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International Year of Astronomy (IYA-2009) and its significance

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The United Nations Organisation (UNO) following a global scheme laid out by the International Astronomical Union (IAU) has declared the year 2009 as the *International year of Astronomy* to commemorate and celebrate the important occasion just 400 years back, when Galileo invented the first astronomical telescope in 1609 and instantly turned it around to heavens. The year is intended to be a global celebration of astronomy and its contributions to society and culture, stimulating worldwide interest not only in astronomy but science in general, with a particular slant towards young people. Galileo's astronomical discoveries and investigations into the Copernican theory have led to a lasting legacy which includes the categorisation of the four large moons of Jupiter discovered by Galileo as the Galilean moons. It was an important milestone in the field of astronomy and of science in general. Till that discovery, science was mostly theoretical and speculative. It was the beginning of a new era of science, that of acquiring knowledge through observation and experimentation. In this article, we shall try to explore, in brief, the important achievements in the field of astronomy during last 50 years.

Galileo's Discovery

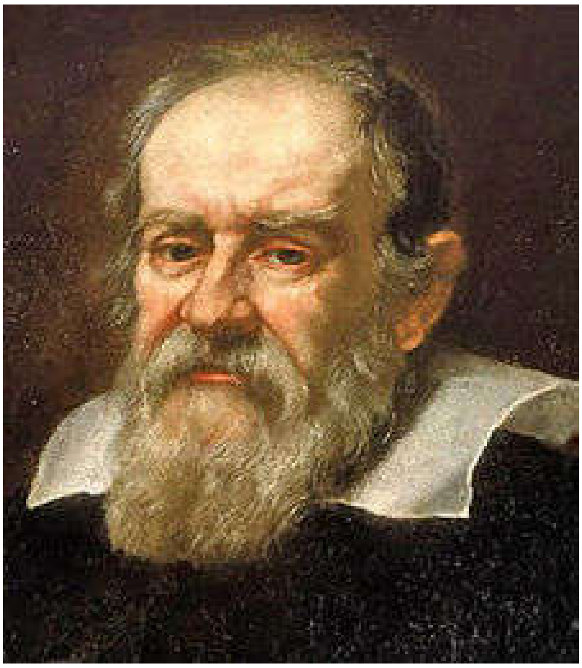
Galileo Galilei was born on February 15, 1564 in Pisa, Italy, the first of six children of Vincenzo Galilei and Giulia Ammannati. Although he seriously considered the priesthood as a young man, he enrolled for a medical degree at the University of Pisa at his father's urging. He did not complete this degree, but instead studied mathematics. In 1589, he was appointed to the chair of mathematics in Pisa. In 1592, he moved to the University of Padua, a city which belonged to the maritime republic of Venice and taught geometry, mechanics, and astronomy until 1610.

Based only on uncertain descriptions of the first practical telescope, invented by Hans Lippershey in the Netherlands in 1608, Galileo came to know of it in the following year, and made a telescope with about 3x magnification. He immediately realised that such an instrument would be of immense value to the navy. He never actually saw a specimen of the telescope but worked on the assumption that only a particular combination of concave and convex lenses could produce the effect he had learnt about. Within a month the scientist had developed his own telescope with a magnification factor of three. It allowed Vatican admirals and merchants to identify the approaching ships a full two hours before they could be actually seen with the naked eye.

On 25 August 1609, he demonstrated his first telescope to Venetian lawmakers. His telescopes were a profitable sideline. He could sell them to merchants who found them useful both at sea and as items of trade. He published his initial telescopic astronomical observations in March 1610 in a brief treatise entitled *Sidereus Nuncius* (*Starry Messenger*). On December 1, 1609, he held another telescope in his hands which achieved a magnification factor of 20. On the next clear night, he trained his instrument on the moon for the first time. This was the beginning of modern astronomy.

On 7 January 1610 Galileo observed with his telescope what he described at the time as "three fixed stars, totally invisible by their smallness," all close to Jupiter, and lying on a straight line through it. He had discovered three of Jupiter's four largest satellites (moons): Io, Europa, and Callisto. He discovered the fourth, Ganymede, on 13 January. Galileo named the four satellites he had discovered *Medicean stars*, in honour of his future patron, Cosimo II de' Medici, Grand Duke of Tuscany, and Cosimo's three brothers. Later astronomers, however, renamed them the *Galilean satellites* in honour of Galileo himself. Their existence proved conclusively that it was not the Earth alone, around which all celestial bodies circled. Galileo wrote at one place in his book the *Dialogue*: "All knowledge is provisional and correct only till it is proven false. And the laws of nature can be explored only through precise experimentation and exact observation". This is Galileo's radical, anti-metaphysical, modern message. This is why he is regarded as the first scientist of the modern age or the 'father of modern science'.

