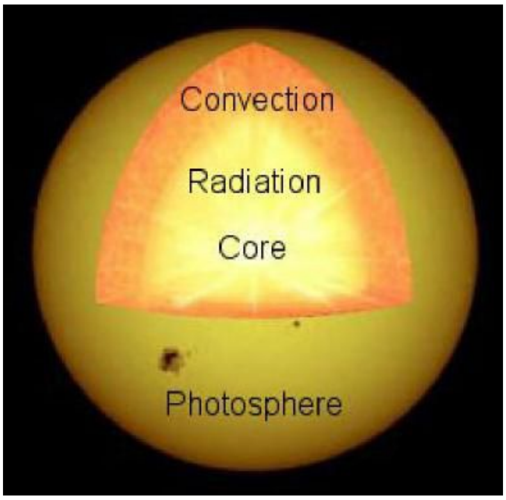
Aryabhat Astronomy Quiz

Study Material Part 1

The Sun

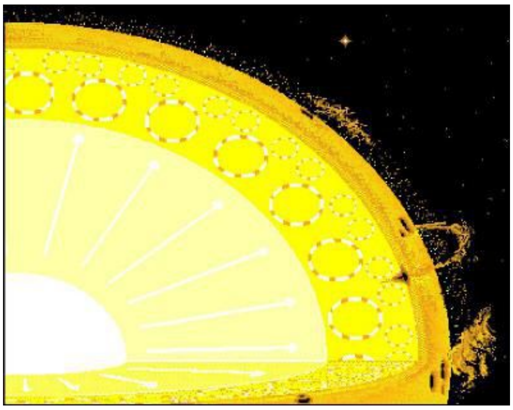
Our Sun (called Sol by the Romans from which we get the word solar) is a main sequence G2 dwarf star. This means that it is fusing hydrogen into helium as its main power source, and that its mass is such that it emits its most intense light at a yellow frequency at about 5800 degrees Kelvin (a G2 star).



The Sun is a micro variable star. We used to think that the Sun was a constant star, but we have learned that every star is variable to some degree.

The Sun has an absolute magnitude of 4.8 at the standard distance of 10 parsecs (2062648 AUs). This compares to an apparent magnitude -26.7 at 1 AU (8.3 light minutes). Of the hundred nearest stars only three Sirius, Alpha Centauri 1&2 are larger. Alpha Eridani is almost as large and then stars get small fast. Most are faint red dwarfs. The Sun has many features, which have no counterpart in the planets. Here are some of these features:

The Sun emits a thin **solar wind** of particles driven from the Sun's surface by light pressure, electrical charges or magnetic fluxes. This solar wind can be detected throughout the solar system. Where these solar winds encounter magnetic fields in some of the large planets, these particles stream down along the lines of force causing auroras.



The Sun's **corona** is its very fragile outermost atmosphere, an extremely hot gas which is in the millions of degrees. We normally do not see this gas, but during eclipses these pale outer atmosphere creates strange flame like images much larger than the Sun's disk.

The **chromosphere** is the "atmosphere" of the Sun. It is much more dense than the corona (and much cooler) but it still is relatively thin when compared to the photosphere. The chromosphere absorbs certain frequencies of the Sun's light. Each absorbed frequency is specific to a particular type of atom. The pattern of alternating bright and dark bands (the Sun's spectra) gives us a great deal of information about the Sun's composition and chemistry.

The **photosphere** is what we think of as the Sun's "surface". When you look at the Sun through filters, it is the photosphere, which displays texture. The photosphere emits the large majority of the Sun's light. This photosphere is not uniform. The Sun's surface has a mottled texture, which reminds many people of the surface of a pot of cooking oatmeal. This **granulation** is the top of "bubbles" percolating up from lower levels in the Sun.

Sunspots are blotches, which are slightly cooler than the surface as a whole. They would be brilliant if they weren't against the even more brilliant general surface. They increase and decrease in a pair of 11 years cycles (north and south hemispheres). During periods of intense sunspots, long-range communications on the Earth may be disrupted. The area surrounding a sunspot is called an **active region**, which has intense magnetic flux.

Some solar storms create huge loops of gas along lines of magnetic force forming a **prominence**. These eruptions can be hundreds of times the diameter of the Earth. Solar **flares** occur when a granulation bubble breaks through the surface before it cools to the surface temperature. Material from the much hotter interior is exposed. Not only does visible light increase but so does the Sun's ultraviolet and x-ray radiation. Solar flares can be extremely disruptive. Sometimes the Sun's belches out a huge puff of electrically charged gas **plasma**. If this **coronal mass** (or discharge) happens to hit the Earth, power lines can be damaged, astronauts must seek shelter in the deepest parts of their spacecraft and auroras are intense.

The Sun generates its power in a central **fusion core** where the temperature is 15 million degrees Kelvin. Hydrogen gas is transmuted (changed) into helium with a great release of energy similar to the process in a hydrogen bomb. The Sun does not explode because its huge gravity holds the nuclear explosion in check. The **radiation zone** lies above the core. It is electrically conductive gas (properly called a plasma) transmits the electromagnetic radiation by direct radiation. As the radiation works its way outwards, it is progressively reduced in frequency from very short wavelength gamma radiation to x-rays and ultraviolet frequencies. The **convective zone** lies above the radiative zone and below the photosphere. This layer transmits energy by rotating vortices (bubbles). This "boiling" occurs in gas which is no longer so hot that it is a charged plasma.

Eclispse

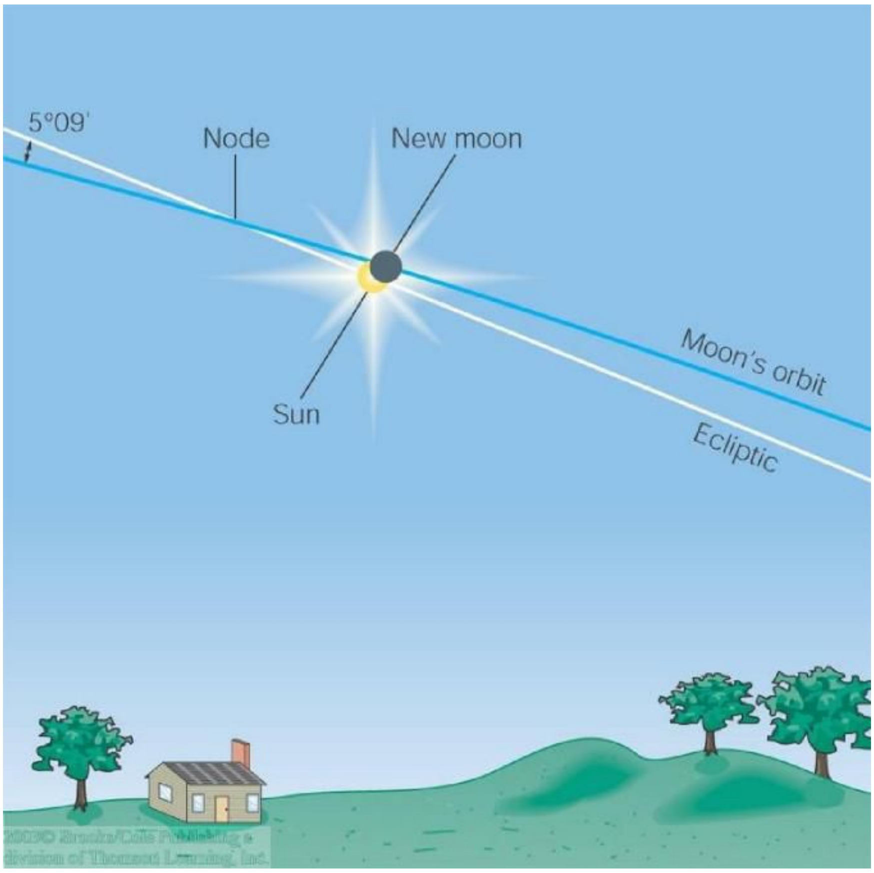
An eclipse is the concealment of a body by another. This happens if the involved bodies are aligned, in such way that one of them darkens, even if it's just in partial form, to the other body.

In the Sun-Earth-Moon system, the eclipses happen due to the rotation of the Earth around the Sun and due to the rotation of the Moon around the planet Earth. In the moment in that the Sun, the Earth and the Moon are aligned and if the Moon is going by one of its nodes an eclipse happens. Before seeing why the eclipses happens we'll revise first some basic concepts.

Apparent size: It is the size of the celestial bodies seen from the surface of the Earth. As the diameter of the Sun it is 400 times bigger than the diameter of the Moon and as the Moon is 400 times nearer, seen from the Earth, the Sun and the Moon almost has the same size (a fortunate astronomical coincidence). Because the Moon has an elliptic orbit, in some occasions it is nearer the earth than in others. Because the Earth has an elliptic orbit around the Sun in certain seasons of the year it's nearer the Sun than in another. Being more near to a body makes that this seems bigger and if this body is more far it seems smaller, it's for this reason that the apparent size of the Sun and the Moon vary during the year.

Ecliptic: It is the apparent line that describes the Sun in the sky. Imagine that the Sun goes coloring a line during its journey for the sky, this line is the ecliptic how it's seen from the earth. The old astronomers observed as the Moon should be crossing this line in order to an eclipse happens, for this reason they called it ecliptic. This line touches twelve constellations, these constellations were baptized by the old astronomers with mythological names, and when a person was born, they said that the person had been born under the constellation (or sign of the zodiac) that was behind the sun in that moment (one of the twelve zodiacals).

Plane of the ecliptic: The Earth moves around the Sun in an elliptical orbit. The plane of the ecliptic is the plane of the orbit of the Earth. The plane of the orbit of the Moon is inclined with regard to the ecliptic, approximately 5,1º. It causes that during the movement of the Moon around the Earth, the Moon only passes in two points on the plane of the ecliptic.

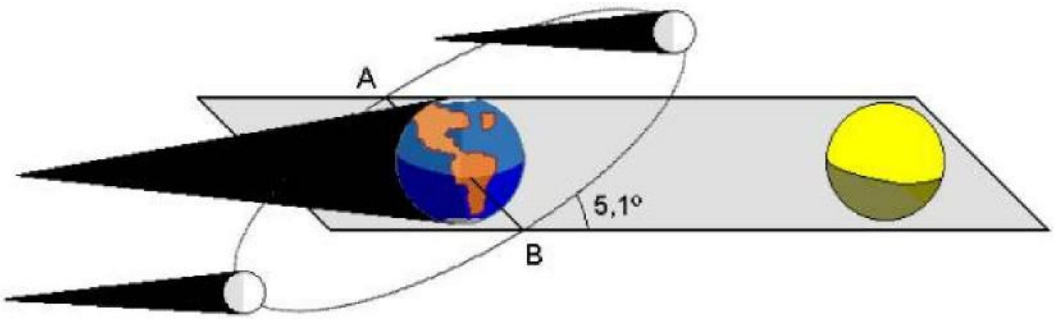


In the following illustration is shown how view from the terrestrial surface, the path of the Moon (in blue) is inclined with regard to the ecliptic (in white).

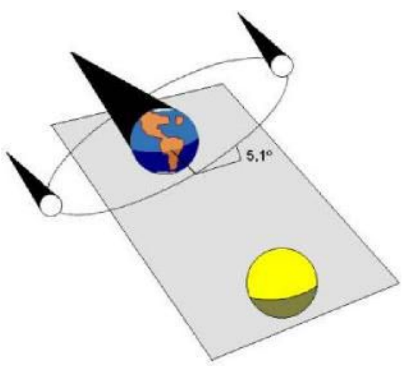
Nodes: They are the points in which the moon crosses the plane of the ecliptic. Of the above-mentioned one can deduce that during half of its orbit, the Moon is above the plane of the ecliptic and during the other half the Moon is below.

Line of nodes: It is the line that passes by the two nodes.

In the following illustration the plane of the ecliptic is observed (in gray), the plane of the orbit of the moon and its inclination of 5,1º with regard to the ecliptic. Also in this graph the points of cut of the lunar orbit with the plane of the ecliptic can be appreciated in the nodes A and B, as well as the line that unites the node A with the node B, called line of nodes.



In the previous image one can observe that if the moon passes in the front side of the Earth without be near of one of its nodes, the cone of lunar shade doesn't touch the terrestrial surface and therefore there won't be an eclipse of Sun. In the same way, if the moon passes behind of the earth, being far from one of its nodes, it doesn't introduce inside the cone of terrestrial shade and it doesn't happen an eclipse of Moon.



But, due to the mutual movement of the Earth and the Moon, the line of nodes changes its orientation. Being the line of nodes pointing toward the Sun, if the Moon crosses the ecliptic by the node that is in front of the Earth, it will cover in total (or partial) form the sun, taking place a solar eclipse. If the Moon goes by the node that is behind the Earth, the planet will cover in total (or partial) form the light of the Sun that the Moon receives and a lunar eclipse will take place. All this you can appreciate in the given graphic.

It is necessary to make note that if would not exist the inclination of the plane of the lunar orbit with regard to the ecliptic, every time that the moon would pass in front of the Earth (New Moon), an eclipse of sun would take place in the regions near to the terrestrial equator (never in the area near to the poles) and every time that the Moon would pass behind the Earth (Full Moon), it would happen a total eclipse of Moon.

The Planets

New definition : In the 26th General Assembly for the International Astronomical Union, more than 2500 astronomers participated. During 17 Joint discussions, the Astronomer from world-over resolved the new definition of a planet through Resolution 5A. The IAU has resolved that "planets" and other bodies in our Solar System be defined into three distinct categories in the following way :

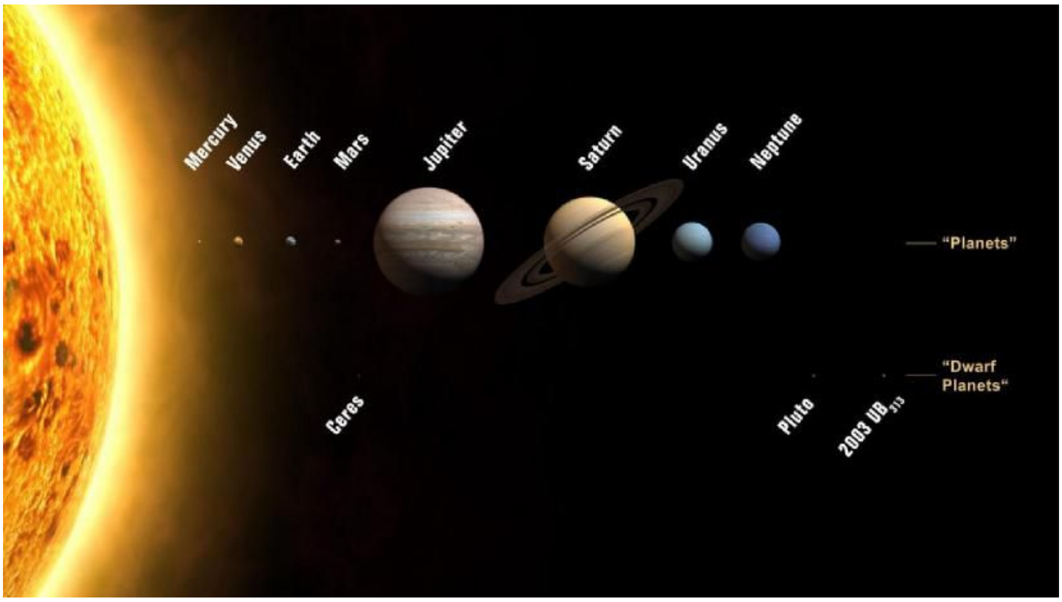
A **planet** is a celestial body that

- moves in a definite orbit around the Sun,
- has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
- has cleared the neighborhoods of its orbit.

A **dwarf planet** is a celestial body that

- moves in a definite orbit around the Sun,
- has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape,
- has not cleared the neighbourhood of its orbit, and
- is not a satellite.

All other objects orbiting the Sun except satellites shall be referred to collectively as “Small Solar-System Bodies”.



According to the new definition, our Solar System has EIGHT planets now, the statistics if which are given below :

Statistics of Planets						
Planet	**Diameter**	**Mass**	**Mean distance from Sun**	**Rotation period**	**Revolution period**	**Escape Velocity**
	(kms)	(kgs)	(10^6 kms)	(hours)	(earth days)	(km/s)
Mercury	4878	3.3×10^{23}	57.90	1403.73	87.97	4.25
Venus	12104	4.87×10^{24}	108.20	5816.20	224.70	10.36
Earth	12756	5.98×10^{24}	149.60	23.93	365.26	11.18
Mars	6787	6.42×10^{23}	227.90	24.62	686.98	5.02
Jupiter	142,800	1.90×10^{27}	778.30	9.84	4332.66	59.60
Saturn	120660	5.69×10^{26}	1427.00	10.23	10759.34	35.60
Uranus	51118	8.68×10^{25}	2869.60	17.24	30685.15	21.10
Neptune	49528	1.02×10^{26}	4496.60	18.40	60191.63	24.60

The innermost planets in the solar system are formed with a central core surmounted by a rocky mantle and a thin crust (and a very thin ocean on Earth). Although we do not have a great deal of direct evidence, we believe that these worlds formed while the newly ignited Sun was propelling a titanic solar wind. Although the rocky materials and heavy metallic cores could form, a dense hydrogen and helium atmosphere similar to the outer gas giants was not possible.

All these worlds bear scars from the period roughly 4.5 billion years ago when they were formed out of the collisions of countless smaller bodies. Mercury presents a visual surface that is easy to confuse with the Moon. It is heavily crated. Earth bears definite crater marks, although the forces of weather and plate tectonics have erased many of these scars. We can see traces of craters on Mars and radar images of Venus reveal similar terrain. All this confirms that the early solar system abounded with small proto-planets that cris-crossed the more circular orbits of what became the major planets.

Some of these cris-crossing worlds hit the planets and merged with them. We recently say Showmaker-Levy 9 revisit this process on Jupiter and we know that 65 million years ago, the dinosaurs died when a relatively small remaining proto-planetesimal struck the Yucatan Peninsula. Eventually only relatively large bodies in relatively circular orbits survived. Today, only Pluto is in a cris-crossing orbit and it survives simply because it is in a strange 2 to 3 synchronous orbit with Neptune which always keeps them at least 1/3 of Neptune's orbit apart.

Mercury

Mercury, the innermost of the planets, shows the effects of it close proximity to the Sun in many ways. While it looks like the Moon as far as its topology goes, it differs from the Moon drastically. Its iron nickel core is a much larger percentage of its total volume. Mercury would also be the densest planet if it were as large as the Earth. Its gravity is too little to significantly compress its core.

It was once though that Mercury was tidally locked to the Sun, much the same way as the Moon is tidally locked to the Earth or the Galilean Moons are tidally locked to Jupiter. Tidally locked bodies rotate on their axis such that their "day" and their "year" are identical. Mercury revolves in synchrony with it orbit about the Sun in a ration of three Mercurian days in a Mercurian year.

The combined effects of Mercury's high eccentricity orbit and the planet's proximity to the Sun make it impossible to successfully used Newtonian physics to predict its position over long periods of time. The orientation of the orbit revolves slowly in accordance with Einstein's General Theory of Relativity.

Venus

The planet Venus has long been imagined as a paradise or at least an Eden. It great brilliance and its lunar like phases (suspected although not viewed since antiquity) made it a natural connection to the Moon. It is not coincidence alone that both bodies where associated with Goddesses - Venus/Aphrodite and Diana/Selene. From the middle of the 19th century until about 2/3rds of the way through the 20th century, Venus was believed to be a damp, watery world, somewhat warmer than Earth but still a very likely abode for life. Numerous stories were written about this cloud-covered world with people slogging through swamps or being besieged by rains as amphibian wildlife provided the local monsters.

The first signs that Venus might not be quite such a rainy swampland were the microwave signals from large radio telescopes. If the curves were to be believed, the temperatures weren't merely very warm but positively blast furnace like in intensity. This was confirmed when the first probes parachuted into a hellish world where the surface was hot enough to melt lead or tin, the air was as dense as water thirty feet deep, the clouds were boiling sulfuric (battery) acid, and water was no where to be found.

Venus had other surprises. It rotates backwards. Its north pole points in the same direction as the other planet's south pole. It has an extremely long day (18 of our days longer than its year). Weirdly, three Venerean days is just about exactly two Earth years.

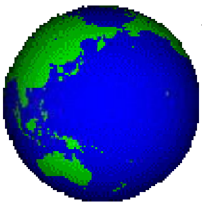
The air is so dense that light is refracted completely around the planet. The cloud layer is so dense that daytime is only somewhat brighter than nighttime. If we could see much of anything on the surface, everything in the distance would seem red or orange because other frequencies of light are absorbed far above the surface.

Venus is just close enough to the Sun, so that a runaway greenhouse effect took place. Electromagnetic radiation is trapped beneath the cloud deck. When volcanoes and crevasses open, any sulfurous gasses remain gas rather than cooling to a solid as they would on Earth.

Venus' apparent diameter changes radically from its farthest position to nearest point. At its most distant, it is about 1.8 AUs from the Earth. At its nearest it is about 0.2 AUs from the Earth. If we could see Venus at its very nearest, it would be 9 times as large as when it is at its most distant. Unfortunately, both these extremes occur when it aligns with the Sun.

You might think that Venus would be brightest when it was closest, but this is incorrect. As Venus approaches, it becomes an ever-thinner crescent. As Venus approaches "full Venus" (ala full Moon), it also reaches its smallest disk. Venus is most brilliant at the point where it displays the greatest illuminated surface, a balancing act between its phases and its proximity to Earth.

