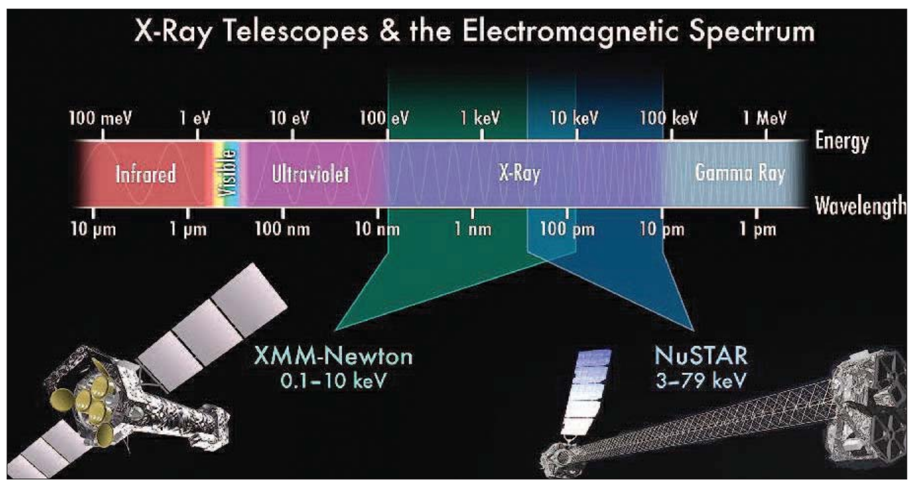
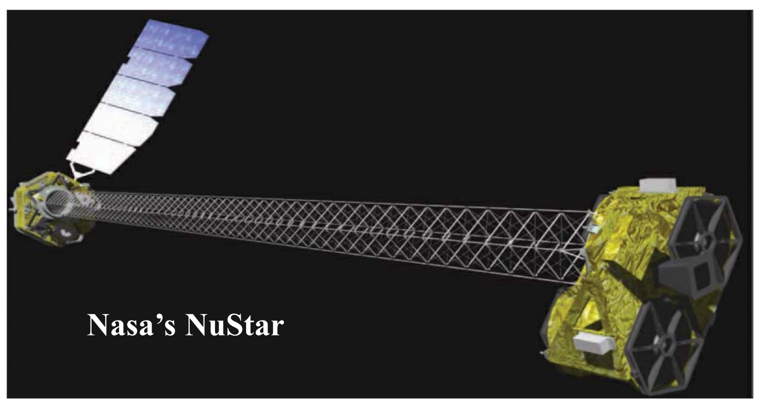
Close look at a distant fireball

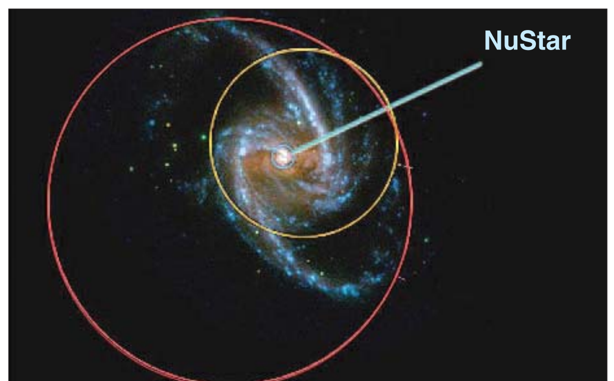
Black holes can now be seen in greater detail, says s ananthanarayanan



THE National Aeronautics and Space Administration's Nuclear Spectroscopic Telescope Array (NuStar) is a newest space-based telescope and it forms images using high energy X-rays. It exceeds the capabilities of Nasa's Chandra X-ray Observatory or the European Space Agency's X-Ray Multi-mirror Mission-Newton (XMM-Newton), the two most powerful facilities so far.

NuStar has enabled views of massive black holes in the centre of a nearby galaxy and has enabled working out how fast the black hole is spinning – information that will help us understand the way black holes form.





This image of NGC 1365 is by the ESA's XMM-Newton. NuStar could look closely at the AGN in the centre.

A group of scientists from Italy, Denmark, the UK and institutes in the USA report in the journal *Nature* the results of data collected by NuStar, which resolves an important question about the spin of the active core of one nearby galaxy.