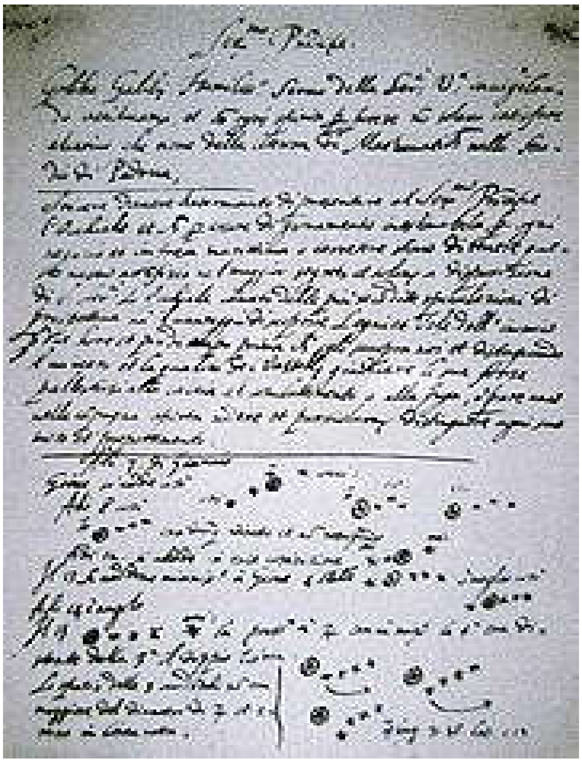
When Galileo trained his telescope on the heavens, he saw a number of strange and curious things: craters on the moon, satellites around the Jupiter, stars in the Milky Way, and so on. And when he advocated a new principle of science, namely observation as the way to knowledge, he came into conflict with many powerful opponents – the philosophers and the spiritual leaders. They



Portrait of Galileo by Giusto Sustermans

targeted their criticisms at the telescope. Galileo's discoveries, they said, were nothing more than the 'conceited illusions of the lenses'. The spyglass did not show the reality, they claimed; instead it projected a reality that either did not exist at all or existed only through the lenses. Their best and conclusive proof; if one took the lenses away, whatever had been seen through them also disappeared.

His observation did not conform to the principles of Aristotelian Cosmology, which held that all heavenly bodies should circle the Earth, the main dogma of the structure of the universe back then and many astronomers and philosophers initially refused to believe that Galileo could have discovered such a thing. Galileo had no resources to fight these attacks. He could not scientifically prove the validity of his discoveries. Nor was there an established theory of optics at that time, with which he could explain magnification. One sim-



It was on this page in *Sidereus Nuncius* that Galileo first noted an observation of the moons of Jupiter. This observation upset the notion that all celestial bodies must revolve around the Earth.

ply had to believe the telescope. This was a miserably weak position for Galileo.

In February 1632, Galileo published a book "*Dialogue Concerning the Two Chief World Systems: the Ptolemic and the Copernican*." In this book he accepted and validated the 'heliocentric' theory of Copernicus and explained all his discoveries theoretically. Ptolemy in the 2nd century C.E. elaborated Aristotle's 'geocentric' view of the universe by means of a complex system. This theory, based on the works of Aristotle held that the Earth was at the centre of the universe, and the moon, the Sun, the planets and all the stars revolved around it in perfectly circular motion. This idea was accepted by all for a very long period of almost 1500 years.

In 1542, Nicolaus Copernicus (1473-1543) had put forward the radical idea that it was not the Earth that lay at the centre of the universe, but the Sun. Copernicus was the first to use the Sun-centric model to explain planetary motion with mathematical precision. But unfortunately, his theory did not find any supporter during his lifetime. It was only some 60 years later, that the Copernican theory of the Earth in motion found real support through the discoveries of Galileo and works of Kepler.

