République Algérienne Démocratique et Populaire
Ministère de l'EnseignementSupérieur Etde La Recherche
Scientifique

Université de Ghardaïa

N°d'ordre :
N° de série:

Faculté desSciencesetTechnologie
DépartementdesSciencesetTechnologie

Projet de fin d'étude présenté en vue de l'obtention du diplôme de

LICENCE

Domaine : Science et Technologie

Filière : Génie électrique

Spécialité : Maintenance en instrumentation industrielle

THEME:

Space Instrumentation

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ANNEE UNIVERSITAIRE: 2013/2014

1.1-Instrumentation

Instrumentation is defined as the art and science of measurement and control of process variables within a production or manufacturing area.

An instrument is a device that measures a physical quantity such as flow, temperature, level, distance, angle, or pressure. Instruments may be as simple as direct reading thermometers or may be complex multi-variable process analyzers. Instruments are often part of a control system in refineries, factories, and vehicles. The control of processes is one of the main branches of applied instrumentation. Instrumentation can also refer to handheld devices that measure some desired variable. Diverse handheld instrumentation is common in laboratories, but can be found in the household as well. For example, a smoke detector (fig 1.1) is a common instrument found in most western homes.

FIGURE 1.1: SMOKE DETECTOR

Instruments attached to a control system may provide signals used to operate solenoids, valves, regulators, circuit breakers, or relays. These devices control a desired output variable, and provide either remote or automated control capabilities. These are often referred to as final control elements when controlled remotely or by a control system.

A Transmitter is a device that produces an output signal, often in the form of a 4–20 mA electrical current signal, although many other options using voltage, frequency, pressure, or Ethernet are possible. This signal can be used for informational purposes, or it can be sent to a PLC, DCS, SCADA system, Lab View or other type of computerized controller, where it can be interpreted into readable values and used to control other devices and processes in the system.

Control instrumentation plays a significant role in both gathering information from the field and changing the field parameters, and as such are a key part of control loops.

In The Oxford English Dictionary says (as its last definition of Instrumentation), "The design, construction, and provision of instruments for measurement, control, etc…; the state of being equipped with or controlled by such instruments collectively." It notes that this use of the word originated in the U.S.A. in the early 20th century. More traditional uses of the word were associated with musical or surgical instruments. While the word is traditionally a noun, it is also used as an adjective (as instrumentation engineer, instrumentation amplifier and instrumentation system). Other dictionaries note that the word is most common in describing aeronautical, scientific or industrial instruments.

Measurement instruments have three traditional classes of use:

- ✓ Monitoring of processes and operations.
- ✓ Control of processes and operations.
- ✓ Experimental engineering analysis.

While these uses appear distinct, in practice they are less so. All measurements have the potential for decisions and control. A home owner may change a thermostat setting in response to a utility bill computed from meter readings.

For example:

In some cases the sensor is a very minor element of the mechanism. Digital cameras and wristwatches might technically meet the loose definition of instrumentation because they record and/or display sensed information. Under most circumstances neither would be called instrumentation, but when used to measure the elapsed time of a race and to document the winner at the finish line, both would be called instrumentation.

Another example of an instrumentation system is a home security system. Such a system consists of sensors (motion detection, switches to detect door openings), simple algorithms to detect intrusion, local control (arm/disarm) and remote monitoring of the system so that the police can be summoned. Communication is an inherent part of the design.

Kitchen appliances use sensors for control.

A refrigerator maintains a constant temperature by measuring the internal temperature.

A microwave oven sometimes cooks via a heat-sense-heat-sense cycle until sensing done.

An automatic ice machine makes ice until a limit switch is thrown.

Pop-up bread toasters can operate by time or by heat measurements.

Some ovens use a temperature probe to cook until a target internal food temperature is reached. A common toilet refills the water tank until a float closes the valve. The float is acting as a water level sensor.

1.2-Measurement

Instrumentation is used to measure many parameters (physical values). These parameters include:

- ✓ Pressure, either differential or static
- ✓ Flow
- ✓ Temperature
- ✓ Levels of liquids, etc…
- ✓ Density.
- ✓ Viscosity.
- ✓ Other mechanical properties of materials
- ✓ Properties of ionizing radiation
- ✓ Frequency.
- ✓ Current.
- ✓ Voltage
- ✓ Inductance
- ✓ Capacitance
- ✓ Resistivity
- ✓ Chemical composition
- ✓ Chemical properties
- ✓ Properties of light
- ✓ Vibration
- ✓ Weight

1.3-Instrumentation engineering

Instrumentation engineering is the engineering specialization focused on the principle and operation of measuring instruments that are used in design and configuration of automated systems in electrical, pneumatic domains etc. They typically work for industries with automated processes, such as chemical or manufacturing plants, with the goal of improving system productivity, reliability, safety, optimization, and stability. To control the parameters in a process or in a particular system, devices such as microprocessors, microcontrollers or PLCs are used, but their ultimate aim is to control the parameters of a system.

Instrumentation engineering is loosely defined because the required tasks are very domain dependent. An expert in the biomedical instrumentation of laboratory rats has very different concerns than the expert in rocket instrumentation. Common concerns of both are the selection of appropriate sensors based on size, weight, cost, reliability, accuracy, longevity, environmental robustness and frequency response. Some sensors are literally fired in artillery shells. Others sense thermonuclear explosions until destroyed. Invariably sensor data must be recorded, transmitted or displayed. Recording rates and capacities vary enormously. Transmission can be trivial or can be clandestine, encrypted and low-power in the presence of jamming. Displays can be trivially simple or can require consultation with human factors experts. Control system design varies from trivial to a separate specialty.

Instrumentation engineers are commonly responsible for integrating the sensors with the recorders, transmitters, displays or control systems. They may design or specify installation, wiring and signal conditioning. They may be responsible for calibration, testing and maintenance of the system.

In a research environment it is common for subject matter experts to have substantial instrumentation system expertise. An astronomer knows the structure of the universe and a great deal about telescopes - optics, pointing and cameras (or other sensing elements). That often includes the hard-won knowledge of the operational procedures that provide the best results. For example, an astronomer is often knowledgeable of techniques to minimize temperature gradients that cause air turbulence within the telescope.

Laboratory instrumentation

Among the possible uses of the term is a collection of laboratory test equipment controlled by a computer through an IEEE-488 bus (also known as GPIB for General Purpose Instrument Bus or HPIB for Hewlett Packard Instrument Bus). Laboratory equipment is available to measure many electrical and chemical quantities. Such a collection of equipment might be used to automate the testing of drinking water for pollutants. [1]

1.Instumentation

2. The Astronomy

3. Space instrumentation

4.Exemple of space agency

Summary

List of figure

4.1-NASA


Figure 4.1: NASA's Vehicle Assembly Building (VAB)

NASA stands for National Aeronautics and Space Administration (fig 4.1). NASA is a United States government agency that is responsible for science and technology related to air and space (fig4.1). The Space Age started in 1957 with the launch of the Soviet satellite Sputnik. NASA was created in 1958. The agency was created to oversee U.S. space exploration and aeronautics research.

4.2-What Has NASA Done?

When NASA started, it began a program of human spaceflight. The Mercury, Gemini and Apollo programs helped NASA learn about flying in space and resulted in the first human landing on the moon in 1969. Currently, NASA has astronauts living and working on the International Space Station

NASA's vision: To reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind.

To do that, thousands of people have been working around the world -- and off of it -- for more than 50 years, trying to answer some basic questions. What's out there in space? How do we get there? What will we find? What can we learn there, or learn just by trying to get there, that will make life better here on Earth? [25]

Figure 4.2: NASA has field centers and test and research facilities in several states.

4.3- General conclusion

In this research, I tried to overview in all matters relating to space technology

and that will answer scientists's questions about the origin of human and the secrets of our universe, and the more advanced we were able to get more replied to for that is considered is so important for drive science to the forward and to better.

References

[1]http://en.wikipedia.org/wiki/Instrumentation

[2]http://www.space.com/16014-astronomy.html

[3] http://scienceblogs.com/startswithabang/files/2012/07/Millenium-bare-590x442.jpg

[4] http://www.esa.int/esaKIDSen/SEMX4EBE8JG_OurUniverse_0.html

[5]http://hubpages.com/hub/Different-Types-of-Stars-in-the-Universe

[6]http://en.wikipedia.org/wiki/Planetary_nebula

[7]http://www.ask.com/question/what-is-the-definition-of-a-planet

[8]http://www.space.com/15421-black-holes-facts-formation-discovery-sdcmp.html

[9] http://www.universetoday.com/60072/what-is-a-moon/#ixzz2zQYbm1lZ

[10]http://www.space.com/51-asteroids-formation-discovery-and-exploration.html

[11] http://kids.discovery.com/tell-me/curiosity-corner/science/how-do-telescopes-work

[12] http://www. Astronomy for kids.com

[13] http://en.wikipedia.org/wiki/Optical_telescope

[14]http://www.ehow.com/how-does_4926295_xray-telescopes-work.html

[15] http://www.castlerock.wednet.edu/HS/stello/Astronomy/TEXT/CHAISSON/BG303/HTML/BG30305.htm

[16]http://www.britannica.com/EBchecked/topic/225099/gamma-ray-telescope

[17] http://en.wikipedia.org/wiki/Infrared_telescope

[18]http://www.ehow.com/how-does_4926827_infrared-telescope-work.html#ixzz2ws6oEiLv

[19]http://www.astro.wisc.edu/sirtf/glimpse-about.html

[20]http://spaceplace.nasa.gov/review/cosmic-colors/uv.html

[21]http://wiki.answers.com/Q/What_do_Ultraviolet_Telescopes_Do?#slide=1

[22]http://www.atnf.csiro.au/outreach/education/everyone/radio-astronomy/index.html

[23] http://en.wikipedia.org/wiki/satillate

[24] http://en.wikipedia.org/wiki/Rover

[25]http://www.nasa.gov/audience/forstudents/5-8/features/what-is-nasa-58.html#.U4orqtKSyxU

3.2-Satellites

3.2.1-Definition

A satellite is an object that moves around a larger object. Earth is a satellite because it moves around the sun. The moon is a satellite because it moves around Earth.

But here we are referring to "human made" satellites.

These objects are launched into space and orbit Earth, or another body in space, and carry instruments for collecting information and communicating it back to Earth.

3.2.2-Kinds of Satellites

There are many different kinds of satellites designed for many different purposes. They can be grouped in the following general categories.

This exhibit focuses on the first two categories.

3.2.4-Weather and Atmosphere Monitoring

Are artificial satellite used to gather data on a global basis for improvement of weather forecasting. Information includes cloud cover, storm location, temperature, and heat balance in the earth's atmosphere.

3.2.5-Earth Observation and Mapping.

Are satellites intended for non-military uses such as environmental monitoring, meteorology, map making etc. (See especially Earth Observing System.)

3.2.6- Astronomical and Planetary Exploration

Are satellites used for observation of distant planets, galaxies, and other outer space objects, for example (cassini)(3.12).

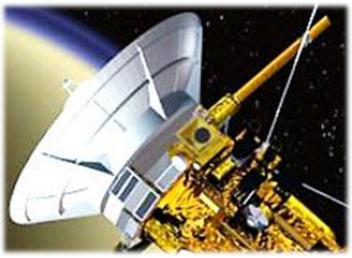


Figure 3.12: Cassini

3.2.7- Communication

Figure 3.13: Communication

Are satellites stationed in space for the purpose of telecommunications. Modern communications satellites typically use geosynchronous orbits, Molniya orbits or Low Earth orbits (fig 3.13).

3.2.8- Navigation (GPS)

Are satellites which use radio time signals transmitted to enable mobile receivers on the ground to determine their exact location. The relatively clear line of sight between the satellites (fig 3.14)and receivers on the ground, combined with ever-improving electronics, allows satellite navigation systems to measure location to accuracies on the order of a few meters in real time

Figure 3.14: GPS

3.2.9- Military:

Anti-Satellite weapons/"Killer Satellites": are satellites that are designed to destroy enemy warheads, satellites, and other space assets.

3.2.10-Space stations

Are man-made orbital structures that are designed for human beings to live on in outer space. A space station (fig 3.15) is distinguished from other manned spacecraft by its lack of major propulsion or landing facilities. Space stations are designed for medium-term living in orbit, for periods of weeks, months, or even years.

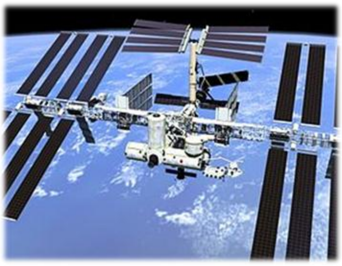


Figure 3.15: space station

3.2.11-Orbit Types (fig 3.16)

3.2.11.1-Centric classifications:

3.2.11.2-Geocentric orbit: An orbit around the planet Earth, such as the Moon or artificial satellites. Currently there are approximately 2465 artificial satellites orbiting the Earth.

3.2.11.3-Heliocentric orbit: An orbit around the Sun. In our Solar System, all planets, comets, and asteroids are in such orbits, as are many artificial satellites and pieces of space debris. Moons by contrast are not in a heliocentric orbit but rather orbit their parent planet.

3.2.11.4-Areocentric orbit: An orbit around the planet Mars, such as bymoons or artificial satellites.

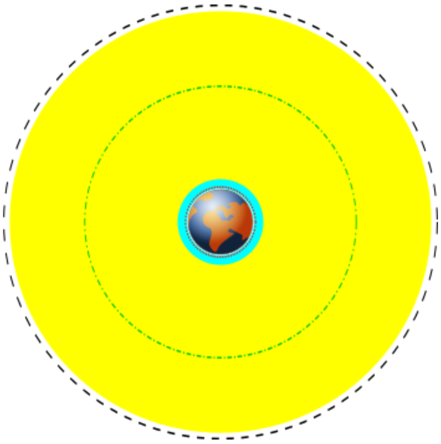


Figure 3.16: Orbit Types

The general structure of a satellite is that it is connected to the earth stations that are present on the ground and connected through terrestrial links.

3.2.12-Altitude classifications (fig 3.17)

3.2.12.1-Low Earth orbit (LEO): Geocentric orbits ranging in altitude from 0–2000 km (0–1240 miles)

3.2.12.2-Medium Earth orbit (MEO): Geocentric orbits ranging in altitude from 2,000 km (1,200 mi) to just below geosynchronous orbit at 35,786 km (22,236 mi). Also known as an intermediate circular orbit.