Telescopes can resolve greater detail if the light that they use is of short wavelength. Many cosmic objects are very hot and emit light in the Ultra Violet or the X-ray region. But this light is absorbed by earth's atmosphere and the images are not visible in telescopes that are on the ground, even atop high mountains. An early solution was to raise the telescopes high into the atmosphere in gas balloons, but this method has limitations. Recent decades have seen better ways, with telescopes placed out in space, in orbit around the earth, conveying the images back to the ground by radio signals. The Chandra and the XMM-Newton (named after S Chandrashekhar and Isaac Newton) are two such, which have collected vast data in the near X-ray region.

A great difficulty in constructing X-ray telescopes is that glass lenses or simple metallic mirrors cannot be used as components. While glass lenses can focus visible light, this does not work with X-rays, which are scarcely affected by glass in their path. And as for mirrors, X-rays do not reflect off a shiny surface when they strike full on, but pass right through, and usual metallic mirrors cannot be used. The method that works is with multiple mirrors that X-rays strike at *grazing angles* and with these an image of the distant object has to be managed.

The Chandra and Newton telescopes had special arrangements like this and NuStar also has a complex, grazing angle mirror system known as a *Wolter Telescope*, which uses a pair of mirrors that are built in concentric shells (there are 133 shells in each mirror) which consist of multi-atom-thin layers of materials to coax the range of X-rays into reflection, so that they form an image. The NuStar optics enables detection of X-rays of about 10 times the energy, or about 10 times shorter wavelength than the SMM-Newton, which is a very great advance in sensitivity.

Active galactic nuclei

While stars and galaxies form when sparse matter in space comes together due to gravity, the extreme end of the process is when matter is crushed so close together that the gravity at its surface is so high that even light cannot escape.

Such an object, which is the *black hole,* will continue to attract matter, which would be accelerated to very high speeds and, despite the name, a black hole can be made out by the radiation from the matter that surrounds it. It is now believed that there is a black hole at the centre of most galaxies and in many, the black hole has become "super-massive" and sports a swirling disk of surrounding matter which emits radiation of millions of suns. Galaxies with this kind of core are said to have *Active Galactic Nuclei*. As the objects are very high energy systems, there is intense radiation in the X-ray region; indeed, even in the higher energy, gamma ray region, and the right kind of telescope can form detailed images.

Objects that form through the accretion of matter increase not only their mass but also their rate of spin, as all the matter that comes in brings along some angular movement. This is the reason that galaxies form into disks or spirals and certain very dense objects, the neutron stars, rotate many times a second and emit pulses of radiation, as *pulsars*. In the same way, black holes are also expected to be rotating and a measure of the speed of rotation could, ironically, "throw light" on how the black hole formed — is it by gobbling large objects all at once or is it gradual? Gradual growth is likely to balance the growth of rotation and result in slower spin.

The rate of spin of black holes can be gauged using the special gravitational effects of a spinning mass. The black hole's gravity on the luminescent disk of surrounding matter would affect the quality of the light emitted and these changes can be detected to make surmises about the rate of spin. The effect of gravity, basically, is to accelerate an object, and this would tend to stretch apart the waves of radiation emerging from the object. The wavelength of light from the object would hence grow longer, or be *shifted to the red side*. The extent of *red shift* is a standard means of measuring the gravity or the speed of movement of a distant object. In the case of the light from around a black hole, it is the X-ray light from the element iron which is of interest and the red shift which has been seen has suggested a rapid rate of spin.

But the trouble with measurements so far has been that there is an alternate, viz, other than spin, explanation for the red shift that is seen – it is possible that the X-ray emitting disk of matter is obscured by many layers of gas. These layers of gas could absorb and re-emit X-rays, which would complicate the X-ray spectrum and mimic effects of spin even if there were none. The effect has "cast a cloud", says Christopher S Reynolds of the University of Maryland, who has reviewed the paper in *Nature* over the effort to detect spin of super-massive black holes.

NuStar results

The images of *NuStar*, with X-rays at frequencies about 10 times higher than those of *Chandra* or *Newton*, have helped resolve the uncertainty, at least in the case of the AGN at the core of the nearby galaxy, *NGC 1365*. The softer X-rays, viewed so far, had energies of *less than 10 keV* (kilo electron Volts) as compared to the *79 keV* possible with NuStar. The soft X-ray pictures showed variability due to movement of clouds of intervening, scattering material. With NuStar, it became possible to view the emission of X-rays at higher ranges of frequency to see if there was a change in the effect of the moving clouds. The amount of radiation received in the bands of 3-5 keV and 6-10 keV, and 7-15 keV and 15-80 keV bands were studied and with statistical analyses and it was suggested that there was variability in the soft region, due to absorption of radiation.