Earth



When we are asked what planets are visible, we almost always forget to mention the single planet, which is always visible, day or night. It is the one underfoot, the Earth. The planet Earth (called Terra by the Romans and Gaia by the Greeks) really should probably be called planet Water. About 7/10ths of it surface is washed by oceans, seas, lakes and rivers. Earth is a very high contrast planet, with brilliant white clouds against large blue areas and smaller orange brown areas. It has two very prominent polar ice caps.

Earth is not only the only known abode of life in the solar system, but a planet, which has been radically altered, by life. Our very atmosphere was manufactured by a mutant strain of bacteria. These strange bluish green bacteria started to break down compounds and emit ferociously caustic gas oxygen. Most of the life on Earth died when in came in contact with this deadly poison. Today only in a few places where oxygen cannot reach do we find the survivors of this first and most dramatic case of air pollution. The mutant bacteria live on everywhere as blue/green algae. The scant survivors are the anaerobic bacteria found in hot springs and badly sterilized cans of food - botulism. You might think that life was basically a surface feature but you would be wrong. Our deepest wells and mines encounter bacteria many miles inside the Earth, living on whatever chemicals can sustain life.

Moon

Isn't it a bit out of place to call the Moon a rocky planet? Isn't the definition of a planet a large world, which revolves around the Sun? Aren't things, which revolve around planets called satellites? The answer to all of these questions simply points out how very odd the Moon really is.

The Moon is a large world, bigger than Pluto and not much smaller than Mercury.

While the Moon circles the Earth, it always moves forward relative to the Sun. In fact the Sun's gravity controls the Moon's orbit about 3 times as strongly as the Earth's gravity. This does not happen with any other natural satellite. It is not adequate to compute the position of the Moon simply by treating the problem as finding where the Earth is and then computing an elliptical sub orbit for the Moon. All other natural satellites can be calculated this way for almost all purposes.

Add to these two conditions the effect of tidal drag, and you get a world, which is more difficult to compute than any other object in the solar system except for comets, and asteroids, which happen to come very close to large worlds.

The Moon is composed of a rocky mantle, which is extremely similar to its co-planet Earth, but it lacks a metal core. [We can tell this through various tests such as a lack of a magnetic field and "moon quakes" which allow seismometers placed on the surface to allow examining the interior as we do on Earth. Only one theory has survived rigorous computational modeling. The Moon must have been formed when the Earth was struck a glancing blow by an early proto-planet in an elliptical orbit. This proto-planet must have been the size of Mars approximately. Some of the material from the proto-planet and a great deal of the material from the Earth's mantle collected in a dense ring quite close to the surface. Eventually this coalesced into the Moon.

Tides

Throughout most of the world, there are two high tides and two low tides every lunar day (just under 25 hours). If gravity alone were the cause of the tides, there would be just one on the side of the Earth facing the Moon. In any case, the Sun would raise a much greater tide because the gravity of the Sun on the Earth is 832 times the force of the Moon on the Earth.

Tides are caused by an imbalance between orbital speeds at the center of a body and orbital speeds at the surface. Consider our diagram. Assume the body is following the gray line. The yellow dot at the center of gravity follows this orbit with neither an excess no a deficit of speed. However, the red outer particle is actually in a slightly larger orbit but still traveling at the same speed as the yellow dot. This means that the red particle is traveling slightly too fast for the orbit it is in. Left to itself the red particle would change its orbit's shape slightly creating a larger elliptical orbit. The situation for the blue dot is very similar, except that it is going just a bit too slow and would like to drop into a smaller orbit.

If the body were perfectly rigid, all that would happen is a tension at right angles to the orbit. However if the body is either completely fluid or covered with a fluid, a bulge is created on both the inward and outward sides of the body - a tide. On Earth, additional complications occur. First the Earth is spinning once in 24 hours (rather than just under 25 hours for the Moon). This means Earth is trying to accelerate the tidal bulge. This in turn exerts a breaking action on the Earth (the Earth's rotation is slowing a small amount every day and has been for billions of years). The loss of angular momentum must be matched by the laws of physics and the result is the Moon slowly recedes from us. A second complication is that the Sun also raises a smaller tide, which is in a 24-hour cycle. This means that throughout the lunar month the tides sometimes reinforce each other and sometimes counter each other. This causes flood and neap tides.

The tides are not only raised on the Earth, but on the Moon. The Moon's tidal bulge is cast in concrete or more precisely in granite. The face we see is raised. If the Moon drifts to one side or another (a motion called libration), the Earth exerts a torque on the bulge and returns the Moon to face us.

The closer you get to a massive body the more severe the tidal forces on an extended body. Inside a certain distance (Roche's Limit), solid bodies cannot form. Would be satellites which venture too close to large planets become rings.

Extremely massive bodies with extremely small diameters (white dwarfs, neutron stars, pulsars and black holes) can have tides so strong that nothing can withstand them. An astronaut venturing too close to one of these monsters would feel his feet pulled into the black hole (or whatever) while his head was being wrenched off into outer space.

Mars

No planet has held a greater fascination for us than Mars. It is a place we might be able to live on if we provided ourselves with breathable air and some warmth. For those of us born before the space age, Mars was almost magical. It was the only planet with a surface that could be seen. At closest oppositions, it is quite possible to pick out polar caps, mountainous areas and plains.

However, Mars' image plays tricks on our eyes. The edges of two types of terrain seemed to be marked by long "canali". When Schaparelli used this term, it only meant "channel" in Italian but it wasn't long before the word was being called "canals". In turn, canals implied canal builders, and this in turn became ever more fanciful stories of dying races and desperate attempts to eke out meager water reserves from the polar caps for farms along the canals. Mars had other tricks to play on our eyes. Sometimes canals changed. We now know that these changes if there were seen at all were simply the result of dust storms covering and revealing the land below.

Mars is currently the target of a quixotic mission to send men to the planet. Whatever the social forces that prompt this, relatively little scientific information will be gained that could not be gained remotely.

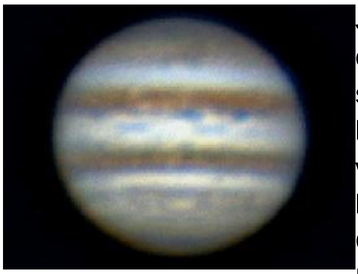
Gas Giants

During the formation of the solar system, many planetesimals formed as whirls in a disk that spun around the proto-sun. Heavy elements sank towards the center of these bodies while the outer portions were wrapped in gasses - primarily hydrogen and helium. Once the Sun reached a point where its internal temperatures allowed it to ignite nuclear fusion, everything changed. The innermost planetesimals were lashed by extremely powerful solar winds which stripped away most of the hydrogen and helium. All the while all of the large planetesimals were accumulating smaller planetesimals eventually forming the eight large planets.

By now the innermost worlds were scoured clear of most of their atmospheres. Only denser and heavier gasses remained. On Earth, much of the hydrogen combined with oxygen to form water.

However, farther out the solar wind abated and the growing planetesimals could gather huge reserves of hydrogen and helium. So much hydrogen was gathered that it began to compress into unusual forms such as metallic hydrogen.

Jupiter



Jupiter is a planet of superlatives. Only Earth rivals it for markings. It outweighs all the other planets put together by at least a factor of 2. It spins on its axis faster than any planet. A Jovian day takes less than 10 hours. Its "surface" gravity is more than twice that of the Earth. It has vast storms, larger in diameter than the Earth that swirls madly for hundreds (perhaps thousands?) of years. One such storm called the Great Red Spot has been continuously viewed since Galileo's time. Moving pictures from spacecraft dramatically show the clouds racing around the center at speeds of several hundred miles per hour.

Jupiter has a huge core of metallic hydrogen. Metallic hydrogen is hydrogen gas compressed so densely that it begins to behave like metals on Earth. In particular, it carries electrical current. This in turn creates a magnetic field, which acts as a vast buffer between Jupiter and the Sun's solar wind. If we could see magnetic lines of force the magnetosphere would be larger in our sky than either the Moon or the Sun. Jupiter has huge lightning storms with bolts so powerful that its innermost satellites, Amalthea and Io are sometimes hit by them.

Jupiter volume is just about as large as it is possible for a body to be without becoming a star. If you dumped more material into Jupiter, its diameter would begin to actually shrink as gravity increased the density faster than material could be added.

It is a mistake to think that Jupiter is nearly big enough to make a star. It is nowhere close to that mass. It would have to be between 15 times its current mass to be a brown dwarf and 80 times its current mass to be the smallest main sequence red dwarf. In spite of not being able to sustain nuclear reactions in its core, Jupiter generates more than twice as much light (in the infrared spectrum) as falls on it from the Sun.

Saturn

When you think of Saturn, the words "the ringed planet" almost certainly jumps to mind. While all the other gas giants have rings, none were discovered before the advent of spacecraft and some of them can only be detected when they blot out a background star as the planets passes in front. With Saturn there is no such problem. Saturn's Rings can be seen with the most modest tools.

The rings are swarms of tiny rock sized pieces of icy material. Long before the 20th century, astronomers and physicists knew that the rings where formed of countless particles. No rigid ring could have survived the tidal stresses on it.

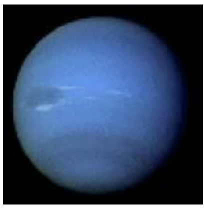
Uranus

Uranus has to be the most featureless planet in the solar system. It is called green, but it is not the beautiful green of an emerald or an aquamarine but a pot of day old pea soup. You do not see the banding or cloud structures you see on Jupiter, Saturn or Neptune.

Uranus does have four substantial Moons, though none of them as large as Pluto. Perhaps the most interesting thing about Uranus is that its axis is tilted an extraordinary 98 degrees. It keeps its north pole pointing towards the Sun. Effectively, it has a warm pole and a cold pole, but differences in temperature are minimized by surface airflow.

Uranus was the first planet found by telescopes. This is a little odd because this planet is visible to the unaided eye under favorable conditions. However, it is so dim and unremarkable, that no one ever noticed it was moving slowly.

Neptune

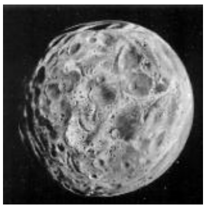


Neptune is a deep blue with white wispy clouds and a dark blue spot similar to the Great Red Spot on Jupiter. Its orbit is nearly circular, with only Venus slightly more so. Neptune is the first planet, which cannot be seen with the unaided eye. However, even the most modest binoculars can make it out as a faint bluish star, if you know where to look. At Neptune's distance, sunlight is almost a thousand times dimmer than on Earth. Sun appears as a small disk, but could be easily mistaken for an extremely bright star.

Once we past Neptune, the solar system changes radically. The hydrogen gas required to form a gas giant thinned too much to form a ninth large planet. Only icy clumps of water, methane and ammonia with chunks of rocky planetesimals and dust were left to form bodies. Just outside Neptune's orbit various small icy worldlets formed. Much farther out where the Sun's gravity feebly contends with passing stars, the final layer of the solar system the cemetery Oort cloud lies.

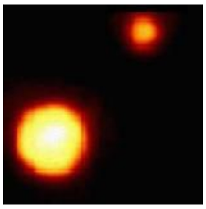
Dwarf Planets

Ceres



Once considered to be the largest Asteroid, **Ceres** is now the oldest member of the Dwarf Planets group. Ceres is in the asteroid belt between Mars and Jupiter. It is roughly 1000 kms in diameter and has many scars on its face. With its dark gray complexion, it does not shine adequately, and has a low albedo,

Pluto



Pluto is the celestial body demoted from its planethood. The structure of both Pluto and its satellite Charon are very similar in nature to the icy satellite of Neptune, Triton. Two new moons of Pluto have been confirmed recently. When discovered, Pluto was assumed to be a very large world as it causes "perturbation" of Neptune's orbit. Later the "perturbations" turned out to be measurement and round off errors. A second reason that Pluto was thought to be large was its high relative brightness. This turned out to be a byproduct of its snowy icy surface (rather than duller rock or gas). Beyond the orbit of Neptune lie a variety of icy worlds and planetesimals collectively called **trans-Neptunian objects**. If these objects happen to approach the sun we would call them by a more familiar name - a comet. The plane of its orbit was well outside the plane of the ecliptic. It lacked either the rocky structure of the inner planets or the gaseous structure of the outer planets.

Eris

On Friday the 29th July 05, Dr. Mike Brown of the California Institute of Technology declared that a new planet has been found beyond Pluto. The International Astronomy Union eventually declared it as a Dwarf Planet and named it as Eris. It is at a distance of nearly 14.5 billion kilometers from the Sun, which is 97 times the distance between Sun and Earth. Its size is estimated to be less than 3200 kilometers in diameter, still 1.4 times the width of Pluto. The object had been temporarily named as 2003-UB313. It was also nicknamed as Xena.

Satellites

Satellites in the solar system range from rocky planetesimals only a handful of miles across to great worlds larger than Pluto or Mercury. Some of these satellites had atmospheres and another seems to have a watery ocean. One satellite is white on one side and coal dark on the other. One has a huge crater that makes the satellite look like an eyeball.

Satellite Count *(as on 31 March 2014)*	
Mercury	None
Venus	None
Earth	1
Mars	2
Jupiter	67
Saturn	62
Uranus	27
Neptune	14

Dwarf Planets	
Ceres	None
Pluto	5
Eris	1

Some small rocky and icy planetesimals of irregular dimensions end up as captured moons of the outer planets. Capturing an asteroid requires something to slow asteroid down such as a brush with the planet's atmosphere or a close pass by a large moon. Unless the excess speed of an asteroid can be discarded by brushing the atmosphere or by slingshot orbit changes around a large Moon, any incoming asteroid will simply shoot by a large planet.

Io Europa Ganymede Callisto

When our first robot spacecraft reach the Jovian System we could not believe what we were seeing. We expected that the four Galilean Moons would be more or less alike. Astronomers had predicted they would be a rocky center with an icy covering. We will look at some of the large satellites, but the smaller satellites are worthy of study as well.

Io is a festival world of brilliant reds, and yellows, black smudges and white streaks. You say you don't like the way it looks, well wait a few weeks and Io will change - dramatically. It is by far and away the most tectonically active world in the solar system. Io turns itself inside out ever million years or so. It has active volcanoes, which spew sulfurous compounds onto the surface at a pace, which far exceeds anything on Earth. It is as if the whole surface was like Volcano National Park on Hawaii.

If the surface wasn't wild enough, Io goes around Jupiter in a doughnut shaped cloud tube of ionized material (probably sulfur). It is as if Io has a strange atmosphere going all away around Jupiter.

Io has a really rough time being so close to Jupiter. Jupiter raises tremendous tidal forces in Io bending the rock and minerals back and forth. All this causes a great deal of heat from friction as materials rubs each other. Jupiter periodically blasts the surface of Io with great lightning bolts. The static from these flashes create the loudest radio noise in the 10-meter wavelengths.

Europa is the next major satellite out from Jupiter. It takes Europa twice as long to circle Jupiter as Io and half as long as Ganymede. Look at the surface of Europa. Those long lines are actually cracks, not in rock but ice. Mounting evidence suggests that this ice floats on a world wide watery ocean that in turn lies on a rocky core. If this sounds like our polar seas, it is hardly surprising.

While astronomers are fairly certain that Europa has some sort of an ocean, there are questions whether it is water, slush or some more exotic mixture with water and other materials acting as an antifreeze.

Ganymede is a very respectable world in its own right. While not as dense as Mercury it has a diameter, which is greater. It has a surface, which is three quarters of the Earth's land area. Ganymede is more like the Moon than any of the other Galilean Moons. It shows the type of cratering we see on both the Moon and Mercury.

Callisto is more like Pluto than any of the other Moons. Far enough from Jupiter so that tidal forces do not create frictional heat in huge amounts, it is the coldest of the Galilean Moons. Much of Callisto is icy material.

Titan

Titan, seconding size to Ganymede by a scant few miles, is another very substantial world. This moon is an orange brown color, but not because we see some tan colored soil by the only substantial atmosphere retained by any natural satellite. Its composition appears to be primarily methane with perhaps some ammonia. The molecular weight of methane is high enough that unlike hydrogen or helium, a small world can retain large quantities of it. It is through that this atmosphere is very similar to the original atmosphere of Earth before blue/green algae changed the atmosphere to a nitrogen and oxygen rich air.

Companions

Companions are bodies which orbits a third body yet are linked together in various odd ways.

Saturn has two moons Epimetheus and Janus which both orbit Saturn on opposite sides of a thin ring. Because one of the moons is an orbit, which is closer to Saturn, it travels faster and eventually overtakes the outer moon. As it gets close the outer moon decelerates the inner moon while the inner moon accelerates the outer moon. The two moons exchange orbits with the prior outer moon now on the inside and vice versa.

Earth has a companion as well, a small asteroid called Cruithne (pronounced croo-en-ya - a Celtic hero). Although its orbit is tipped steeply to the Earth's orbit, it has a semi-major axis that AVERAGES about 0.9999 AU. The Earth is so large that it scarcely is affected by Cruithne's minuscule gravity. What happens to Cruithne is quite something else. When Cruithne is slightly inside the Earth's orbit it catches up and the Earth slingshots to a slightly outer orbit, which causes it to start to lose ground to the Earth. Eventually it loses enough ground that Cruithne is overtaken by the Earth at which time the slingshot works in reverse pulling Cruithne into an orbit closer to the Sun and speeding up the asteroid. If you counted the Earth and the Sun as a fixed line, Cruithne would trace a horseshoe pattern with respect to the Earth. It travels on the inside of the shoe when it is catching up and the outside of the shoe when it slows down. The whole cycle takes about 4 centuries.

Co-planets

When a satellite is extremely massive with respect to its planet, it really forms a binary system with both bodies revolving around a common center of gravity (the barycenter). Most satellites are very small with respect to the planet. Ganymede is the largest satellite in the solar system, but Jupiter mass is 12,817 times that of Ganymede. The pull of Ganymede is trivial compared to the pull of Jupiter on Ganymede. Two planets have satellites, which are very large relative to the primaries Earth and Pluto. The Earth is only 81 times as massive as the Moon. Pluto is about 8 times as massive as Charon.

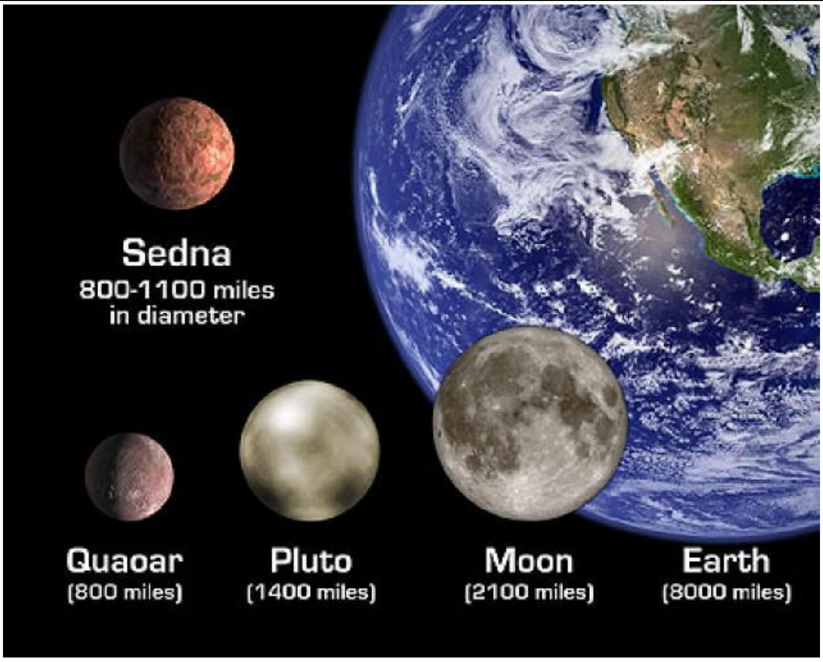
Pluto and Charon rotate about their barycenter which is 1/8 the distance from Pluto to Charon. The barycenter lies outside of Pluto.

The barycenter of the Earth and the Moon lies about 4740 kilometers from the center of the Earth in the direction of the Moon. If you didn't see the Moon from Mars, you could easily deduce it was there because the Earth moves about 1/3 of it diameter side to side every 29.5 days. This also greatly complicates calculating where the planets are because we cannot ignore our movement around the barycenter for precise calculations.

Planet X Quests

In quest of search for a new planet in our Solar System, three objects, namely Quaoar, Sedna and 2004 DW had been discovered by the Astronomers. None these could be designated as a planet.

Quaoar (KWAH-o-ar) is estimated to be nearly 1200 kilometers in diameter. This rocky object orbits the Sun every 288 years, mostly beyond Pluto's orbit. Nearly 6.5 billion kilometers away from the Sun, it is the most distant thing in the solar system photographed by an optical telescope.

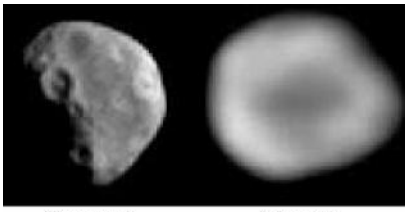


Artist's rendition shows comparative sizes of Earth, Moon, Pluto,Quaoar & Sedna

Sedna is another object found beyond Quaoar. Astronomers presume it to be 1200 to 1700 kilometers in diameter. Sedna has been named after the Inuit goddess of the ocean. It is 13 billion kilometers away from the Sun, in the farthest reaches of the solar system. Sedna is in the coldest known region of our solar system, where temperatures never rise above minus 240 degrees Celsius. At its most distant, Sedna is 130 billion kilometers from the sun, which is 900 times Earth's solar distance.