Astronomy and Astrophysics

Astronomy as a subject evolved out of observations of the cosmos and may well claim to be oldest science. Cosmic phenomena are of two types: (a) those which show regularity, e.g., the rising and setting of stars, the steady shining of the Sun, etc., and (b) the dynamic type events, e.g., the solar eclipse, the explosion and death of stars, etc.

The inquisitiveness of human mind has always looked for a scientific understanding of all observed astronomical phenomena. Astrophysics, a branch of physics, thus evolved as a subject that offered explanations for cosmic events in terms of known laws of physics. Why does eclipse occur? Why does the Sun shine? Why does a star explode? What will happen to the Sun when it stops shining?

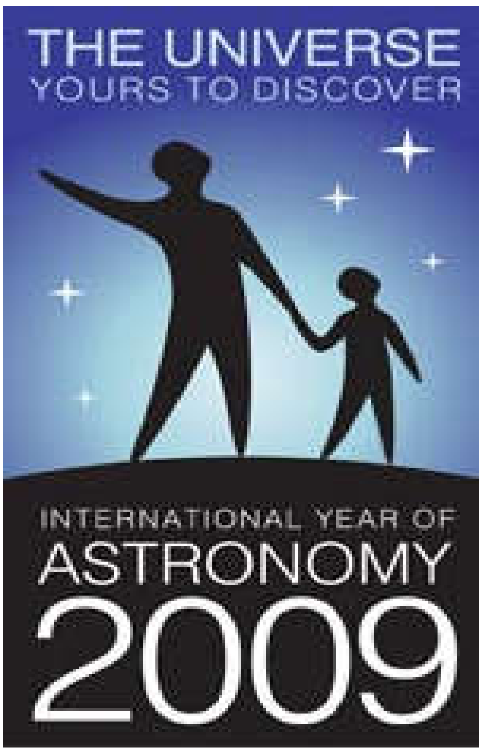
Questions such as these can now be answered by the physics we know from our laboratory experiments. In this sense, the entire universe is a laboratory for testing the laws of physics. But unlike the laboratories on the Earth, the cosmos lies beyond the observer's control. A laboratory scientist can alter the parameters of his equipments and test his hypothesis to a high degree of accuracy. An astronomer can only observe from a distance and use only such data as are available to test his theories. That is why astronomical theories and their predictions are not as accurate as their laboratory counterparts.

But, whereas the laboratory scientist has to contend with the terrestrial confinement of his theories, the astrophysical theories have no such limitations. The astronomical observations play an indispensable role in strengthening our confidence in universal validity of the basic laws of physics. In terms of size, mass, time scale, energy, density etc. astronomical systems exhibit a wide range that can never be matched by anything here on the Earth. In this sense, the two subjects – astronomy and astrophysics go hand in hand and deal with anything beyond the Earth up to the extent of the whole universe.

Different Branches of Astronomy

The subject of astronomy would not have been existed had there been no electromagnetic radiation. The fact that the Sun and other stars radiate light which reaches our eyes led to the subject of 'Optical Astronomy' in the first place. Naturally observational astronomy evolved initially by making observations in the visible optical region. In fact, beginning with Galileo till the end of World War II, astronomers observed the universe using only optical telescopes.

However, as we know, visible light is tiny part of electromagnetic spectrum. The heavenly objects radiate not only light waves but also other types of electromagnetic waves. Since 1945,



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therefore, there has been intense developments to observe radiation emitted by astronomical sources in all possible frequency bands, viz, radio waves, infra-red (IR), ultra-violet (UV), X-rays, gamma rays, etc. Thus different branches of astronomy were developed corresponding to different types of radiation with the simultaneous developments of telescopes.

The atmosphere around the Earth blocks most of the radiations coming in from outer space, but allows only two types of waves. These are light waves and radio waves. Thus both optical telescopes and radio telescopes can be placed on the ground but other telescopes used for receiving other types of waves should be placed in space or satellites above the Earth's atmosphere. Thus astronomy is basically divided into two groups: ground based astronomy and space astronomy. In this article, we simply mention some of the useful telescopes in the world in different branches of astronomy. Our country India has also advanced rapidly in this field in last 50 years and few of her achievements are also mentioned below.