3.2.12.3-High Earth orbit (HEO): Geocentric orbits above the altitude of geosynchronous orbit 35,786 km (22,236 mi). [23]

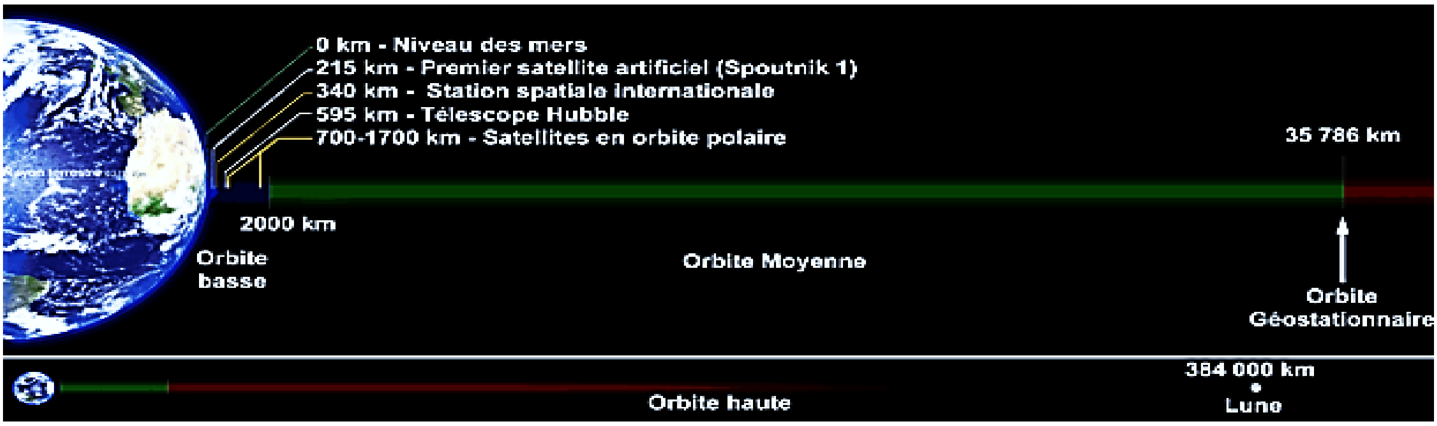


Figure 3.17: Altitude classifications

2.1.1-The Astronomy

Astronomy is the study of the sun, moon, stars, planets, comets, gas, galaxies, gas, dust and other non-Earthly bodies and phenomena. In curriculum for K-4 students, NASA defines astronomy as simple “the study of stars, planets and space.” Astronomy and astrology were historically associated, but astrology is not a science and is no longer recognized as having anything to do with astronomy. Below we discuss the history of astronomy and related fields of study, including cosmology.

Historically, astronomy has focused on observations of heavenly bodies. It is a close cousin to astrophysics. Succinctly put, astrophysics involves the study of the physics of astronomy and concentrates on the behavior, properties, and motion of objects out there. However, modern astronomy includes many elements of the motions and characteristics of these bodies, and the two terms are often used interchangeably today.

Modern astronomers tend to fall into two fields: the theoretical and the observational.

2.1.2-Observational astronomers in the observational field focus on direct study of stars, planets, galaxies, and so forth.

2.1.3-Theoretical astronomers model and analyze how systems may have evolved.

Unlike most other fields of science, astronomers are unable to observe a system entirely from birth to death; the life of worlds, stars, and galaxies span millions to billions of years. As such, astronomers must rely on snapshots of bodies in various stages of evolution to determine how they formed, evolved, and died. Thus, theoretical and observational astronomy tend to blend together, as theoretical scientists use the information actually collected to create simulations, while the observations serve to confirm the models — or to indicate the need for tweaking them.

Astronomy is broken down into a number of subfields, allowing scientists to specialize in particular objects and phenomena.

2.1.4-Planetary astronomers, for instance, focus on the growth, evolution, and death of planets, while solar astronomers spend their time analyzing a single star—our sun. Stellar astronomers turn their eyes to the stars, including the black holes, nebulae, white dwarfs, and supernova that survive stellar deaths.

2.1.5-Galactic astronomers study our galaxy, the Milky Way, while extragalactic astronomers peer outside of it to determine how these collections of stars form, change, and die.

2.1.6-Cosmologists focus on the universe in its entirety, from its violent birth in the Big Bang to its present evolution, all the way to its eventual death. Astronomy is often (not always) about very concrete, observable things, whereas cosmology typically involves large-scale properties of the universe and esoteric, invisible and sometimes purely theoretical things like string theory, dark matter and dark energy, and the notion of multiple universes.

Astronomical observers rely on different wavelengths of the electromagnetic spectrum (from radio waves to visible light and on up to X-rays and gamma rays) to study the wide span of objects in the universe. The first telescopes focused on simple optical studies of what could be seen with the naked eye, and many telescopes continue that today

But as light waves become more or less energetic, they move faster or slower. Different telescopes are necessary to study the various wavelengths. More energetic radiation, with shorter wavelenghts, appears in the form of ultraviolet, x-ray, and gamma-ray wavelengths, while less energetic objects emit longer-wavelength infrared and radio waves.

2.1.7-Astrometry, the most ancient branch of astronomy, is the measure of the sun, moon, and planets. The precise calculations of these motions allows astronomers in other fields to model the birth and evolution of planets and stars, and to predict events such as eclipses, meteor showers, and the appearance of comets.

2.1.8-Early astronomers noticed patterns in the sky and attempted to organize them in order to track and predict their motion. Known as constellations, these patterns helped people of the past to measure the seasons. The movement of the stars and other heavenly bodies was tracked around the world, but was prevalent in China, Egypt, Greece, Mesopotamia, Central America, and India.

The image of an astronomer is a lone soul at a telescope during all hours of the night. In reality, most hard-core astronomy today is done with observations made at remote telescopes — on the ground or in space — that are controlled by computers, with astronomers studying computer-generated data and images.

Since the advent of photography, and particularly digital photography, astronomers have provided amazing pictures of space that not only inform science but enthrall the public

Astronomers and spaceflight programs also contribute to the study of our own planet, when missions primed at looking outward (or travelling to the moon and beyond) look back and snap great pictures of Earth from space. [2]

2.2-The universe

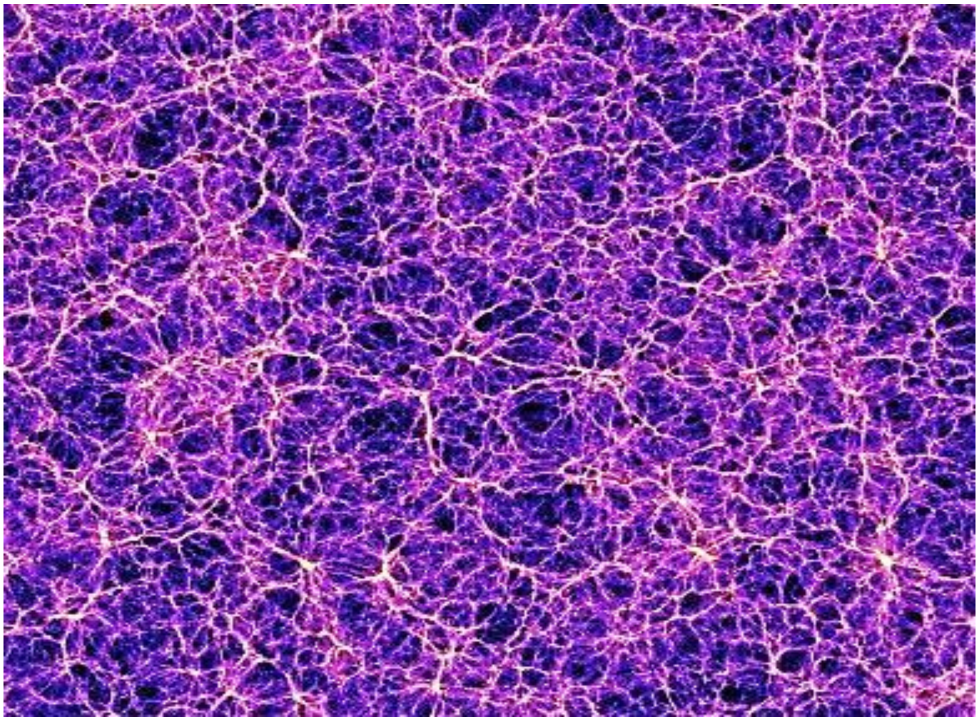


Figure 2.1: Photo of the universe

The Universe (Fig2.1) [3] is everything we can touch, feel, sense, measure or detect. It includes living things, planets, stars, galaxies, dust clouds, light, and even time. Before the birth of the Universe, time, space and matter did not exist.

The Universe contains billions of galaxies, eachcontaining millions or billions of stars. The space between the stars and galaxies is largely empty. However, even places far from stars and planets contain scattered particles of dust or a few hydrogen atoms per cubic centimeter. Space is also filled with radiation (e.g. light and heat), magnetic fields and high energy particles (e.g. cosmic rays).

The Universe is incredibly huge. It would take a modern jet fighter more than a million years to reach the nearest star to the Sun. Travelling at the speed of light (300,000 km per second), it would take 100,000 years to cross our Milky Way galaxy alone.

No one knows the exact size of the Universe, because we cannot see the edge – if there is one. All we do know is that the visible Universe is at least 93 billion light years across. (A light year is the distance light travels in one year – about 9 trillion km.)

The Universe has not always been the same size. Scientists believe it began in a Big Bang, which took place nearly 14 billion years ago. Since then, the Universe has been expanding outward at very high speed. So the area of space we now see is billions of times bigger than it was when the Universe was very young. The galaxies are also moving further apart as the space between them expands [4].

2.3-Galaxy

There are billions of Galaxies in the Universe. Some are very small with only a few million stars. While others could have as many as 400 billion stars, or even more. There are three kinds of Galaxies, Spiral, Elliptical, and Irregular. The only difference between the three is what shape they are

2.3.1-Spiral

Figure 2.2: spiral galaxy

The most beautiful type of galaxies are Spiral Galaxies (fig2.2).Their long twisting arms are areas where stars are being formed.

Where do the spirals come from?
Like ripples in a pond, the spiral arms seen in this kind of galaxy are circling waves. These waves cause new stars to form. That's right, they are like star farmers, planting star seeds where ever they go.

What causes the waves to glow?
Some of the new stars created in the wave are very large. Because of their size these large stars glow brighter than their smaller cousins, causing the nearby dust clouds to glow brightly. Thus any area near one of these waves glows like a fluorescent light.
In other words you can't actually see the waves, the spirals that we see are the glowing clouds illuminated by large, hot stars. As the waves move on the clouds behind them dim down, no longer glowing until another wave passes through.

Why doesn't the whole galaxy shine brightly?
The large bright stars created in the waves don't live very long. Their large size makes them burn all their fuel quickly. Usually they die before they ever leave the wave. Only the smaller stars which do not glow brightly survive to leave the waves they formed in.

2.3.2-Elliptical

The stars found in Elliptical Galaxies are often very old. This is because elliptical galaxies don't actively create new stars. The only stars found within them were created a long time ago. Although they are usually smaller, this type of galaxy can be large. Most have only a few thousand stars, but some can have billions of stars.
The stars in an elliptical galaxy are often very close together making the center look like one giant star. If the Earth were inside an elliptical galaxy it would be bright both day and night.

2.3.3-Irregular Galaxies

Figure 2.3: irregular galaxy

(fig2.3) Irregular Galaxies are simply all the galaxies which are not spiral or elliptical. They can look like anything and have many different characteristics. Many irregular galaxies probably used to be spiral, or elliptical until they had some kind of accident which changed them such as crashing with another galaxy.
Many other irregular galaxies probably were never spiral or elliptical; they simply didn't evolve that way.

2.3.4-The Local Group

There are billions of galaxies in our Universe. Most of these are clumped together in small groups. Our own galaxy which is called The Milky Way Galaxy lies within a group of galaxies that we call The Local Group.

The Local Group consists of about 30 galaxies. The three largest are The Andromeda Galaxy, The Milky Way Galaxy, and Triangulum.

2.4-The stars

When you look at the night sky you can see many beautiful stars. If you are out in the country or camping in the mountains or the desert away from the city lights, you may see thousands of them. You may even be able to see part of the Milky Way. In a town or city, you can't see nearly as many stars because the city lights create a glow in the sky masking many of them.

There are several different kinds of stars in the sky. Some are very big. A couple of stars have been found that are 100 to 200 times larger than the sun. Some very old stars are smaller than the Earth. Scientists study stars and place them in groups based on how they are alike and how they are different

So what is a star?

A star is a huge sphere of very hot, glowing gas. Stars produce their own light and energy by a process called nuclear fusion. Fusion happens when lighter elements are forced to become heavier elements. When this happens, a tremendous amount of energy is created causing the star to heat up and shine. Stars come in a variety of sizes and colors. Our Sun is an average sized yellowish star. Stars which are smaller than our Sun are reddish and larger stars are blue

2.4.1-Types of stars

Stars are often classified according to spectral type. Although they emit all colors of light, spectral classification considers only the peak of this emission as an indicator of the star's surface temperature. Using this system, blue stars are the hottest, and are called O-type. The coolest stars are red and are called M-type. In order of increasing temperature, the spectral classes are M (red), K (orange), G (yellow), F (yellow-white), A (white), B (blue-white), O (blue).

This bland categorization is often abandoned for a more descriptive alternative. As the coolest stars (red) are invariably the smallest, they are called red dwarfs. Conversely, the hottest stars are often called blue giants.

There are a number of physical characteristics that vary for each of the different types of star. These include the surface temperature, luminosity (brightness), mass (weight), radius (size), life time, prevalence in the cosmos, and point in the stellar evolutionary cycle.

When considering these physical features, the different kinds of star are usually compared with our nearest stellar companion, the Sun.

To understand the scale, the notation, 10^{26} means the number has 26 zeroes after it. The types of star identified below will be described in terms of the Sun. For example, a mass of 2 means two solar masses.

2.4.2-Sun: Physical Characteristics (fig2.4)

Lifetime: 10 billion years

Evolution: middle (4.5 billion years)

Luminosity: 3.846×10^{26} W

Temperature: 5,500 °C

Spectral Type: G (yellow)

Radius: 695,500 km

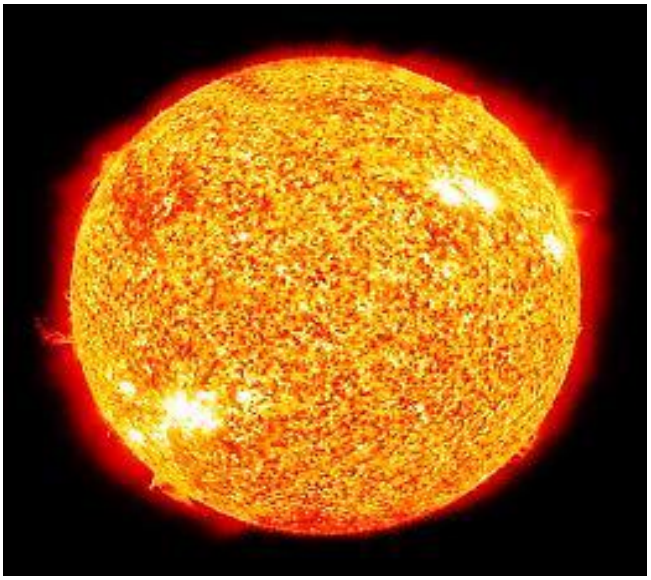


Figure 2.4: our son

Mass: 1.98×10^{30} kg.