Object **2004 DW** is nearly 7 billion kilometers far from the Sun, which is 47 times the distance between the Sun and Earth. It is said to be over 1,000 kilometers in diameter. These statistics are yet to be confirmed.

Asteroids


Dactyl Vesta

Vesta is one of the largest asteroids but as you can see from this photograph, it is not spherical like planets or larger satellites. Residing as it does inside the asteroid belt, even if it had original cooled as a sphere, collisions with countless smaller asteroids would have ensured that it was pockmarked and gouged.

Dactyl is a satellite of Ida. They were the first such pair discovered. Since their discovery other pairs have been discovered. At least a few of the asteroid pairs are contact pairs. They rotate very slowly because their gravitational pull on each other is very small.

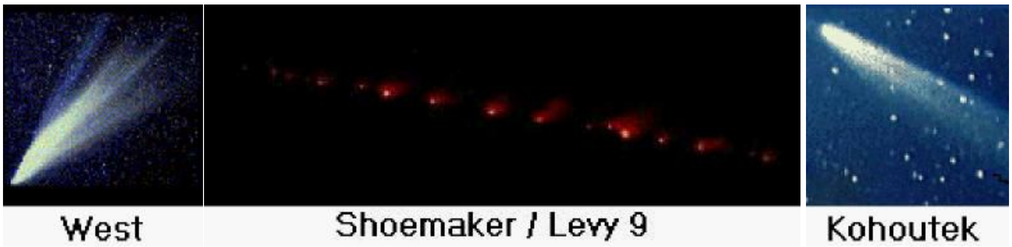

Toutatis / too close!

In the year 2004, Toutatis will come within 6 Moon distances from Earth. Currently there is a lot of activity trying to establish the orbits of asteroids, which cross the orbit of Earth. Unlike long term comets which we may not see until it is too late, it is entirely possible to identify any potentially dangerous **Earth crossing asteroids** early enough to do something meaningful to pull the asteroid out of a dangerous collision.

It is rather frightening to realize how small a civilization ending asteroid can be. The asteroid, which killed the dinosaurs 65 million years ago, was not some huge near planet-sized body, but something on the order of the size of a mountain. The effects of such a collision are far ranging. There is no place on earth that would escape if a ten-mile diameter asteroid hit us. It would compress a shaft of air ten miles across until all the air became nitric oxide - the basis of nitric acid. If the asteroid hit land a huge crater would be dug and ejecta thrown up in the air blotting out the Sun for several years. During this time nothing would grow. Hitting an ocean would have even more terrible effects.

The fact we haven't been hit in 65 million years is not too much comfort to those of us who watched Shoemaker Levy 9 crash into Jupiter.

Comets



Comets are planetesimals composed largely of volatile materials. When a comet comes close enough to the Sun it often out gasses a long and brilliant tail. Comets travel in extremely elongated elliptical orbits. At the most distant point in the orbit, the comet moves so slowly that it may stay out there thousands or even millions of years. When they move into the solar system, the relentless gravity of the Sun accelerates day after day for decade upon decade. They can be traveling at speeds up to 70,000 miles per hours when they round the Sun.

Sometimes long term comets happen to pass near a gas giant - particularly Jupiter. Either the comet will be speeded up or slowed by the encounter. If it is speeded up it will pass the Sun with excess velocity that will cause the comet to leave the solar system forever. If it slows down, the comet may become an inner comet like Halley's, which has a period less than one hundred years. There are two principle reservoirs of comets, the **Kuiper Belt** (home of the trans-Neptunian objects) just outside the orbit of Neptune and the **Oort Cloud** about 50,000 AUs (about 8/10 of a light-year) from the Sun. The Kuiper belt is a disc similar to the asteroid belt but filled with comets. The Oort cloud is spherical. The Oort belt is so far from the Sun that occasionally the Sun and another star pass close enough that the other star pulls comets of the Oort belt. Some are lost to the solar system forever but other are started on their slow way into the inner system.

Debris from comets which have melted and released their stony components, as well as broken pieces of asteroids and occasionally, pieces of planets ejected when comets crash into the planets are scattered all over the solar system. Most of then are dust particles or sand like specks. However, larger pieces exist.

Meteors

Sometimes we see a brief luminous trail in the sky, as a rock piece from space enters the upper atmosphere. This is a meteor, popularly known as *a shooting star*.

If such a rock piece hits the Earth's atmosphere it burns up in air. If the particle is large enough to hit the ground it is called a **meteorite**. Roughly 100 tons of meteors fall on the Earth each and every day.

Meteorites come in three basic forms, ones which are largely iron come from the core of some proto-planet, ones which are stony or a mixture of stone and iron which come from the collision of asteroids, and carbonaceous chondrites which are composed of carbon compounds. The meteorite ALH84001 is believed to have been chipped off Mars and eventually hit the Earth. ALH84001 caused quite a stir when scientist thought they detected fossil Martian bacteria on it. Such claims are very muted now. The bacteria fossils could have been from Earth or simply have been crystalline deposits.

Following the paths of melting comets, the density of particles can become unusually high. These create the so-called meteor storms when the Earth orbit interests the orbit of such a comet. For example, Comet Tempel-Tuttle is the source of the swarm of meteors we call the Leonids. Swarms seem to come from a single point in the sky called the **radiant**. This radiant stays located' basically in a constellation and gives the swarm its name.

Aryabhat Astronomy Quiz

Study Material Part 2

Stars and Constellations

The whole sky has been divided into star groups that move together. In the ancient astronomy, there were 48 constellations but in 1930, the astronomers of the whole world decided to reorganise the stellar objects, and modern astronomy goes with 88 constellations. A list of all constellations is given here :

Names of 88 constellation in the whole sky			
Andromeda	Circinus	Lacerta	Pisces Austrinus
Antlia	Columba	Leo	Puppis
Apus	Coma Berenices	Leo Minor	Pyxis
Aquarius	Corona Australis	Lepus	Reticulum
Aquila	Corona Borealis	Libra	Sagitta
Ara	Corvus	Lupus	Sagittarius
Aries	Crater	Lynx	Scorpius
Auriga	Crux	Lyra	Sculptor
Bootes	Cygnus	Mensa	Scutum
Caelum	Delphinus	Microscopium	Serpens
Camelopardalis	Dorado	Monocerus	Sextans
Cancer	Draco	Musca	Taurus
Canes Venatici	Equuleus	Norma	Telescopium
Canis Major	Eridanus	Octans	Triangulum
Canis Minor	Fornax	Ophiuchus	Triangulum Australe
Capricornus	Gemini	Orion	Tucana
Carina	Grus	Pavo	Ursa Major
Cassiopeia	Hercules	Pegasus	Ursa Minor
Centaurus	Horologium	Perseus	Vela
Cepheus	Hydra	Phoenix	Virgo
Cetus	Hydrus	Pictor	Volans
Chamaeleon	Indus	Pisces	Vulpecula

Brightest Stars

Each star is an individual with its own personality. Thousands are visible on any clear night far removed from city lights. Together, with the faint glow of myriad others, the tapestry of the celestial sphere is fashioned. Stars come in different colors, sizes, shapes and ages. One trait that makes a star unique is its brightness.

Astronomers measure the brightness of a celestial object according to a system originally devised by Hipparchus in 120 B.C. Hipparchus ranked the brightness of stars in the sky on a scale of 1 to 6 as seen from the Earth. The brightest stars he could see were classified as first magnitude and the faintest were sixth magnitude.

Centuries later we still use the magnitude scale of Hipparchus, although it has since been modernized.

The magnitude scale is logarithmic; one magnitude difference is equal to a brightness difference of about 2.5 times. So a magnitude 1 star is about 100 times brighter than a magnitude 5 star. The brighter planets and stars have negative magnitudes. The Sun, being the brightest object in the sky, has a magnitude of –26, followed by the full Moon at magnitude –11. Objects with a magnitude of 6 or less can be seen without optical aid under ideal observing conditions away from all local lighting.

The following is a catalog of the ten brightest stars that grace the celestial sphere, an imaginary projection of Earth into space. All the stars are drawn on the inside of this sphere, even though stars of course exist in space at varying distances. As on Earth, the celestial sphere is split into northern and southern half's, called hemispheres.

As seen from our corner of the galaxy, these are lighthouses of the heavens and can be enjoyed even from the heart of metropolitan areas.

1. Sirius

All stars shine but none do it like Sirius, the brightest star in the night sky. Aptly named, Sirius comes from the Greek word Seirius, meaning, "searing" or "scorching." Blazing at a visual magnitude of –1.42, it is twice as bright as any other star in our sky.

Sirius resides in the constellation Canis Major, the Big Dog, and is commonly called the Dog Star. In ancient Greek times the dawn rising of Sirius marked the hottest part of summer. This is the origin of the phrase "dog days of summer."

Because of Earth’s 26,000-year precession cycle, in which the planet's axis slowly wobbles due to the gravitational attraction of the Sun and Moon on the Earth’s equatorial bulge, Sirius no longer marks the hottest part of summer, rising later in the year. Precession gradually changes the location of stars on the celestial sphere.

Sirius is best seen at a favorable time during the winter months for northern hemisphere observers. To find the Dog Star, use the constellation of Orion as a guide. Follow the three-belt stars -- obvious targets even for casual skywatchers -- 20 degrees southeast to the brightest star in the sky. Your fist at arm's length covers about 10 degrees of sky.

Sirius, the red giant star Betelgeuse, and Procyon in Canis Minor form a popular asterism known as the Winter Triangle.

Intrinsically, Sirius is 23 times more luminous and about twice the mass and diameter of the Sun. Of course it’s farther away from Earth than the Sun. But not too far, cosmically speaking. At a mere 8.5 light-years away, Sirius seems so bright in part because it is fifth closest star to the Sun.

The brilliance of Sirius illuminates not only our night skies, but also our comprehension of them. While observing it in 1718, Edmund Halley, of comet Halley fame, discovered that stars move in relation to one another – a principle now known as proper motion.

In 1844, German astronomer Friedrich Bessel observed that Sirius had a wobble, as if being tugged by a companion. While testing his new 18.5-inch lens in 1862 (the largest refracting telescope in the world at that time), Alvan Clark solved this mystery by discovering that Sirius was not one star but two; the first compact stellar remnant had been discovered, and it would prove to be a pioneer of what would be later referred to as a whole class of white dwarf stars.

The companion, dubbed Sirius B, has the mass of the Sun in a package as small as the Earth, having collapsed after depleting its hydrogen. A single cubic inch of matter from this companion star would weigh 2.25 tons on Earth. At magnitude 8.5, it is 1/400th as luminous as the Sun. The brighter and larger companion is now known as Sirius A

2. Canopus

Canopus resides in the constellation Carina, The Keel. Carina is one of three modern-day constellations that formed the ancient constellation of Argo Navis, the ship Jason and the Argonauts sailed in to search for the Golden Fleece. Two other constellations form the Sail (Vela) and Stern (Puppis).

In modern odysseys, spacecraft such as Voyager 2 used the light from Canopus to orient themselves in the sea of space.

Canopus is a true powerhouse. Its brilliance from our terrestrial vantage point is due more to its great luminosity than its proximity. Though 316 light-years away, No. 2 on our list is 14,800 times the intrinsic luminosity of the Sun. (Recall that the brightest star, Sirius, is just 8.5 light-years distant.)

With a magnitude of –0.72, Canopus is easy to find in the night sky, though it is only visible at latitudes south of 37 degrees north (roughly south of Pittsburg).

To catch a glimpse of it from middle and southern locations in the United States, look for a bright star low on the southern horizon during the winter months. Canopus is located 36 degrees below the brightest star in the sky, Sirius. The further south you are, the better your view will be.

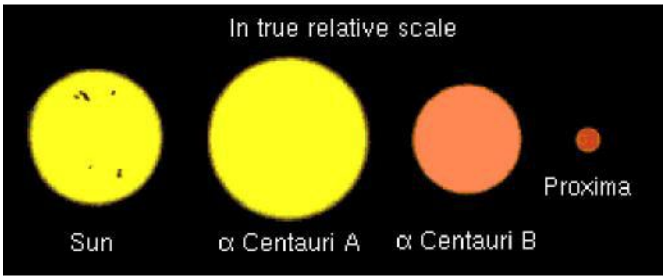
Canopus is a yellow-white F super giant -- a star with a temperature from 10,000 to 14,000 degrees Fahrenheit (6,000 to 8,000 Kelvin) -- that has ceased hydrogen fusion and is now in the process of converting its core helium into carbon. This process as led to its current size, 65 times that of the Sun. If we were to replace our Sun with Canopus, it would almost envelope Mercury.

Canopus will eventually become one of the largest white dwarfs in the galaxy and may just be massive enough to fuse its carbon, turning into a rare neon-oxygen white dwarf. These are rare because most white dwarfs have carbon-oxygen cores. But a massive star like Canopus can begin to burn its carbon into neon and oxygen as the star evolves into a small, dense and cooler object.

Canopus lost its place in the celestial hierarchy for a short time in the 1800s when the star Eta Carinae underwent a massive outburst, surpassing Canopus in brightness and briefly becoming the second brightest star in the sky.

3. Rigil Kentaurus

Alpha Centauri (or Rigel Kentaurus, as it is also known) is actually a system composed of three gravitationally bound stars. The two main stars are Alpha Centauri A and Alpha Centauri B. The tiniest star in the system is a red dwarf known as Alpha Centauri C.



The Alpha Centauri system is a special one. At an average distance of 4.3 light-years, these stars are our nearest known neighbors in space beyond the solar system.

Centauri A and B are remarkably Sun-like, with Centauri A being a near twin of the Sun (both are yellow G stars). In comparison to the Sun, Alpha Centauri A is 1.5 times as luminous and shines at magnitude -0.01 while Alpha Centauri B is half as luminous and shines at magnitude 1.3.

Alpha Centauri C, is 7,000 times fainter and shines at 11th magnitude.

Of the three stars, the littlest is the closest star to the Sun. At 4.22 light-years away, it would take 4.22 years traveling at light speed to get to Alpha Centauri C. Because of its proximity, it is known as Proxima Centauri.

When night falls and the skies are clear, the Alpha Centauri system shines at a magnitude of –0.27 low in the southern sky during the summer months. You can find it at the foot of the Centaur in the constellation of Centaurus.

Because of its position in the sky, the Alpha Centauri system is not easily visible in much of the Northern Hemisphere. An observer must be at latitudes south of 28 degrees north (or roughly from Naples, Florida and locations further south) to see the closest stellar system to us.

The two brighter components of the system make a wonderful double star to observe in a small telescope.

Naked-eye Alpha Centauri appears so bright because it is so close. This also means that it has a large proper motion – the drifting of stars relative to each other due to their actual motion and direction in space. In another 4,000 years Alpha Centauri will have moved near enough to Beta Centauri for the two to form an apparent double star.

4. Arcturus

Arcturus is the brightest star in the northern celestial hemisphere. (The first three stars on this list are actually in the southern celestial sphere, though seasonally they are visible from the northern hemisphere of Earth).

Known as the Bear Watcher, Arcturus follows Ursa Major, the Great Bear, around the north celestial pole. The name itself derives from the Greek word arktos, meaning bear.

Arcturus is an orange giant, twice as massive and 215 times as bright as the Sun. It takes 37 years for the light of Arcturus to reach us, so when we gaze upon it, we are seeing the star as it looked 37 years ago. It glows at magnitude –0.04 in our night skies.

A variable star, Arcturus is in the last stages of its normal life.

During a struggle between gravity and pressure, it has swelled to 25 times the Sun's diameter. Eventually the outer envelope of Arcturus will be peeled away and the material ejected as a planetary nebula similar to the famed Ring Nebula in Lyra. What will be left behind is a white dwarf.

Arcturus is the Alpha (meaning brightest) star of the springtime constellation Bootes, The Herdsman. You can find it by using the Big Dipper as your celestial guidepost. Follow the arc of the handle until you come to a bright orange star. This is Arcturus, forming the point of a pattern of stars resembling a kite.

In the spring, if you keep following the arc, you'll encounter another bright star, Spica. If this all sounds a bit confusing remember this phrase: "Arc to Arcturus, speed on to Spica."

In the 1930's when astronomers were busy measuring the distance to nearby stars, Arcturus was believed to be 40 light-years distant. With emergent photocell technology employed at the 1933 World Fair in Chicago, the light from Arcturus was collected and used to activate a series of switches. Light believed to originate at the time of the previous Chicago World Fair -- the city had hosted it 40 years prior -- was used to illuminate and officially open the Fair in 1933.

We now know Arcturus is 37 light-years away, however.

5. Vega

The name Vega derives from the Arabic word for Swooping Eagle or Vulture. Vega is the luminary of Lyra, the Harp, a small but prominent constellation that is home to the Ring Nebula and the star Epsilon Lyrae.

The Ring is a luminous shell of gas that was ejected from an old star. It resembles a smoke ring or donut. Epsilon Lyrae appears to the naked-eye as a double star, but through a small telescope you can see that the two individual stars are themselves double! Epsilon Lyrae is popularly known as the "double double."

Vega is a hydrogen-burning dwarf star, 54 times more luminous and 1.5 times more massive than the Sun. At 25 light-years away, it is relatively close to us. It shines, therefore, with a magnitude of 0.03 in the night sky.

In 1984, a disk of cool gas surrounding Vega was discovered -- the first of its kind. The disk extends 70 Earth-Sun distances from the star. The discovery was important because a similar disk is theorized to have played an integral role in planet development within our own solar system.

Interestingly, a 'hole' was found in the Vega disk, indicating the possibility that planets might have coalesced and formed around the star. It was not by random choice that Carl Sagan selected Vega as the source of radio transmissions received from an advanced alien culture when he wrote the book that was the basis for the movie "Contact.

Together with the bright stars Altair and Deneb, Vega forms the popular Summer Triangle asterism that announces the beginning of summer in the Northern Hemisphere. The asterism crosses the hazy band of the Milky Way, which is split into two near Deneb by a large dust cloud called the Cygnus Rift.

This area of the sky is ideal for sweeping with binoculars of any size in dark-sky conditions.

Vega was the first star to be photographed, on the night of July 16-17, 1850 by photographer J.A. Whipple. With the daguerreotype camera used at the time, he made an exposure of 100 seconds using a 15-inch refractor telescope at Harvard University. Fainter stars (those of 2nd magnitude and dimmer) would not have registered at all given the technology of the time.

Vega used to be the North Star, but 12,000 years of Earth's precession has altered its place in the celestial sphere. Precession is the 26,000 year wobble of the Earth's axis due to the gravitational attraction of the Sun and Moon on the Earth's equatorial bulge. In another 14,000 years, Vega will be the North Star once again.

6. Capella

Capella is the primary star in the constellation Auriga the "Charioteer" and the brightest star that is near the north celestial pole.

Capella is a fascinating star system comprised of two similar class G yellow giant stars and a pair of much fainter red dwarf stars. The brighter yellow giant, known as Aa, is 80 times more luminous and nearly three times more massive than our Sun. The fainter yellow giant, known as Ab, is 50 times more luminous than the Sun and two-and-a-half times as massive. The combined luminosity of the two stars is about 130 suns.

The Capella system is 42 light-years away, its light reaching us with a magnitude of 0.08.

It is highest in the winter months and circumpolar (meaning it never sets) at latitudes higher than 44 degrees north (or roughly north of Toronto, Canada).

To locate it, follow the two top stars that form the pan of the Big Dipper across the sky. Capella is the brighter star in the irregular pentagon formed by the stars in the constellation Auriga. South of Capella is a small triangle of stars known as the Kids. One of the most ancient legends had Auriga as a goat herder and patron of shepherds. The brilliant golden yellow Capella was known as the She-Goat Star. The nearby triangle of fainter stars represents her three kids.

Both yellow giants are in the process of dying, and will eventually become a pair of white dwarf stars.

7. Rigel

On the western heel of Orion, the Hunter, rests brilliant Rigel. In classical mythology, Rigel marks the spot where Scorpio, the Scorpion stung Orion after a brief and fierce battle. Its Arabic name means the Foot.

Rigel is a multiple star system. The brighter component, Rigel A, is a blue super giant that shines a remarkable 40,000 times stronger than the Sun! Although 775 light-years distant, its light shines bright in our evening skies, at magnitude 0.12.

Rigel resides in the most impressive of the winter constellations, mighty Orion. With the exception of the Big Dipper, it is the most recognized and easiest to identify constellation. It helps too that the shape made by Orion's stars match what the mythical figure represents.

Three bright stars are lined up together to form the belt of the hunter. The other 4 stars surrounding the belt compose its shoulders and legs.

Telescope observers should be able to resolve Rigel’s companion, a fairly bright 7th magnitude star. However the jewel in Orion is the "Great Orion Nebula", a vast stellar nursery where new stars are still being born. It can be found six moon widths south of the belt stars.

A heavy star of 17 solar masses, Rigel is likely to go out with a bang some day, or it might become a rare oxygen-neon white dwarf.

8. Procyon

Procyon resides in the small constellation of Canis Minor, the Little Dog. The constellation symbolizes the smaller of Orion’s two hunting dogs (Canis Minor and Canis Major).

