun in 88 days at an average distance of 0.4 AU. The planet is heavily cratered, has no atmosphere, and does not have any moons.

Since it maximum elongation is never bigger than 28 degrees, Mercury is very elusive to see. It appears for a maximum of 2 hours after sunset or before sunrise.

In the telescope Mercury shows phases like the Moon, and amateur scopes can not resolve any features of the planet.

3.2.2. Venus

Venus is the second planet from the Sun and the closest to Earth. Its diameter is 7,330 miles, its mass 95% of Earth's and circles the Sun in 225 days at an average distance of 0.7 AU. The planet is cratered, does not have any Moons and has a dense atmosphere composed of carbon dioxide and corrosive compounds such as sulphuric acid droplets. All this combines to elevate the surface temperature to 600-700 degrees Kelvin, high enough to melt lead. It is said that if somebody could land in Venus, he/she would be roasted, crashed, suffocated and corroded.

Venus is easily seen before sunset or sunrise. It rises much higher than Mercury, as much as 45 degrees. It is the brightest planet, shining as bright as –4.6 magnitude. It does not show any surface features due to the opacity of its atmosphere, however it shows phases as our Moon.

3.2.3. Mars

Mars is the last of the terrestrial planets. Its diameter is 4,116 miles, its mass 11% of Earth's, and it circles the Sun in 1.88 years at an average distance of 1.5 AU. The planet is cratered, has a thin atmosphere of carbon dioxide, and has two small moons, Deimos and Phobos, beyond the reach of typical amateur scopes. Mars displays a obvious reddish color and can be as bright as –2 magnitude.

Mars has attracted big attention lately due to the data sent to Earth by fly-by probes. Data suggest the existence of water in Mars' past. Mars reaches opposition each 26 months, but due to the eccentricity of the planet's orbit, the distance from the Earth to the planet at opposition varies from 57 to 100 million miles. At its best Mars shows an angular size of approximately 26 arc seconds. During close oppositions scopes of modest size will show major surface features and the planet's polar caps.

3.2.4. Jupiter

Jupiter is the largest planet of the Solar system. It is a gas giant, meaning that its composition consists mainly of gases, hydrogen (85%), helium (15%) and traces of methane, ammonia, and other compounds. Its mass is 317 times that of Earth, its equatorial diameter is 86,500 miles, and it circles the Sun in 11.86 years at an average distance of 5.2 AU. It has more than 20 moons although only the 4 large Galilean moons, Io, Europa, Ganimede and Callisto, are within reach of average amateur telescopes.

Recent data suggest that Europa may contain a vast ocean of water under its frozen surface, while Io seems to be the most active moon of the Solar system with continuous volcanic activity.

Jupiter can shine at –2.7 magnitude, making it the second brightest planet, after Venus, and reach an angular size of 1 arc minute. Even a modest scope will show some of the planet's belts and the four Galilean moons. One of the belts contains the Great Red Spot which is a storm, the size of the Earth, that has been raging in Jupiter's upper atmosphere for the last centuries.

Observing the Galilean moons is a favorite of many amateur astronomers. The moons shift their positions day to day. Some times they are occulted by the planet or transit if front of it, casting a shadow on the planet if the Sun, the Earth and Jupiter are in appropriate position. More rarely, the moons eclipse each other.

Jupiter has a faint ring system not detectable by amateur telescopes.

3.2.5. Saturn

Saturn is the most beautiful object of the Solar system. Although the other gas giants have some kind of ring systems, Saturn's rings are of incomparable splendor. Saturn mass is 95 times greater than Earth's, its equatorial diameter is 72,600 miles, and it circles the Sun in 29.5 years at an average distance of 9.5 AU. The number of its moons, at last count, exceeds 20. Several of them are visible in amateur scopes. Titan, the largest moon of the solar system is easily seen in small scopes. Larger amateur scopes can show as many as 10.