2.4.3- Yellow Dwarf Stars:

Lifetime: 4 - 17 billion years

Evolution: early, middle

Temperature: 5,000 - 7,300 °C

Spectral Types: G, F

Luminosity: 0.6 - 5.0

Radius: 0.96 - 1.4

Mass: 0.8 - 1.4

Prevalence: 10%

2.4.4- Orange Dwarf Stars(fig: 2.5)

Lifetime: 17 - 73 billion years

Evolution: early, middle

Temperature: 3,500 - 5,000 °C

Spectral Types: K

Luminosity: 0.08 - 0.6

Radius: 0.7 - 0.96

Figure 2.5: Orange Dwarf Stars

Mass: 0.45 - 0.8

Prevalence: 11%.

The Sun, Alpha Centauri A, and Kepler-22 are yellow dwarfs. These stellar cauldrons are in the prime of their lives because they are burning hydrogen fuel in their cores. This normal functioning places them on the `main sequence', where the majority of stars are found. The designation `yellow dwarf' may be imprecise, as these stars typically have a whiter color. However, they do appear yellow when observed through the Earth's atmosphere.

2.4.5- Red Dwarf Stars (fig: 2.6)

Lifetime: 73 - 5500 billion years

Evolution: early, middle

Temperature: 1,800 - 3,500 °C

Spectral Types: M

Luminosity: 0.0001 - 0.08

Radius: 0.12 - 0.7

Mass: 0.08 - 0.45

Prevalence: 73%

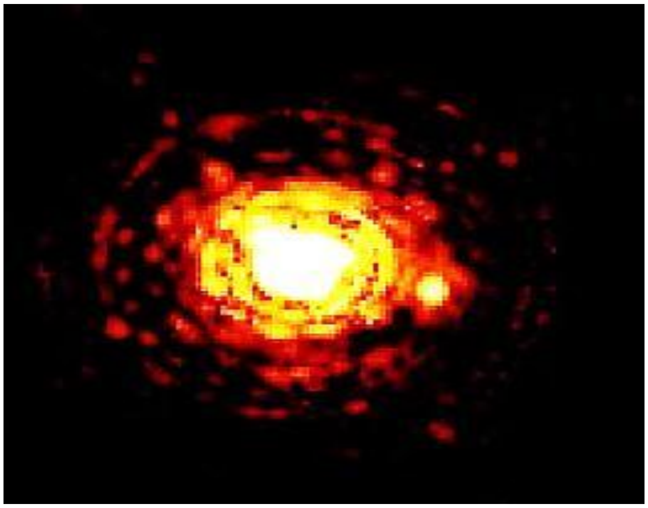


Figure 2.6:RedDwarf Stars

Proxima Centauri, Barnard's Star and Gliese 581 are all red dwarfs. They are the smallest kind of main sequence star. Red dwarfs are barely hot enough to maintain the nuclear fusion reactions required to use their hydrogen fuel. However, they are the most common type of star, owing to their remarkably long lifetime that exceeds the current age of the universe (13.8 billion years). This is due to a slow rate of fusion, and an efficient circulation of hydrogen fuel via convective heat transport.

2.4.6- Brown Dwarfs (fig: 2.7)

Lifetime: unknown (long)

Evolution: not evolving

Temperature: 0 - 1,800 °C

Spectral Types: L, T, Y (after M)

Luminosity: ~0.00001

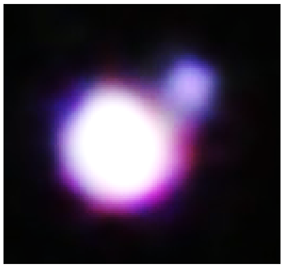


Figure 2.7: Brown Dwarfs

Radius: 0.06 - 0.12

Mass: 0.01 - 0.08

Prevalence: unknown (many)

Brown dwarfs are substellar objects that never accumulated enough material to become stars. They are too small to generate the heat required for hydrogen fusion. Brown Dwarfs constitute the midpoint between the smallest red dwarf stars and massive planets like Jupiter. They are the same size as Jupiter, but to qualify as a brown dwarf, they must be at least 13 times heavier. Their cold exteriors emit radiation beyond the red region of the spectrum, and to the human observer they appear magenta rather than brown. As brown dwarfs gradually cool, they become difficult to identify, and it is unclear how many exist.

2.4.7- Blue Giant Stars (fig: 2.8)

Lifetime: 3 - 4,000 million years

Evolution: early, middle

Temperature: 7,300 - 200,000 °C

Spectral Types: O, B, A

Luminosity: 5.0 - 9,000,000

Radius: 1.4 - 250

Mass: 1.4 - 265

Figure 2.8: Blue Giant Stars

Prevalence: 0.7%

Blue giants are defined here as large stars with at least a slight bluefish coloration, although definitions do vary. A broad definition has been chosen because only about 0.7% of stars fall into this category.

Not all blue giants are main sequence stars. Indeed, the largest and hottest (O-type) burn through the hydrogen in their cores very quickly, causes their outer layers to expand and their luminosity to increase. Their high temperature means they remain blue for much of this expansion (e.g. Rigel), but eventually they may cool to become a red giant, supergiant or hyper giant.

Blue supergiants above about 30 solar masses can begin throw off huge swathes of their outer layers, exposing a super-hot and luminous core. These are called Wolf-Rayet stars. These massive stars are more likely to explode in a supernova before they can cool to reach a later evolutionary stage, such as a red supergiant. After a supernova, the stellar remnant becomes a neutron star or a black hole.

2.4.8- Red Giant Stars (fig:2.9)

Lifetime: 0.1 - 2 billion years

Evolution: late

Temperature: 3,000 - 5,000 °C

Spectral Types: M, K

Luminosity: 100 - 1000

Radius: 20 - 100

Mass: 0.3 - 10

Prevalence: 0.4%

Figure 2.9: RedGiant Stars

Aldebaran and Arcturus are red giants. These stars are in a late evolutionary phase. Red giants would previously have been main sequence stars (such as the Sun) with between 0.3 and 10 solar masses. Smaller stars do not become red giants because, due to convective heat transport, their cores cannot become dense enough to generate the heat needed for expansion. Larger stars become red supergiants or hypergiants.

In red giants, the accumulation of helium (from hydrogen fusion) causes a contraction of the core that raises the internal temperature. This triggers hydrogen fusion in the outer layers of the star, causing it to grow in size and luminosity. Due to a larger surface area, the surface temperature is actually lower (redder). They eventually eject their outer layers to form a planetary nebula, while the core becomes a white dwarf.

2.4.9- Red Supergiant Stars (fig:2.10)

Lifetime: 3 - 100 million years

Evolution: late

Temperature: 3,000 - 5,000 ºC

Spectral Types: K, M

Luminosity: 1,000 - 800,000

Radius: 100 - 1650

Mass: 10 - 40

Prevalence: 0.0001%

Figure 2.10: RedSupergiant Stars

Betelgeuse and Antares are red supergiants. The largest of these types of stars are called red hypergiants. One of these is 1650 times the size of our Sun (NML Cygni), and is the largest known star in the universe.

Like red giants, these stars have swelled up due to the contraction of their cores; however, they typically evolve from blue giants and supergiants with between 10 and 40 solar masses. Higher mass stars shed their layers too quickly, becoming Wolf-Rayet stars, or exploding in supernovae. Red supergiants eventually destroy themselves in a supernova, leaving behind a neutron star or black hole.

2.4.10- White Dwarfs (fig: 2.11)

Lifetime: 10^{15}- 10^{25} years

Evolution: dead, cooling

Temperature: 4,000 - 150,000 ºC

Spectral Types: D (degenerate)

Luminosity: 0.0001 - 100

Radius: 0.008 - 0.2

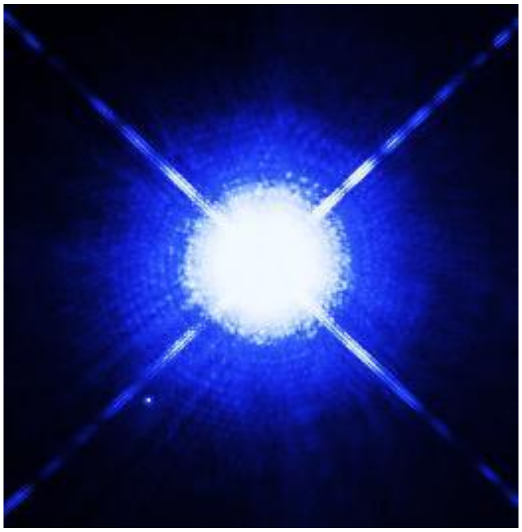


Figure 2.11: White Dwarfs

Mass: 0.1 - 1.4

Prevalence: 4%

Stars less than 10 solar masses will shed their outer layers to form planetary nebulae. They will typically leave behind an Earth-sized core of less than 1.4 solar masses. This core will be so dense that the electrons within its volume will be prevented from occupying any smaller region of space (becoming degenerate). This physical law (Pauli's exclusion principle) prevents the stellar remnant from collapsing any further.

The remnant is called a white dwarf, and examples include Sirius B and Van Maanen's star. More than 97% of stars are theorized to become white dwarfs. These super-hot structures will remain hot for trillions of years before cooling to become black dwarfs.

<u>2.4.11-Black Dwarfs (fig: 2.12)</u>

Lifetime: unknown (long)

Evolution: dead

Temperature: < -270 °C

Spectral Types: none

Luminosity: infinitesimal

Radius: 0.008 - 0.2

Mass: 0.1 - 1.4

Prevalence: ~0%

Figure 2.12: Black Dwarfs

Once a star has become a white dwarf, it will slowly cool to become a black dwarf. As the universe is not old enough for a white dwarf to have cooled sufficiently, no black dwarfs are thought to exist at this time.

<u>2.4.12- Neutron Stars (fig:2.13)</u>

Lifetime: unknown (long)

Evolution: dead, cooling

Temperature: < 2,000,000 ºC

Spectral Types: D (degenerate)

Luminosity: ~0.000001

Radius: 5 - 15 km

Mass: 1.4 - 3.2

Prevalence: 0.7%

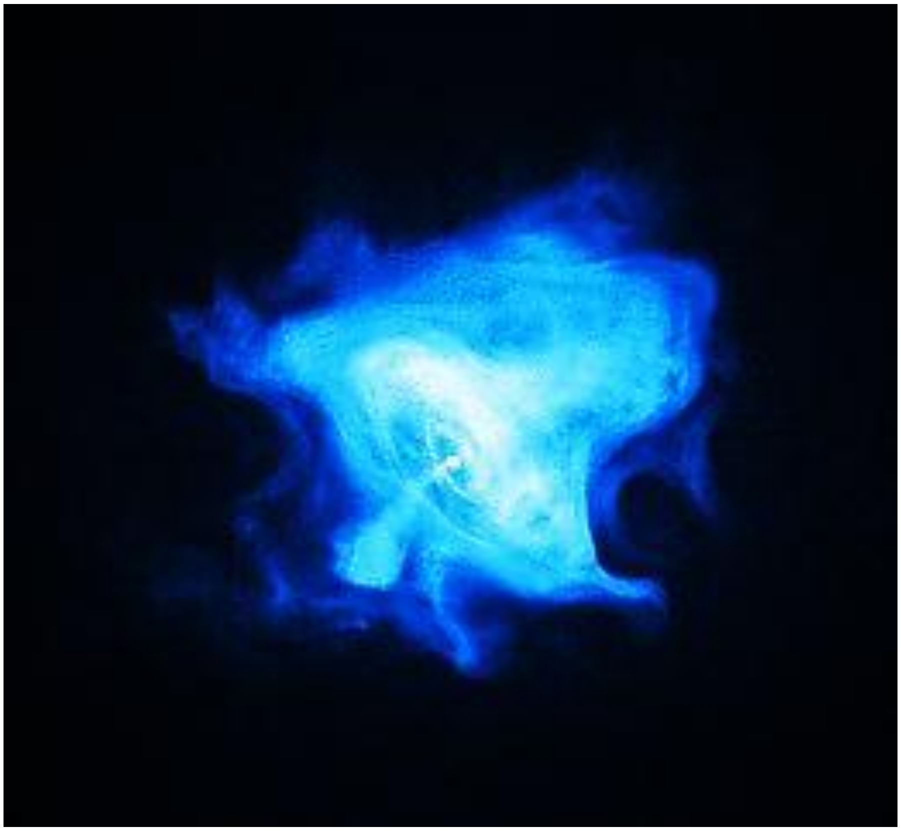


Figure 2.13:Neutron Stars

When stars larger than about 10 solar masses exhaust their fuel, their cores dramatically collapse to form neutron stars. If the core has a mass above 1.4 solar masses, electron degeneracy will be unable to halt the collapse. Instead, the electrons will fuse with protons to produce neutral particles called neutrons, which are compressed until they can no longer occupy a smaller space (becoming degenerate).

The collapse throws off the outer layers of the star in a supernova explosion. The stellar remnant, composed almost entirely of neutrons, is so dense that it occupies a radius of about 12 km. Due to conservation of angular momentum; neutron stars are often left in a rapidly rotating state called a pulsar.

Stars larger than 40 solar masses with cores larger than about 2.5 solar masses are likely to become black holes instead of neutron stars. For a black hole to form, the density must become great enough to overcome neutron degeneracy, causing a collapse into a gravitational singularity.

While stellar classification is more precisely described in terms of spectral type, this does very little to fire the imagination of those who will become the next generation of astrophysicists. There are many different types of stars in the universe, and it's no surprise that those with the most exotic sounding names receive the greatest levels of attention.[5]

2.5-Planetary Nepal (fig: 2.14)

A planetary nebula, often abbreviated as PN or plural PNe, is a kind of emission nebula consisting of an expanding glowing shell of ionized gas ejected from old red giant stars late in their lives. The word 'nebula' is Latin for mist or cloud and the term 'planetary nebula' is a misnomer that originated in the 1780s with astronomer William Herschel because when viewed through his telescope, these objects appeared to him to be newly forming planetary systems. Herschel's name for these objects was adopted by astronomers and has not been changed. They are a relatively short-lived phenomenon, lasting a few tens of thousands of years, compared to a typical stellar lifetime of several billion years.