The word Procyon is Greek for Before the Dog, for the reason that in the Northern Hemisphere, Procyon announces the rise of Sirius, the Dog Star.

Procyon is a yellow-white main sequence star, twice the size and 7 times more luminous than the Sun. With the exception of Alpha Centauri, it is the least intrinsically luminous star on this list. Like Alpha Centauri it appears so bright only because at 11.4 light-years, it is relatively close.

Procyon is an example of a main sequence "sub giant" star, one that is beginning the death process by converting its remaining core hydrogen into helium. Procyon is currently twice the diameter of the Sun, one of the largest stars within 20 light-years.

Canis Major can be found relatively easy east of Orion during Northern Hemisphere winter months. Procyon, along with Sirius and Betelgeuse, form the Winter Triangle asterism.

Procyon is orbited by a white dwarf companion detected visually in 1896 by John M. Schaeberle. The fainter companion's existence was first noted in 1840, however, by Arthur von Auswers who observed irregularities in Procyon's proper motion best explained by a massive albeit faint companion.

At just one-third the size of Earth, the companion dubbed Procyon B contains 60 percent of the Sun’s mass. The brighter component is now known as Procyon A.

9. Achernar

Achernar is derived from the Arabic phrase meaning "the end of the river," an appropriate name for a star that marks the southernmost flow of the constellation Eridanus, the River.

Achernar is the hottest star on this list. Its temperature has been measured to be between 24,740 and 33,740 degrees Fahrenheit (14, 000-19,000 Kelvin). Its luminosity ranges from 2,900 to 5,400 times that of the Sun. Shining at magnitude 0.45, its light takes 144 years to reach your eye.

Achernar is more or less tied with Betelgeuse (No. 10 on the list) for brightness. However, Achernar is generally listed as the ninth brightest star in the sky because Betelgeuse is a variable whose magnitude can drop to less than 1.2, as was the case in 1927 and 1941.

For Northern Hemisphere observers, Achernar rises in the southeast during the winter months and is visible only from latitudes south of 32 degrees north; those further north only see a portion of the constellation.

For Star Trek fans: Eridanus is home to Epsilon Eridanus, the star around which Mr. Spock's home planet of Vulcan revolves.

Achernar is a massive class B star containing up to eight solar masses. It is currently burning its hydrogen into helium and will eventually evolve into a white dwarf star.

10. Betelgeuse

Don't let Betelgeuse's ranking as the tenth brightest star in the sky fool you. Its distance -- 430 light-years -- hides the true scale of this supergiant. With a whopping luminosity of 55,000 suns, Betelgeuse still shines bright in our skies at a magnitude of 0.5.

Betelgeuse (pronounced beetle juice by most astronomers) derives its name from an Arabic phrase meaning "the armpit of the central one."

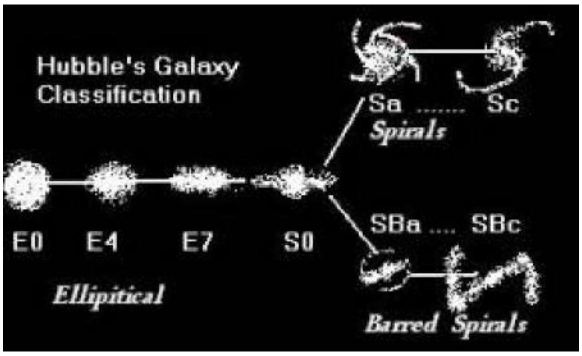
The star marks the eastern shoulder of mighty Orion, the Hunter. Another name for Betelgeuse is Alpha Orionis, indicating it is the brightest star in the winter constellation of Orion. However, Rigel (Beta Orionis) is actually brighter. The misclassification happened because Betelgeuse is a variable star (a star that changes brightness over time) and it might have been brighter than Rigel when Johannes Bayer originally categorized it.

Betelgeuse is an M1 red supergiant, 650 times the diameter and about 15 times the mass of the Sun. If Betelgeuse were to replace the Sun, planets out to the orbit of Mars would be engulfed!

Betelgeuse is an ancient star approaching the end of its life cycle. Because of its mass it might fuse elements all the way to iron and blow up as a supernova that would be as bright as the crescent Moon, as seen from Earth. A dense neutron star would be left behind. The other alternative is that it might evolve into a rare neon-oxygen dwarf.

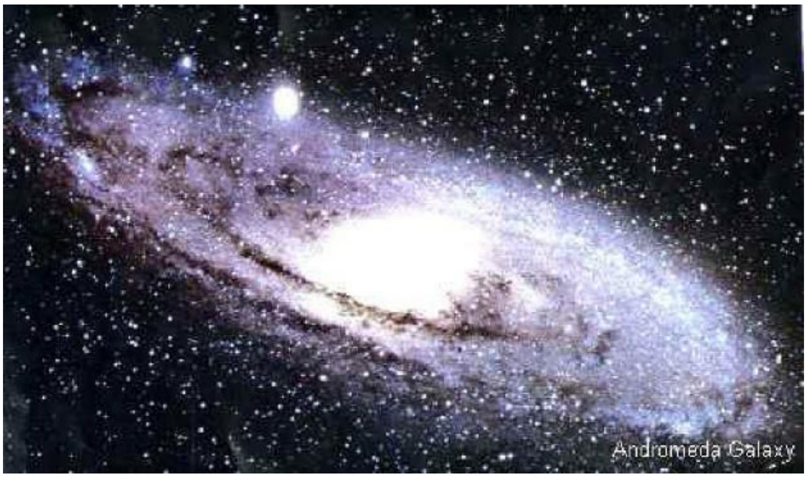
Betelgeuse was the first star to have its surface directly imaged, a feat accomplished in 1996 with the Hubble Space Telescope.

Galaxies



Edwin Hubbell assigned a naming convention to galaxies, which remains in use today. Galaxies come in three main forms, irregular galaxies with shapes that are amorphous, elliptical galaxies with a large core and almost no disk, and spiral galaxies which come in two forms, those with a large central cylinder of stars (barred) and those where the spirals go all the way to the core.

The shapes of galaxies appear to start as spirals of one sort or the other. Over time galaxies pas near or actually through each other. Currently, a small galaxy [the Sagittarius Galaxy] is colliding with our Milky Way. When they do this the smaller galaxy loses many of it stars to the larger galaxy. If the smaller galaxy comes into too close a contact it may be simply swallowed by the greater galaxy. If it is somewhat farther away it may escape badly tattered as an irregular galaxy. This is what seems to have happened to the Large and Small Magellenic Clouds. After swallowing enough smaller galaxies, the spiral shape disappears and the galaxy assumes an ever more elliptical shape.


Andromeda Galaxy

The Great Andromeda is a classic spiral galaxy. At the leading edges of reaching rotating arm, a wave of gas compression occurs triggering areas of star formation. Andromeda is nearly edge on in this image but it would look like M74 if we saw it face on.

Virgo A also known as M87 is many hundreds the times the mass of our own galaxy. Trillions of stars are believed to populate this great object. Virgo A is the largest of the galaxies in the so-called Realm of the Galaxies, which spans parts of Virgo, Coma Berenices and Leo. This area has more galaxies to seen than it has stars visible to your eye. While it looks rather like a globular cluster, it is billions of times as large.

NGC1300 is a clear example of a barred spiral. Unlike a traditional spiral, the swirling arms star at the ends of a cylinder of stars, which extends for many tens of thousands of light years from the center of the barred spiral.

Star Clusters

Open clusters of stars are formed in a common stellar nursery. In time birthing grounds like M42 and the Omega Nebula in the southern hemisphere will drive out gas which has not been included in the newly formed stars. In some open clusters like the Pleiades traces of the gas still can be seen in photographs sensitive to blue and ultraviolet light. [This gauzy gas is not visible to the human eye]. When the stars were formed they were densely packed. However they each had their own motions, which over time causes them to disperse.

Globular clusters are effectively satellites of the galaxy in which they reside. They travels as units into the central areas of the galaxy on orbits somewhat like comets around the Sun. Stars in globular clusters are quite unlike stars in the main disk of the galaxy. Main disk stars like the Sun carry a great deal of heavier elements (metals to astronomers no matter what the chemists call them). Sun like stars are called Population I stars. Stars found in globular clusters lack more than a tiny percentage of heavy elements and form the Population II stars. The thin halo of stars outside the plane


Globular Star Cluster - Tucanae 47

of the galaxy are also Population II stars. Population II stars formed before there had been many supernovae to create heavier elements. They are first generation stars for the most part. Population I stars form in the wake of supernovae and contain the heavier elements.

As the globular clusters orbit about the central core, they tend to be densest near the core and sparser farther out. In our galaxy, the great concentration of globular clusters in Sagittarius confirms that this constellation harbors the center of the Milky Way. Further tests have shown that the exact center is a small volume in Sagittarius with at least a mass of 2 billion Suns. This dense area is believed to be a black hole and is called Sagittarius A*.

Nebulae

An emission nebula is gas excited by ultraviolet radiation from fierce new blue violet stars. This is the same condition, which occurs in fluorescent and neon lamps. This type of nebula is typified by M42, the Great Nebula in Orion. The Trapezium as well as many unseen embedded stars provide the' sources of ultraviolet radiation.

An absorption nebula is a mixture of gas and particularly dust dense enough to absorb, redden and even blot out light. These cause dark nebulae like the Horsehead and the Coal Sack. They cause dark areas like Sagittarius and the Sombrero. However they do not include "empty lanes" in the Milky Way.

Sometimes a nebula can have regions, which emit while other regions absorb. This is the case in the Horsehead Nebula shown here. The dark regions are areas where light has been absorbed so heavily that the area looks like a dark cloud. The bright regions are where hydrogen gas is fluorescing emitting a reddish frequency called the hydrogen beta line. Near the edges of the dark regions areas absorb much but not all of the light and it is possible to use a spectrograph to determine the clouds chemical make up.

When light from a foreground stars shines on background clouds, a reflection nebula is formed. In some cases, an absorbing nebula can hide the foreground star. Reflection nebula can sometimes be precisely mapped and measured by timing the pulses of light from a variable star or a supernova.

Planetary nebulae arise when an aging stars sheds shells of gas as the fusing of hydrogen leaves the core and moves towards the star's surface. Large explosions (but not as large as supernovae), progressively strip the star of material. If the star manages to shed enough material, then it will end up as a white dwarf with a ring about it, which grows year by year. Eventually these rings become so large and thin that they are no longer illuminated by the hot central white dwarf.

Messier Objects

Charles Messier, a dedicated comet hunter, often came across fuzzy objects that caused confusion. He started to compile a list of these objects which eventually became known as the Messier Catalogue. Ironically, Charles Messier is now more famous for his list of galaxies, nebulae and clusters than for his comet discoveries.

Identification Number(s)		Popular Name	Constellation	Description
M1	NGC1952	Crab Nebula	Taurus	supernova remnant
M2	NGC7089		Aquarius	globular cluster
M3	NGC5272		Canes Venatici	globular cluster
M4	NGC6121		Scorpius	globular cluster
M5	NGC5904		Serpens	globular cluster
M6	NGC6405	Butterfly Cluster	Scorpius	open cluster
M7	NGC6475	Ptolemy's Cluster	Scorpius	open cluster
M8	NGC6523	Lagoon Nebula	Sagittarius	diffuse nebula
M9	NGC6333		Ophiuchus	globular cluster
M10	NGC6254		Ophiuchus	globular cluster
M11	NGC6705	Wild Duck Cluster	Scutum	open cluster
M12	NGC6218		Ophiuchus	globular cluster
M13	NGC6205	Great Globular Cluster	Hercules	globular cluster
M14	NGC6402		Ophiuchus	globular cluster
M15	NGC7078		Pegasus	globular cluster
M16	NGC6611	Eagle Nebula	Serpens	diffuse nebula and open cluster
M17	NGC6618	Horseshoe Nebula, Mega Nebula, Swan Nebula	Sagittarius	diffuse nebula
M18	NGC6613		Sagittarius	open cluster
M19	NGC6273		Ophiuchus	globular cluster
M20	NGC6514	Triffid Nebula	Sagittarius	diffuse nebula
M21	NGC6531		Sagittarius	open cluster
M22	NGC6656		Sagittarius	globular cluster
M23	NGC6494		Sagittarius	open cluster
M24	NGC6603	part of the Milky Way	Sagittarius	star cloud
M25	IC4725		Sagittarius	open cluster
M26	NGC6694		Scutum	open cluster
M27	NGC6853	Dumbbell Nebula	Vulpecula	planetary nebula
M28	NGC6626		Sagittarius	globular cluster
M29	NGC6913		Cygnus	open cluster
M30	NGC7099		Capricornus	globular cluster
M31	NGC224	Andromeda Galaxy	Andromeda	spiral galaxy
M32	NGC221		Andromeda	elliptical galaxy
M33	NGC598	Triangulum Galaxy	Triangulum	spiral galaxy
M34	NGC1039		Perseus	open cluster
M35	NGC2168		Gemini	open cluster
M36	NGC1960		Auriga	open cluster
M37	NGC2099		Auriga	open cluster
M38	NGC1912		Auriga	open cluster
M39	NGC7092		Cygnus	open cluster
M40	WNC4	Winnecke 4	Ursa Major	binary star
M41	NGC2287		Canis Major	open cluster
M42	NGC1976	Great Orion Nebula	Orion	diffuse nebula
M43	NGC1982	part of the Orion Nebula	Orion	diffuse nebula
M44	NGC2632	Beehive Cluster Praesepe	Cancer	open cluster
M45		Pleiades	Taurus	open cluster
M46	NGC2437		Puppis	open cluster
M47	NGC2422		Puppis	open cluster
M48	NGC2548		Hydra	open cluster
M49	NGC4472		Virgo	elliptical galaxy
M50	NGC2323		Monoceros	open cluster
M51	NGC5194	Whirlpool Galaxy	Canes Venatici	spiral galaxy
M52	NGC7654		Cassiopeia	open cluster

Identification Number(s)		Popular Name	Constellation	Description
M53	NGC5024		Coma Berenices	globular cluster
M54	NGC6715		Sagittarius	globular cluster
M55	NGC6809		Sagittarius	globular cluster
M56	NGC6779		Lyra	globular cluster
M57	NGC6720	Ring Nebula	Lyra	planetary nebula
M58	NGC4579		Virgo	barred spiral galaxy
M59	NGC4621		Virgo	elliptical galaxy
M60	NGC4649		Virgo	elliptical galaxy
M61	NGC4303		Virgo	spiral galaxy
M62	NGC6266		Ophiuchus	globular cluster
M63	NGC5055		Canes Venatici	spiral galaxy
M64	NGC4826	Blackeye Galaxy	Coma Berenices	spiral galaxy
M65	NGC3623		Leo	spiral galaxy
M66	NGC3627		Leo	spiral galaxy
M67	NGC2682		Cancer	open cluster
M68	NGC4590		Hydra	globular cluster
M69	NGC6637		Sagittarius	globular cluster
M70	NGC6681		Sagittarius	globular cluster
M71	NGC6838		Sagitta	globular cluster
M72	NGC6981		Aquarius	globular cluster
M73	NGC6994		Aquarius	asterism of four stars
M74	NGC628		Pisces	spiral galaxy
M75	NGC6864		Sagittarius	globular cluster
M76	NGC651	Butterfly Nebula Little Dumbbell Nebula	Perseus	planetary nebula
M77	NGC1068		Cetus	spiral galaxy
M78	NGC2068		Orion	diffuse nebula
M79	NGC1904		Lepus	globular cluster
M80	NGC6093		Scorpius	globular cluster
M81	NGC3031	Bode's Galaxy	Ursa Major	spiral galaxy
M82	NGC3034	Cigar Galaxy	Ursa Major	irregular galaxy
M83	NGC5236		Hydra	spiral galaxy
M84	NGC4374		Virgo	lentucular galaxy
M85	NGC4382		Coma Berenices	lenticular galaxy
M86	NGC4406		Virgo	lenticular galaxy
M87	NGC4486	Virgo A	Virgo	elliptical galaxy
M88	NGC4501		Coma Berenices	spiral galaxy
M89	NGC4552		Virgo	elliptical galaxy
M90	NGC4569		Virgo	spiral galaxy
M91	NGC4548		Coma Berenices	barred spiral galaxy
M92	NGC6341		Hercules	globular cluster
M93	NGC2447		Puppis	open cluster
M94	NGC4736		Canes Venatici	spiral galaxy
M95	NGC3351		Leo	barred spiral galaxy
M96	NGC3368		Leo	spiral galaxy
M97	NGC3587	Owl Nebula	Ursa Major	planetary nebula
M98	NGC4192		Coma Berenices	spiral galaxy
M99	NGC4254		Coma Berenices	spiral galaxy
M100	NGC4321		Coma Berenices	spiral galaxy
M101	NGC5457	Pinwheel Galaxy	Ursa Major	spiral galaxy
M102		There is some controversy as to the identity of this object. Some think that Messier made a mistake and re-identified M101 as M102. Others believe that this object is actually the lenticular galaxy NGC5866 in the constellation Draco.		
M103	NGC581		Cassiopeia	open cluster
M104	NGC4594	Sombrero Galaxy	Virgo	spiral galaxy
M105	NGC3379		Leo	elliptical galaxy
M106	NGC4258		Canes Venatici	spiral galaxy
M107	NGC6171		Ophiuchus	globular cluster

Identification Number(s)		Popular Name	Constellation	Description
M108	NGC3556		Ursa Major	spiral galaxy
M109	NGC3992		Ursa Major	barred spiral galaxy
M110	NGC205		Andromeda	elliptical galaxy

Quasars

Quasars are extremely bright objects, which can be seen across the universe. The only known source of such power would be a huge black hole swallowing the gas from stars unfortunate enough to get too near the black hole. The light is not emitted by the black hole itself, but a disk of material spiraling into the black hole. Quasars normally have long jets of material shooting out at nearly the speed of light. These jets can be luminous for years.

Active galactic nuclei are suspected of containing black holes in their centers. In fact some theories say that all galaxies arose around a central black hole formed at the big bang [a pure guess so far]. Those, which are so suspected, have something very energetic at the core.

Aryabhat Astronomy Quiz

Study Material Part 3

The Big Bang

The universe formed some 12.5 billion years ago. Much is speculation, but somehow from a tiny speck everything including space, time, matter and energy unfolded into something that became recognizable as an early version of the universe we see about us today. Initially, the temperature was too intense to allow matter to condense from energy. All of the energy was in the form of fierce gamma radiation.

After expanding for many thousands of years, the temperature of the Universe had cooled to the point where gamma radiation could form neutrons, protons and electrons. Almost all of this matter was in the form of hydrogen (91+%) and helium (8%) and less than a percent lithium, an isotope of hydrogen (deuterium) and an isotope of helium (helium 3). Almost no other elements were created at this time. It is a matter of debate whether **primordial black holes** were also created. The forces were enough so that dense knots of matter could create black holes. These black holes may be the "seed" around which galaxies formed.

The Universe

Today large clouds of gas exist throughout the universe. Most of it is simple atoms, but some of these clouds contain simple molecules and dust. Most of it has collected in and around galaxies. While we see star formation throughout the universe, and we see the absorption of smaller galaxies when the encounter larger galaxies, we no longer see the formation of new galaxies.

The nature of the interstellar gas is very different today from the original gas. While hydrogen and helium still abound, other elements can be found in densities as high as 7%. This has profound consequences for the type of stellar systems that can form. Most importantly, heavy elements allow rocky planets such as the Earth to form. These new elements came from the transmutation of elements in the hearts of first generation stars. Elements up to iron in weight can be formed in normal stars and ejected into space as solar winds and exploding shells when the stars reach the red giant stage. Elements heavier than iron are created and distributed by a much more dramatic process - supernovas.

Star Formation

Stars are continually being formed from the huge reservoirs of hydrogen gas the fill the galaxies. It was once thought that gravity played the role of "gas compressor", but we now know that there hasn't been time since the formation of the universe to have many clouds compress naturally into stars. A triggering event is required. The two principle events are density waves and supernovae.

The center of every galaxy appears to contain a black hole. This is by no means certain, but something large and dense exists there. Lines of magnetic force stream outwards and are bent along the leading edges of the galactic arms. This creates a **density wave**, which sweeps up and compresses hydrogen and helium along with any other elements, which may be in the region. Although we cannot look down on the Milky Way to see such area, we can see similar areas in thousands of other galaxies. Along the leading edge of their arms, young fierce glowing blue white stars abound, a sure sign of star formation.

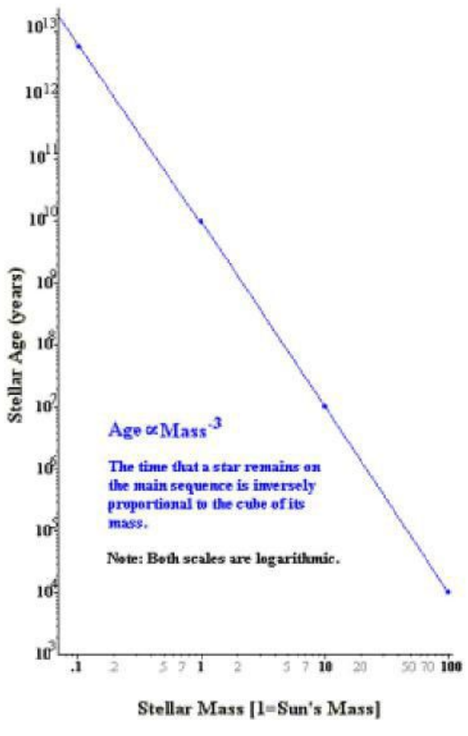
Stellar Luminosity

The luminosity (the total emitted energy) of a star is directly proportional to the fourth power of it mass. To maintain this power output, the star must consume its fuel proportional to its fourth power as well. If one main sequence star is 3 times as massive as another star, it will shine 81 times as brightly. It also fuses its fuel 81 times as rapidly. As stars leave the main sequence this relationship is disrupted.