Saturn, is the superstar of the night sky, a showpiece unmatched by anything else seen through the telescope. Although the image of Saturn in a good quality, moderate aperture scope can be breathtaking, virtually any scope will show the rings. The rings are not a single ring but are split into several smaller rings with empty divisions between them, The most prominent division is the Cassini Division which can be seen with a 3" scope. Other divisions are more difficult to see with amateur scopes.

Saturn itself reaches an angular size of approximately 20 arc seconds. When the rings are included the angular size reaches almost 1 arc minute. The magnitude of the planet/ring system varies from 0 to 1. Sometimes one or two dusky bands can be seen at its equatorial region.

3.2.6. Uranus

Uranus is another of the gas giants. It has a mass 14.6 times greater than Earth's, its equatorial diameter is 30,750 miles, and it circles the Sun in 84 years at an average distance of 19.2 AU. Uranus has 5 moons, however the planet is so far away that they are not visible in amateur scopes.

Uranus is at the limit of naked eye visibility shining at 5.8 magnitude and can be seen with binoculars as a star-like object. Its angular size is only 3.7 arc seconds and a telescope is required to show the planet's green-bluish disk.

3.2.7. Neptune

Neptune is the smallest and uttermost of the gas giants. It has a mass 17.2 times greater than Earth's, its equatorial diameter is 29,950 miles, and it circles the Sun in 165 years at an average distance of 30 AU. Uranus has two moons, Triton and Nereid, but only Triton is within reach of amateur scopes.

Neptune shines at a magnitude of 7.7 and has an angular diameter of only 2.3 arc seconds and, although can be seen with binoculars, a telescope is required to resolve it bluish disk.

3.2.8. Pluto

Pluto is the last planet of the Solar system. Its mass is 23% of the Earth mass, its equatorial diameter is 1,800 miles, and it circles the Sun in 248 years at an average distance of 39.5 AU. Pluto has a moon, Charon, which is out of reach of amateur scopes.

Just seeing Pluto is a challenge. Pluto shines at 13.7 magnitude, and appears like a star in amateur scopes. It requires at least a 6" good quality scope. The best way to recognize Pluto is to draw a detailed chart of the portion of the sky where it is located, observe it through a few days, and record the "star" that appears to be moving across the background.

3.3. Asteroids

The asteroids consist of a large number of rocky objects ranging in diameter from a few miles to several hundred miles. They circle the Sun in 4.6 years in a vast cloud between the orbits of Mars and Jupiter at an average distance of 2.8 AU.

Ceres, with a diameter of 560 miles, was the first asteroid found, and the list increased rapidly to reach numbers in the thousands. Today more than 7,000 asteroids have been observed long enough for an accurate determination of their orbits.

Of all the asteroids, only Vesta can be occasionally, and barely, seen with the unaided eye, although many more can be seen as star-like objects in amateur scopes.

3.4 Comets

Comets are essentially dirty ice balls left over after the formation of the Solar system. They are thought to originate in a deep-freeze area beyond the orbits of Neptune and Pluto, within the Kuiper belt and the Oort Cloud. They orbit the Sun taking centuries or millennia to complete an orbit. Occasionally, small gravitational tugs from Neptune or a nebula passing near the Solar system may perturb the orbit of one of these ice balls and plunge it toward the inner Solar system.

As they approach the Sun, the ice starts to be vaporized by sunlight. In the vacuum of space, the vapors and dust create a huge tail-like cloud that extends for millions of miles. The latest bright comet Hale-Bopp, featured a tail that spanned a colossal 60 million miles.

4. Deep Space

Deep space comprises everything out of the Solar system. Deep space includes whatever is within the Milky way Galaxy to the furthest quasars. There are many different celestial objects, from single stars with special features, to galaxies comprising billions of stars. We will describe them in the following pages.

4.1 Stars

The stars are the most obvious, if not the only celestial objects that most of the people get to see during their lives. Stars show only as points of light even in the largest telescopes. However some stars show features that makes them extremely beautiful or interesting.