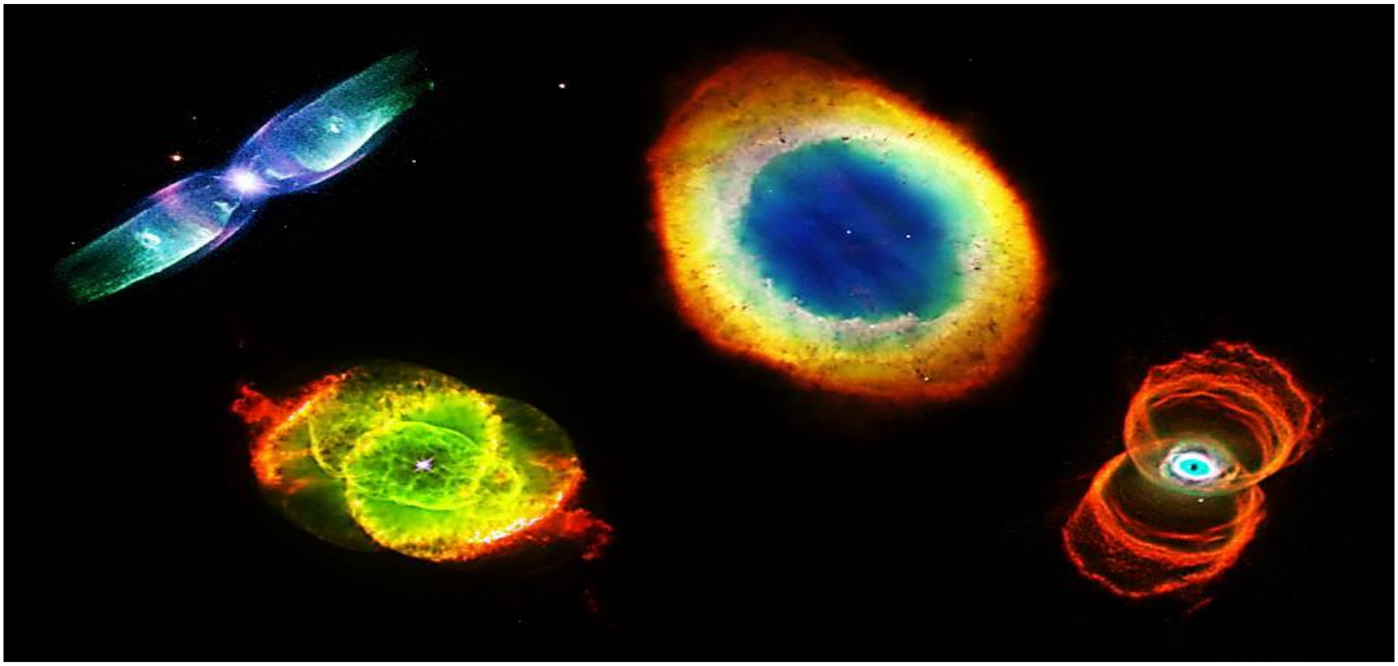


Figure 2.14 : Planetary Nepal

A mechanism for formation of most planetary nebulae is thought to be the following: at the end of the star's life, during the red giant phase, the outer layers of the star are expelled via pulsations and strong stellar winds. The exposed hot, luminous core emits ultraviolet radiation that ionizes the ejected outer layers of the star. This energized shell of nebulous gas reradiates the absorbed ultraviolet energy at visible frequencies and appears as a planetary nebula.

Planetary nebulae may play a crucial role in the chemical evolution of the galaxy, returning material to the interstellar medium from stars where heavy elements, the products of nucleosynthesis (such as carbon, nitrogen, oxygen and calcium), have been created. In more distant galaxies, planetary nebulae may be the only objects that can be resolved and yield useful information about chemical abundances.

In recent years, Hubble Space Telescope images have revealed many planetary nebulae to have extremely complex and varied morphologies. About one-fifth are roughly spherical, but the majorities are not spherically symmetric. The mechanisms which produce such a wide variety of shapes and features are not yet well understood, but binary central stars, stellar winds and magnetic fields may play a role. [6]

2.6-Solar system

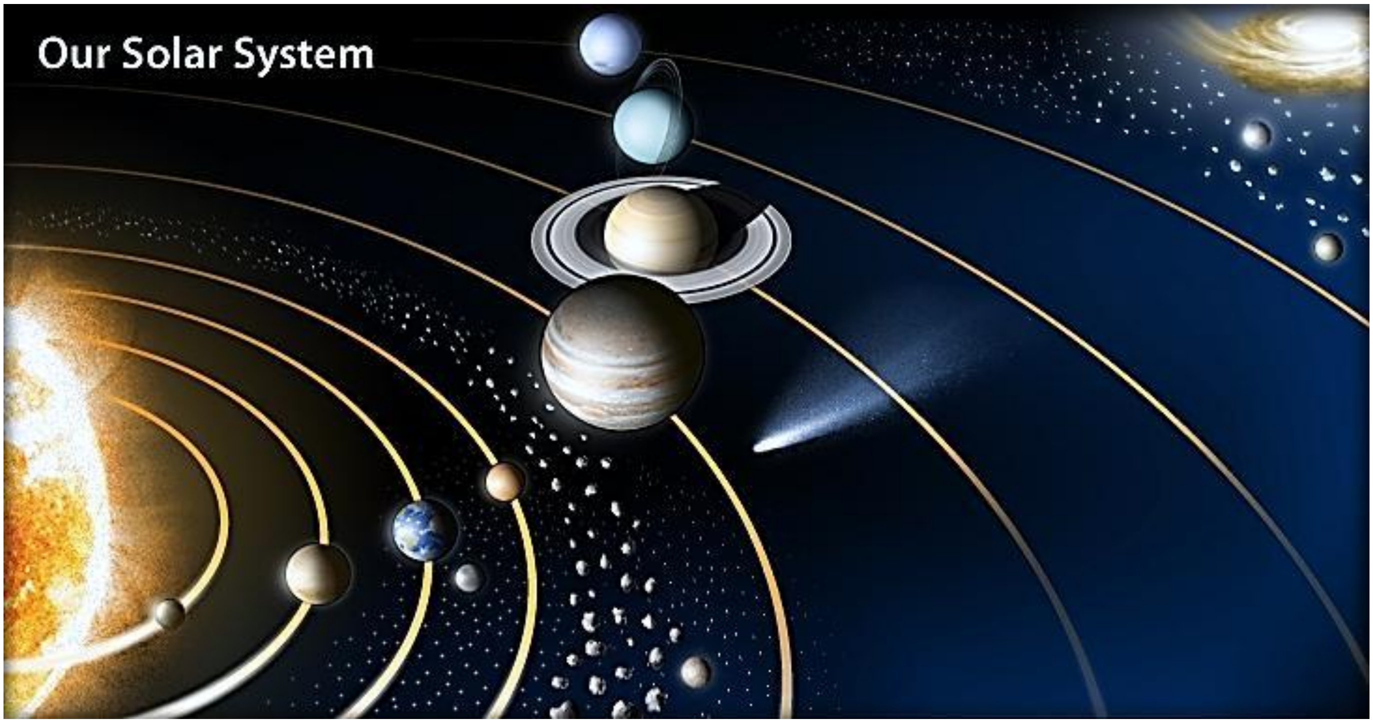


Figure 2.15: Our Solar system

The Solar System is made up of all the planets that orbit our Sun. In addition to planets, the Solar System also consists of moons, comets, asteroids, minor planets, and dust and gas. (fig: 2.15) Everything in the Solar System orbits or revolves around the Sun. The Sun contains around 98% of all the material in the Solar System. The larger an object is, the more gravity it has. Because the Sun is so large, its powerful gravity attracts all the other objects in the Solar System towards it. At the same time, these objects, which are moving very rapidly, try to fly away from the Sun, outward into the emptiness of outer space. The result of the planets trying to fly away, at the same time that the Sun is trying to pull them inward is that they become trapped half-way in between. Balanced between flying towards the Sun, and escaping into space, they spend eternity orbiting around their parent star.

2.7-The planets

The term planet is defined as a celestial body orbiting a star or stellar remnant that is massive enough to be rounded by its own gravity. The planets of the solar system are either gas giants; Jupiter, Saturn, Uranus, and Neptune or smaller rocky bodies; Mercury, Venus, Earth, Mars and Pluto. [7]

2.8-The black holes

Black holes are some of the strangest and most fascinating objects found in outer space. They are objects of extreme density; with such strong gravitational attraction that even light cannot escape from their grasp if it comes near enough.

Albert Einstein first predicted black holes in 1916 with his general theory of relativity. The term "black hole" was coined in 1967 by American astronomer John Wheeler, and the first one was discovered in 1971. [8]

2.9-Moon

Before the invention of the telescope in the early 1600′s, man just knew of the Moon (fig 2.16)- a round, mysterious astronomical object that people would gaze up to in the night sky. As time progressed however, astronomers discovered that the moon isn’t exactly unique to earthlings, and other planets had their own moons. So exactly what is a moon?

Figure 2.16: Our Moon

A moon is defined to be a celestial body that makes an orbit around a planet, including the eight major planets, dwarf planets, and minor planets. A moon may also be referred to as a natural satellite, although to differentiate it from other astronomical bodies orbiting another body, e.g. a planet orbiting a star, the term moon is used exclusively to make a reference to a planet’s natural satellite.

The first moons to be discovered outside of the Earth’s moon were the Galilean moons of Jupiter, named after astronomer and discoverer Galileo galilee. The moons Io, Europa, Ganymede, and Calisto are Jupiter’s largest and only the first four to be revealed, as to date, the planet has 63 moons.

Other than the four Galilean moons, Saturn’s Titan and Neptune’s Triton are two other moons which are comparable in size to the Earth’s Moon. In fact, these seven moons are the largest natural satellites in the solar system, measuring more than 3,000 kilometers in diameter. Only the inner planets Mercury and Venus have no moons.

An interesting fact about some of the solar system’s largest moons that most people may not be aware of is that a few of them are geologically active. While we may not see the Moon spewing lava or displaying any evidence of tectonic activity, Jupiter’s Io and Europa, Saturn’s Titan and Enceladus, and Neptune’s Triton have been found to be volcanically active bodies.

If the moon count had a grand total of just one in the olden times, that number has ballooned to 336 as of July 2009, with 168 moons orbiting the six planets, while the rest are moons of dwarf planets, asteroids moons, and natural satellites of Trans-Neptunian objects. [9]

2.10-Asteroids and comets

Asteroids are small, airless rocky worlds revolving around the sun that are too small to be called planets. They are also known as planetoids or minor planets. In total, the mass of all the asteroids is less than that of Earth's moon. But despite their size, asteroids can be dangerous. Many have hit Earth in the past, and more will crash into our planet in the future. That's one reason scientists study asteroids and are eager to learn more about their numbers, orbits and physical characteristics. If an asteroid is headed our way, we want to know that.

Most asteroids lie in a vast ring between the orbits of Mars and Jupiter. This main asteroid belt holds more than 200 asteroids larger than 60 miles (100 kilometers) in diameter. Scientists estimate the asteroid belt also contains more than 750,000 asteroids larger than three-fifths of a mile (1 km) in diameter and millions of smaller ones. Not everything in the main belt is an asteroid — for instance, comets have recently been discovered there, and Ceres, once thought of only as an asteroid, is now also considered a dwarf planet.

Many asteroids lie outside the main belt. For instance, a number of asteroids called Trojans lie along Jupiter's orbital path. Three groups -Aton’s, Amor’s, and Apollo’s- known as near-Earth asteroids orbit in the inner solar system and sometimes cross the path of Mars and Earth.

2.10.1-Formation

Asteroids are leftovers from the formation of our solar system about 4.6 billion years ago. Early on, the birth of Jupiter prevented any planetary bodies from forming in the gap between Mars and Jupiter, causing the small objects that were there to collide with each other and fragment into the asteroids seen today.

2.10.2-Physical characteristics

Asteroids can reach as large as Ceres, which is 940 km (about 583 miles) across. On the other hand, one of the smallest, discovered in 1991 and named 1991 BA, is only about 20 feet (6 meters) across.

Nearly all asteroids are irregularly shaped, although a few are nearly spherical, such as Ceres. They are often pitted or cratered — for instance, Vesta has a giant crater some 285 miles (460 km) in diameter.

As asteroids revolve around the sun in elliptical orbits, they rotate, sometimes tumbling quite erratically. More than 150 asteroids are also known to have a small companion moon, with some having two moons. Binary or double asteroids also exist, in which two asteroids of roughly equal size orbit each other, and triple asteroid systems are known as well. Many asteroids seemingly have been captured by a planet's gravity and become moons — likely candidates include among Mars' moons Phobos and Deimos and most of the distant outer moons of Jupiter, Saturn, Uranus and Neptune.

The average temperature of the surface of a typical asteroid is minus 100 degrees F (minus 73 degrees C). Asteroids have stayed mostly unchanged for billions of years — as such, research into them could reveal a great deal about the early solar system.

2.10.3-Classification

In addition to classifications of asteroids based on their orbits, most asteroids fall into three classes based on composition. The C-type or carbonaceous are greyish in color and are the most common, including more than 75 percent of known asteroids. They probably consist of clay and stony silicate rocks, and inhabit the main belt's outer regions. The S-type or silicaceous asteroids are greenish to reddish in color, account for about 17 percent of known asteroids, and dominate the inner asteroid belt.

They appear to be made of silicate materials and nickel-iron. The M-type or metallic asteroids are reddish in color, make up most of the rest of the asteroids, and dwell in the middle region of the main belt. They seem to be made up of nickle-iron. There are many other rare types based on composition as well — for instance, V-type asteroids typified by Vesta have a basaltic, volcanic crust.

2.10.4-Earth impacts

Ever since Earth formed about 4.5 billion years ago, asteroids and comets have routinely slammed into the planet. The most dangerous asteroids are extremely rare, according to NASA.

An asteroid capable of global disaster would have to be more than a quarter-mile wide. Researchers have estimated that such an impact would raise enough dust into the atmosphere to effectively create a "nuclear winter," severely disrupting agriculture around the world. Asteroids that large strike Earth only once every 1,000 centuries on average, NASA officials say.

Smaller asteroids that are believed to strike Earth every 1,000 to 10,000 years could destroy a city or cause devastating tsunamis.

On Feb. 15, 2013, an asteroid slammed into the atmosphere over the Russian city of Chelyabinsk, creating a shock wave that injured 1,200 people. The space rock is thought to have measured about 65 feet (20 meters) wide when it entered Earth's atmosphere.

Dozens of asteroids have been classified as "potentially hazardous" by the scientists who track them. Some of these, whose orbits come close enough to Earth, could potentially be perturbed in the distant future and sent on a collision course with our planet. Scientists point out that if an asteroid is found to be on a collision course with Earth 30 or 40 years down the road, there is time to react. Though the technology would have to be developed, possibilities include exploding the object or diverting it. [Image Gallery: Potentially Dangerous Asteroids]

For every known asteroid, however, there are many that have not been spotted, and shorter reaction times could prove more threatening.