The data was fitted to different models of black hole and accretion disk geometries. The investigation shows that the observed distortion of the emission lines of the metal iron is best explained by reflection off a fast rotating inner edge of the accretion disk. The extent of spin that is worked out leads to an estimate of the spin of the black hole itself and it is found to be 84 per cent of the theoretical maximum spin. This is a important addition to the information about the process by which the black hole could have acquired the spin, which spurs the drive for more powerful X-ray observation tools.

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Quasars & red shift

THE discovery of *Quasars, or Quassi Stelar Radio Sources*, by Maarten Schmidt at the Mount Palomar Observatory in 1963 happens to be the 50th. Anniversary. Schmidt was studying radio source 3C 273, which had the unusual feature of being a source of radio signals that was also bright, like a star. But what was more puzzling was that the spectrum of light received did not fit the emission spectrum of any known element. Till Schmidt realised that it was the spectrum of the element iron, but strongly shifted to the red side. A red shift indicates a high speed of recession or a moving away of the source. It was known then that the universe was expanding and accelerating as it moved out and the speed of recession had become a measuring rod of how far away an object was.


Maarten Schmidt

This formula, known as Hubble's law, led to 3C 273 being placed billions of light years away and, therefore, tremendously powerful, of the order of millions of galaxies, to be visible like a star at such a great distance. The power comes from the largest AGN at the centre of the Quasar, at the early stages of its growth. And it has been shown that the gravitation from the AGM cannot account for the red shift.

That the object was so far away implies that it belonged to a very early part of the history of the universe. Many such objects have been found since then, but they are all at similar and greater distances. The discovery was a major reason to drop the "steady state" theory of the growth of the universe, as against the "big bang" theory.

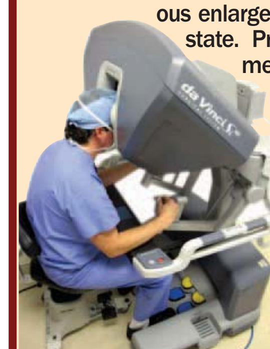
According to the "steady state", young galaxies should be uniformly distributed over the universe. But Maarten Schmidt showed that the youngest galaxies were found only at great distances.

Indian perspective

narmada p gupta **explains the pitfalls of prostate cancer wherein ageing is an important factor**

WITH the continuing improvement in India's healthcare scenario, longevity has increased from 31 years at the time of Independence to 67 years as per the last census. Eleven per cent of the population will enjoy more than 60 years in the coming decade but with the number of elderly increasing so too is the number of patients suffering from prostatic diseases.

Prostate is an accessary sex gland at the opening of the bladder. Every man has some enlargement of prostate after the age of 50 years and approximately 17 per cent above 50 years and 35 per cent above 70 years suffer from Lower Urinary Tract Symptoms. The common causes of prostrate enlargement include benign (non-cancerous) enlargement or cancerous enlargement of the prostate. Prostrate enlargement may result in Luts symptoms like frequency of urination, a sudden strong desire to pass urine, urge incontinence or poor urinary stream, etc. A check-up is done by digital rectal examination for prostate, ultrasound for kidney, bladder, prostate, post-void residual urine and blood examination for Prostate Specific Antigen. If PSA is elevated, then prostatic biopsy is advisable for confirmation of cancer prostate.



The incidence of this is lower in India in comparison with the West but the reason for lower incidence can be due to genetic, racial, environmental and dietary factors or methods of detection. Due to the lack of a screening programme and poor awareness of prostatic diseases in general, cancer prostate may go undetected.

If diagnosed early, this can be completely cured whereas when diagnosed at an advanced stage, it can only be controlled for some time. If untreated, prostate cancer can be a cause for significant morbidity and mortality. In USA, 90-95 per cent of prostate cancer cases are diagnosed early, whereas in India, 90-95 per cent are diagnosed in an advanced stage. This reverse scenario is primarily due to lack of routine screening, ignorance, financial constraints, non-availability of PSA testing in remote and rural areas and non-specialty surgical practices.

The PSA test was available in India around 1998 and cases are diagnosed in the early stages. Changing the outlook of this disease in India is a big challenge and results can be achieved only by periodic check-ups and public awareness.

The treatment options for localised disease are radical prostatectomy/ open laparoscopy/robotic, radiotherapy-external beam/brachytherapy, cryotherapy, High Intensity Focused Ultrasound /Cyberknife.