4.1.1. Binary or Multiple Stars

More than half the stars we see are multiple systems consisting of two or more stars. It may happen that two stars appear to be close together from the observer's point of view but they are really dstant from each other. These are called *optical binaries* but they are not real binary systems. A more common class of binary stars consists of two or more stars in each other's gravitational field and visible as multiples in a telescope. These are real binary systems and are called *visual binaries*.

Sometimes *visual binaries* are so close to each other that even the largest telescopes cannot separate them. However they can be identified as binaries by the Doppler shift of their spectrum. These systems are called *spectroscopic binaries.*.

An example of the above classification can be found in Mizar and Alcor in the handle of the Big Dipper. Both stars are members of a real *visual binary* system and both can be seen with the unaided eye in a dark location. If you look at Mizar with a small telescope you can see that Mizar is another *visual binary*. Its brightest component is Mizar A and its dimmer is Mizar B. Now, if you were to analyze the spectra of the three stars you would see that Alcor, Mizar A and Mizar B are each *spectroscopic binaries*. Thus the system is composed of six stars.

Finally there are some binary systems that even their spectrum cannot separate. The astronomer then can identify them as binaries by the wobble that the stars make while revolving around each other. These binaries are called *astrometric binaries.*

Observing binary systems can be very rewarding. Many times there is a striking color contrast between the two stars as is the case in Albireo, in the constellation of Cygnus, the Swan. One of the components is golden while the other is a beautiful blue color. Sometimes the stars eclipse each other and the light output changes. These are called *eclipsing binaries*. A well know example is Algol, in the constellation of Perseus.

4.1.2. Variable Stars

We have seen stars that appear to change in luminosity (Algol). However there are stars whose real luminosity varies due to changes in their physical make up. These are called *variable stars*. The best known type of variable stars is the δ Cephei type. These type of variables change their light output in a very regular cycle. The light output of δ Cepheid doubles in a period of 5.4 days. Another well known Cepheid variable is Polaris with a small variation of 0.1 magnitude in a period of 4 days.

The Cepheid variables are of special interest because there is a relationship between their light period and their absolute magnitude, thus making them very useful to measure distances to other galaxies.

There are other types of variable stars which are outside the intent of these notes, however there are amateur astronomers dedicated to observe *variable stars* and whose observations substantially support the work of professional astronomers.

We finish this section on *variable stars* by mentioning Mira, a star in the constellation of Cetus, the Whale. Mira changes its luminosity from a maximum magnitude of 3 to 5 to a minimum magnitude of 8 to 10, a 100 fold luminosity, over a period of 330 days. Mira was called the Wonder because sometimes it was visible and then it disappeared from sight.

4.2. Star Clusters

When looking at the night sky with a telescope, we see from a few dozen to a few hundred of stars no matter where the scope is pointing to. Certain areas, however, contain accumulations of stars that appear to fill the ski as diamonds on a black velvet background. These accumulations are called *star clusters*. One of the best known examples is the Pleiades, in the constellation of Taurus, the Bull. The Pleiades also known as the “Seven Sisters” appear to the naked eye as a miniature dipper. When viewed with a telescope the cluster explodes and fills the field of view with hundreds of stars.

Star clusters are, perhaps, one of the few celestial objects in which the eye beats photographic plates which many times overexpose the center of the cluster in order to capture the fainter or more scattered stars at the edges. Clusters like the Double Cluster in Perseus or M13 in Hercules are astonishingly beautiful when observed through a moderately sized scope.

There are two types of star clusters: *galactic or open clusters*, and *globular clusters*.

4.2.1. Galactic Clusters

They are so called because they occur mainly in the disk of our galaxy. They are also known as *open clusters*.

Galactic clusters contain mainly young and hot stars numbering in the hundreds. They form a loosely bound system that may disperse in a matter of a few tens of millions to a few billion years due to the gravitational forces within the Milky Way.