When an asteroid, or a part of it, crashes into Earth, it's called a meteorite. Here are typical 2.10.5-

2.10.5-compositions

2.10.5.1-Iron meteorites

•Iron 91 percent

•Nickel 8.5 percent

•Cobalt 0.6 percent

2.10.5.2-Stony Meteorites

•Oxygen 36 percent

•Iron 26 percent

•Silicon 18 percent

•Magnesium 14 percent

•Aluminum 1.5 percent

•Nickel 1.4 percent

•Calcium 1.3 percent

2.10.6-Discovery

In 1801,while making a star map, Italian priest and astronomer Giuseppe Piazzi accidentally discovered the first and largest asteroid, Ceres, orbiting between Mars and Jupiter. Ceres accounts for a quarter of all the mass of all the thousands of known asteroids in or near the main asteroid belt.

2.10.7-Naming

Since the International Astronomical Union is less strict on how asteroids are named when compared to other bodies, there are asteroids named after Mr. Spock of "Star Trek" and rock musician Frank Zappa as well as more solemn tributes, such as the seven asteroids named for the crew of the Space Shuttle Columbia killed in 2003. Naming asteroids after pets is no longer allowed.

Asteroids are also given numbers — for example, 99942 Apophis.

2.10.8-Exploration

The first spacecraft to take close-up images of asteroids was NASA's Galileo in 1991, which also discovered the first moon to orbit an asteroid in 1994.

In 2001, after NASA's NEAR spacecraft intensely studied the near-earth asteroid Eros for more than a year from orbit, mission controllers decided to try and land the spacecraft. Although it wasn't designed for landing, NEAR successfully touched down, setting the record as the first to successfully land on an asteroid.

In 2006, Japan's Hayabusa became the first spacecraft to land on and take off from an asteroid. It returned to Earth in June 2010, and the samples it recovered are currently under study.

NASA's Dawn mission, launched in 2007, began exploring Vesta in 2011 and is slated to explore Ceres in 2015 and will be the first spacecraft to visit either body.

In 2012, a company called Planetary Resources, Inc. announced plans to eventually send a mission to a space rock to extract water and mine the asteroid for precious metals. [10]

3.3.1-The space craft

A spacecraft is a vehicle, vessel or machine designed to fly in outer space. Spacecraft are used for a variety of purposes, including communications, earth observation, meteorology, navigation, planetary exploration and transportation of humans and cargo.
On a sub-orbital spaceflight, a spacecraft enters space and then returns to the surface, without having gone into an orbit. For orbital spaceflights, spacecraft enter closed orbits around the Earth or around other celestial bodies. Spacecraft used for human spaceflight carry people on board as crew or passengers from start or on orbit (space stations) only, while those used for robotic space missions operate either autonomously or telerobotically. Robotic spacecraft used to support scientific research are space probes. Robotic spacecraft that remain in orbit around a planetary body are artificial satellites. Only a handful of interstellar probes, such as Pioneer 10 and 11, Voyager 1 and 2, and New Horizons, are currently on trajectories that leave our Solar System.

Orbital spacecraft may be recoverable or not. By method of reentry to Earth they may be divided in non-winged space capsules and winged space planes.

Currently, humanity has achieved space flight but only twenty-four nations actually have spacefaring technology: Russia (Roscosmos, the Russian Space Forces), the United States (NASA, the US Air Force, Space X (a U.S private aerospace company)), the member states of the European Space Agency, the People's Republic of China (China National Space Administration), Japan (Japan Aerospace Exploration Agency), and India (Indian Space Research Organization).

3.3.2Rover (space exploration)

A rover (or sometimes planetary rover) is a space exploration vehicle designed to move across the surface of a planet or other celestial body. Some rovers have been designed to transport members of a human spaceflight crew for example: Apollo 15 Lunar Rover (fig 3.18); others have been partially or fully autonomous robots (fig 3.19). Rovers usually arrive at the planetary surface on a lander-style spacecraft.

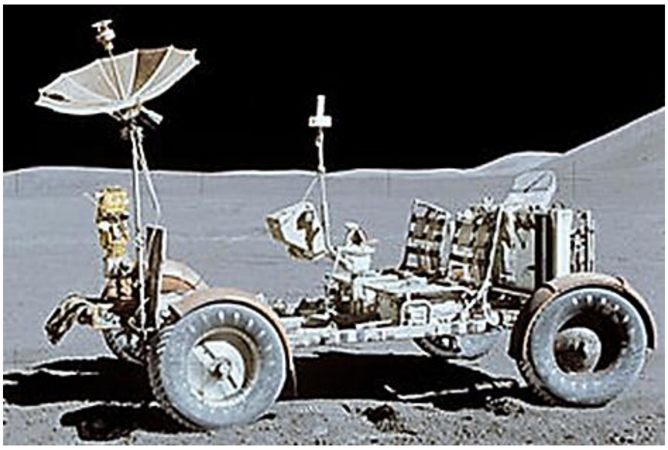


Figure3.18 :Apollo 15 Lunar Rover

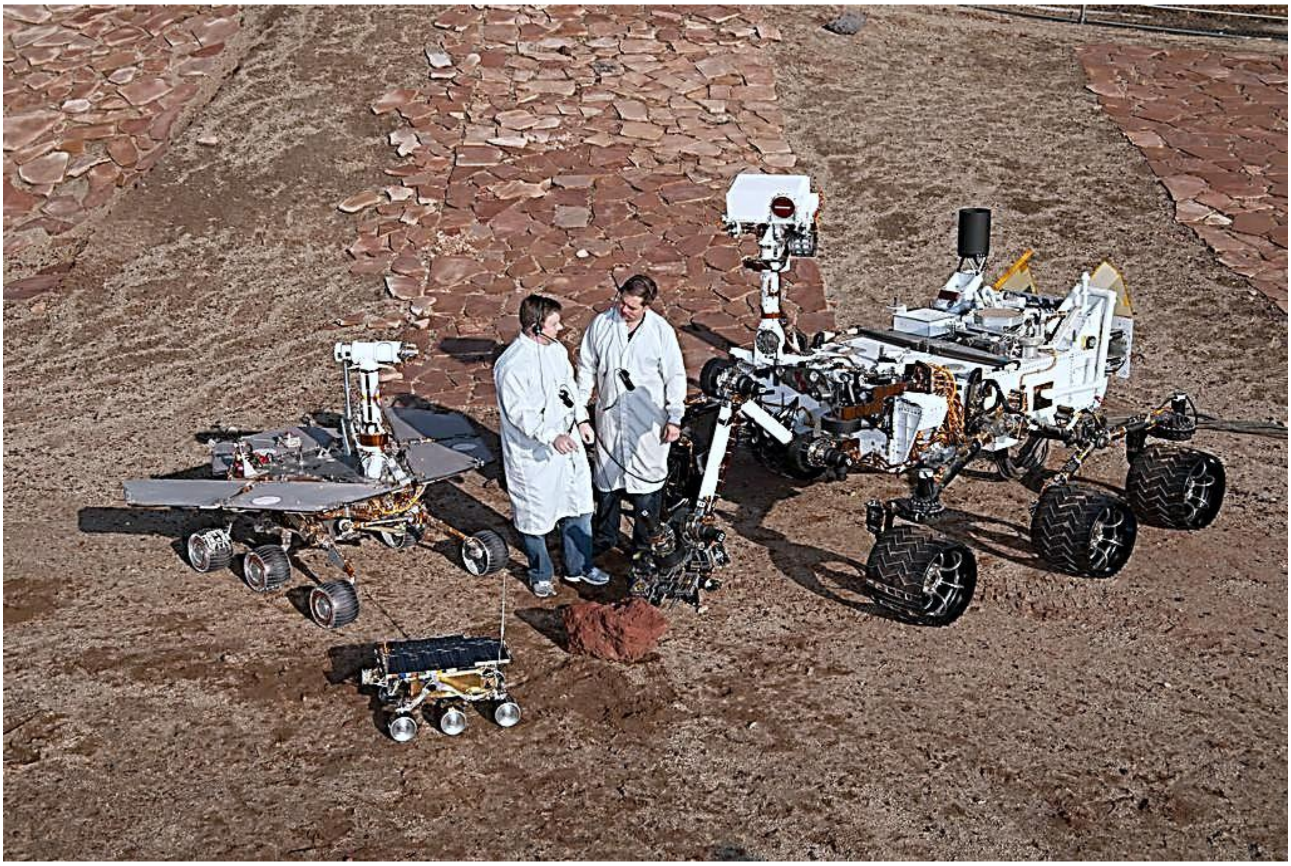


Figure 3.19: Three different Mars rover designs; Sojourner, MER and Curiosity.

3.3.3- Comparison with space probes of other types

Rovers have several advantages over stationary landers: they examine more territory and they can be directed to interesting features. If they are solar powered, they can place themselves in sunny positions to weather winter months. They can also advance the knowledge of how to perform very remote robotic vehicle control which is necessarily semi-autonomous due to the finite speed of light.

Their advantages over orbiting spacecraft are that they can make observations to a microscopic level and can conduct physical experimentation. Disadvantages of rovers compared to orbiters are the higher chance of failure, due to landing and other risks, and that they are limited to a small area around a landing site which itself is only approximately anticipated

3.3.4-Features

Rovers have to withstand high levels of acceleration, high and low temperatures, pressure, dust, corrosion, cosmic rays, remaining functional without repair for a needed period of time.

Mars rover Sojourner in cruise configuration

3.3.5- Compactness

Rovers are usually packed for placing in a spacecraft, because it has limited capacity, and have to be deployed. They are also attached to a spacecraft, so devices for removing these connections are installed.

3.3.6- Autonomy

Rovers which land on celestial bodies far from the Earth, such as the Mars Exploration Rovers, cannot be remotely controlled in real-time since the speed at which radio signals travel is far too slow for real time or near-real time communication. For example, sending a signal from Mars to Earth takes between 3 and 21 minutes. These rovers are thus capable of operating autonomously with little assistance from ground control as far as navigation and data acquisition are concerned, although they still require human input for identifying promising targets in the distance to which to drive, and determining how to position itself to maximize solar energy. Giving a rover some rudimentary visual identification capabilities to make simple distinctions can allow engineers to speed up the reconnaissance.

3.3.7- History

3.3.7.1- Lunokhod 1A

The Soviet rover was intended to be the first roving remote-controlled robot on the Moon, but crashed during a failed start of the launcher 19 February 1969

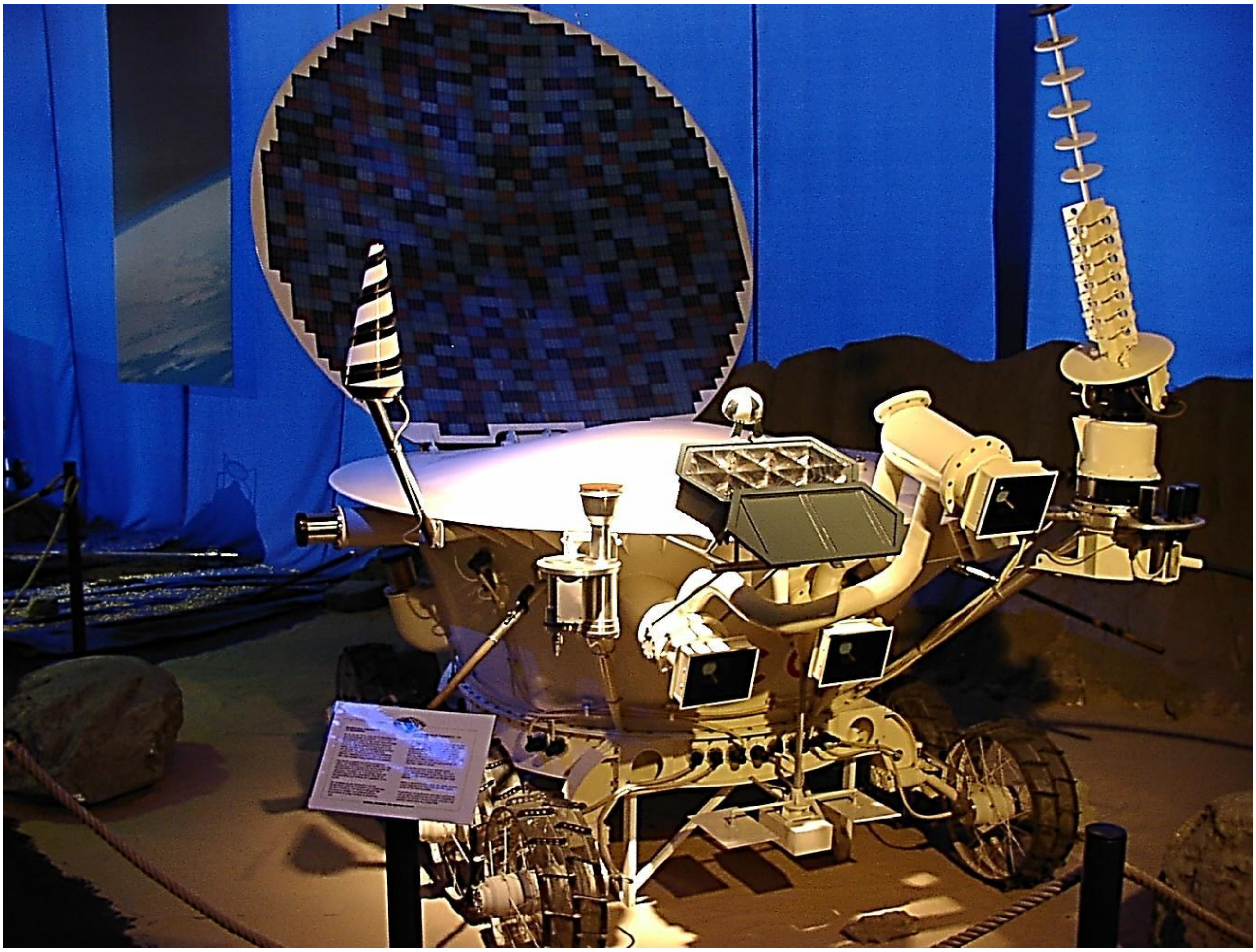
3.3.7.2- The Lunokhod 1

The Lunokhod 1 rover landed on the Moon in November 1970. It was the first roving remote-controlled robot to land on any celestial body. The Soviet Union launched Lunokhod 1 aboard the Luna 17 spacecraft on November 10, 1970, and it entered lunar orbit on November 15. The spacecraft soft-landed in the Sea of Rains region on November 17. The lander had dual ramps from which Lunokhod 1 could descend to the lunar surface, which it did at 06:28 UT. From November 17, 1970 to November 22, 1970 the rover drove 197 m, and during 10 communication sessions returned 14 closes up pictures of the Moon and 12 panoramic views. It also analyzed the lunar soil. The last successful communications session with Lunokhod 1 was on September 14, 1971. Having worked for 11 months, Lunokhod 1 held the durability record for space rovers for more than 30 years, until a new record was set by the Mars Exploration Rovers.