The term luminosity is the preferred to describe the brightness of a star. For historical reason, the portion of a star's spectrum that lies in the visual range is measured by a magnitude scale. Stars of the first magnitude **seem** to be twice as bright as those of the second magnitude, which in turn seem to be twice as bright as those of the third magnitude. In fact, a closer relation ship is that every five magnitudes in brightness represent a 100-fold change in luminosity. Luminosity is measured directly. Magnitude is measured on an inverse logarithmic scale. Larger magnitudes mean dimmer stars, which is counterintuitive. Larger luminosities mean brighter stars exactly as you would think.

Do not confuse apparent luminosities with absolute luminosities. Apparent brightness depends on how a star looks to us on Earth. Absolute brightness depends on how bright a star would be at the standard distance of ten parsecs (33.26 light-years).

Stellar Lifetimes



The time that a star spends on the main sequence is INVERSELY proportional to the cube of its mass. This is a direct result of the luminosity relationship we just discussed. Since a stars luminosity (and hence its rate of fuel consumption) is proportional to the fourth power of the mass but its mass is only the first power, stars have a lifetime which is proportional to M/M^4 or simply M^{-3}.

Large stars have very short lifetimes. A maximal sized star of 100 solar masses will live 1 millionth as long as the Sun. A minimal sized star of 0.08 solar masses will live 1950 times than the Sun. Since the Sun will live about 10 billion years, the largest stars burn out in just about 10000 years but smallest stars will live 19.5 TRILLION years.

Stellar Classifications

When stars coalesce from interstellar gas clouds, their temperature and pressure rise from frictional heating and gravity. Once nuclear processes begin gas already falling in from the spinning disk collides with gas expanding from nuclear fusion. One way that **Herbig-Haro** stars relieve this problem is to eject mass at the poles of the new star.

Young stars have yet to achieve hydrostatic balance between the rate of energy production and the size of the star. As much as ten times the material that will eventually form the finished star exists in the new stellar system. This material must be driven back into the interstellar medium. Stars in this stage of development are called **T-Tauri** stars.

Brown dwarfs weighing between 0.01 and 0.08 stellar masses are neither true stars nor planets but intermediate objects. They radiate in the infrared. Most of their heat comes from gravitational contraction. However, sometimes their central cores are hot enough to fuse deuterium, lithium or beryllium. These elements fuse at a temperature several million degrees cooler than the minimum required for hydrogen fusion. However, there are so few of these atoms that they are unlike to encounter each other in a core that is largely hydrogen and helium. When these elements do fuse, they expand the core cooling it enough to shut down the reactions.

Once a body of hydrogen reaches 0.08 solar masses, it has enough material so that gravitational contraction will raise the central core to 15 million degrees. Hydrogen begins to fuse. A true star is born.

When the new star has a mass between 0.08 and 0.4 solar masses, it forms a small dim **red dwarf** star. Of the 100 nearest stars 92 are red dwarfs. They form in great numbers but their total luminosity is so low that galaxies seem blue white. Indeed, Proxima Centauri, the nearest star to the solar system is 13th magnitude - no brighter than dim little Pluto.

Most normal sized stars are the so-called **main sequence dwarfs**. They are in the spectral classes K, G, F and A with masses between 0.4 and 3.3 solar masses. The term "dwarf" is unfortunate because it seems to imply a star of small dimensions. In fact they are much larger and brighter than an average star. For example the Sun is a yellow G2 dwarf, yet of the 100 nearest stars only 3 are a bit larger and another is just a bit smaller. 95 stars have diameter, which are less than 60% of the Sun, and masses, which are less than 40% of the Sun. No nearby star is really large, although Sirius is almost twice the mass of the Sun. Some orange, yellow, white (green) stars fall into a category of **subgiants**. Subgiants are large stars, which are in the process of leaving the main sequence. These stars swell as the hydrogen fusion shell approaches the surface. Most of these stars are variables.

The largest main sequence stars are the **blue giants**. They are between 3.3 and 100 solar masses. While they are called blue giants, they can be blue, violet or even ultraviolet in color. These stars are extremely bright and short lived. Of the roughly 6000 stars that can be seen by the human eye, all but 50 are either red or blue giants. Blue giants of necessity are all very young stars. Some of these blue giants become unstable - like Dschubba and Gamma Cassiopeia - throwing off huge shells of gas and briefly becoming very bright. A few actually become supernovae without first becoming red giants.

Red giants posed a paradox to early astronomers. They were very red (hence they were cool) and they were very bright (which seemed impossible - because the black body laws [which we shall learn about in the Physics Section] say the red objects emit light dimly).

Finally, astronomers realized that a star with a very low brightness per square meter could actually put out a huge luminosity if its surface area was enormous.

Red giants have HUGE volumes although they have low density. A typical red giant like Antares or Betelgeuse will have a volume as large as the orbit of Mars. The largest known red giant VV Cassiopeia is calculated to have a diameter as large as the orbit of Saturn.

Red giants are aging stars, which have converted a large portion of their hydrogen to helium (typically 40-50%). As the core fills up with helium "ashes" the fusion zone approaches the surface. However at some point the gas above the star has too little remaining mass and the star stops being stable and begins to swell. The swollen star emits more light that before cooling it at a new less healthy stage. Red giants with lower mass (such as the Sun will become) will eventually simply become white dwarfs. High mass red giants are rapidly on their way to becoming supernova.

Class	Temperature (Kelvin)	Conventional color	Apparent color	Mass (solar masses)	Radius (solar radii)	Hydrogen lines
O	≥ 30,000 K	blue	blue	≥ 16	≥ 6.6	Weak
B	10,000–30,000 K	blue to blue white	blue white	2.1–16	1.8–6.6	Medium
A	7,500–10,000 K	white	white to blue white	1.4–2.1	1.4–1.8	Strong
F	6,000–7,500 K	yellowish white	white	1.04–1.4	1.15–1.4	Medium
G	5,200–6,000 K	yellow	yellowish white	0.8–1.04	0.96–1.15	Weak
K	3,700–5,200 K	orange	yellow orange	0.45–0.8	0.7–0.96	Very weak
M	≤ 3,700 K	red	orange red	≤ 0.45	≤ 0.7	Very weak

Stellar Instability : Variable stars

Eclipsing binaries are binary stars have the plane of their orbit edge on to the solar system. As the stars revolve around their barycenter they will regularly pass in front of one another. Since at least some of the total surface area is masked, the luminosity will drop. If one star is much brighter than its companion, there will be alternating large and small dips in the luminosity. By timing the dips precisely and determining the stars mass and velocity by applying Newton's laws of gravitation, it is possible to determine the diameters of the stars very accurately.

Flare stars appear to change more profoundly than they really do. All main sequence stars appear to emit flares. Against a bright star such as the Sun, Sirius or Rigil, a flare is lost in the overall brightness of the star. Against a dim red dwarf however, the flare can actually be brighter than the rest of the star's surface. All stars have flares where a pocket of overheated gas erupts at the surface. Momentarily, the star emits radiation of shorter wavelengths (blue, violet, ultra violet and x-rays). On a moderate star like the Sun, a flare tends to fade into surface brightness. Flares are unnoticeable on large blue stars. However, on a small red dwarf, a flare can actually be brighter than the star itself. For periods of a few minutes to a few hours the star may brighten several magnitude. Some amateurs watch a collection of red dwarfs looking for these flares.

Certain yellow orange subgiants (called **Cepheid variables**) pulsate in a very regular manner. It is possible to determine exactly how far these stars are from the solar system by timing the pulse rate. What makes these Cephied variables unusually useful is that they are bright enough to be seen in distant galaxies.

Hydrostatic balance is the balance between the expanding forces from the heat produced by fusion and compressive forces from gravity. Imbalances between the expansion and compression can cause pulsations. These stars expand when they are hottest, emit radiation more rapidly when they are inflated, cool and contract in a cycle. Cepheid variables are examples of pulsating stars.

Stellar Deaths :

Supernovae are the deaths of very large stars. Stars which start out at least 10 times the mass of the Sun cannot shed enough mass by ejecting shells by the time their core reaches 1.4 solar masses (Chandrashekhar's limit) [details to follow in Physics]. This results in an enormous explosion where all the elements of the periodic table beyond the first groups are produced. Supernovae can outshine their galaxy (billions and even trillions of star power) for a few weeks. Even this most titanic of nuclear explosions does not totally destroy the star. A core of compressed material remains. If the core is less than 1.4 solar masses it creates a white dwarf. If it is between 1.4 and 3 solar masses it forms a neutron star. More than 3 solar masses results in a black hole.

White dwarfs can result from supernovae, but they also are the end product of stars, which go through the red giant stage without going supernova. The sun will someday become a white dwarf after it swells into a red giant stage. You can see a white dwarf at the center of the Cat's Eye nebula.

White dwarfs no longer fuse hydrogen into helium. The core is composed of helium or some heavier element (usually, carbon, oxygen, neon, silicon, magnesium or sulfur). Since there is no steady source of fusion energy, white dwarfs slowly cool down eventually become cold inert [hundreds of trillions of years] black dwarfs. No white dwarf is believed to have entered black dwarf stage yet.

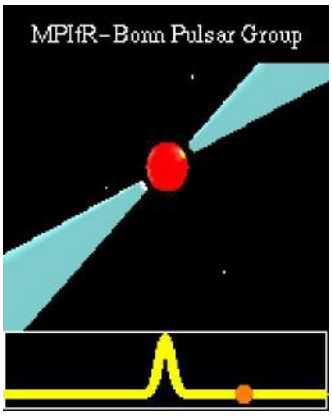
Astronomers used to think that **nova** and supernova were differing degrees of the same thing - stellar explosions. However, they are really quite dissimilar. Supernovae are titanic explosions, which rip stars scattering elements into the universe. Novae are recurring small explosions, which leave their "star" intact.

Novae are white dwarfs or neutron stars in close orbit around a main sequence star. The fierce gravity of the burnt out star strips the outer layers of hydrogen from the main sequence star. When enough accumulates on the burnt out star, a hydrogen bomb type explosion takes place.

We have already seen that **neutron stars** are supernovae remnants where the core is greater than 3 solar masses. These objects are very odd things indeed. In "normal" white dwarfs, the elements left after the supernova explosion, are left as plasma (sort of a gas where the electrons have been stripped away). The white dwarf does not have fusion energy to hold the star up from collapse, but the "electron pressure" (like charges repel) keeps the white dwarf steady at about the size of the planet Earth in diameter.

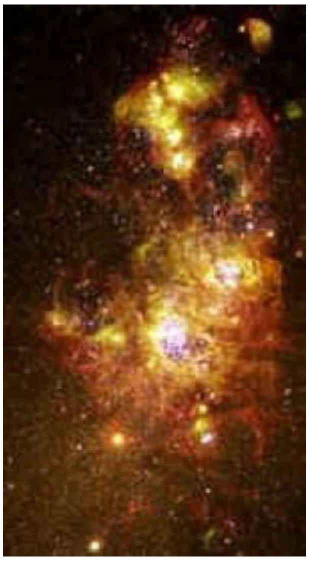
All this changes in neutron stars. Once the mass reaches 1.4 Sol, the gravity becomes so intense that the electrons are dragged kicking and screaming into the core. They get squished into the protons (positively charged nuclear particles) neutralizing them and becoming neutrons (uncharged nuclear particles). The star loses the pressure of the "degenerate electrons" and it collapses into a ball about 10 miles in diameter spinning at hundreds and thousands of times per second. The surface of a neutron star spins very near the speed of light.

Effectively, this neutron star is a single giant (fiercely radioactive) atom. It is very nearly the densest object in the universe. A sugar cube chunk of this stuff would weigh more that Mount Everest.



Pulsars (a type of neutron star) spin extremely rapidly. Near their poles, they emit charged particles at very near the speed of light. Think of them as swizzle sticks spinning around blindingly fast. The swizzle sticks of charged particles sweep up and stir around the gas in the system they reside in causing a form of electromagnetic radiation. Some of this is in the radio frequencies and the rest in higher frequencies up to visible flashes. If the beam of charged particles is lined up in the direction of the Solar system, the electromagnetic radiation will flash on us. When these very regular flashes were first detected many astronomers suspected they were artificially produced by alien species.

Supernova remnants greater than 3 solar masses cannot remain stable at the neutron star stage. They become the most exotic of all stellar objects - **black holes**. Gravity again begins its relentless pull. The gravity reaches a point where no particles, not even light can escape because they would have to travel above the speed of light (the universal maximum) to leave the ex-star. [There is an odd form of radiation (Hawking radiation) which can leave the event horizon of a black hole through quantum mechanical processes but we will not discuss it here].



Role of Supernovae

We are such things as dreams are made on," said Shakespeare. I wonder what he would have said if he realized that it is also quite literally true that once our very elements were forged in the hearts of the largest stars. Look at the Crab Nebula as the explosion, which tore it apart, sends material through space. However, the material which pours out of a supernova is not just the hydrogen and helium which formed the star but nitrogen, oxygen, carbon, silicon, sulfur, magnesium, neon, iron and in fact to some degree or other every element in the natural world.

One role of a supernova is to create the elements from which Population I (metal rich) stars are formed. These are the stars that can have rocky, watery worlds where life can form. The other crucial role that supernova play is becoming another source of gas compression and the triggering of new stars. Like density waves, the bow wave of a supernova explosion pushes everything before it and compresses gas until its own gravity can take over forming a new set of stars.

For our purposes, the event horizon marks the point where anything that enters the black hole cannot leave. There is a false belief that black holes are all powerful vacuums, which slurp anything and everything into their maw. This is not so. For example if you squeezed the Earth into a black hole (an event horizon about the size of a marble), and stood at a distance of 6,400 kilometers from it (our current distance from the center of the Earth) the gravity would be exactly 1 G. The field would only become great as we came very close to the black hole.

- -

Some useful terms & definitions

Asteroids : Asteroids (sometimes called planetoid) are planetesimals, which orbit a star. Ideally, all asteroids would be planetesimals, however some larger asteroids are actually worlds. The dividing line is an arbitrary 1000 km.

Brightness : A measure of a star's magnitude or brightness as seen from the Earth. Brightness is dependent on luminosity and distance.

Degrees : The separation between two points of light on the celestial sphere is measured in degrees. A closed fist held at arms length is about 10 degrees while a finger would be 1 degree or two moon widths.

Dwarf Stars : Dwarfs are regular stars like the Sun, which have modest masses and modest volumes. Stars, which are not some sort of “giant”, are called dwarfs no matter what their size. super dense star is called a white or a black dwarfs.

Giant Stars : Giant Stars have volumes many thousands of times that of the Sun. Some "sub-giants" and "blue giants" have masses much greater than the Sun, but volumes, which are not radically larger than the Sun.

Luminosity : The intrinsic brightness of a star -- as it would appear if you orbiting it -- compared to the Sun. The Sun's luminosity is 1. Sirius has a luminosity of 23 and Betelgeuse 55, 000.

Magnitude : A logarithmic brightness scale, the difference between magnitude 1 and magnitude 5 is 100 fold. The larger the magnitude, the fainter the object. The lower the magnitude, the brighter the object. The brightest stars have negative magnitudes.

Main Sequence Stars : Main Sequence Stars are huge bodies, which derive the vast majority of their energy primarily from fusing hydrogen to helium. Main sequence stars are in *hydrostatic balance* between the forces of gravity and nuclear fusion. Stars too young to have achieved this balance throw off huge amounts of material via jets and fierce solar winds. Stars that have used up their hydrogen fuel supply swell enormously.

Planetesimals : Planetesimals are bodies, which is too small to attain spherical shape simply through their own gravity. A planetesimal melted by passing too close to a star and becoming spherical due to surface tension (a result of electromagnetic force) does not count, because the forming was not done primarily by gravity.

Rogues : Rogues are suspected (but unproven) worlds like planets that do not orbit stars. These are believed to be ejected from star systems as the systems grow older. See Planets.

Satellites : Satellites (often called moons) are either worlds or planetesimals, which orbits a planet.

Worlds : Worlds are bodies large enough to be pulled into roughly spherical shape by their own gravity. All stars fall within this definition as do major planets and large moons.

Indian Space Research

Milestones in Indian Space Research	
2014	PSLV-C23 successfully launches SPOT 7 and four co-passenger satellites - AISAT, NLS 7.1, NLS 7.2 and VELOX-1 from Sriharikota (June 30, 2014)
	PSLV - C24 successfully launches IRNSS-1B from Sriharikota (Apr 04, 2014)
	GSLV-D5 successfully launches GSAT-14 from Sriharikota (Jan 05, 2014)
2013	PSLV - C25 successfully launches Mars Orbiter Mission Spacecraftfrom Sriharikota (Nov 05, 2013)
	Successful launch of GSAT-7 by Ariane-5 VA-215 from Kourou French Guiana (August 30, 2013)
	Successful launch of INSAT-3D by Ariane-5 VA-214 from Kourou French Guiana (July 26, 2013)
	PSLV - C22 successfully launches IRNSS-1A from Sriharikota (Jul 01, 2013)
	PSLV - C20 successfully launches SARAL and six commercial payloadsfrom Sriharikota (Feb 25, 2013)
2012	Successful launch of GSAT-10 by Ariane-5 VA-209 from Kourou French Guiana (September 29, 2012)
	ISRO's Polar Satellite Launch Vehicle, PSLV-C21 successfully launches SPOT 6 and PROITERES from Sriharikota (September 09, 2012)
	PSLV-C19 successfully launches RISAT-1 from Sriharikota (April 26, 2012)
2011	PSLV-C18 successfully launches Megha-Tropiques, Jugnu, SRMSat andVesselSat-1 from Sriharikota (October 12, 2011)
	PSLV-C17 successfully launches GSAT-12 from Sriharikota (July 15, 2011)
	Successful launch of GSAT-8 by Ariane-5 VA-202 from Kourou French Guiana, (May 21, 2011)
	PSLV-C16 successfully launches Three Satellites - RESOURCESAT-2,YOUTHSAT, X-SAT from Sriharikota (April 20, 2011)

Milestones in Indian Space Research	
2010	GSLV-F06 launched from Shriharikota (Dec 25, 2010). GSAT-5P could not be placed into orbit as the GSLV-F06 mission was not successful
	Successful launch of advanced communication satellite HYLAS (Highly Adaptable Satellite), built by ISRO on a commercial basis in partnership with EADS-Astrium of Europe, by Ariane-5 V198 from Kourou French Guiana (November 27, 2010)
	PSLV-C15 successfully launches Five Satellites - CARTOSAT-2B, ALSAT-2A, two nanosatellites-NLS-6.1 & 6.2 and a pico-satellite- STUDSAT from Sriharikota (July 12, 2010)
	GSLV-D3 launched from Sriharikota (Apr 15, 2010). GSAT-4 satellite could not be placed in orbit as flight testing of the Indigenous Cryogenic Stage in GSLV-D3 Mission was not successful
2008	PSLV-C9 successfully launches CARTOSAT-2A, IMS-1 and 8 foreign nano satellites from Sriharikota (April 28, 2008)
	PSLV-C10 successfully launches TECSAR satellite under a commercial contract with Antrix Corporation (January 21, 2008)
2007	Successful launch of of GSLV (GSLV-F04) with INSAT-4CR on board from SDSC SHAR (September 2, 2007)
	ISRO's Polar Satellite Launch Vehicle, PSLV-C8, successfully launched Italian astronomical satellite, AGILE from Sriharikota (April 23, 2007).
	Successful launch of INSAT-4B by Ariane-5 from Kourou French Guyana, (March 12, 2007).
	Successful recovery of SRE-1 after manoeuvring it to reenter the earth’s atmosphere and descend over the Bay of Bengal about 140 km east of Sriharikota (January 22, 2007).
	ISRO's Polar Satellite Launch Vehicle, PSLV-C7 successfully launches four satellites - India’s CARTOSAT-2 and Space Capsule Recovery Experiment (SRE-1) and Indonesia’s LAPAN-TUBSAT and Argentina’s PEHUENSAT-1 (January 10, 2007).
2006	Second operational flight of GSLV (GSLV-F02) from SDSC SHAR with INSAT-4C on board. (July 10, 2006). Satellite could not be placed in orbit.
2005	Successful launch of INSAT-4A by Ariane from Kourou French Guyana, (December 22, 2005).
	ISRO's Polar Satellite Launch Vehicle, PSLV-C6, successfully launched CARTOSAT-1 and HAMSAT satellites from Sriharikota(May 5, 2005).
2004	The first operational flight of GSLV (GSLV-F01) successfully launched EDUSAT from SDSC SHAR, Sriharikota (September 20, 2004)

Milestones in Indian Space Research	
2003	ISRO's Polar Satellite Launch Vehicle, PSLV-C5, successfully launched RESOURCESAT-1 (IRS-P6) satellite from Sriharikota(October 17, 2003). Successful launch of INSAT-3E by Ariane from Kourou French Guyana, (September 28, 2003). The Second developmental launch of GSLV-D2 with GSAT-2 on board from Sriharikota (May 8, 2003). Successful launch of INSAT-3A by Ariane from Kourou French Guyana, (April 10, 2003).
2002	ISRO's Polar Satellite Launch Vehicle, PSLV-C4, successfully launched KALPANA-1 satellite from Sriharikota(September 12, 2002). Successful launch of INSAT-3C by Ariane from Kourou French Guyana, (January 24, 2002).
2001	ISRO's Polar Satellite Launch Vehicle, PSLV-C3, successfully launched three satellites -- Technology Experiment Satellite (TES) of ISRO, BIRD of Germany and PROBA of Belgium - into their intended orbits (October 22, 2001). The first developmental launch of GSLV-D1 with GSAT-1 on board from Sriharikota (April 18, 2001)
2000	INSAT-3B, the first satellite in the third generation INSAT-3 series, launched by Ariane from Kourou French Guyana, (March 22, 2000).
1999	Indian Remote Sensing Satellite, IRS-P4 (OCEANSAT), launched by Polar Satellite Launch Vehicle (PSLV-C2) along with Korean KITSAT-3 and German DLR-TUBSAT from Sriharikota (May 26, 1999). INSAT-2E, the last satellite in the multipurpose INSAT-2 series, launched by Ariane from Kourou French Guyana, (April 3, 1999).
1998	INSAT system capacity augmented with the readiness of INSAT-2DT acquired from ARABSAT (January 1998).
1997	INSAT-2D, fourth satellite in the INSAT series, launched (June 4, 1997). Becomes inoperable on October 4, 1997. (An in-orbit satellite, ARABSAT-1C, since renamed INSAT-2DT, was acquired in November 1997 to partly augment the INSAT system). First operational launch of PSLV with IRS-1D on board (September 29, 1997). Satellite placed in orbit.
1996	Third developmental launch of PSLV with IRS-P3 on board (March 21, 1996). Satellite placed in polar sunsynchronous orbit.

