X-RAY ASTRONOMY

Introduction
X-rays are electromagnetic radiation of energy ranging from 0.1 keV to a few 100 keV.

We see many objects in the sky that emit visible light but some objects emit X-rays and some are even more bright in X-rays than in visible light.

The study of the Universe seen with X-ray eyes is called X-ray Astronomy.

Properties of X-rays
X-rays have energies a thousand times that of optical photons.

Visible light can be easily reflected but not X-rays. X-rays are either absorbed or scattered or are passed through unaltered when they hit matter.

Refractive index of most materials at X-ray wavelength is slightly less than 1, which helps X-rays to undergo total external reflection if they fall from vacuum on a smooth denser surface at an angle less than the grazing angle.

X-rays and Earth’s atmosphere
X-rays do not penetrate earth’s atmosphere.

All the X-rays are absorbed until they reach about 40 km above the Earth’s surface.

So X-rays cannot be detected on Earth’s surface. Rockets, Balloons and Satellites are used for detection of X-rays from cosmos.

History of X-ray Astronomy
The first technology useful for research about the atmosphere was that of the V2 rockets available after World War II. With this, scientist revealed that Sun is a powerful source of UV and X-radiation. This is only because Sun is extremely close to us, but this discovery caused many scientists to lose interest in search for other sources of X-rays.

X-ray Detectors

Almost all the detectors of X-rays work on the basic principle of photoelectric effect. These detectors respond to energy deposited by photoelectrons.

Proportional counters consist of a tube with a central wire filled with Argon gas at pressure slightly more than 1 atm.

Proportional counters measure energy of incoming photon at the time of arrival.

1. Proportional Counters

X-ray Satellites and ASTROSAT

Almost 60 X-ray satellites have been launched till now since 1960s. XMM Newton launched by Europe, RXTE, Chandra X-ray (all launched by NASA) are some active X-ray observation satellites.

India is going to launch a multi-wavelength astronomy satellite called ASTROSAT.

ASTROSAT will be a leading X-ray astronomy satellite in the near future.

European Photon Imaging Cameras

A comparison between two cameras (EPIC MOS and EPIC pn) is shown below.

EPIC MOS

Registers photons in soft portion of X-rays (below 10 keV).

Low quantum efficiency.

Better angular resolution (4.4’FWHM)

European Photon Imaging Cameras

There are two identical spectrometers for high resolution spectroscopy and spectrophotometry. RGS has higher resolution but lower flux faint X-rays with spectral energy range of 0.2 keV to 2.5 keV.

For an astrophysical source, the position and the size of the peaks in the spectrum are a measure of temperature and relative abundance of different elements.

X-ray sources

Accretion Neutron Stars and Black Holes are the brightest sources of X-rays.

Solar type stars, remnants of supernovae, active galactic nuclei, diffuse hot gas in galaxies and clusters, gamma ray burst sources are among other prominent sources of X-rays.

Some Discoveries....

First X-ray image of Sun. The X-rays detected from the Sun usually come from gamma corona, and the solar surface.

The discovery of hot corona created a big problem for astronomers and physicists. It is called the Coronal Heating Problem.

X-ray sources

Accretion Neutron Stars and Black Holes are the brightest sources of X-rays.

Solar type stars, remnants of supernovae, active galactic nuclei, diffuse hot gas in galaxies and clusters, gamma ray burst sources are among other prominent sources of X-rays.

Some Discoveries....

First X-ray image of Sun. The X-rays detected from the Sun usually come from gamma corona, and the solar surface.

The discovery of hot corona created a big problem for astronomers and physicists. It is called the Coronal Heating Problem.

Chandra image of Centaurus A shows a bright central source. The active galactic nucleus suspected of harboring a supermassive black hole. A jet emanating from the core is also seen.

Crab Nebula

The observations of crab nebula in X-rays revealed the existence of a pulsar at the center of nebula.

The pulsar at the center of crab nebula is a neutron star that spins around about 30 times in a second.

The pulsar was created from a supernova explosion in our galaxy that was observed by astronomers in China and other countries in the year 1054.

Acknowledgements: Prof. Gulab Chand Dewangan, Sibasish Laha, Mainpal Rajan