Robot-Assisted Radical Prostatectomy is a rapidly evolving technique for the treatment of localised prostate cancer in India and the first robot for the urological programme was installed at the All India Institute of Medical Sciences, New Delhi, in July 2006, followed by many centres in the country. Over the last six years, we have done more than 500 such procedures.

In spite of the high cost of the robotic system and instruments, the overall cost of the procedure is significantly less in India in comparison to the USA and Europe, with same standard of patient care and outcome. This is due to the lower cost of hospital charges and manpower. More and more patients are accepting Ralp for localised cancer prostate.

The other treatment option is Radical Radiotherapy, Conformal /IMRT/IGRT. Few centres have HIFU but we have not seen good results. There are only two centres for Cyberknife and the long-term results are awaited.

In advanced stages, hormonal treatment is preferred because it can control the disease. After a year or two, the patient develops resistance that can be treated by anti-cancer drugs.

Ageing is an important factor, apart from which there is higher incidence in families known to have cancer prostate in men. It is advisable that every man have a check-up after the age of 50 once to know the status and thereafter according to the findings.

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Discovering organelles

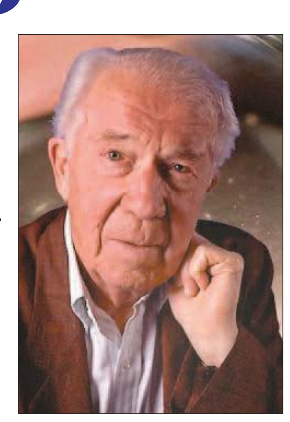
tapan kumar mailtra **explains the importance of centrifuges and chance observations**

HAVE you ever wondered how the various organelles within eukaryotic cells were discovered? There are almost as many answers to that question as there are kinds of organelles. In general, they were described by microscopists before their role in the cell was understood. As a result, the names of organelles usually reflect structural features rather than physiological roles. Thus, chloroplast simply means "green particle" and endoplasmic reticulum just means a "network within the plasm (of the cell)".

Such is not the case for the lysosome, however. This organelle was the first to have its biochemical properties described before it had even been reported by microscopists. Only after fractionation data had predicted the existence and properties of such an organelle were lysosomes actually observed in cells. A suggestion of its function is even inherent in the name given, because the Greek root *lys* means "to digest". (The literal meaning is "to loosen", but that's essentially what digestion does to chemical bonds!)

The lysosome is something of a newcomer on the scene; it was not discovered until the early 1950s. The story of that discovery is fascinating because it illustrates how important chance observations can be, especially when made by the right people at the right time. The account also illustrates how significant new techniques can be, since the discovery depended on sub-cellular fractionation, a technique that was then still in its infancy.

The story begins in 1949 in the laboratory of Christian de Duve, who later received a Nobel Prize for this work. Like so many scientific advances, the discovery of lysosomes depended on a chance observation made by an astute investigator. Because of an interest in the effect of insulin on carbohydrate metabolism, de Duve was attempting to pinpoint the cellular location of glucose-6-phosphatase, the enzyme responsible for the release of free glucose in liver cells. As a control enzyme (that is, one not involved in carbohydrate metabolism), de Duve happened to choose acid phosphatase.


Christian de Duve

He first homogenised liver tissue and resolved it into several fractions by the new technique of differential centrifugation, which separates cellular components on the basis of differences in size and density. In this way, he was able to show that glucose-6-phosphatase activity could be recovered with the microsomal fraction. (Microsomes are small vesicles that form from ER fragments when tissue is homogenised.) This in itself was an important observation because it helped establish the identity of microsomes, which at the time tended to be dismissed as fragments of mitochondria.

But the acid phosphatase results turned out to be still more interesting, even though they were at first quite puzzling. When de Duve and colleagues assayed their liver homogenates for this enzyme, they found only a fraction of the expected activity. When assayed again for the same enzyme a few days later, however, the same homogenates had about 10 times as much activity.

Speculating that he was dealing with some sort of activation phenomenon, de Duve subjected the homogenates to differential centrifugation to see with what sub-cellular fraction the phenomenon was associated. He and his colleagues were able to demonstrate that much of the acid phosphatase activity could be recovered in the mitochondrial fraction, and that this fraction showed an even greater increase in activity after standing a few days than did the original homogenates.