There are over 1,000 galactic clusters known in our Galaxy. Well known naked eye examples are the Pleiades in Taurus, the Beehive in Cancer, and the Double Cluster in Perseus.

4.2.2. Globular Clusters

Globular clusters consist of an enormous number of stars packed in a sphere as big as 200 lght years across. A globular cluster can pack 500,000 stars or more. Viewed through the telescope the stars appear to be so close as to touch each other. The center of these clusters is so dense that even large scopes can not resolve individual stars at the center, showing just a glow.

Globular clusters form a halo around the Milky Way. They do not participate in the revolution of the Milky way, but rather seem to have elliptical orbits, moving in and out of the central regions of the Milky Way in a random fashion.

Well known examples of globular clusters are 47 Tucanae, visible only in the Southern hemisphere, omega Centauri, the most spectacular globular cluster, visible in the Southern USA, and M13, the Great Hercules Cluster, visible in the USA.

4.3. Nebulas

Very early after the invention of the telescope, astronomers discover faint objects that resembled clouds floating in space. They called these clouds *nebulas*, the latin word for cloud. As telescopes improved and more advanced instrumentation was developed for astronomical observation, the nature of these clouds was better understood and a classification for the nebulas was developed.

4.3.1. Gas and dust nebulas

Drifting on the interstellar vacuum of the Milky Way spiral arms, there are enormous clouds of gas and dust that can span 20-30 light years. The most obvious visible manifestation of these gas clouds is the *emission nebula*. One of the most visible emission nebulas is the Great Orion Nebula, M42,. The gases in the Orion Nebula emit light because its gas is ionized by the ultraviolet radiation of some very hot and young stars embedded within the nebula. Other good examples of emission nebulas are the Lagoon Nebula, M8, and the Trifid Nebula, M20.

Interstellar gas consists of solid particles of appreciable size compared to the size of the hydrogen atoms of the gas clouds. Dust clouds manifest themselves as the *reflection nebula* and the *absorption nebula*.

Reflection nebulas consist of dust that merely reflects the light emitted by nearby starts. A good example is the nebulosity, seen in moderately sized amateur scopes, around some of the stars of the Pleiades.

Absorption nebulas are seen because they block the light of objects located beyond the nebula. The Horsehead Nebula is an example of an absorption nebula.

4.3.2 Planetary Nebulas

Somewhat smaller is another type of nebula that resembles a hazy globe of smoke. This nebula is composed of the same rarified gases found in the emission nebulas. These objects are called *planetary nebulas* because they resemble the pale disc of a planet when seen through a small scope. The size of these objects can be about one light year in diameter versus the 20-30 light years of an emission or dust nebula.

Planetary nebulas are formed when a star sheds its outer gas layers at the end of its life. The star then contracts into a very hot and small object called a white dwarf. The light emitted by the white dwarf illuminates the gas and make the nebula shine. Many times the star (central star) that illuminates the nebula can be seen at the center of the nebula. Well known examples of planetary nebulas are the Ring Nebula, M57, in the constellation of Lyra, and the Dumbbell Nebula, M27, in Vulpecula.

4.4. Galaxies

Galaxies are large conglomerations of stars outside the Milky Way. They are so distant that only very large telescopes can resolve some of their constituent stars. *Galaxies* were known to astronomers for many years, and sometimes they were called *spiral nebulas*. They were thought to be part of our galaxy until Edwin Hubble was able to isolate Cepheid variables in the spiral arms of the Andromeda Galaxy. Using the Cepheid variables as a yard stick he found that the Andromeda Galaxy was an “island universe” outside our galaxy. The current estimate for the distance to the Andromeda Galaxy is over 2.5 million years and it is estimated that it contains over 100 billion stars.

