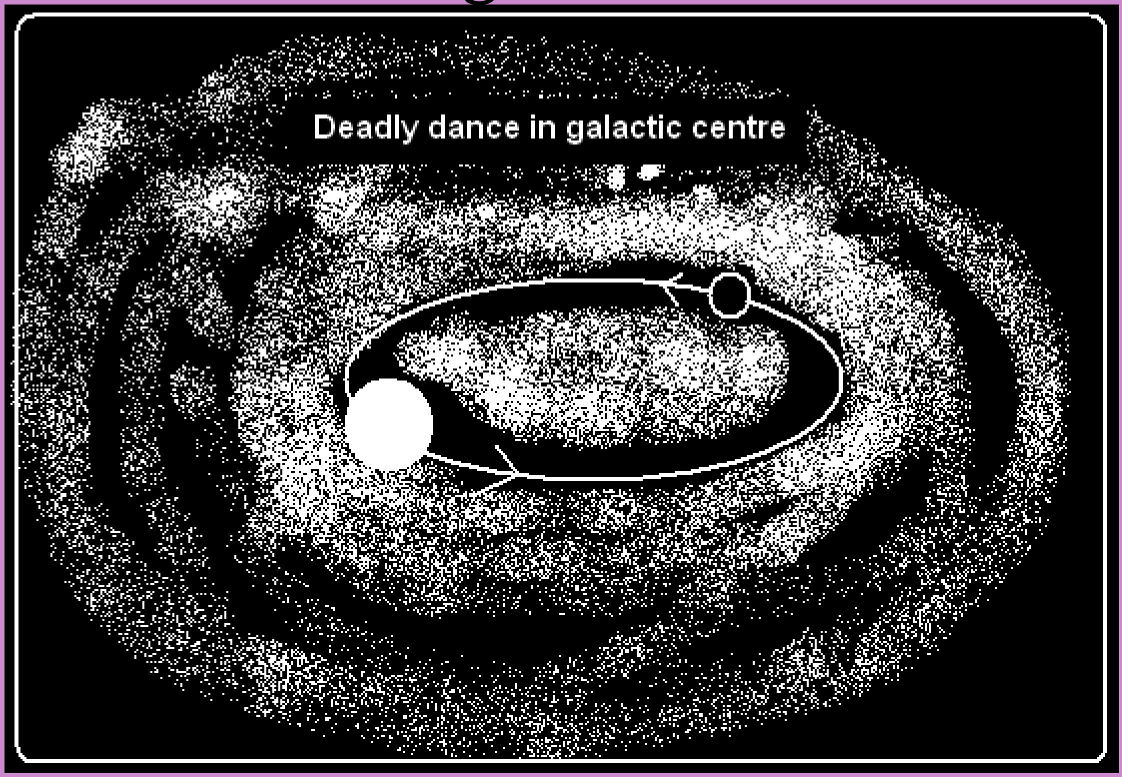
appeared on 23rd Feb 2009

Black holes in tango of death



Data survey has revealed black holes in fatal embrace, says S.Ananthanarayanan.

Black holes are objects so dense that the gravity at their surface keeps even light from escaping from the object. Other objects in their vicinity are drawn by intense gravity and crash in with speeds that approach the speed of light. These objects get ***stretched***, because of the end nearer the black hole is pulled ahead of the parts further away. The high speeds set gamma rays flashing, relativistic effects come into play, time is at a standstill and the environment is hellish and outside experience.

A further degree of extreme conditions is when we imagine two black holes crashing into each other. What may be the conditions when their two surfaces merge? And yet, as the result is a still more massive black hole, could the merger be detected at all, because no radiation can escape, for anybody to see?

Cosmic mergers

Ordinary stars hardly ever coalesce and merge, because the distance between them is too great. The evolution of stars itself is believed to be by the matter in a large area coming together through mutual attraction. Star-birth would hence sweep away all matter within many light years and the new-born must needs be isolated.

But galaxies, at the galactic scale, are not as far apart as stars, relative to their size, that is, and the current theory of formation of galaxies is that they do grow through mergers. But the theory of formation of young galaxies itself suggests that galaxies harbour a massive black hole at their centre – the primogenitor of star formation and the development of the galaxy. Merger of two such galaxies would thus draw the two black holes to rush to the centre of the new, greater galaxy and how impressive might the display of fireworks be at their meeting?