3.3.7.8- Apollo Lunar Roving Vehicle

NASA included Lunar Roving Vehicles in three Apollo missions: Apollo 15 (which landed on the Moon July 30, 1971), Apollo 16 (which landed April 21, 1972) and Apollo 17 (which landed December 11, 1972).

3.3.7.9- Lunokhod 2



The Lunokhod 2 (fig 3.20) was the second of two unmanned lunar rovers landed on the Moon(fig 3.21) by the Soviet Union as part of the Lunokhod program. The rover became operational on the Moon on 16 January 1973. It was the second roving remote-controlled robot to land on any celestial body. The Soviet Union launched Lunokhod 2 aboard the Luna 21 spacecraft on January 8, 1973, and it entered lunar orbit on January 12. The spacecraft soft-landed in the eastern edge of the Mare Serenitatis region on January 15. Lunokhod 2 descended from the lander's dual ramps to the lunar surface at 01:14 UT on 16 January. Lunokhod 2 operated for about 4 months, covered 37 km (23 mi) of terrain, including hilly upland areas and rilles, and sent back 86 panoramic images and over 80,000 TV pictures. Based on wheel rotations Lunokhod 2 was thought to have covered 37 km but

Russian scientists at the Moscow State University of Geodesy and Cartography (MIIGAiK) have revised that to an estimated distance of about 42.1 to 42.2 km based on Lunar Reconnaissance Orbiter (LRO) images of the lunar surface.

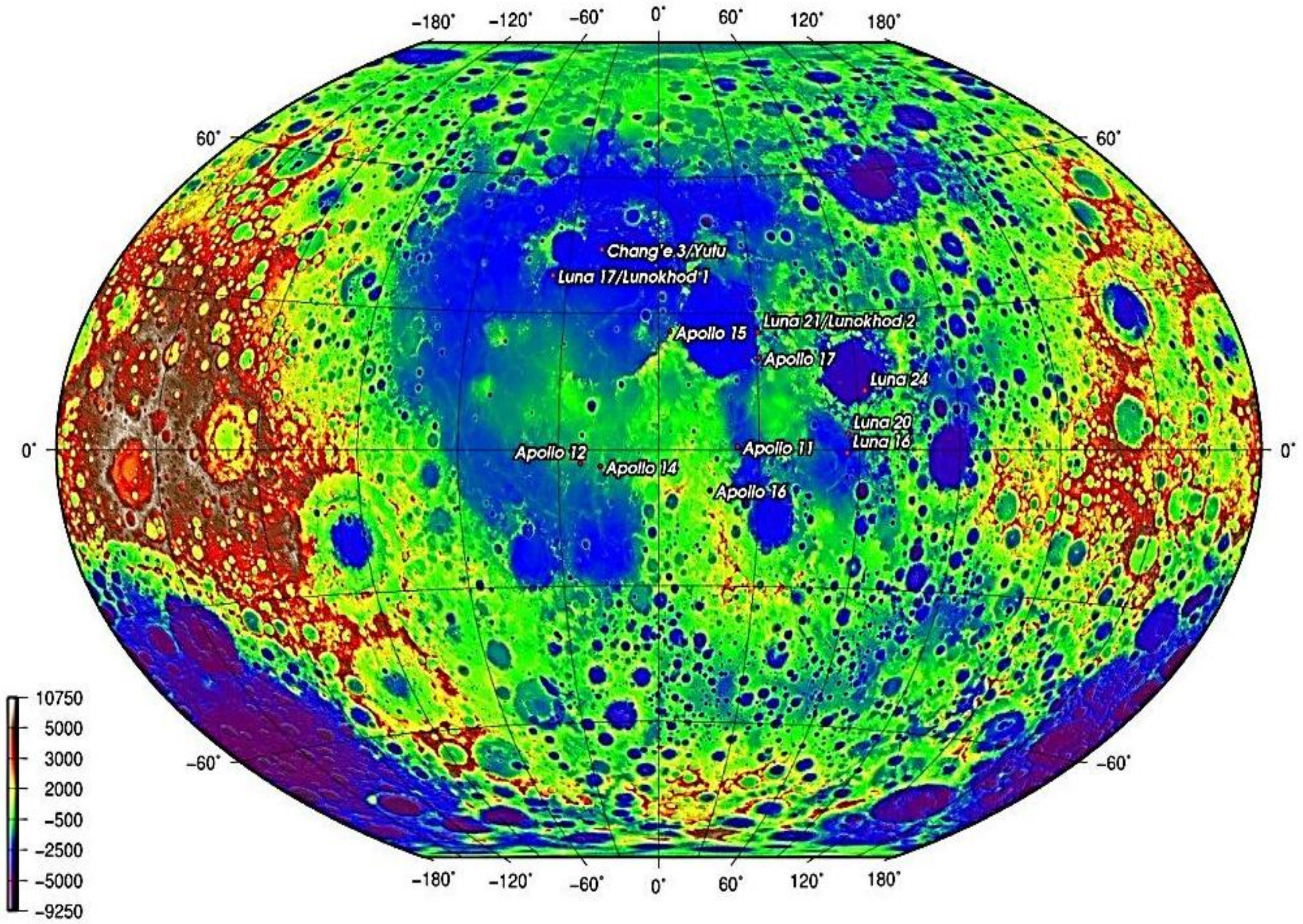


Figure 3.21:Landing sites of sample return and rover missions

3.3.7.10- Mars Exploration Rover B Opportunity

Opportunity is a robotic rover on the planet Mars, active since 2004. It is the remaining rover in NASA's ongoing Mars Exploration Rover Mission. Launched from Earth on July 7, 2003, it landed on the Martian Meridiani Planum on 25 January 2004 at 05:05 Ground UTC (about 13:15 local time), three weeks after its twin Spirit (MER-A) touched down on the other side of the planet.

3.3.7.11- Mars Science Laboratory Rover "Curiosity"

On 26 November 2011, NASA's Mars Science Laboratory mission (Fig 3.22) was successfully launched for Mars. The mission successfully landed the robotic "Curiosity" rover on the surface of Mars in August 2012, whereupon the rover is currently helping to determine whether Mars could ever have supported life, and search for evidence of past or present life on Mars[24]

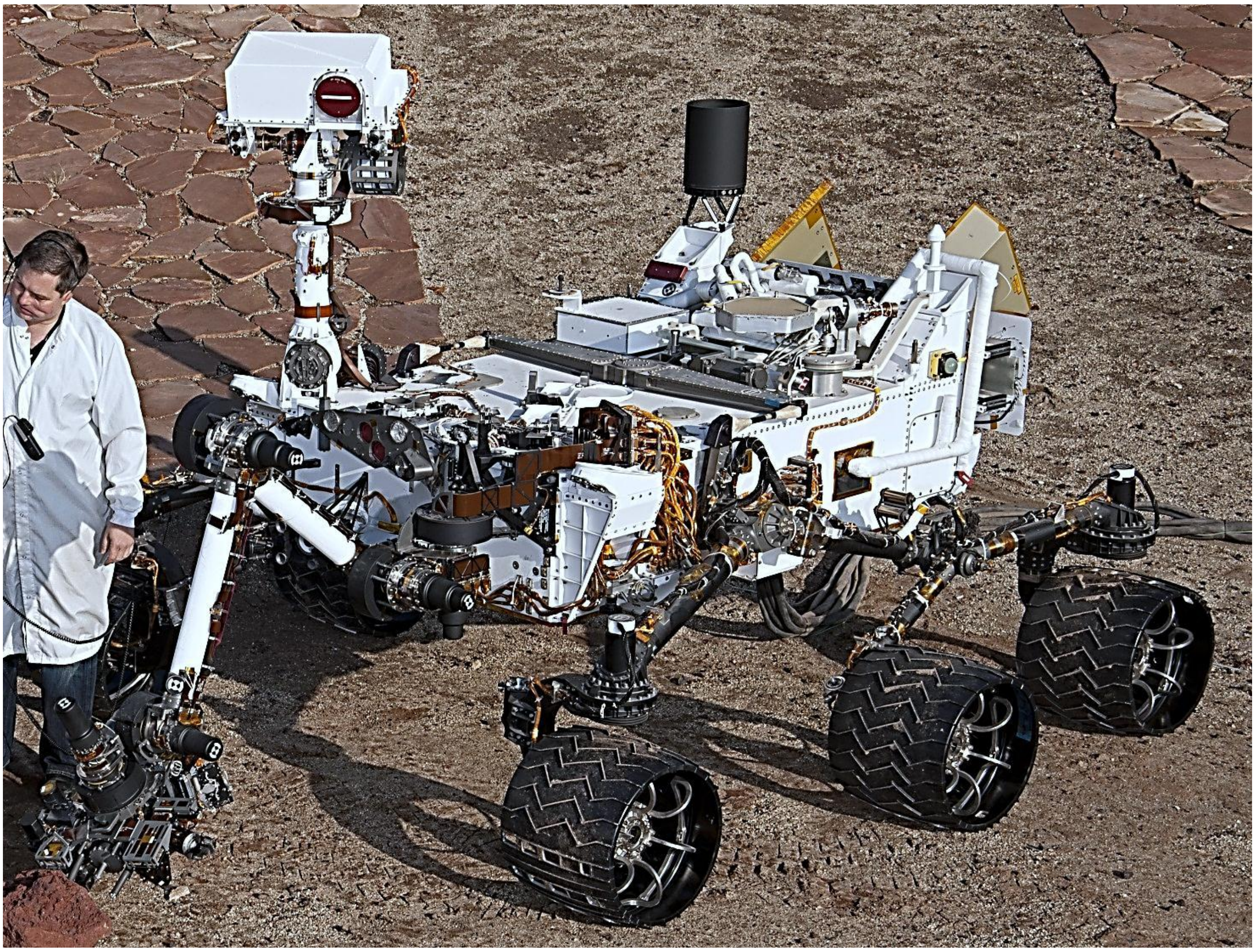


Figure 3.22 : Curiosity

3.1- The telescope

3.1.1-What is telescope?

The purpose of a telescope is to make objects that are far away from you appear closer, so you can see them better. You can use a telescope to see the writing on a dime that's 150 feet (55 meters) away from you. Why can't you see the writing at this distance without a telescope? Because the object is so far away, it doesn't take up much room on your retina (the "movie screen" inside your eye). A telescope, however, magnifies the image that you see, so it takes up more room on your retina. A magnifying glass also enlarges an image so that it takes up more room on your retina so you can see it better. The larger the lens or mirror used in a telescope, the more light the telescope can collect. The more light you get, the brighter the image is and the clearer you can see it. [11]

As time went on, one theory about the night sky became widely accepted. The thought was that the Earth lay inside a glass sphere or ball, and that the stars were simply holes in that ball through which light from the heavens could pass. [12]

3.1.2.1-Optical telescopes

An optical telescope(Fig 3.1) is a telescope that gathers and focuses light, mainly from the visible part of the electromagnetic spectrum, to create a magnified image for direct view, or to make a photograph, or to collect data through electronic image sensors.

Figure3.1: optical telescope

There are three primary typesof optical telescope:

refractors, which use lenses (dioptrics)

reflectors, which use mirrors (catoptrics)

catadioptric telescopes, which combine lenses and mirrors.

A telescope's light gathering power

and ability to resolve small detail is directly related to the diameter (or aperture) of its objective (the primary lens or mirror that collects and focuses the light). The larger the objective, the more light the telescope collects and the finer detail it resolves.

People use telescopes and binoculars for activities such as observational astronomy, ornithology, pilotage and reconnaissance, and watching sports or performance arts. [13]

3.1.2.1.1-Refracting Telescope

A refracting or refractor telescope is a type of optical telescope that uses a lens as its objective to form an image (also known as a dioptric telescope). This type of telescope has at least one primary lens and one lens at the eyepiece where the viewer sees the image. The refracting telescope design was first used in spy glasses and astronomical telescopes but is now also used for long focus camera lenses. Although large refracting telescopes were very popular in the second half of the 19th century, researchers tend to prefer reflecting or catadioptric telescopes instead.

3.1.2.1.2-Advantages

There are several advantages to a refracting telescope:

The buyer will get a low maintenance, straightforward telescope with a refractor.

The refractor telescope produces high-contrast, sharp images.

The tight air seal of a refractor telescope keeps air currents from affecting the view.

Whether interested in long distance terrestrial viewing or looking at the planets and stars, the refractor telescope is ideal.

The advantages need to be considered in light of some disadvantages as well.

3.1.2.1.3-Disadvantages

There are several disadvantages of this type of optical telescope:

This type of telescope costs more than the reflector and catadioptric telescope when comparing models of the same aperture size.

The refractor telescope isn’t the best for viewing faint astronomical bodies due to the design of the telescope and aperture, the opening through which the light passes.

Though the images come across clearly, there may be unexpected color fringes around the objects in view.

The lower end models of the refractor telescope usually lack the quality needed for decent astronomy viewing.

Despite the disadvantages of these types of telescopes, they are the most user-friendly versions and would be best suited for amateur star gazers.

3.1.2.2.1-Reflecting Telescope

A reflecting telescope (also called a reflector) has a concave mirror that gathers light from the object and focuses it into an adjustable eyepiece or combination of lenses through which the reflection of the object is enlarged and viewed. The reflecting telescope was invented in the 17th century as an alternative option to the refracting telescope. Even though reflecting telescopes produce other types of optical aberrations, this design allows for objects that are larger in diameter. Almost all of the major telescopes used in astronomical research are reflectors. Reflecting telescopes come in many designs and variations and often use extra optical elements to improve image quality or to help with the placement of the image which makes it easier to be seen. Since reflecting telescopes use mirrors, the design is sometimes referred to as a catoptric telescope.

Advantages

There are several advantages associated with reflecting telescopes:

Easy to use and to construct.

Great for faint deep sky objects such as remote galaxies, nebulae, and star clusters because of their larger apertures for light gathering.

Low in optical irregularities and delivers very bright images.

Reasonably compact and portable.

A reflector costs less per inch of aperture compared to refractors and catadioptrics since mirrors can be manufactured at less cost than lenses.

The advantages need to be considered in light of some disadvantages as well.

Disadvantages:

There are several disadvantages of this type of optical telescope:

Not usually suited for terrestrial applications.

Mirrors cause some slight light loss when compared to the lenses of a refractor telescope.

It has an open design which means that more dust can penetrate the mirrors and lead to more cleaning.