Hubble classified the galaxies into three groups: *spiral, elliptical and irregular*. *Spiral galaxies* are comparatively flat with beautiful spiral arms converging in their nucleus. *Elliptical galaxies* are large concentrations of stars shaped as spheres. *Irregular galaxies* are conglomerations of stars of irregular shape.

The *elliptical galaxies* are divided in groups according to the eccentricity of their shape. A *spherical galaxy* is designated E0 and galaxies that are more eccentric are designated successively E1, E2,….,E7.

The *spiral galaxies* are subdivided into three classes. Those with a large and bright nucleus and tightly wrapped spiral arms are designated *Sa*. Galaxies in which the brightness is more evenly distributed between nucleus and spiral arms are designated *Sb*. The last classification, *Sc*, has a smaller nucleus and bright open arms.

Within the *spiral galaxies* fall the *barred spirals*, a type which appear to have a barlike distribution of brightness running trough their nuclei. The same subdivision of spirals applies to barred spirals. Therefore barred spirals will be represented as *SBa, SBb, SBc*.

Irregular galaxies are subdivided in Class I and Class II, depending on reasons beyond the scope of this notes.

Examples of spiral galaxies are M51, a face-on Sc spiral in Canes Venatice (the Hunting Dogs). M87, in Virgo, is an example of E0 elliptical galaxy, and M82, in Ursa Major is an irregular galaxy.

5. Properties of Astronomical Objects

It was mentioned before that stars show in the telescope as points of light, regardless how powerful the scope was. However, some other objects, such as planets and deep sky objects show in the scope as extended objects.

It was mentioned before, also, that some objects are intrinsically bright while others can not be observed with the unaided eye requiring some type of optical aid.

5.1. Point and Extended Objects. Angular Size

The angular size of an object is the angle subtended by the object as seen through our eye or a telescope. Figure 3 illustrates graphically the concept.

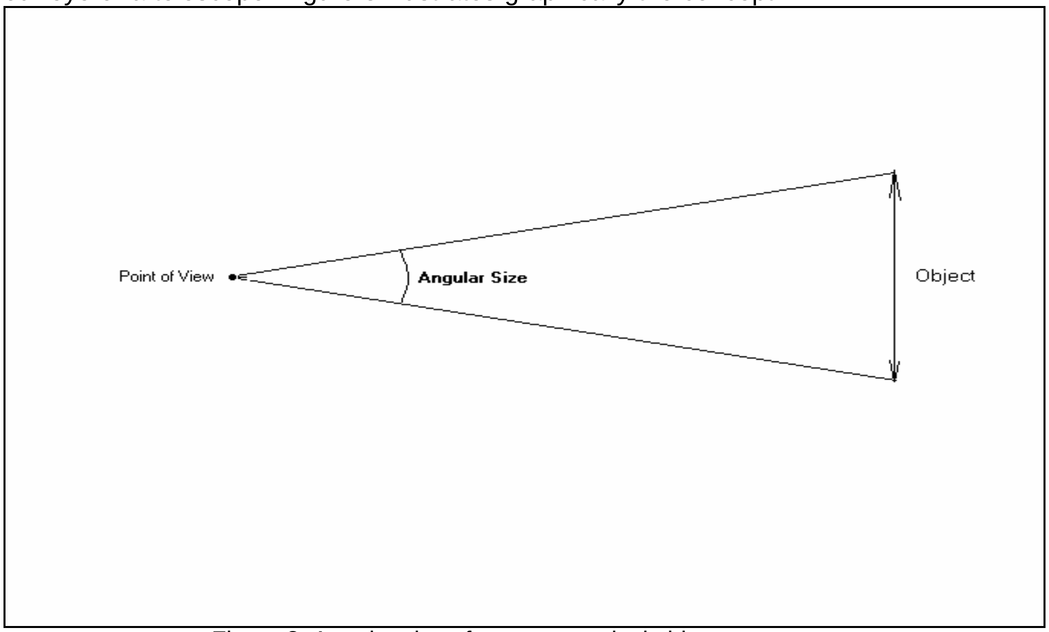

Figure 3. Angular size of an astronomical object.