Red shift

Instances of such coalescing of galactic cores, however, are difficult to find and observe. The main reason is the great distance of galaxies and the great distances that light has traveled before reaching the earth. Because the universe is expanding, with points further apart receding faster, these distant galaxies are receding at great speeds and the light they emit is dramatically ***red shifted***. Red shift is the lowering of the frequency of any wave that is emitted by a body that is moving away – like the whistle of a receding railway engine. We may have all experienced that the whistle is shrill when the engine is coming towards us but the pitch falls as the engine goes past and starts moving away.

In the same way, the colour of light emitted by receding cosmic bodies is shifted towards lower frequencies. This red-shift of light from the furthest galaxies can be such that the light coming from them is mainly in the infra red or microwave region, apart from being faint, in the first place.

Low resolution

Now, the resolution of telescopes or other detection devices is very low for low frequencies and the images formed of distant galaxies are thus far from clear and sharp. The implication is that as black holes, which are low diameter objects, can be detected by telescopes only so far as they are fairly well separated. Black holes about to merge are thus beyond the limits of resolution at the low frequencies involved.

The alternate method is by spectroscopy, or the analysis of the wavelength of the light received. When black holes approach, they will first begin circling each other and spiral towards each other. Their movement is in near circles of rapidly reducing diameter, and as the distance reduces, they will circle faster and faster. The black holes are thus moving towards the viewer some of the time and away from the viewer the rest of the time – which results in light of two different frequencies being received on the earth. Measuring the frequency of the radiation received can thus lead to the distance separating the black holes, and this data can be correlated with other data about processes going on.

Data base

The trouble is that making this kind of analysis in respect of the thousands of faint galaxies out there is hardly feasible in reasonable time frames. Recourse has then to be had to repositories of data collected by all astronomers and observatories the world over. There is a number of such collections, at optical, infra red or radio frequencies, usually covering specific areas of the sky or specific kinds of astronomical objects.

Once such collection is the ***Sloan Digital Sky Survey (SDSS)***, which records redshift data in different frequencies using a 2.5 metre optical telescope at Apache Point Observatory in New Mexico. The survey began in 2000, to map 25% of the sky and observe around 100 million objects and record spectroscopic data of 1 million objects. The telescope uses filters to process and classify images and then select targets for spectroscopic analysis. The detectors are a battery of microchips that allow very sensitive imaging and the method is to use the rotation of the earth to record small strips of the sky at a time. The telescope records about 200 GB of data every night.

Todd Boroson and Tod Lauer at Tuscon, Arizona analysed the huge data base of the SDSS and picked 17,500 quasars for further study. Quasars (**QUA**si **S**tell**A**r **R**adio **S**ources) are extremely powerful and distant active galactic nuclei, now accepted as being a compact region surrounding a supermassive black hole.

Boroson and Lauer's study of the 17,500 cases has netted the first convincing instance so far of a tightly bound black hole pair. The two black holes are separated by a distance of about half a light year and the result is an important validation of our understanding of growth processes in the universe.

A tool more promising than optical methods for detecting black hoes pairs is to look for gravitational waves that a coupled black hole pair should generate. Detecting gravity waves calls for simultaneous measurements separated by huge distances and a system is being developed in the ***Laser Interferometer Space Array (LISA)***. The LISA detectors, in orbit around the earth, would be separated by 5 million kilometers and would be an apparatus of great sensitivity.

That only one black hole pair could come out of 17,500 sets of SDSS data suggests that LISA also may not find many instances. But LISA would access many more galaxies than was possible in the Sloan Survey and there is the possibility that black hole pairs lurk in 'normal' galaxies. But the work of Boroson and Lauer is believed to be the start of further theoretical and observational work in the field.

Radiation from black holes?

How can there be radiation from black holes if light just cannot escape a black hole? Well, the radiation is not from inside the black hole, but from the maelstrom of activity around it. The stream of objects in the vicinity are streaming in at near light speeds and are also subject to stupendous shearing forces. Most matter has split into positive and negative charges and they radiate as they fall in by gravity. The streaming particles and the black hole itself, which, in formation, acquires a violent spin, and they generate magnetic fields. These again add to movement of the streaming create further radiation. And then, there is the 'Hawking radiation', which is a quantum mechanical oddity, pairs of elementary particles get created – part within and part without and the outside part streams away from the black hole!