Milestones in Indian Space Research	
1995	Launch of third operational Indian Remote Sensing Satellite, IRS-1C (December 28, 1995). INSAT-2C, the third satellite in the INSAT-2 series, launched (December 7, 1995).
1994	Second developmental launch of PSLV with IRS-P2 on board (October 15, 1994). Satellite successfully placed in polar sunsynchronous orbit. Fourth developmental launch of ASLV with SROSS-C2 on board (May 4, 1994). Satellite placed in orbit.
1993	First developmental launch of PSLV with IRS-1E on board (September 20, 1993). Satellite could not be placed in orbit. INSAT-2B, the second satellite in the INSAT-2 series, launched (July 23, 1993).
1992	INSAT-2A, the first satellite of the indigenously-built second-generation INSAT series, launched (July 10, 1992). Third developmental launch of ASLV with SROSS-C on board (May 20, 1992). Satellite placed in orbit.
1991	Second operational Remote Sensing satellite, IRS-1B, launched (August 29, 1991).
1990	INSAT-1D launched (June 12, 1990).
1988	INSAT-1C launched (July 21, 1988). Abandoned in November 1989. Second developmental launch of ASLV with SROSS-2 on board (July 13, 1988). Satellite could not be placed in orbit. Launch of first operational Indian Remote Sensing Satellite, IRS-1A (March 17, 1988).
1987	First developmental launch of ASLV with SROSS-1 satellite on board (March 24, 1987). Satellite could not be placed in orbit.
1984	Indo-Soviet manned space mission (April 1984).
1983	INSAT-1B, launched (August 30, 1983). Second developmental launch of SLV-3. RS-D2 placed in orbit (April 17, 1983).
1982	INSAT-1A launched (April 10, 1982). Deactivated on September 6, 1982.

Milestones in Indian Space Research	
1981	Bhaskara-II launched (November 20, 1981). APPLE, an experimental geo-stationary communication satellite successfully launched (June 19, 1981). RS-D1 placed in orbit (May 31, 1981) First developmental launch of SLV-3.
1980	Second Experimental launch of SLV-3, Rohini satellite successfully placed in orbit. (July 18, 1980).
1979	First Experimental launch of SLV-3 with Rohini Technology Payload on board (August 10, 1979). Satellite could not be placed in orbit. Bhaskara-I, an experimental satellite for earth observations, launched (June 7, 1979).
1977	Satellite Telecommunication Experiments Project (STEP) carried out.
1975-1976	Satellite Instructional Television Experiment (SITE) conducted.
1975	ISRO First Indian Satellite, Aryabhata, launched (April 19, 1975). Becomes Government Organisation (April 1, 1975).
1972-1976	Air-borne remote sensing experiments.
1972	Space Commission and Department of Space set up (June 1, 1972). ISRO brought under DOS.
1969	Indian Space Research Organisation (ISRO) formed under Department of Atomic Energy (August 15, 1969).
1968	TERLS dedicated to the United Nations (February 2, 1968).
1967	Satellite Telecommunication Earth Station set up at Ahmedabad.
1965	Space Science & Technology Centre (SSTC) established in Thumba.
1963	First sounding rocket launched from TERLS (November 21, 1963).
1962	Indian National Committee for Space Research (INCOSPAR) formed by the Department of Atomic Energy and work on establishing Thumba Equatorial Rocket Launching Station (TERLS) started.

Observational Opportunities

Largest Telescopes :

Name	Aperture		Mirror type	Nationality / Sponsors	Location
	mtr	inch			
Gran Telescopio Canarias	10.4 m	409″	Segmented, 36	Spain (90%), Mexico, USA	Canary Islands
Keck 1	10 m	394″	Segmented, 36	USA	Hawaii
Keck 2	10 m	394″	Segmented, 36	USA	Hawaii
Southern African Large Telescope	9.2 m	362″	Segmented, 91	South Africa, USA, UK, Germany, Poland, New Zealand	South Africa
Hobby-Eberly Telescope	9.2 m	362″	Segmented, 91	USA, Germany	Texas
Large Binocular Telescope	8.4 m × 2	330″ × 2	Multiple mirror, 2	USA, Italy, Germany	Arizona
Subaru	8.2 m	323″	Single	Japan	Hawaii
VLT UT1 (Antu)	8.2 m	323″	Single	ESO Countries, Chile	Chile
VLT UT2 (Kueyen)	8.2 m	323″	Single	ESO Countries, Chile	Chile
VLT UT3 (Melipal)	8.2 m	323″	Single	ESO Countries, Chile	Chile
VLT UT4 (Yepun)	8.2 m	323″	Single	ESO Countries, Chile	Chile
Gemini North (Gillett)	8.1 m	318″	Single	USA, UK, Canada, Chile, Australia, Argentina, Brazil	Hawaii
Gemini South	8.1 m	318″	Single	USA, UK, Canada, Chile, Australia, Argentina, Brazil	Chile
MMT	6.5 m	256″	Single	USA	Arizona
Magellan 1 (Walter Baade)	6.5 m	256″	Honeycomb	USA	Chile
Magellan 2 (Landon Clay)	6.5 m	256″	Honeycomb	USA	Chile
BTA-6	6 m	238″	Single	USSR/Russia	Russia
Large Zenith Telescope	6 m	236″	Liquid	Canada, France, USA	British Columbia
Hale Telescope	5.08 m	200″	Single	USA	California
LAMOST	4.9 m	193″	Segmented (37 + 24)	PRC (China)	Xinglong, China
MMT	4.7 m	186″	Segmented, 6	USA	Arizona
Discovery Channel Telescope	4.3 m	169″	Single	USA	Arizona
William Herschel Telescope	4.2 m	165″	Single	UK, Netherlands, Spain	Canary Islands
SOAR	4.1 m	161″	Single	USA, Brazil	Chile
VISTA	4.1 m	161″	Single	ESO Countries, Chile	Chile
Victor M Blanco Telescope	4 m	157″	Single	USA	Chile
Nicholas U Mayall	4 m	149.5″	Single	USA	Arizona
Anglo-Australian Telescope	3.89 m	154″	Single	Australia, UK	New South Wales
AEOS Telescope	3.67 m	145″	Single	USA	Hawaii
Telescopio Nazionale Galileo	3.58 m	138″	Single	Italy	Canary Islands
New Technology Telescope	3.58 m	142″	Single	ESO countries	Chile
Canada-France-Hawaii Telescope	3.58 m	141″	Single	Canada, France, USA	Hawaii
ESO 3.6 m Telescope	3.57 m	140″	Single	ESO countries	Chile
MPI-CAHA	3.5 m	138″	Single	West Germany, Spain	Almería, Spain
USAF Starfire	3.5 m	138″	Single	USA	New Mexico
WIYN Telescope	3.5 m	138″	Single	USA	Arizona
Space Surveillance Telescope	3.5 m	138″	Single	USA	New Mexico
Astrophysical Research Consortium	3.48 m	137″	Single	USA	New Mexico
Shane Telescope	3.05 m	120″	Single	USA	California
NASA Infrared Telescope Facility	3.0 m	120″	Single	USA	Hawaii
NASA-LMT	3 m	118″	Liquid	USA	New Mexico

High Altitude Telescopes :

Observatory Name	Elevation	Location	Coordinates	Type of Observatory
University of Tokyo Atacama Observatory(TAO)	5,640 m	Atacama Desert, Chile	22°59′12″S 67°44′32″W	Optical, infrared
Chacaltaya Astrophysical Observatory	5,230 m	Andes, Bolivia	16°21′12″S 68°07′53″W	Cosmic ray, gamma ray
James Ax Observatory	5,200 m	Atacama Desert, Chile	22°57′30″S 67°47′10″W	Microwave
Atacama Cosmology Telescope	5,190 m	Atacama Desert, Chile	22°57′31″S 67°47′16″W	Microwave
Llano de Chajnantor Observatory	5,104 m	Atacama Desert, Chile	23°01′22″S 67°45′17″W	Millimeter wave, submillimeter
Shiquanhe Observatory (NAOC Ali Observatory)	5,100 m	Tibet Autonomous Region, China	32°19′N 80°01′E	Optical
Llano de Chajnantor Observatory	4,800 m	Atacama Desert, Chile	22°58′17″S 67°42′10″W	Submillimeter
Large Millimeter Telescope Alfonso Serrano	4,580 m	Puebla, Mexico	18°59′06″N 97°18′53″W	Microwave
Indian Astronomical Observatory	4,500 m	Hanle, Ladakh, India	32°46′46″N 78°57′51″E	Infrared, gamma ray, Optical[14]
Meyer-Womble Observatory	4,312 m (14,148 ft)	Colorado, United States	39°35′12″N 105°38′24″W	Optical, Infrared
Yangbajing International Cosmic Ray Observatory	4,300 m	Tibet Autonomous Region, China	30°05′N 90°33′E	Cosmic ray
Mauna Kea Observatory	4,190 m	Hawaii, United States	19°49′28″N 155°28′24″W	Optical, infrared, submillimeter
High-Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory	4,100 m	Puebla, Mexico	18°59′40″N 97°18′33″W	Gamma ray
Barcroft Observatory	3,890 m	California, United States	37°35′19″N 118°14′31″W	Infrared, millimeter wave
Very Long Baseline Array (VLBA), Mauna Kea Site	3,730 m	Hawaii, United States	19°48′05″N 155°27′20″W	Radio telescope
Llano del Hato National Astronomical Observatory	3,600 m	Andes, Venezuela	8°47′11″N 70°52′19″W	Optical telescope
Sphinx Observatory	3,571 m	Bernese Alps, Switzerland	46°32′51″N 7°59′6″E	Optical telescope
Mauna Loa Observatory	3,394 m	Hawaii, United States	19°32′10″N 155°34′34″W	Optical, millimeter wave
Magdalena Ridge Observatory	3,230 m	New Mexico, United States	33°58′36″N 107°11′05″W	Optical, infrared
Mount Graham International Observatory	3,191 m	Arizona, United States	32°42′05″N 109°53′31″W	Optical, submillimeter
Gornergrat Observatory	3,135 m	Pennine Alps, Switzerland	45°59′04″N 7°47′09″E	Infrared, submillimeter
Haleakala Observatory	3,036 m	Hawaii, United States	20°42′30″N 156°15′27″W	Optical, millimeter wave

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

aberration	in optics, an imperfect focus caused when a mirror or lens fails to bring light to a sharp focus
absolute magnitude	the apparent brightness an object would have if it were 10 parsecs (32.6 light-years) from Earth
absolute zero	the coldest theoretical temperature, equal to 0 kelvin (-459.67°F or -273.15°C)
absorption lines	dark lines in a spectrum caused by the absorption of light by atoms or molecules in a star or planet's atmosphere
accretion disk	a disk surrounding a black hole or star in which matter gravitationally falls onto the central object
achromatic lens	a two-element lens, or doublet, that significantly reduces chromatic aberration
active galactic nuclei	the exceptionally bright cores of some galaxies, thought to be fueled by matter falling into supermassive black holes
active galaxy	a galaxy emitting unusually large amounts of energy from a compact central source
active optics	The techniques by which corrections are made to the shape of a large mirror or radio dish to adjust for minute distortions in its shape. These variations arise as a telescope is subjected to forces such as gravity and temperature changes.
adaptive optics	a system of telescopes, computers, and deformable mirrors used to compensate for atmospheric blurring
Airy disk	the bright disk-like image of a point source of light, such as a star, as seen in an optical system with a circular aperture
albedo	the percentage of light that an object reflects
altazimuth mount	a mount that enables a telescope to move freely both vertically (in altitude) and horizontally (in azimuth)
altitude	the height above sea level
anaglyph	a stereoscopic, composite image in which the right component (usually red in color) is superimposed on the left component (usually blue) to produce a three dimensional effect when viewed through correspondingly colored filters
Andromeda Galaxy	the largest member of the Local Group of galaxies; roughly twice the size of the Milky Way; also known as M31
angular size	the apparent width of an object as seen by an observer, usually expressed in degrees, arcminutes, or arcseconds
anisotropies	differences in physical properties depending on direction
anisotropy	the variation of a physical property depending on direction
annular eclipse	a solar eclipse in which the moon does not fully cover the sun's disk, allowing observers to see a thin ring of sunlight
antimatter	matter consisting of particles that have the same mass and properties as their matter counterparts but opposite electrical charges
anti-tail	The name given to a comet's tail when it points toward the sun. This rare event typically occurs when Earth crosses the plane of the comet's orbit and the comet is relatively close to the sun.
aperture	the diameter of a telescope's primary lens or mirror; the larger the aperture, the greater the telescope's light-gathering power
aphelion	the point farthest from the sun in an object's orbit
apochromatic lens	a lens with three or more elements that reduces chromatic aberration even more than an achromatic lens
apogee	the point in a satellite's orbit when it is farthest from Earth

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

Apollo	1. U.S. space program that sent astronauts to the moon in the 1960s and '70s 2. an asteroid with a perihelion less than 1.017 AU (and thus comes within the orbit of Earth)
apparent field of view	the angular diameter of the circle of light that the eye sees through an eyepiece
apparent magnitude	the measure of the brightness of an object as seen from Earth
apparition	the period of time during which a particular celestial object can be seen
archeoastronomy	the study of physical artifacts with astronomical connections
arcminute	a unit of angular size equal to 1/60 of a degree; abbreviated by '. Arcminutes are used to measure of the separation between two sky objects or the angular size of an object.
arcsecond	a unit of angular size equal to 1/3,600 of a degree (or 1/60 of an arcminute); abbreviated by ". Arcseconds are used to measure of the separation between two sky objects or the angular size of an object.
asterism	a small grouping of stars in the night sky
asteroid	a small, rocky body that orbits a star
asteroid belt	the zone in which most asteroids orbit the sun, located between the orbits of Mars and Jupiter
astrometry	the study of the positions and motions of celestial objects
astronomical unit	the average distance from Earth to the sun, equal to about 93,000,000 miles (150,000,000 km)
astronomical units	a measurement used by astronomers within the solar system; one astronomical unit (AU) is the average distance between Earth and the sun (about 93,000,000 miles or 150,000,000 kilometers)
astronomy	the branch of science concerned with objects beyond Earth
astrophotography	the photography of astronomical objects
astrophysics	the branch of astronomy that deals with the physical characteristics of celestial objects
atmosphere	a gaseous envelope surrounding a moon, planet, or star
atom	the fundamental unit of matter; can consist of protons, neutrons, and electrons
atomic nucleus	the central region of an atom; can consist of protons and neutrons
attitude	the orientation of a spacecraft relative to the direction of its motion
AU	a measurement used by astronomers within the solar system; one astronomical unit (AU) is the average distance between Earth and the sun (about 93,000,000 miles or 150,000,000 kilometers)
aurora	the emission of light when charged particles from the solar wind slam into and excite atoms and molecules in a planet's upper atmosphere
aurora australis	the southern lights; see definition for aurora
aurora borealis	the northern lights; see definition for aurora
aurorae	the plural of aurora (the emission of light when charged particles from the solar wind slam into and excite atoms and molecules in a planet's upper atmosphere)
autoguider	a CCD camera used to automatically guide a telescope during long-exposure photography
autumnal equinox	the time of year around September 23 when the sun crosses the celestial equator heading south

Glossary of Terms related to Astronomy & Space Science

averted vision	a technique that uses the more light-sensitive rods in the eye to better see a faint object by looking at it indirectly
axis	a straight line about which an object rotates
azimuth	the angle along the horizon measured eastward from due north to the point on the horizon directly below an object
Barlow lens	a lens attached behind the eyepiece of a telescope that increases magnification
Barnard's star	a red dwarf in the constellation Ophiuchus that has the highest proper motion than any other known star; it was discovered by E. E. Barnard in 1916
barred spiral galaxy	a spiral galaxy with a central bar consisting of stars and gas
baryonic	made up of baryons (elementary particles such as protons and electrons)
baryonic matter	"normal" matter composed of elementary particles called baryons
baryons	elementary particles such as protons and neutrons composed of three quarks
baseline	the line between two observational points or two telescopes of an interferometer
Big Bang	the giant explosion that is theorized to have created the universe 10 billion to 20 billion years ago
billion	1,000,000,000 (in American usage)
binary star	a system of two stars that orbit a common center of gravity; also known as a double star
binoculars	a small, usually hand-held instrument with two tubes that is used to magnify the view of astronomical objects; the two numbers used to describe the binoculars refer to its magnification and its aperture in millimeters, respectively
black hole	a region of space where gravity is so powerful that not even light can escape; black holes can form either from the death of high-mass stars or in the cores of galaxies
black holes	regions of space where gravity is so powerful not even light can escape; black holes can form either from the death of high-mass stars or in the cores of galaxies
blazar	a high-energy, variable type of quasar which astronmers believe has a jet of material aimed in our direction that causes it to appear more energetic than other quasars
blink comparator	An instrument that allows astronomers to view two images of the same region of sky simultaneously. Objects that have changed their brightness or position appear to stand out of the plane of the picture.
blueshift	a decrease in the wavelength of light coming from an object due to its motion toward Earth
Bok globule	a small, dark nebula thought to be a region of star formation
bolide	a brilliant meteor or fireball that explodes in mid-air
bolides	brilliant meteors or fireballs that explode in mid-air
Bose-Einstein condensate	atoms crowded close together in ultra-low temperatures that behave as if they were one fluid-like superatom
brown dwarf	a gaseous object that forms like a star but lacks the necessary mass to sustain nuclear fusion in its core; a body intermediate in mass between a star and planet
buckyball	a naturally occurring form of carbon known as C-60, its molecular structure resembles the geodesic domes once designed by Buckminster Fuller
bulge	the generally spherical, central region of a spiral galaxy

Glossary of Terms related to Astronomy & Space Science

cannibal coronal mass ejections	fast-moving solar eruptions that appear to overtake and often devour their slower-moving kin
carbon star	a red giant star with much more carbon than oxygen in its surface layers
carbonaceous chondrites	a class of stony meteorites and asteroids which contain organic (carbon) compounds and may be the most primitive samples of the early solar system
Cassegrain telescope	a reflecting telescope in which a secondary mirror reflects light back through a hole in the center of the primary mirror
cataclysmic variable	a close binary system which includes a white dwarf accreting matter from a less massive companion
catadioptric telescope	a telescope that combines the primary mirror of a reflector with a lens placed in front of the mirror that corrects for aberrations; most catadioptric telescopes for amateurs are Schmidt-Cassegrain telescopes
CCD	a silicon chip used to detect light; charge-coupled devices (CCDs) are far more efficient at collecting light than conventional film
celestial pole	the imaginary projection of Earth's rotational axis onto the celestial sphere
celestial sphere	the apparent sphere of the sky; an imaginary sphere of immense radius centered on Earth often used to plot the coordinates of objects in the sky
Cepheid variable	a class of luminous stars that vary in brightness; used to calibrate distances to galaxies
Chandrasekhar limit	the maximum mass of a white dwarf star, equivalent to 1.4 solar masses
charge-coupled device	a silicon chip used to detect light; charge-coupled devices (CCDs) are far more efficient at collecting light than conventional film
Charles Messier	A French astronomer and comet hunter who discovered 13 comets independently and codiscovered a half-dozen others. While hunting for comets, Messier compiled a list of fuzzy objects that were not comets in order to avoid them. These catalog entries were later identified as star clusters, nebulae, and galaxies and became the Messier Catalog. Published in various versions beginning in 1771, the catalog grew to 103 objects by 1781. Charles Messier lived from June 26, 1730, to April 12, 1817.
chondrite	a stony meteorite containing small, round, silicate granules called chondrules
chromosphere	a layer in a star's atmosphere lying below the corona and above the photosphere
circumpolar	Circumpolar stars are permanently above the horizon from a given observing point on Earth; that is to say, they never set. At Earth's Geographical North Pole (90°north latitude), all stars in the sky are cirumpolar. On Earth's equator, no stars are circumpolar.
clock drive	a motor attached to an equatorial mount that compensates for Earth's rotation and thus keeps the telescope pointing at the same area of sky
CME	huge eruptions of electrified, magnetic gas ejected from the solar corona; this gas is hurled into space with speeds from 12 to 1,250 miles per second (about 20 to 2,000 kilometers per second); CMEs can produce geomagnetic storms and auroral displays on Earth
coated optics	optics treated with a thin, uniform coating that greatly reduces scattered light and thus makes the image brighter
collapsar	a giant star that collapses of its own weight at the end of its normal lifetime
collimation	the act of putting a telescope's optics into perfect alignment
coma	the bright shroud of gas that surrounds a comet's nucleus
Coma Berenices	A constellation between Bootes the Herdsman and Leo the Lion. Coma Berenices is an attractive swarm of stars known as Berenice's Hair.

