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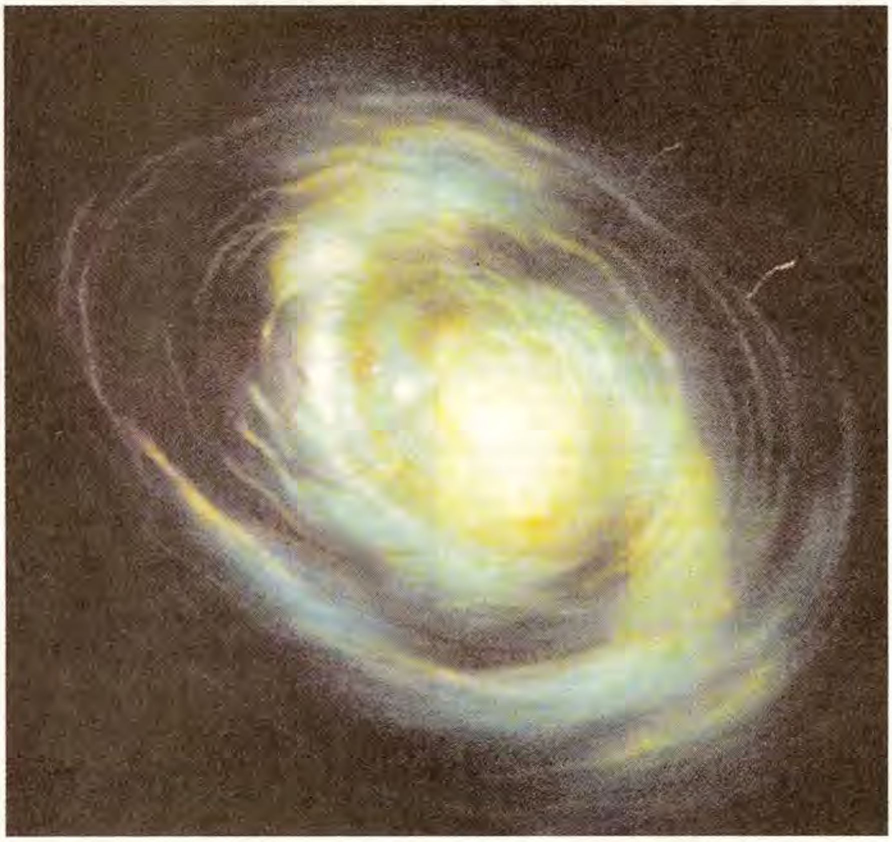
What the stars tell...



- The sun emits in one second the amount of energy that mankind will consume (at the present global power production of ten trillion watts) in a hundred million years.
- The nearest star *Proxima Centauri* is 20,000 times fainter than the sun and not visible to the naked eye.
- A hundred trillion of solar neutrinos pass through our bodies every second without interaction! Several galaxies including our own host supermassive black holes in their core.
- A big discovery of radioastronomy has been that of cosmic microwave background, the left over all pervading remnant radiation from the hot dense early phase (the so-called big bang) of our universe.
- Every second, a supernova is exploding somewhere in the universe.

C Sivaram talks about the evolution of astronomy, from discoveries of distant stars and planets to subatomic particles called neutrinos.

The year 2009 is being recognised as the International Year of Astronomy (IYA). It marks the four hundredth anniversary of the year 1609 when Galileo Galilei used the then newly-invented telescope to observe astronomical objects after publishing his discoveries in his work *Sidereus Nuncius*.

His discovery of the four moons (satellites) orbiting planet Jupiter opened up astronomical frontiers while providing support to the Copernican picture of the earth being no longer the centre of the universe around which everything revolved! Today, we know there are over 160 moons orbiting giant planets with Jupiter and Saturn having several dozens of satellites each.

The past decade has witnessed the discovery of over 300 exoplanets orbiting nearby stars and hundreds of smaller Trans-Neptunian objects orbiting on the fringes of our solar system.