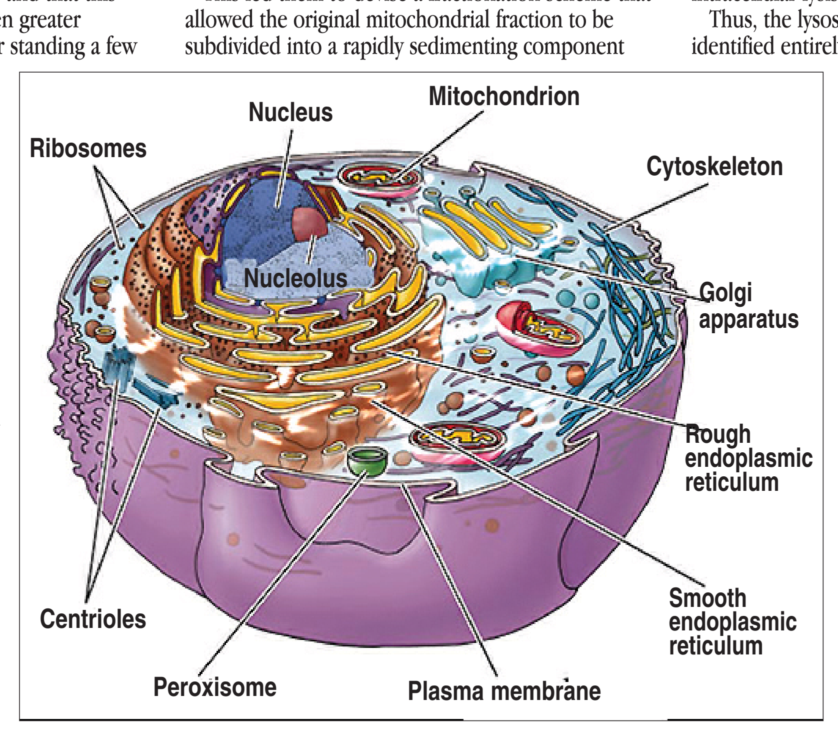
To their surprise, they then discovered that, upon recentrifugation, this elevated activity no longer sedimented with the mitochondria but stayed in the supernatant. They went on to show that the activity could be increased and the enzyme solubilised by a variety of treatments, including harsh grinding, freezing and thawing and exposure to detergents or hypotonic conditions. From these results, de Duve concluded that the enzyme must be present in some sort of membrane-bounded particle that could easily be ruptured to release the enzyme. Apparently, the enzyme could not be detected within the particle, probably because the membrane was not permeable to the substrates used in the enzyme assay.

Assuming that particle to be the mitochondrion, they continued to isolate and study this fraction of their liver homogenates. At this point, another chance observation occurred, this time because of a broken centrifuge. The unexpected breakdown forced one of de Duve's students to use an older, slower centrifuge and the result was a mitochondrial fraction that had little or no acid phosphatase in it. Based on this unexpected finding, de Duve speculated that the mitochondrial fraction, as they usually prepared it, might in fact contain two kinds of organelles: the actual mitochondria, which could be sedimented with either centrifuge; and some sort of more slowly sedimenting particle that came down only in the faster centrifuge.

This led them to devise a fractionation scheme that allowed the original mitochondrial fraction to be subdivided into a rapidly sedimenting component and a slowly sedimenting component. As you might guess, the rapidly sedimenting component contained the mitochondria, as evidenced by the presence of enzymes known to be mitochondrial markers. The acid phosphatase, on the other hand, was in the slowly sedimenting component, along with several other hydrolytic enzymes, including ribonuclease, deoxyribonuclease, b-glucuronidase and a protease.

Each of these enzymes showed the same characteristic of increased activity upon membrane rupture, a property that de Duve termed latency.

By 1955, he was convinced that these hydrolytic enzymes were packaged together in a previously undescribed organelle. In keeping with his speculation that this organelle was involved in intracellular lysis (digestion), he called it a lysosome.



Thus, the lysosome became the first organelle to be identified entirely on biochemical criteria. At the time, no such particles had been described by microscopy. But when de Duve's lysosome-containing fractions were examined with the electron microscope, they were found to contain membrane-bounded vesicles that were clearly not mitochondria and were, in fact, absent from the mitochondrial fraction. Knowing what the isolated particles looked like, microscopists were then able to search for them in fixed tissue. As a result, lysosomes were soon identified and reported in a variety of animal tissues. Within six years, the organelle that began as a puzzling observation in an insulin experiment became established as a bona fide feature of most animal cells.

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