Glossary of Terms related to Astronomy & Space Science

comet	a small piece of ice and rock that orbits a star usually in a highly elongated orbit; long-period comets have orbital periods longer than 200 years, short-period comets have orbital periods less than 200 years
comet nucleus	a solid, compact mass of rock and ice that heats up when exposed to sunlight and releases gas and dust
conjunction	a time when two or more bodies appear close together in the sky
constellation	one of the 88 patterns of stars in the sky, often named for a mythological god, hero, or animal
convection	the transfer of heat energy by moving currents of material
core	the central region of a planet, brown dwarf, star, or galaxy
corona	the outer atmosphere of the sun or a star
coronagraph	an instrument designed to block light from the solar disk, allowing the corona to be observed
coronagraphic mask	an disk-shaped instrument designed to block light from the disk of a star, allowing the region very close to a target star to be studied
coronal mass ejection	a huge eruption of electrified, magnetic gas ejected from the solar corona; this gas is hurled into space with speeds from 12 to 1,250 miles per second (about 20 to 2,000 kilometers per second); CMEs can produce geomagnetic storms and auroral displays on Earth
coronal mass ejections	huge eruptions of electrified, magnetic gas ejected from the solar corona; this gas is hurled into space with speeds from 12 to 1,250 miles per second (about 20 to 2,000 kilometers per second); CMEs can produce geomagnetic storms and auroral displays on Earth
cosmic background radiation	microwave radiation that permeates the universe and represents the still-cooling heat generated from the Big Bang
cosmic microwave background	microwave radiation that permeates the universe and represents the still-cooling heat generated from the Big Bang
cosmic ray	an atomic nucleus (most are protons) moving at a speed approaching that of light
cosmological constant	a term in the equations of general relativity that represents a repulsive force in the universe
cosmology	the branch of science concerned with the structure and evolution of the universe
cosmos	a synonym for universe
crescent	the phase of a planet or moon during which less than half the surface is illuminated
critical density	the density of the universe that provides just enough gravity to bring the expansion to a halt after an infinite time
crust	the thin, outermost geological layer of a planet, moon, or asteroid
cryovolcanism	the eruption of water and other liquid or vapor-phase volatiles, together with gas-driven solid fragments, onto the surface of a planet or moon due to internal heating
Damocloid	a rare type of asteroid with an elliptical, comet-like orbit; named for the first one discovered, asteroid 5335 Damocles
dark adaptation	the process by which the human eye becomes well adjusted to seeing dim objects in the dark.
dark energy	a type of "negative gravity" that seems to play a role in the acceeleration of universal expansion

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

dark matter	matter that exerts gravitational force but does not emit any detectable light or radiation; dark matter comprises most of the mass of the universe but its exact nature remains unknown
dark nebula	a cloud of dust grains that is thick enough to obscure the light from background stars
declination	the angular distance of a celestial object above or below the celestial equator; the celestial sphere equivalent of latitude
deep-sky objects	objects located beyond the solar system; consist of stars, nebulae, star clusters, and galaxies.
degree	1. a unit of angular size equal to 1/360 the circumference of the celestial sphere; the sun and full moon both appear about half a degree wide
Degree Angular Scale Interferometer (DASI)	a 13-element microwave interferometer, located at the NSF Amundsen-Scott South Pole station, used to measure temperature and polarization in the Cosmic Microwave Background
Denison Olmsted	Denison Olmsted (1791-1859) is credited with giving birth to meteor science after the 1833 Leonid Meteor Storm over North America spurred him to study this phenomenon. He subsequently demonstrated that meteors are not an atmospheric phenomenon, but cosmic in origin. Olmsted was born in East Hartford, Connecticut on June 18, 1791. He attended Yale University and graduated with a degree in physics in 1813. In 1817, he became the chair of chemistry, mineralogy, and geology at the University of North Carolina. He returned to Yale in 1825 where he was appointed professor of mathematics and natural philosophy. Olmstead had many academic pursuits on which he published several textbooks and papers before his death in New Haven, Connecticut on May 13, 1859.
density	the amount of mass per unit volume of an object or region of space
deuterium	an isotope of hydrogen; its nucleus, consisting of one proton and one neutron, has double the mass of the nucleus of ordinary hydrogen
diffraction	the spreading out of light as it passes the edge of an obstacle
Dobsonian telescope	a telescope with a simple but stable altazimuth mount that rotates easily
Doppler effect	the change in wavelength of radiation coming from a source that's moving toward or away from an observer; produces either a blueshift or redshift
dust	tiny particles floating in space
dwarf galaxy	a small galaxy containing a few million stars; the most common type of galaxy in the universe
dwarf star	a main-sequence or smaller star
eccentric	deviating from a circle (used to describe the shape of an orbit)
eccentricity	the extent to which a body's elliptical orbit deviates from a circle
eclipse	an event in which one body passes in front of another, blocking it partially or completely from view; a specific type of occultation
eclipsing binary	a binary star with an orbital plane oriented so that one star passes in front of the other, thus completely or partially blocking the light from the other star during each orbital period
ecliptic	the plane of Earth's orbit around the sun; all the planets except Mercury and Pluto have orbits in nearly the same plane

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

Edwin Hubble	Edwin Hubble was born in Marshfield, Missouri on November 20, 1889. He studied at the University of Chicago and at Oxford as a Rhodes Scholar. His interests turned to astronomy around 1914, but he delayed his entry into the field to enlist in the U.S. Army in 1917. He served in France during World War I and returned to the United States to begin work at Mount Wilson Observatory. There, he determined that other galaxies existed and were moving away from the Milky Way, proving that the universe was still expanding. He also discovered Cepheid variable stars in the Andromeda Galaxy as well as other galaxies. By comparing these variable stars to stars in the Milky Way, Hubble was able to determine that Cepheids were far beyond the boundaries of our galaxy. It was these compelling discoveries that proved the universe was far greater than imagined.
ejecta	material thrown about by an impact or volcano
electromagnetic radiation	the various forms of light; includes radio waves, infrared light, visible light, ultraviolet light, x rays, and gamma rays
electromagnetic spectrum	the spectrum encompassing the entire range of electromagnetic radiation (light)
electron	a subatomic particle with a negative electric charge; electrons surround the atomic nucleus and are much less massive than protons or neutrons
electron volt	a unit of energy equal to the energy gained by an electron that falls through a potential difference of one volt; 1.60 x 10^-19 joule
element	a fundamental unit of matter; consists of a fixed number of protons, although the number of neutrons and electrons can vary
elliptical galaxy	a gravitationally bound system of stars in a spherical or elliptical shape with no spiral structure
elongation	the apparent angular separation of an object from the sun
emission	the discharge of electromagnetic radiation from an object
emission nebula	a cloud of very hot gas that is being illuminated from within by the radiation of energetic, young stars
ephemeris	a table that gives the positions of astronomical objects at certain intervals of time
equatorial mount	a telescope mount in which one axis lies parallel to Earth's rotational axis; the motion of the telescope about this axis can compensate for Earth's rotation
equinox	the two times of year when the sun crosses the celestial equator, giving day and night an equal 12-hour length everywhere on Earth
escape velocity	the velocity an object or rocket needs to escape the gravitational clutch of a more massive object
evening star	the planet Venus when it appears in the evening sky
event horizon	the boundary of a black hole from inside which light cannot escape
exit pupil	the image of the objective lens or primary mirror of a telescope formed on the eye side of the eyepiece
exobiologists	a person who studies the origin, development, and distribution of 'living' systems that may exist outside of Earth
extragalactic	beyond the Milky Way Galaxy
extrasolar	beyond the sun
extraterrestrial	beyond Earth
eye relief	the distance between the eyeball and the lens nearest the eye of an eyepiece at which an observer can clearly see the entire field of view

Glossary of Terms related to Astronomy & Space Science

eyepiece	a magnifying lens used to view the image produced by a telescope's primary lens or mirror.
far ultraviolet	ultraviolet radiation with the shortest wavelengths ("farthest" from visible light in the electromagnetic spectrum)
field of view	the area of sky visible in a telescope or binoculars
filter	a device that transmits light of only certain wavelengths; used by astronomers to observe specific wavelengths or to reduce the light of exceptionally bright objects
finder scope	a small, low-powered telescope attached to a larger telescope that helps the observer locate objects in the sky
fireball	an extremely bright meteor; generally brighter than magnitude -4
fireballs	extremely bright meteors; generally brighter than magnitude -4
first quarter	the phase of the moon a quarter of the way around its orbit from new moon; the eastern half is illuminated during this phase
flare	a sudden, violent outburst of energy from the surface of a star
focal length	the distance from a lens or mirror to the point where it brings light to a focus
focal ratio (f/ratio):	the ratio of the focal length of a lens or mirror to its diameter
focus	the point at which rays of light passing through a lens (or reflecting off a mirror) converge
focuser	the device on a telescope that holds an eyepiece and moves to allow an observer to bring light to a sharp focus
fork mount	an equatorial mount in which the telescope swings in declination between the two prongs of a fork
frequency	the number of wave crests or troughs that pass a particular point in a given interval of time (usually one second); usually expressed in hertz (cycles per second)
full moon	the phase of the moon when it is halfway around its orbit from new moon and opposite the sun in the sky; the full disk is illuminated
galactic disk	the disk of a spiral galaxy
galactic nucleus	the central region of a galaxy; often contains a high density of stars and gas, and a supermassive black hole
galactic plane	the projection of the Milky Way's disk on the sky.
galaxy	an enormous gravitationally bound assemblage of millions or billions of stars
galaxy cluster	a gravitationally bound assemblage of dozens to thousands of galaxies
Galilean moons	Jupiter's four largest moons: Io, Europa, Ganymede, and Callisto; discovered by Galileo Galilei in 1610
Galilean satellites	Jupiter's four largest moons: Io, Europa, Ganymede, and Callisto; discovered by Galileo Galilei in 1610
gamma rays	the form of light (electromagnetic radiation) with the shortest wavelength and the most energy
gamma-ray burst	a short, intense burst of high-energy radiation emanating from the distant universe
gas giant	a large planet made primarily of gas, such as Jupiter, Saturn, Uranus, and Neptune
general relativity	the theory of relativity governing accelerated motion that describes gravity as a curvature of space-time

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

german equatorial mount	a mount in which the declination axis sits on top of the polar axis, with the telescope on one end of the declination axis and a counterweight on the other
giant molecular cloud	interstellar clouds of cold gas and dust that contain tens or hundreds of thousands of solar masses
gibbous	the phase of the moon between first quarter and last quarter, when the moon appears more than half illuminated
globular cluster	a roughly spherical congregation of hundreds of thousands of stars; most globular clusters consist of old stars and exist in a galaxy's halo
gravitational lens	a massive object which magnifies or distorts the light from a more distant object along the same line of sight
gravitational lensing	the distortion or amplification of an object's light due to the presence of a massive object in the light path
gravitational waves	weak, wavelike disturbances which represent the radiation related to the gravitational force; produced when massive bodies are accelerated or otherwise disturbed
gravity	the attractive force that all objects exert on one another; the greater an object's mass, the stronger its gravitational pull
gravity waves	weak, wavelike disturbances which represent the radiation related to the gravitational force; produced when massive bodies are accelerated or otherwise disturbed
habitable zone (or ecosphere)	the zone around a star in which a planet can maintain liquid water on its surface
halo	the outer region of a galaxy; contains globular clusters, a few stray stars, and dark matter
heliacal rising	the period of time when an object, such as a star, is briefly seen in the eastern sky before dawn and is no longer hidden from the glare of the sun
heliosphere	a vast region around the sun dominated by the solar wind
helium	the second lightest element; consists of two protons, and usually two neutrons and two electrons; about 8 percent of the atoms in the universe are helium
Hertz	a unit of frequency equal to one cycle per second
Hertzsprung-Russell diagram	a diagram that plots luminosity against temperature for a group of stars
HII region	an area filled with clouds of ionized hydrogen; the ionization is usually caused by radiation from newborn stars
HST	The Hubble Space Telescope makes its observations from above Earth's atmosphere. The telescope orbits 600 kilometers (375 miles) above Earth, working around the clock. It was originally designed in the 1970s and launched in 1990. The telescope is named for astronomer Edwin Hubble.
Hubble law	the principle that a distant galaxy's recessional velocity is proportional to its distance from Earth
Hubble Space Telescope	The Hubble Space Telescope makes its observations from above Earth's atmosphere. The telescope orbits 600 kilometers (375 miles) above Earth, working around the clock. It was originally designed in the 1970s and launched in 1990. The telescope is named for astronomer Edwin Hubble.
hydrazine	a colorless liquid which burns rapidly and is used as a common rocket and missile fuel
hydrogen	the simplest and lightest element; usually consists of just a single proton and electron; about 90 percent of the atoms in the universe are hydrogen

hypered film	film that has been treated, usually with gas, to enhance its response to low light levels
igneous rock	rock formed by the solidification of magma
inclination	the angle between a planet's orbit and the ecliptic plane; or the angle between a satellite's orbit and its host planet's rotational plane
inferior conjunction	the configuration of an inferior planet when it lies between the sun and Earth
inferior planet	a planet that orbits the sun inside of Earth's orbit; includes Mercury and Venus
inflation	a brief and extraordinarily rapid period of expansion a fraction of a second after the Big Bang
infrared	a form of light with slightly lower energy than visible light but with greater energy than radio waves
interacting galaxies	galaxies caught in each other's gravitational embrace, often results in galactic mergers or extreme star formation
interference fringes	a wave-like pattern resulting from the successful combination of two beams of light which amplifies the light
interferometer	a system of two or more widely separated telescopes that achieves the resolving power of a much larger telescope
interferometric fringes	a wave-like pattern resulting from the successful combination of two beams of light which amplifies the light
interferometry	the technique of using two or more widely separated telescopes to achieve the resolving power of a much larger telescope
intergalactic	the space between the galaxies
International Space Station	a global cooperative program between the United States, Russia, Canada, Japan, and Europe, for the joint development, operation, and utilization of a permanently habitated space station in low-Earth orbit
interplanetary	the space between the planets
interstellar	the space between the stars of a galaxy
interstellar medium	the gas and dust located between the stars
ion	an atom that is electrically charged due to the loss or gain of one or more electrons
ionization	the process by which an atom gains or loses electrons
ionized gas	a gas that has been heated to a state where it contains ions and free-floating electrons; also known as a plasma
ionosphere	an atmospheric layer with a high concentration of ions and free electrons
irregular galaxy	a galaxy without a clearly defined spiral or elliptical shape
isotope	forms of an element in which the atoms all have the same number of protons but different numbers of neutrons
jet	a narrow stream of gas or particles ejected from an accretion disk surrounding a star or black hole
Jet Propulsion Laboratory	the lead U.S. center for robotic exploration of the solar system, located in Pasadena, California; JPL spacecraft have visited all known planets except Pluto
jet stream	a high-speed, wandering wind current in the upper troposphere that blows from west to east and affects weather
Jovian planet	a planet with characteristics similar to Jupiter (see gas giant).

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

kelvin	a unit of temperature equal to one degree on the Celsius scale and 1.8 degrees on the Fahrenheit scale; also the absolute temperature scale defined so that 0 kelvin is absolute zero
kelvins	temperature units equal to degrees Celsius; 0 on the Kelvin scale is absolute zero
Kuiper Belt	a region in the outer solar system beyond Neptune's orbit that contains billions of small, icy bodies; Pluto is the largest known Kuiper Belt Object
L chondrite	a chondrite (a stony meteorite containing small, round, silicate granules called chondrules) that has a low amount of iron
Lagrange point	one of five locations in space relative to two bodies where a third, less massive body can maintain a stable orbit around a common center of mass
Large Magellanic Cloud	an irregular galaxy that orbits the Milky Way Galaxy
last quarter	the phase of the moon three-quarters of the way around its orbit from new moon; the western half is illuminated
latitude	the angular distance north or south from the equator to a point on Earth's surface, measured on the meridian of the point
lens	a curved piece of glass that brings light to a focus
lenticular galaxy	a galaxy possessing a large bulge and small disk
libration	the small oscillations in the moon's motion that allow Earth-based observers to see slightly more than half the moon's surface
light pollution	light, typically from artificial sources, that reaches the night sky, obscuring the view of faint astronomical objects
light-gathering power	the ability of a telescope to collect light; the larger a telescope's aperture, the greater its light-gathering power
light-year	the distance light travels in one year, equivalent to approximately 5.9 trillion miles (9.5 trillion km)
limb	the apparent edge of a celestial object
limiting magnitude	the apparent magnitude of the faintest objects that can be seen given the local observing conditions and any telescope, film, or other detector you may be using
LINER galaxy	A low-ionization nuclear emission-line region galaxy belongs to a common class of otherwise normal galaxies that display low-ionization line emissions near their central regions
Local Group	the galaxy cluster containing roughly 35 galaxies to which the Milky Way Galaxy belongs
local supercluster	the galaxy supercluster to which the Local Group belongs; it spreads over 100 million light-years and boasts the Virgo Cluster as its dominant member
longitude	the angular distance of a particular place on Earth as measured east or west from the prime meridian running through Greenwich, England
long-period comet	Comets that have orbital periods greater than 200 years.
luminosity	the total amount of light that an object radiates
lunar eclipse	a phenomenon caused by the Earth passing between the sun and moon
lunar month	the period of one complete revolution of the moon around Earth, 29.5 days
lunation	the time between two successive new moons; approximately 29.5 days
magnetograph	an instrument that maps the strength, distribution, and direction of magnetic fields on the sun's disk

magnetometer	an instrument used to measure the strength and direction of a magnetic field
magnetopause	the boundary between Earth's magnetic field and the solar wind
magnetosphere	the dynamic region around a planet where the magnetic field traps and controls the movement of charged particles from the solar wind
magnitude	the measurement of an object's brightness; the lower the number, the brighter the object
main sequence	the band of stars on a Hertzsprung-Russell diagram stretching from the upper left to the lower right; stars spend most of their lives in the main sequence phase, in which they are fusing hydrogen into helium in their cores
Maksutov telescope	a catadioptric telescope that uses a deeply curved meniscus lens as the correcting plate
mantle	the portion of a planet's interior above the core but below the crust
mare	a dark and relatively smooth area on the surface of the moon or a planet.
mass	a measure of the total amount of matter within an object
mass loss	the loss of mass by a star during its evolution; some of the causes of mass loss include stellar winds, bipolar outflows, and the ejection of material in a planetary nebula or supernova
megaparsec	one million parsecs; equal to 3.26 million light-years
meridian	an imaginary circle on the celestial sphere that connects the zenith to the north (or south) celestial pole
Messier Catalog	A catalog of 107 bright deep-sky objects that belong to a catalog compiled by French astronomer Charles Messier in the 1700s
Messier objects	A catalog of 107 bright deep-sky objects that belong to a catalog compiled by French astronomer Charles Messier in the 1700s
meteor	a flash of light that occurs when a meteoroid burns up in Earth's atmosphere; also popularly known as a shooting star
meteor shower	a period of enhanced meteor activity that occurs when Earth collides with a swarm of meteoroids; an individual shower happens at the same time each year and has all its meteors appearing to radiate from a common point
meteor showers	a period of enhanced meteor activity that occurs when Earth collides with a swarm of meteoroids; an individual shower happens at the same time each year and has all its meteors appearing to radiate from a common point
meteor storm	Meteor storms are rare events that occur when Earth encounters dense regions within a meteor stream. Such encounters can increase normal meteor rates by more than 1,000 meteors per minute.
meteorite	a rock from space that survives passage through Earth's atmosphere and falls to the ground
meteoroid	a small rock that orbits the sun
microgravity	a condition in which the force of gravity is very low, producing a near-weightless environment
microlensing	the effect of gravity from a small astronomical body or bodies focusing light rays, similar in manner to lenses
micron	one-millionth of a meter
microwaves	the most energetic form of radio waves
Milky Way	the band of light that encircles the entire sky and results from the combined light of billions of stars in our galaxy's disk
Milky Way Galaxy	the spiral galaxy to which Earth belongs