1. Optical Astronomy

Since the time of Galileo, larger and larger optical telescopes were developed. With the advent of these telescopes our solar system was the first thing to be explored systematically. Beyond that, our galaxy, the Milky Way was also explored. Modern astronomical observations are so advanced that, our best telescopes can see out to the range of 10^{10} light years and in this region there may be as many as 10^9 galaxies. At present, the world's two largest optical telescopes with diameter 10 m each is built on Mauna Kea at Hawaii, USA. In India, we still have at best only 2 m class telescopes at Nainital, U.P., at Kavalur, T.N., at Hanle in Ladakh, J.K. and one near Pune. The observatories at Nainital (1953) and Kavalur (1972) were established by MK Vainu Bappu, one of our greatest astronomers.

2. Radio Astronomy

The Earth's atmosphere is transparent to radio waves of wavelengths between about 5 mm to 50 m. Radio waves from cosmic sources were first observed in 1930 by Karl Jansky at Bell Lab in USA. Radio telescopes use metal antenna as receiver and the signal are then amplified and recorded electronically. Radio astronomy developed after World War II when the technology of radio transmission and reception grew rapidly. At present, the world's largest radio telescope VLA (Very Large Array) is situated in New Mexico, USA. It is a collection of 27 movable radio telescopes arranged in Y-shape with length of each arm about 20 km. In India, there are two large radio telescopes – ORT (Ooty Radio Telescope) at Ooty and GMRT (Giant Meterwave Radio Telescope) near Pune. Both ORT and GMRT were designed and fabricated fully indigenously by Indian scientists. Other useful radio telescopes are at Bangalore, Gauribidanur, and Ahmedabad.

3. Microwave Astronomy

In 1965, Penzias and Wilson in USA observed that a radiation of about 10 cm wavelength is pervading the entire universe uniformly. This radiation is called Cosmic Microwave Background Radiation (C.M.B.R.) and its observation was the first convincing evidence for the big bang model of the creation and evolution of the universe. Two specialized space probes COBE and WMAP were launched exclusively to study CMBR.

4. Infra-red Astronomy

Radiation having wavelengths longer than that of the red light is termed as infra-red (IR) radiation?. To receive such radiations from cosmic sources, we need spececraft, baloons or satellites as these are mostly absorbed by Earth's atmosphere. The large scale IR observations were first done by IRAS (Infra Red Astronomical Satellite) launched in 1983. The next ISO (Infrared Space Observatory) was launched in 1995 and it operated for 2 years. These telescopes have discovered many other distant galaxies beyond our own galaxy, the Milky Way as they emit primarily in the IR band. In India, we have Gurusikhar IR observatory at Mount Abu in Rajasthan.

5. Ultra-violet Astronomy

UV rays are radiations of wavelengths less than that of violet rays. Cosmic UV radiations in the range of 120-320 nm (1 nm = 10^{-9} m) was first studied extensively by IUE (International Ultraviolet Explorer) launched in 1978. These observations show that active galaxies and quasars are strong emitters in UV band. The important discovery in UV band is that of deuteron which was produced only during the early phase of the evolution of the universe.

6. X-ray Astronomy

Many cosmic X-ray sources were observed during 1960s by rocket borne detectors. The first X-ray satellite UHURU was launched in 1961 to do a systematic sky survey and found more than 300 X-ray sources. Later many satellites were launched viz EXOSAT in 1983, ROSAT in 1990, RXTE in 1995, CHANDRA in 1999 and so on. Our Sun is a strong source of both X-ray and UV radiations and it has been studied in great details. Besides, X-ray observations have established the existence of neutron stars and the black hole Cygnus X-1 in our galaxy and also massive black holes at the centers of other distant galaxies.

7. Gamma ray Astronomy

There are many galactic and extra-galactic sources which are emitters of gamma rays. In particular, sky survey shows that plane of our galaxy is dominated by gamma ray emission. This was in detail studied by OSO (Orbiting Solar Observatory) satellite launched in 1967. Later CGRO (Cosmic Gamma Ray Observatory) and GLAST (Gamma rays Large Area Space Telescope) satellites carried sensitive observations of diffuse gamma ray background and also found many individual gamma ray sources like pulsars, supernova remnants etc. Another important discovery is that of gamma ray bursts. These are showers of electron-photon which are produced when ultra high energy gamma rays (E~10^{12} eV) interact with particles in upper atmosphere. In India, we have gamma ray observatories in Panchmari in MP and at Gulmarg in JK.