Reflectors may require a little more care and maintenance than its counterparts.

Despite its disadvantages, reflecting telescopes are best suited for use by children, amateur star-gazers as well as those pursuing a more professional level in astronomy.

Catadioptric Telescope:

Catadioptric telescopes are optical telescopes that combine specifically shaped mirrors and lenses to form an image. This allows for fewer aberrations than the refractor or reflector telescope which use only one or the other. By using both lenses and mirrors, the operator can focus in on more distant objects along with those that reflect less light. Professional stargazers as well as scientists prefer this type of telescope.

Advantages:

There are several advantages associated with this type of optical telescope:

Most versatile type of telescope.

Has a better near-focus capability than other types of telescopes.

Excellent for deep sky observing or astrophotography with fast films or charged-coupled devices (CCDs) used in detecting images.

Great for lunar, planetary, and binary star observing plus terrestrial viewing and photography.

Closed tube design reduces the need for cleaning as the dust can’t penetrate as easily.

Compact and durable.

There is also the need to consider the disadvantages as well.

Disadvantages:

There are several disadvantages associated with catadioptric telescopes:

Much more expensive than reflectors or refractors.

Not as appealing to the eye as its counterparts.

Some slight light loss due to secondary mirror obstruction when compared to refractors.

Despite the disadvantages, the catadioptric telescope is by far the best one of the three main types to use. The multiple lenses and mirrors cut out aberrations and allow users to see more than they would with the refractor or reflector telescopes.

<u>Types of Catadioptric Telescopes:</u>

There are two popular types of catadioptric telescopes: the Schmidt-Cassegrain and the Maksutov-Cassegrain. The Maksutov-Cassegrain telescope design has essentially the same advantages and disadvantages as the Schmidt. It has a thick meniscus-correcting lens with a strong curvature and a secondary mirror that is usually an aluminized spot on the corrector. The Maksutov secondary mirror is mostly smaller than the Schmidt's which gives it a slightly better resolution for planetary observing.

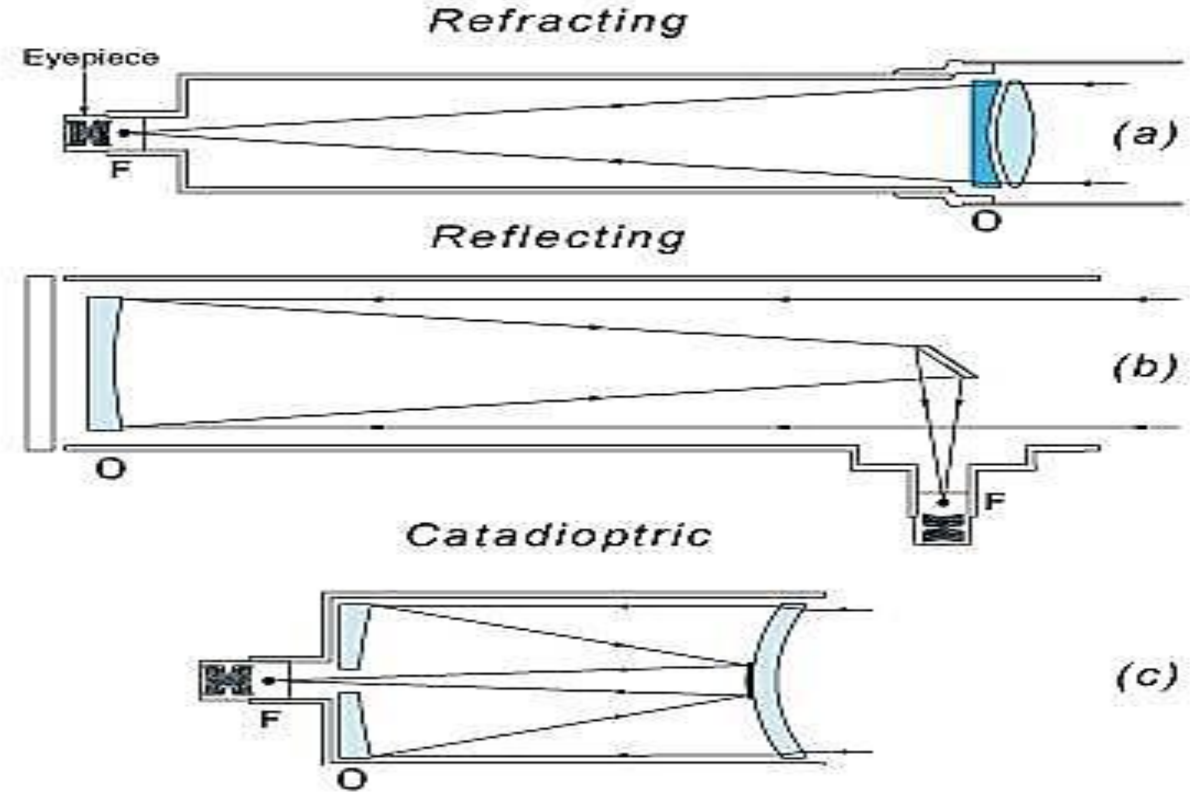


Figure3.2:different princip of telescope

On the other hand, the Maksutov is heavier than the Schmidt, and, due to the thick correcting lens, it can take longer to reach thermal stability at night in larger apertures. The Maksutov optical design is usually easier to manufacture, but requires more material for the corrector lens than the Schmidt-Cassegrain.

Terms Associated with Optical Telescopes:

Some terms that are good to know when purchasing or while using an optical telescope are listed below:

Term	**Definition**
Aberration	Aberrations are basically a flaw in the performance of an optical system. The specific types of aberrations includes the following: blurring of the image which is produced by an image-forming optical system. This happens when light from a certain point of an image after transmission through the system does not meet into (or does not diverge from) one point.
Coma	Coma is another type of aberration, which it gets its name from the comet-like look of the aberrated object.
Focal length and f-ratio	The focal length of the optical telescope is the length of the light path to create an actual object. These numbers will help in knowing how wide a visual field can be attained with a particular eyepiece or certain photographic equipment. In between the focal length of the telescope and the diameter of the primary light gathering place lies the f-ratio of an optical telescope. Low f-ratios, like f/4, indicate wide fields of view with low normal magnification limits, and high f-ratios, like f/10, show hard to see fields with high practical magnification limits.
Meniscus	Convex-concave (meniscus) lenses can be both positive or negative, depending on the how the two surfaces curve. In order to obtain exactly zero optical power, a meniscus lens will have to have somewhat unequal curvatures to take into consideration the effect of the lens' thickness.
Optical Coating	The process of placing a thin layer of material on an optical component like a lens or a mirror in which the optic reflects and transmission light is altered is referred to as optical coating. A antireflection coating is one specific type of optical coating, and it is commonly used on refractor telescope lenses.
Wavefront error	Known as an imaginary surface, wavefront joins all points in space that are reached at the same instant by a wave propagating through a medium, which is like

Term	Definition
	optics. Wavefront error is shown in fractions, such as 1/25, which explains the optics’ abilities to correctly focus the light waves.

There are many terms associated with an optical telescope, but these are a few which buyers may commonly encounter. While these are far from all that can be found, they will help explain the many different terms expressed by astronomers who use optical telescopes and terms buyers may find in advertisements or instructions with personal optical telescopes.

3.1.3-x-ray telescope

An X-ray telescope (fig:3.3)(XRT) is a telescope that is designed to observe remote objects in the X-ray spectrum. In order to get above the Earth's atmosphere, which is opaque to X-rays, X-ray telescopes must be mounted on high altitude rockets or artificial satellites

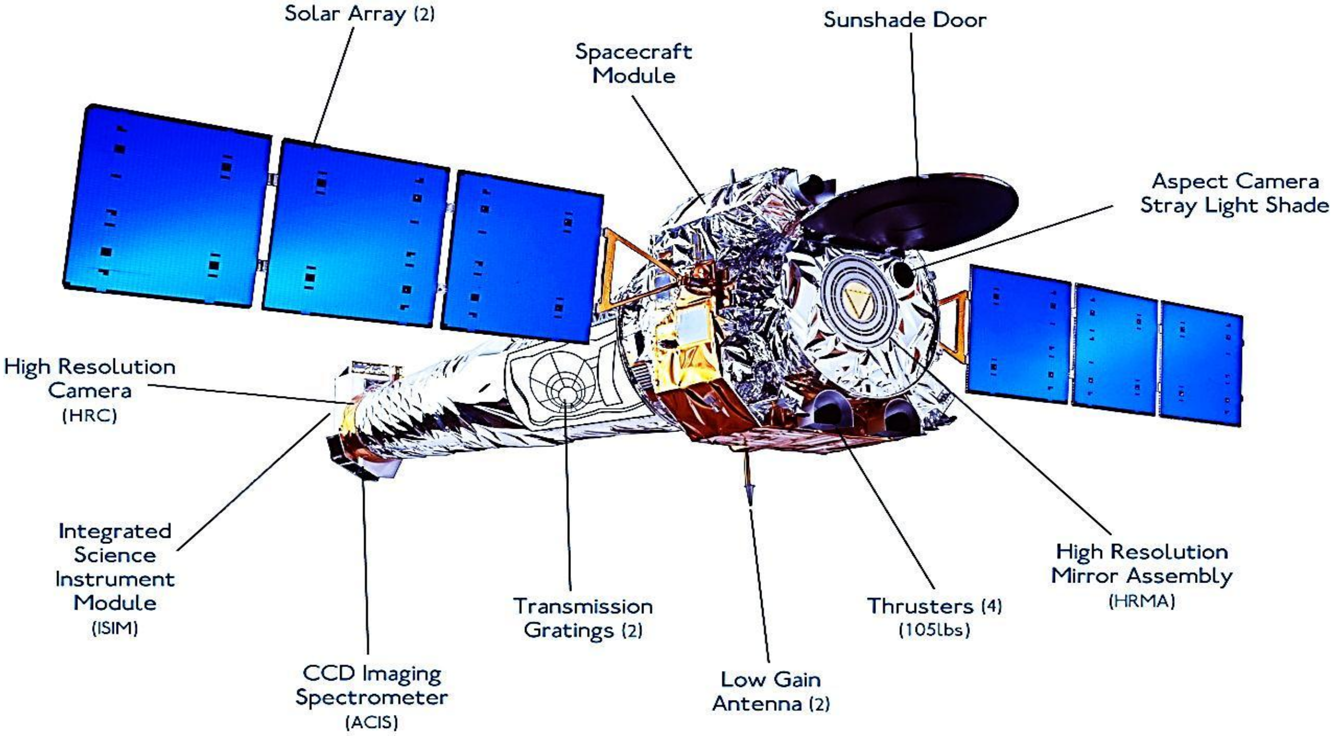


Figure 3.3 : x-ray telescope

X-ray telescopes collect the X-rays that are emitted from the sun, stars, and super novas in space using a series of curved lenses and an electronic eye. This technology permits astronomers to produce an image of these celestial bodies which can be studied. Over time, the X-ray images of the same star give the astronomers information that helps them to describe the conditions, patterns, and changes that may be happening. The technology became usable for these purposes in the early 1960s and, by the 1970s, X-ray telescopes were placed into orbit on satellites[14].

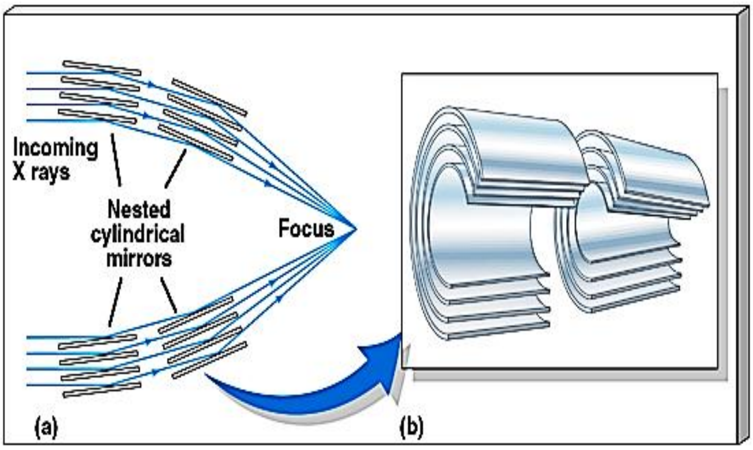


Figure3.4 : the mirror design is fairly complex of XRT

High-energy astronomy studies the universe as it presents itself to us in X rays and gamma rays—the types of radiation whose photons have the highest frequencies and hence the greatest energies. How do we detect radiation of such short wavelengths? First, it must be captured high above Earth's atmosphere because none of it reaches the ground. Second, its detection requires the use of equipment basically different from that used to capture the relatively low-energy radiation discussed up to this point.