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

million	1,000,000 (in American usage)
millisecond pulsar	a neutron star that rotates hundreds of times per second, which typically accretes matter from a stellar companion
minor planet	a rocky body that orbits the sun; also known as an asteroid
mirror	a piece of glass coated with a highly reflective material
molecule	a combination of two or more atoms that represents the smallest part of a compound that has the chemical properties of that compound
moon	a smaller body orbiting a larger body; often refers to Earth's moon
morning star	planet Venus when it appears in the morning sky
motor drive	see clock drive
multicultural astronomy	the variety of ways in which cultures of the past and present have observed, recorded, interperted, and made use of astronomy to structure their lives and/or satisfy their curiosity about the universe
multiple star system	a gravitationally bound system in which two or more stars orbit a common center of mass.
MUSES-C	The MUSES-C Mission will investigate an asteroid known as an Earth-approaching type. Through this mission, the Institute of Space and Astronautical Science (ISAS) in Japan intends to establish the technology to bring back samples of an asteroid's surface to Earth. MUSES stands for a series of missions performed launched by the MU rocket and C means the third mission of this series.
naked-eye	something visible or accomplished without the aid of binoculars or a telescope (e.g. a naked-eye object or naked-eye observing)
near-infrared	light from the part of the infrared band of the electromagnetic spectrum closest to the visible range
nebula	a cloud of interstellar gas and dust; some nebulae represent stellar nurseries, others represent stellar graveyards
neutrino	a subatomic particle produced in nuclear reactions and in supernovae that very rarely interacts with matter; neutrinos have no electrical charge and travel at or very close to the speed of light
neutron	a subatomic particle with no electric charge that resides in an atomic nucleus; it has about the same mass as a proton
neutron star	the collapsed, extraordinarily dense, city-sized remnant of a high-mass star
new moon	the phase in which the moon is in the same direction as the sun in Earth's sky, so it is unilluminated and invisible
Newtonian telescope	a reflecting telescope in which a flat secondary mirror (called the diagonal) in the center of the tube reflects light to a focus outside the tube
NGC	New General Catalogue, a 19th-century compendium of deep-sky objects such as galaxies, globular clusters, and nebulae
NGC objects	deep-sky objects such as galaxies, globular clusters, and nebulae included in the New General Catalogue
North Celestial Pole	the point in the sky to which Earth's Geographical North Pole points
nova	an explosion on the surface of a white dwarf that is accreting matter from a companion star, which causes the system to temporarily brighten by a factor of several hundred to several thousand
nuclear fusion	the process by which two atomic nuclei combine to form a heavier atomic nucleus; this is the energy source that causes most stars to shine
nucleosynthesis	the creation of heavy elements from lighter ones by nuclear fusion

Glossary of Terms related to Astronomy & Space Science

nucleus	the central region of an atom, comet, or galaxy
OB association	a loose grouping of O and B stars, which are the most luminous, most massive, and shortest-lived stars
objective	a telescope's primary lens or mirror that gathers light and brings it to a focus
obliquity	the angle between a planet's equator and the plane of its orbit
occultation	the passage of one object in front of a smaller one, temporarily obscuring all or part of the background object from view
omega	1. the ratio of the density of the universe to the critical density 2. the 24th letter of the Greek alphabet
Omega Centauri	a massive globular cluster in the southern constellation Centaurus located about 17,000 light-years from Earth; also known as NGC 5139
Omega nebula	One of the Milky Way's numerous stellar nurseries, the Omega Nebula is about 5,000 light-years from Earth and can be seen in the constellation of Sagittarius the Archer. It is also known as the Swan Nebula, M17, NGC 6618, the Horseshoe Nebula, and the Lobster Nebula.
Oort Cloud	a cloud of cometary nuclei that surrounds the sun at a distance of many thousands of astronomical units
open cluster	a system containing a few dozen to a few thousand stars that formed from the same stellar nursery
opposition	the moment when a planet farther from the sun than Earth appears opposite the sun in the sky; it is the best time to observe a planet
optical double	Two stars at different distances that lie along nearly the same line of sight and thus appear close together
optics	the study of light and its properties; or lenses and mirrors
orbit	the path an object follows around a more massive object or common center of mass; usually elliptical in shape
orbital period	the length of time it takes one body to orbit another
O-type star	a hot, massive blue star that emits strongly at ultraviolet wavelengths and has a surface temperature between about 28,000 to 40,000 kelvins
outgassing	the release of gas from a rocky body
PAHs	Polycyclic aromatic hydrocarbons (PAHs) are a class of very stable organic molecules. They are flat molecules made only of carbon and hydrogen atoms. PAH molecules are quite common and highly carcinogenic. They are one of the by-products of combustion from automobiles and airplanes, and some are present in charcoal broiled hamburgers.
parallax	the apparent shift of a relatively nearby object against a fixed background due to the motion of the observer; astronomers observe the parallax of stars to measure their distances
parsec	the distance an object would have to be from Earth so that its parallax when viewed from two points separated by 1 AU would be one arcsecond; equal to 3.26 light-years.
patera	an irregular, saucer-shaped volcanic structure
penumbra	1. the region of a shadow from which part of the light source remains visible 2. the lighter region of a sunspot surrounding its dark center (umbra)
penumbral eclipse	an event that occurs when the moon passes into the outer ring of Earth's shadow (penumbra), causing a slight shading in the moon's appearance
periastron	the point in an object's orbit at which it is closest to the star it orbits
perigee	the point in a satellite's orbit when it is closest to Earth

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

perihelion	the point in an object's orbit when it's closest to the sun
period	the time interval for a regular event to take place
periodic comet	a comet that has been seen to orbit the sun more than once (Comet Halley was the first recognized as periodic)
phase	the regular cycle of changes in the appearance of a moon or planet
photometer	a detector that measures the amount of light coming from an object
photometry	the measurement of light intensities
photons	individual "particles/waves" of light
photosphere	the visible surface of the sun
photovoltaic	conversion of light energy into electricity
pixel	short for "picture element," the individual light detectors on a CCD chip
Planck scale	the smallest units of measurement scientists use to describe the universe; a Planck unit of length is 10^-33 centimeters
planet	a large rocky or gaseous body that orbits a star
planetary nebula	a glowing shell of gas ejected by a dying, low-mass star
planetary nebulae	glowing shells of gas ejected by dying, low-mass stars
planetesimals	asteroid-size bodies in a young planetary system that collide to form larger bodies
planisphere	a two-dimensional map of the sky with an adjustable overlay to show the part of the sky visible at any time of the night or year
plasma	a gas that has been heated to a state where it contains ions and free-floating electrons; also known as ionized gas
plasmasphere	a region of cold, high-density plasma above the ionosphere
plate tectonics	a theory that describes how Earth's crust is broken into plates and how those plates move across Earth's surface
polar cap	an icy region at the north or south pole of a planet
polarization	a state in which the directions of the electric or magnetic field in an electromagnetic wave changes in a regular pattern; light from celestial objects is often polarized
polycyclic aromatic hydrocarbons	Polycyclic aromatic hydrocarbons (PAHs) are a class of very stable organic molecules. They are flat molecules made only of carbon and hydrogen atoms. PAH molecules are quite common and highly carcinogenic. They are one of the by-products of combustion from automobiles and airplanes, and some are present in charcoal broiled hamburgers.
position angle	the direction in the sky of one celestial object from another, measured eastward from due north
power	the ability of a telescope or binoculars to increase the apparent size of a distant object
Poynting-Robertson effect	a drag on interplanetary particles caused by their interaction with solar radiation, which causes the particles to lose orbital momentum and spiral into the sun
precession	the slow, periodic change in the direction an object's rotational axis caused by the gravitational influence of another body
primary lens	a telescope's main lens which gathers light and brings it to a focus
primary mirror	a telescope's main mirror which gathers light and brings it to a focus
prime meridian	the line of longitude that runs through Greenwich, England

prism	a wedge-shaped piece of glass that breaks white light into its constituent colors
prograde	objects that move or appear to move in the same direction of most solar system bodies, or for moons, the same direction as the planet rotates
prominence	a large eruption of gas streaming off the surface of the sun into the corona
proper motion	the apparent yearly motion of a star across the sky
proton	a subatomic particle that resides in an atom's nucleus and possesses a positive electric charge
protoplanet	a body that is accreting gas, dust, and rocks en route to becoming a full-fledged planet
protoplanetary disk	a disk of gas and dust that surrounds a newborn star; planets form from collisions of particles inside the disk
protostar	a cloud of hot, dense gas and dust that is gravitationally collapsing to form a star
Proxima Centauri	the nearest star to the sun at a distance of 4.2 light-years
pulsar	a rapidly rotating neutron star that bathes Earth in regular pulses of electromagnetic radiation
quadrillion	1,000,000,000,000,000 (in American usage)
quantum mechanics	the physical laws that describe the behavior of matter at the atomic and subatomic level
quasar	the highly energetic core of a young galaxy thought to be powered by a supermassive black hole; short for quasi-stellar object
radial velocity	the velocity of an object toward or away from an observer
radiant	1. the point in the sky from which the meteors belonging to a meteor shower appear to originate 2. vividly bright and shining
radiation	electromagnetic waves (in astronomical usage)
radiation pressure	a very small amount of pressure exerted on a surface by light or other electromagnetic radiation
radio galaxy	a galaxy that emits an unusually large amount of radio waves
radio telescope	a telescope designed to detect radio waves coming from space
radio waves	the form of light with the longest wavelength and the least energy
radiometer	a device that measures the total energy or power from an object in the form of radiation, especially infrared radiation
red dwarf	a low-mass, main-sequence star much smaller, cooler, and less luminous than the sun
red giant	a cool star near the end of its life cycle that has expanded to a size of a few dozen to a hundred times the diameter of the sun
red supergiant	a cool, massive star near the end of its life that has expanded to a size from a hundred to a thousand times the diameter of the sun
redshift	an increase in the wavelength of light coming from an object due to its motion away from Earth, the expansion of the universe, or a strong gravitational field
reflection nebula	a cloud of gas and dust that is visible because the dust reflects a nearby star's light
reflector	a telescope that uses a curved mirror to gather light
refractor	a telescope that uses a glass lens to gather light

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

regolith	the unconsolidated residual or transported rock and soil that overlies solid bedrock on Earth, the moon, or another planet the powdery soil of the moon produced by meteorite impacts
relativity	the theories of physics developed by Albert Einstein that describe measurements made by two observers who are in relative motion
resolution	the ability of a telescope or camera to pick out fine detail
resolving power	the ability of a telescope or camera to pick out fine detail
reticule	a grid or pattern of two or more fine wires set inthe focal plane of a telescope eyepiece and used in determining the position and/or size of a celestial object
retrograde	objects that move or appear to move in the opposite direction of most solar system bodies; for example planets that appear to move east-to-west in the sky or objects that revolve or rotate clockwise as seen from north of the solar system
reusable launch vehicle (RLV)	a single-stage-to-orbit spacecraft that may be reused on successive missions
revolution	the orbital motion of one body around another body or a common center of mass
ribonucleic acid	a nucleic acid that transmits genetic information
rich clusters	large galaxy clusters with unusually high population densities
rich-field telescope	a telescope designed to show a large field of view at low magnification
right ascension	the angular distance of a celestial object east of the vernal equinox; the celestial sphere equivalent of longitude
RNA	a nucleic acid that transmits genetic information
rotation	the spin of a galaxy, star, planet, moon, or asteroid about a central axis
rotation period	the length of time it takes a body to complete one rotation
satellite	a small body that orbits a planet or asteroid
Schmidt camera	a catadioptric telescope used as a camera to take wide-angle photos of the sky
Schmidt-Cassegrain telescope	a compact telescope in which light passes through a correcting lens at the front of the telescope, then reflects off a primary mirror back up to a secondary mirror, which directs the light through a hole in the primary and out the back of the scope; a popular telescope for backyard observers.
secondary mirror	a relatively small mirror used in a telescope to redirect the light gathered by the primary mirror
seeing	the quality of observing conditions induced by turbulence in Earth's atmosphere, which blurs the images of astronomical objects
semimajor axis	the average distance of an orbiting body from its parent body
SETI	the search for extraterrestrial intelligence
setting circles	circular scales on the two axes of an equatorial mount that help an observer point a telescope to a specific right ascension and declination
Seyfert galaxy	a galaxy (usually a spiral) with a very bright nucleus and strong spectral emission lines; the first was discovered in 1943 by Carl Seyfert
shock wave	a powerful wave caused by a sudden change in density, pressure, or temperature that travels though a medium faster than sound travels through that same medium
short-period comet	Comets that have orbital periods of less than 200 years.
sidereal	relating to or measured with respect to the stars

sidereal year	the amount of time it takes one body to revolve about another with respect to the stars
siderostat	a flat mirror that can be moved to reflect light from a celestial object to a specific spot
singularity	a point at which space and time are infinitely distorted, such as the central point of a black hole where matter is concentrated into an area of zero volume and infinite density
Small Magellanic Cloud	a small, irregular dwarf galaxy that orbits the Milky Way Galaxy
solar eclipse	an eclipse of the sun caused by the moon passing between Earth and the sun
solar filter	a filter used to block almost all of the sun's light so our star can be viewed safely and comfortably
solar irradiance	the radiant energy emitted by the sun over all wavelengths that falls each second on one square meter of Earth's atmosphere
solar mass	the amount of mass contained in the sun, about 330,000 times that of Earth's mass
solar system	the system containing the sun and all the smaller bodies in orbit around it
solar wind	the stream of charged subatomic particles emanating from the sun
solstice	either of the two points on the celestial sphere where the sun is farthest north or south of the celestial equator; when the sun is at a solstice, the amount of daylight hours is greatest for summer and least for winter
South Celestial Pole	the point in the sky to which Earth's Geographical South Pole points
space weathering	the process of altering the surface of an object in space by such phenomena as micrometeoroid impacts, cosmic rays, and the solar wind
space-time	the intertwining of the three dimensions of space with one dimension of time within which events can be specified exactly
special relativity	the theory of relativity governing uniform motion; it states the equivalence of mass and energy and differs from Newtonian physics only when speeds approach that of light
spectra	plural of "spectrum" (the energy emitted by a radiant source)
spectral class	the designation of a star based on its spectrum, which is determined by its surface temperature
spectral line	a particular wavelength of light corresponding to the energy transition of a specific atom or molecule
spectral type	the designation of a star based on its spectrum, which is determined by its surface temperature
spectrograph	an instrument attached to a telescope to record the spectrum of an astronomical object
spectroheliograph	a device for photographing the sun in a single wavelength of light
spectrometer	an instrument attached to a telescope to record the spectrum of an astronomical object
spectroscope	an instrument for examining spectra
spectroscopy	the study of spectra from astronomical objects
spectrum	1. the energy emitted by a radiant source 2. the entire range of electromagnetic radiation (light)
speed of light	the fastest possible speed in a vacuum, equivalent to 186,000 miles per second (300,000 km per second)

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

spiral arm	a concentration of gas, dust, and young stars that winds its way out from the nuclear region of a spiral galaxy
spiral galaxy	a spiral-shaped system of billions of stars, gas clouds, and dust
standard candle	an astronomical object of known luminosity; can be used to determine distances
star	a self-luminous sphere of hot gas held together by gravity; ordinary stars generate energy by nuclear fusion in their cores
star atlas	an collection of maps that marks the positions of stars, nebulae, galaxies, and other astronomical objects on a coordinate system
star hopping	the technique of using recognizable patterns of stars to "hop" from one part of the sky to another; useful in observing both with the naked eye and a telescope
star party	a gathering of people to observe the night sky
starburst galaxy	a galaxy undergoing an extremely high rate of star formation
stellar evolution	the life cycle of stars
stellar wind	a stream of electrically charged subatomic particles given off by stars
stereocomparator	An instrument that allows astronomers to view two images of the same region of sky simultaneously. Objects that have changed their brightness or position appear to stand out of the plane of the picture.
sublimate	the transition of a solid substance evaporating into a gas without passing through a liquid phase
sublimated	the transition of a solid substance evaporating into a gas without passing through a liquid phase
sublimation	the process by which a solid substance evaporates into a gas without passing through a liquid phase
summer	a season that begins around June 21 in the Northern Hemisphere
sunspot	a dark, temporary, relatively cool spot on the surface of the sun
sunspot cycle	a cycle averaging 11 years in which the number of sunspots increases and decreases
supercluster	an enormous congregation of galaxy clusters that stretches across hundreds of millions of light-years
superfluid	an unusual state of matter characterized by apparently frictionless flow, found only in liquid helium cooled to near absolute zero
superior conjunction	the configuration of an inferior planet when it lies on the far side of the sun
superior planet	a planet farther from the sun than Earth; includes Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto
superluminal motion	motion that appears to be faster than the speed of light
supermassive black hole	a black hole at the core of a galaxy that contains millions or billions of solar masses
supernova	the cataclysmic explosion of a star
supernova remnant	an expanding cloud of gas that represents the outer layers of an exploded star
synchronous rotation	when a satellite rotates at the same rate at which it revolves around a more massive object; a body with synchronous rotation shows only one hemisphere to the object it orbits
synchrotron emission	electromagnetic radiation from high-energy electrons moving in a magnetic field

Aryabhat Astronomy Quiz

Glossary of Terms related to Astronomy & Space Science

telescope	a tubed instrument used to brighten and magnify the view of astronomical objects (telescopes gather more light than the eye)
tera	a trillion (1,000,000,000,000 in American usage)
terminator	the boundary on a planet or moon separating the illuminated side from the unilluminated.
terrestrial	of or relating to Earth
terrestrial planet	a small, rocky planet such as Mercury, Venus, Earth, and Mars
thermal radiation	electromagnetic radiation emanating from any object not at absolute zero
tidal force	the difference in gravitational force between two points on an object caused by the gravity of another object; the tidal force often leads to a deformation of an object
tides	the distortion of a body caused by the gravitational influence of another body
transit	the passage of a smaller body in front of a larger body; also, the passage of a celestial body across an observer's meridian
Trans-Neptunion Object	an object in our solar system lying beyond the orbit of Neptune; abbreviated TNO
transparency	the clarity of the sky
Trapezium	an open cluster of young stars, protostars, gas, and dust in the Orion Nebula featuring four prominent stars that form a trapezium
tremolite	a common mineral in some metamorphic rocks, composed mainly of calcium and magnesium; it occurs from the conversion of dolomite (a sedimentary rock), silica, and water
trillion	1,000,000,000,000 (in American usage)
Trojan	an asteroid that lies in or near one of the Lagrange points 60 degrees ahead or behind Jupiter along the planet's orbit; Trojan asteroids have also been found accompanying Mars and Neptune
tropical year	the time it takes Earth to revolve around the sun with respect to the vernal equinox
true field of view	the angle of sky seen through an eyepiece when it is attached to a telescope; the true field equals the apparent field divided by the magnification
type Ia supernova	the explosion of a white dwarf that occurs when it accretes enough mass from a companion star to go above the Chandrasekhar limit
type II quasars	a quasar enshrouded in gas and dust that emits very little visibile light, however, is easily seen in the infrared and x-ray region of the electromagnetic spectrum
type II supernova	the explosion of a massive star that occurs when its core runs out of nuclear fuel; these explosions leave behind a neutron star or a black hole
ultraviolet light	radiation with higher energy than visible light, but without as much energy as x rays
ultraviolet radiation	radiation with higher energy than visible light, but without as much energy as x rays
umbra	1. the dark, central region of a shadow from which none of the light source can be seen 2. the dark center of a sunspot
unidentified infrared bands (UIBs)	mysterious objects in space that give off as yet unidentified infrared emission patterns

Glossary of Terms related to Astronomy & Space Science

Universal Time	the local time of day on a line of longitude centered on Greenwich, England; also known as Greenwich Mean Time, it forms the basis for all civil timekeeping
Universe	everything that exists
UT	abbreviation for Universal Time, the local time of day on a line of longitude centered on Greenwich, England; also known as Greenwich Mean Time, it forms the basis for all civil timekeeping
UV	short for ultraviolet; UV radiation has more energy than visible light but less energy than x rays
Van Allen belts	two belts of charged particles from the solar wind that have been trapped by Earth's magnetic field above Earth's atmosphere
variable star	a star that varies in luminosity
vernal equinox	the time of year around March 21 when the sun crosses the celestial equator heading north
vignetting	uneven or reduced illumination over the image plane in a telescope or camera, causing distortion such as dimming near the edge of an image
Virgo Cluster	a group of about 2,500 known galaxies lying near the north galactic pole in the constellation Virgo
visible light	the portion of the electromagnetic spectrum visible to the human eye
voids	enormous regions of relatively empty space between galaxy superclusters
volatiles	chemical compounds that are gaseous at low temperatures.
waning	the period between full moon and new moon
wavelength	the distance between two successive wave crests or troughs
waxing	the period between new moon and full moon
weight	the force exerted on an object due to gravity
white dwarf	the dense, collapsed, Earth-sized remnant of an intermediate-mass star like the sun
winter	a season that begins around December 21 in the Northern Hemisphere
Wolf-Rayet star	a very luminous and very hot star with temperatures reaching as high as 90,000 kelvins
X rays	electromagnetic radiation more energetic than ultraviolet light but less energetic than gamma rays
X-class flares	the brightest and most energetic type of solar flares
zenith	the point on the celestial sphere directly over the head of an observer
zenithal hourly rate	the number of meteorites expected to be seen per hour when a meteor shower's radiant is at an observer's zenith; abbreviated ZHR
zodiac	a band around the celestial sphere 18°in width and centered on the ecliptic
zodiacal light	a faint, cone-shaped glow of light seen in the west after nightfall or in the east before dawn, caused by sunlight reflecting and scattering off interplanetary dust particles lying along the ecliptic plane