Research with ASTROSAT

To mark the important occasion and to celebrate the international year of astronomy, our country India is likely to launch its first indigenously built astronomical satellite ASTROSAT this year. It is India's first satellite dedicated solely for astronomical observations. It will be launched by I.S.R.O. (Indian Space Research Organisation) into a 650 km, low inclination (<10°) orbit using P.S.L.V. A number of leading astronomy research institutions in India is jointly building the instruments for the satellite.

The unique features of this satellite is that it will deploy 5 different instruments on board for simultaneous observations of cosmic objects at UV and X-ray regions of electromagnetic waves in a wide spectral range of about 1 eV to 100 KeV. The five instruments of ASTROSAT are:

1. Ultra-Violet Imaging Telescope (UVIT)
2. Soft X-ray Telescope (SXT)
3. Large Area Xenon Proportional Counter

(LAXPC)
4. CdZnTe Imager (CZTI), and
5. Scanning Sky Monitor (SSM)

Among many different types of interesting cosmic sources, X-ray instruments on board ASTROSAT will be particularly suitable for temporal and spectral studies of neutron star and black hole candidates. Black hole sources are among the brightest sources of high energy photons and mainly comprise:

a) black hole binaries in our galaxy and other nearby galaxies,
b) medium and supermassive black holes in the centre of active galaxies and
c) the recently discovered intermediate mass black holes in some nearby galaxies.

Black hole astrophysics has greatly advanced in recent years with data collected by ASCA, RXTE, CHANDRA and XMM-NEWTON satellites. Study of black hole sources will be one of the important objectives of ASTROSAT. The other objectives of ASTROSAT are:

1. Multi-wavelength spectral and timing studies of X-ray binaries, pulsars, AGNs, galaxy clusters etc.
2. High resolution studies of galaxy- morphology in UV band
3. Sky survey in hard X-rays and UV bands
4. Detection of new X-ray transients and routine monitoring of bright X-ray sources
5. UV background studies.

After successful launching of the satellite, the data collected from it will be locked in for a period of one year. After that, the data will be available for research students and scholars for research purpose. It is hoped that, with our own satellite in operation, the new frontiers in astrophysical research will be opened up for the students of our country.

Nobel Prizes in Astronomy and Astrophysics

1974 – Sir Martin Ryle, UK and Antony Hewis, UK: Pioneering research in Radio Astrophysics. Invention of the aperture synthesis technique and the discovery of a radio pulsar.

1978 – A. A. Penzias, USA and R.W. Wilson, USA: For discovery of cosmic microwave background radiation (C.M.B.R.), remnants of the sea of light emitted by the universe at its origin in the Big Bang. It is pervading the whole universe at an almost uniform temperature of 2.73 K.

1983 – S. Chandrasekhar, USA (India) and W.A. Fowler, USA: For theoretical work on the structure and evolution of the stars. Discovery of ‘Chandrasekhar Limit’. Also theoretical and experimental studies of nucleo-synthesis in the universe.

1993 – R.A. Hulse, USA and J.H. Taylor, USA: For the discovery of a new type of pulsar and investigations of the energy loss due to gravitational radiation.

2002 – Raymond Davis Jr. USA, Masatoshi Koshiba, Japan & Riccardo Giacconi, USA: For pioneering contributions in astrophysics, in particular for the detection of cosmic neutrino and also for the discovery of cosmic X-ray sources. Their works led to the new intensive fields of research – Neutrino Astronomy and X-ray Astronomy.

2006 – John C. Mather, USA and George F. Smoot, USA: For their discovery of blackbody form and anisotropy of the cosmic microwave background radiation (C.M.B.R.). Their precise satellite measurements of CMBR, have confirmed fundamental predictions arising from the big bang theory, leading to its further acceptance as the standard model of cosmology.

References

1. Hawking S (1988). *A Brief History of Time*. Bantam Books, New York.
2. Kauffman W J. *Discovering the Universe.* W.H. Freeman & Co., New York.
3. Narlikar JV. *The Frontiers between Physics and Astronomy.* McMillan Co., New Delhi.
4. Sharratt M (1994). *Galileo: Decisive Innovator.* Cambridge University Press, Cambridge, UK.
5. Taton R & Wilson C, eds (1989). *Planetary astronomy from the Renaissance to the rise of astrophysics Part A: Tycho Brahe to Newton.* Cambridge University Press, Cambridge, UK.