Galileo had a puny three-inch telescope. Today, we have giant telescopes over ten metres across and have plans for 30-metre and 100-metre telescopes. The Hubble Space Telescope has a two-metre aperture and has been orbiting the earth for nearly two decades. The light gathering power of our giant telescopes is over 3,000 times that of Galileo's tiny instrument and has enabled us to glimpse galaxies and other objects more than ten billion light years away. These objects were formed nine billion years before the sun and the solar system were born!

Today's telescopes are accompanied by sophisticated instruments like photometers and spectrometers enabling astronomers to detect elements like uranium, thorium (and unstable elements like technetium, no longer present on the earth), in distant stars and monitor positions of these objects to high precision.

We know the distance to the moon to a fraction of a centimetre and can measure the slowing down of the earth's rotation (about a millisecond per century) with the help of atomic clocks. Astronomy is no longer confined to the optical part of the spectrum, i.e, the wavelengths of the electromagnetic part that our eyes are sensitive to. We have distant objects like quasars emitting energy in X-rays; in one second, a hundred trillion times the sun's luminosity. The sun itself emits in one second the amount of energy that mankind will consume (at the present global power production of ten trillion watts) in a hundred million years. Advances in nuclear physics have enabled us to understand the precise sequence of nuclear interactions that powers the sun's energy output.

Trillions of solar neutrinos

In recent years, this has involved detecting subatomic particles called neutrinos, which are copiously produced in these nuclear interactions and pass right through the sun. A hundred trillion of these solar neutrinos pass through our bodies every second without interaction! Yet very large detectors underground have detected these neutrinos, opening up a new branch of astronomy, neutrino astronomy!

The stars range in size from a billion kilometres (red giants) to ten kilometres (neutron stars, the size of a city!). They have densities from being much more rarefied than air to that of a billion tons per cubic centimetre. There are stars emitting several million times what the sun emits! The nearest star Proxima Centauri is 20,000 times fainter than the sun and not visible to the naked eye.

Yet the realisation that stellar objects are the various stages of evolution in the lives of stars has enabled us to get a detailed picture of how stars live and die! The sun will end up a white dwarf. Massive stars will explode as supernovae which at their peak emit ten billion times the sun's luminosity and are visible billions of light years away! The most massive ones have cores that collapse into so-called black holes; their gravity field being so strong that even light is trapped.

Several galaxies including our own host supermassive black holes in their core.

Quasars are powered by such exotic objects which accrete the surrounding matter. Radioastronomy has led to the precise monitoring of pulsars (spinning neutron stars), some of them slowing down so precisely that they keep time better than atomic clocks!

A big discovery of radioastronomy has been that of cosmic microwave background, the left over all pervading remnant radiation from the hot dense early phase (the so-called big bang) of our universe. This led to two Nobel Prizes.

Pulsar radioastronomy also led to two Nobel Prizes. We also have cosmic X-ray and gamma ray background radiation around us. In February 1987, a massive star exploded as a supernova in our neighbouring galaxy, the Large Magellanic Cloud. Neutrinos emitted from its collapsing core were detected on earth. Every second, a supernova is exploding somewhere in the universe.

We are witnessing energetic events like gamma ray bursts (emitting in one second high energy gamma rays equal to the entire radiative output of the sun in ten billion years!), colliding galaxies etc. The most energetic events like collisions of supermassive black holes, tidal disruptions of neutron stars, etc. will in the future be monitored by gravitational wave astronomy.

Astrobiology

Also, there is excitement about astrobiology and detection of life, especially possible intelligent life, on the innumerable worlds populating the universe.

Powerful radio beacons and laser beams from advanced civilisations are already being scoured with large telescopes.

This year also marks the sesquicentury of Darwin's epochal work 'Origin of Species' which revolutionised biology and the bicentenary of Darwin's birth. It would be appropriate to call 2009 as the year of astrobiology.

(The author is with the Indian Institute of Astrophysics.)