The angular size is measured in arc degrees. A circle has 360 arc degrees, 1 arc degree has 60 arc minutes and 1 arc minute has 60 arc seconds.

The angular size of astronomical objects varies from point sources such as stars to large sizes such as the Andromeda Galaxy, M31, with an angular size in excess of 3 arc degrees. In comparison, the Moon is 30 arc minutes, Jupiter can reach 60 arc seconds, Mars at close oppositions is around 24 arc seconds and the big globular cluster Omega Centauri is as big as the Moon with 30 arc minutes. Any object under 10 arc seconds looks stellar (like a star) under low magnification (less than 75 times).

Finally, there is an approximate way to measure angular distances in the sky using your hands and fingers. The width of your little finger held at arm's length is 1 arc degree, twice the size of the Moon. At arm's length your three middle fingers together cover 5 arc degrees, your fist 10 arc degrees, the distance between your stretched little and index fingers covers 15 arc degrees, and the distance between your stretched little finger and thumb covers 20 arc degrees.

5.2. Brightness

It is apparent to anybody looking at the sky that some stars are brighter than others. In the second century B.C. Hipparchus classified the brightest stars as first magnitude and the faintest naked eye stars as sixth magnitude, classifying another stars as second, third, fourth or fifth magnitude. Hipparchus used only his eyes and judgment to classify a star in a magnitude group.

Modern astronomers, using photometry techniques, have found a wide range of brightness within stars classified in a given magnitude. The scale was extended on both sides. Some stars reached a negative magnitude. The Sun for instance has a magnitude of –26.5, Sirius, the brightest star in the sky, has a magnitude of -1.4, and Rigel, in Orion, has a magnitude of 0.0. The range was also extended to include magnitudes bigger than 6.

A star with a magnitude of 1 is 100 times brighter than a star with a magnitude of 6. The difference in brightness corresponding to a magnitude increase of 1 magnitude is 2.512 times. In the same way, if the magnitude difference is 2, then the increase in brightness is 2.512 x 2.512 or 6.3 times, if the magnitude difference is 3, then the increase in brightness is 2.512 x 2.512 x 2.512 or 15.9 times, and so forth.

A very good example of magnitude increases can be found in the four stars of the Little Dipper's bowl. They are of magnitudes 2, 3, 4 and 5 approximately, and therefore can be used to evaluate how increases of 1,2 and 3 magnitudes look like.

A star that may look brighter than other but may actually be dimmer. The magnitude of a star or astronomical object is a function of two values: its intrinsic brightness and its distance to us. An object can be dim but very close to us and therefore it will look brighter in the same way that a small flashlight inches away from our eyes looks brighter than a powerful searchlight a few miles away.

The magnitude of the stars as we see them is called *apparent magnitude*. However astronomers have established another way to measure the brightness of stars which tell us which star is actually brighter regardless of their distance to us. To do this, the astronomers place stars at a distance of 10 parsecs (32.6 light years) and calculate their brightness. Being at the same distance, the brightest stars are the brightest. The magnitude of an object found in this way is called *absolute magnitude.* To illustrate this, if the Sun were placed 10 parsecs away its *absolute magnitude* would be 6, just barely visible to the unaided eye. Rigel on the other hand, which is at a distance of 250 parsecs, with an *apparent magnitude* of 0, would brighten to magnitude –7 if placed at 10 parsecs. Rigel would appear 625 times brighter than it looks now.

There is a relationship between *apparent* and absolute *magnitudes* of an object based on its distance to us. If we can establish the *absolute magnitude* of an object, and then measure its *apparent magnitude*, we can easily determine the distance to that object. This is what Edwin Hubble did, using the light curve of Cepheid variables, to determine the distance to the Andromeda Galaxy.