The difference in the design of high-energy telescopes comes about because X-rays and gamma rays cannot be reflected easily by any kind of surface. Rather, these rays tend to either pass straight through or else be absorbed by any material they strike. When X rays barely graze a surface, however, they can be reflected from it in a way that yields an image, although the mirror design is fairly complex (fig 3.4)

Figure 3.5 : gamma ray space telescope

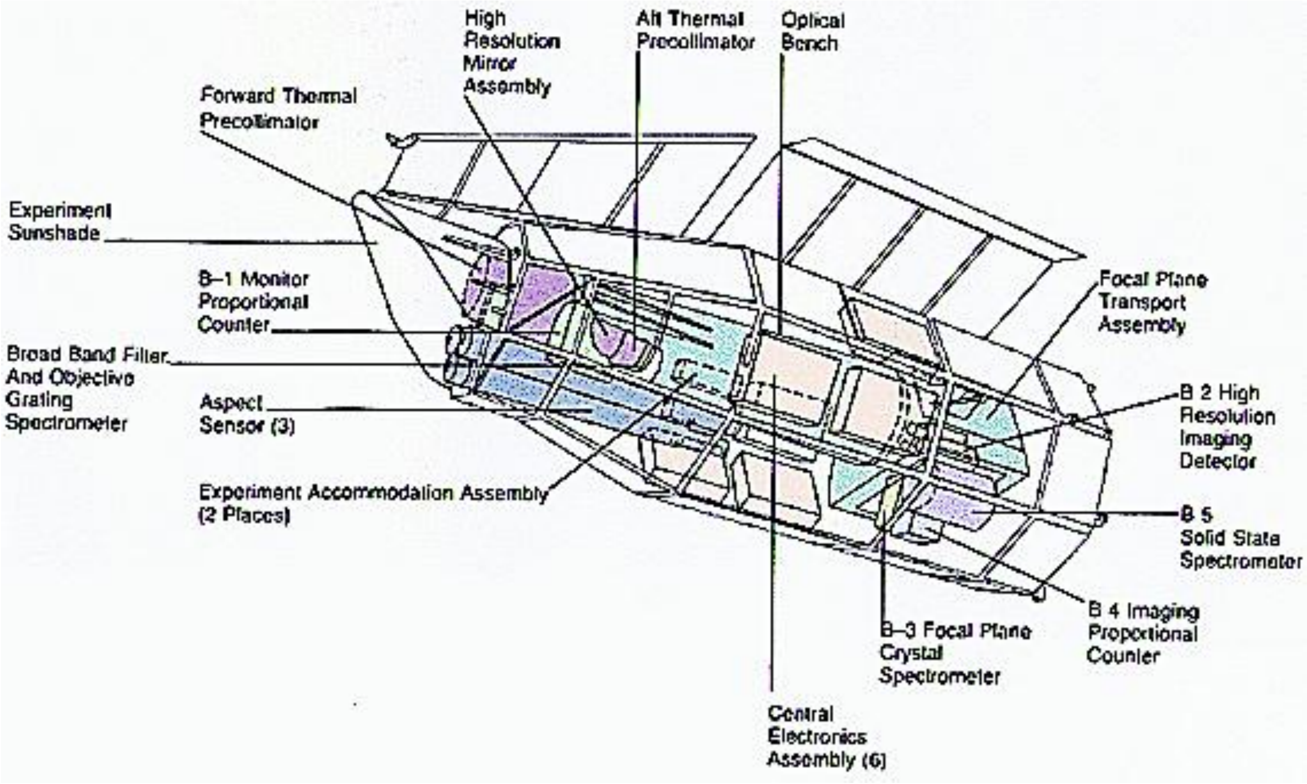


Figure3.6: *the general sectional view of*

The Einstein(fig 3.5) Observatory, launched by NASA in 1978, was the first X-ray telescope capable of forming an image of its field of view. During its two-year lifetime, this spacecraft made major advances in our understanding of high-energy phenomena throughout the universe; its observational database is still heavily used. More recently, the German ROSAT (short for Röntgen Satellite, after Wilhelm Röntgen, the discoverer of X rays) was launched in 1991 and has generated a wealth of high-quality observational data. It was turned off, a few months after its electronics were irreversibly damaged when the telescope was accidentally pointed too close to the Sun. In 1999 NASA launched the Advanced X-Ray Astrophysics Facility (AXAF, renamed Chandra after launch in 1999, in honor of the Indian astrophysicist Subramanyan Chandrasekhar, and shown in Figure 3.6). With greater sensitivity, a wider field of view, and better resolution than either Einstein or ROSAT, Chandra is providing high-energy astronomers with new levels of observational detail .Several examples(fig 3.7) of Chandra imagery are found throughout our text [15]

Figure3.7: orion nebula in x-ray telescope

3.1.4-Gamma-ray telescope

gamma-ray telescope(fig 2.8), instrument designed to detect and resolve gamma rays from sources outside Earth’s atmosphere

Figure 3.8: gamma ray telescope

Gamma rays are the shortest waves (about 0.1 angstrom or less) and therefore have the highest energy in the electromagnetic spectrum. Since gamma rays have so much energy, they pass right through the mirror of a standard optical telescope. Instead, gamma rays are detected by the optical flashes they produce when interacting with the material in a specially designed instrument such as a scintillation detector. Earth’s atmosphere blocks most gamma rays, so most gamma-ray telescopes are carried on satellites and balloons. However, some ground-based telescopes can observe the Cherenkov radiation produced when a gamma ray strikes Earth’s upper atmosphere

The first gamma-ray telescope was carried on board the American satellite Explorer 11 in 1961. In the 1960s the Vela defense satellites designed to detect gamma rays from clandestine nuclear testing serendipitously discovered enigmatic gamma-ray bursts coming from deep space. In the 1970s Earth-orbiting observatories found a number of gamma-ray point sources, including an exceptionally strong one dubbed Geminga that was later identified as a nearby pulsar. The Compton Gamma Ray Observatory, launched in 1991, mapped thousands of celestial gamma-ray sources. It also showed that the mysterious bursts are distributed across the sky, implying that their sources are at the distant reaches of the universe rather than in the Milky Way. The Fermi Gamma-ray Space Telescope, launched in 2008, discovered pulsars that emitted only gamma rays. [16]

3.1.5-infrared telescope

An infrared telescope is a telescope that uses infrared light to detect celestial bodies. Infrared light is one of several types of radiation present in the electromagnetic spectrum

All celestial objects with a temperature above absolute zero emit some form of electromagnetic radiation. In order to study the universe, scientists use several different types of telescopes to detect these different types of emitted radiation in the electromagnetic spectrum. Some of these are gamma ray, x-ray, ultra-violet, regular visible light (optical), as well as infrared telescopes [17]

Infrared telescopes use fundamentally the same components and follow the same principles as visible light telescopes; namely, some combination of lenses and mirrors gathers and focuses radiation onto a detector or detectors, the data from which are translated by computer into useful information. The detectors are usually a collection of specialized solid-state digital devices: the most commonly used material for these is the superconductor alloy HgCdTe (mercury cadmium telluride). To avoid contamination from surrounding heat sources, the detectors must be cooled by a cryogen such as liquid nitrogen or helium to temperatures approaching absolute zero; the Spitzer Space Telescope, which at its launch in 2003 was the largest ever space-based infrared telescope, is cooled to -273 C and follows an innovative Earth-trailing heliocentric orbit whereby it avoids the reflected and indigenous heat of the Earth. [18]

SPITZER FAST FACTS (fig 2.9)

Launch Date: August 25, 2003

Delta 7920H ELV / Cape Canaveral, Florida

Estimated Lifetime: 2.5 years (minimum); 5+ years (goal

Orbit: Earth-trailing, Heliocentric

Wavelength Coverage: 3 - 180 microns

Telescope: 85 cm diameter (33.5 Inches), f/12 lightweight Beryllium, cooled to less 5.5 K

Diffraction Limit: 6.5 microns

Science Capabilities:

Imaging / Photometry, 3-180 microns

Spectroscopy, 5-40 microns

Spectrophotometry, 50-100 microns

Planetary Tracking: 1 arcsec / sec

Cryogen / Volume: Liquid Helium / 360 liters (95 Gallons(Launch Mass: 950 kg (2094 lb) [Observatory: 851.5 kg, Cover: 6.0 kg, Helium: 50.4 kg, Nitrogen Propellant: 15.6kg] [19]

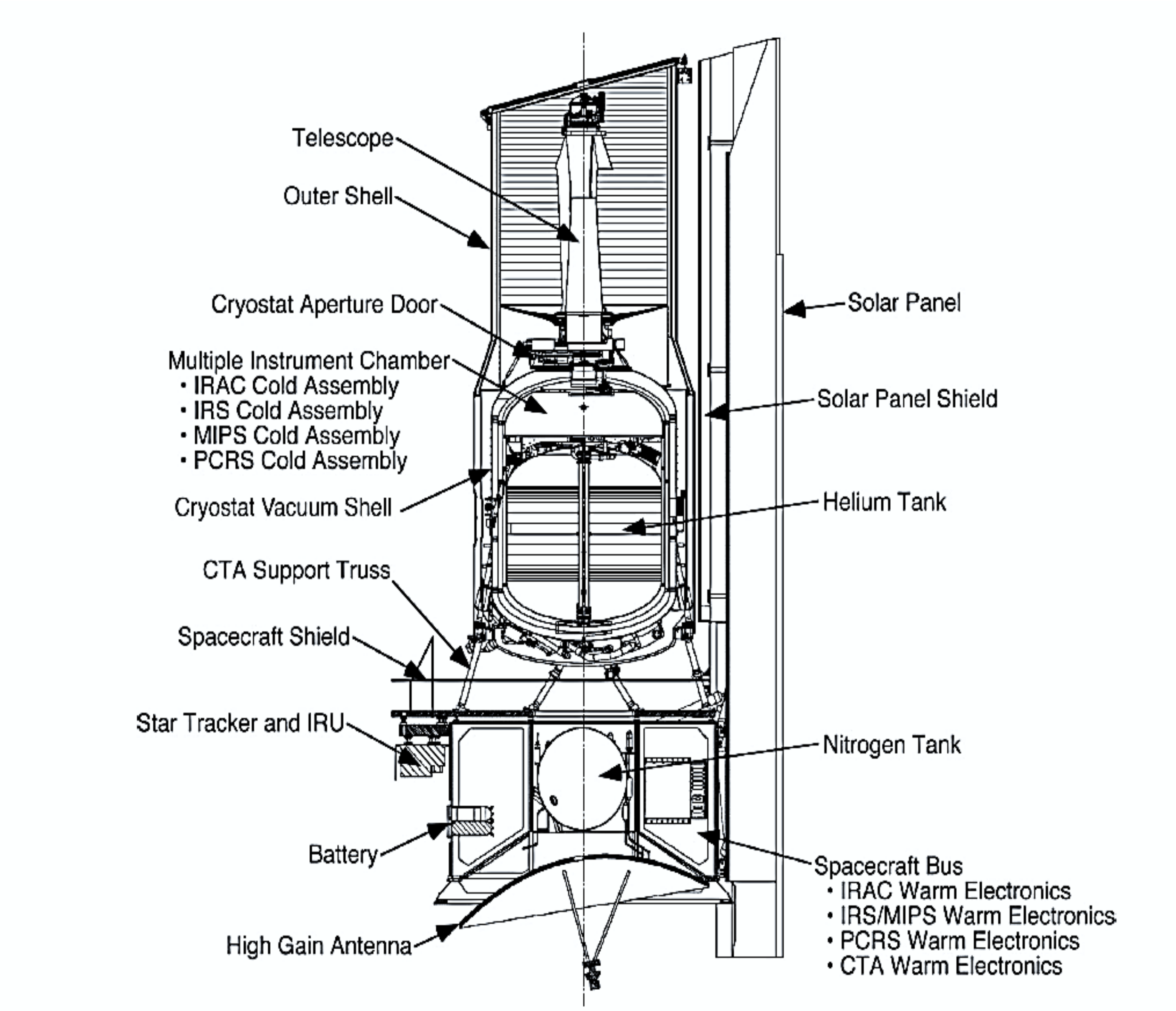


Figure2.9: spitzer space telescope

3.1.7-Ultraviolet telescopes

Ultraviolet telescopes must be space telescopes because very little ultraviolet energy gets through Earth's atmosphere. A new telescope, called GALEX (for Galaxy Evolution Explorer) is taking a survey of nearly the entire sky in ultraviolet light. Hot, young stars put out a lot of ultraviolet light, so GALEX will be able to find the places where stars are being born. [20]

Ultraviolet telescopes are similar to optical reflecting telescopes, but their mirrors have special coatings that reflect ultraviolet light very well.

Ultraviolet telescopes provide much information about interstellar gas, young stars, and the gaseous areas of active galaxies. [21]

3.1.8-Radio astronomy

Figure 2.10: radio astronomy

A radio telescope is simply a telescope that is designed to receive radio waves from space. In its simplest form it has three components (fig 2.10):

One or more antennas to collect the incoming radio waves. Most antennas are parabolic dishes that reflect the radio waves to a receiver, in the same way as a curved mirror can focus visible light to a point. Antennas can be other shapes however. A Yagi antenna, similar to that used for TV reception, can be used for radio astronomy as was the case in the early Dover Heights telescopes.

A receiver and amplifier to boost the very weak radio signal to a measurable level. These days the amplifiers are extremely sensitive and are normally cooled to very low temperatures to minimise interference due to the noise generated by the movement of the atoms in the metal.

A recorder to keep a record of the signal. In the early days of radio astronomy this was normally a chart recorder that drew a graph on paper in ink. Most radio telescopes nowadays record directly to some form of computer memory disk as astronomers use sophisticated software to process and analyse the data.

The photos below show three types of radio telescope. The first shows one of the early telescopes used at Dover Heights in Sydney, Australia following the Second World War. A replica of the original is now on display at the site. The second is the Parkes radio telescope, star of the film The Dish. It opened in 1961 and still operates today. The dish antenna is 64m across. The third telescope is the Australia Telescope Compact Array near Narrabri, northern NSW. It opened in 1988 and comprises six 22m dishes that can be spaced out up to a distance of 6km along a rail track. This modern type of telescope where several dishes operate together is called an interferometer. Radio interferometers allow astronomers to study objects in finer detail than is possible using a single dish. The larger the total collecting area, the fainter the radio signals that can be detected.

Radio dishes do not have to be as smooth or shiny as optical mirrors because the "light" that they are reflecting, radio waves, are longer in wavelength than visible light. The surface of a dish at the Australia Telescope Compact Array is smooth to within a millimeter or so rather than the surface of a glass mirror that is normally a thousand times smoother.[22]

Radio telescopes are directional radio antennas used for radio astronomy. The dishes are sometimes constructed of a conductive wire mesh whose openings are smaller than the wavelength being observed. Multi-element Radio telescopes are constructed from pairs or larger groups of these dishes to synthesize large 'virtual' apertures that are similar in size to the separation between the telescopes; this process is known as aperture synthesis. As of 2005, the current record array size is many times the width of the Earth—utilizing space-based Very Long Baseline Interferometry (VLBI) telescopes such as the Japanese HALCA (Highly Advanced Laboratory for Communications and Astronomy) VSOP (VLBI Space Observatory Program) satellite. Aperture synthesis is now also being applied to optical telescopes using optical interferometers (arrays of optical telescopes) and aperture masking interferometry at single reflecting telescopes. Radio telescopes are also used to collect microwave radiation, which is used to collect radiation when any visible light is obstructed or faint, such as from quasars. Some radio telescopes are used by programs such as SETI and the Arecibo Observatory to search for extraterrestrial life.

3.1.9-Very large telescope.

Figure2.11 : VLT

The Very Large Telescope (VLT) (fig 2.11) is a telescope operated by the European Southern Observatory on Cerro Paranal in the Atacama Desert of northern Chile. The VLT consists of four individual telescopes, each with a primary mirror 8.2 m across, which are generally used separately but can be used together to achieve very high angular resolution. The four separate optical telescopes are known as Antu, Kueyen, Melipaland Yepun, which are all words for astronomical objects in the Mapuche language. The telescopes form an array which is complemented by four movable Auxiliary Telescopes (ATs) of 1.8 m aperture.

The VLT operates at visible and infrared wavelengths. Each individual telescope can detect objects roughly four billion times fainter than can be detected with the naked eye, and when all the telescopes are combined, the facility can achieve an angular resolution of about 0.001 arc-second. This is equivalent to roughly two metres at the distance of the Moon.

The VLT is the most productive ground-based facility for astronomy, with only theHubble Space Telescope generating more scientific papers among facilities operating at visible wavelengths. Among the pioneering observations carried out using the VLT are the first direct image of an exoplanet, the tracking of individual stars moving around the supermassive black hole at the centre of the Milky Way, and observations of the afterglow of the furthest known gamma-ray burst.