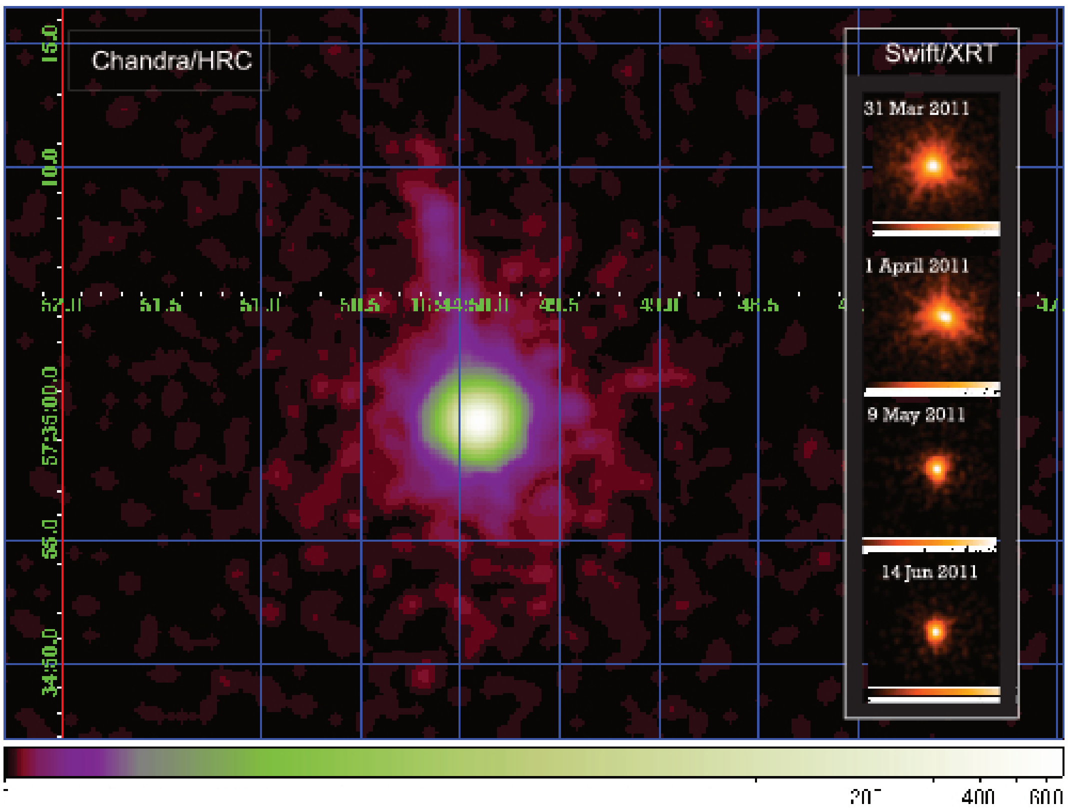
PHYS.ORG

Scientists have invented a new way to weigh intergalactic black holes

September 20 2017



The Chandra/HRC (0.3-10 keV) image of the Swift J1644+57 field of a view (FOV) was observed on 2011 April 4 (MJD=55655) with the 15 ks exposure. Evolution of the Swift/XRT (0.3 - 10 keV) image is plotted in the incorporated vertical panels which clearly demonstrate the outburst decay phase of Swift J1644+57. Credit: Elena Seyfina

Astrophysicists from Moscow State University have found a new way to estimate the mass of supermassive black holes outside our galaxy, even if they are barely detectable. The results of the study were published in *Astronomy and Astrophysics*.

Black holes are hypothetical objects whose gravitational pull is so great that even light cannot escape them. The existence of black holes follows from the solutions of Einstein's equations. Scientists have repeatedly observed the result of black hole interactions with the surrounding matter, for example, gas falling into the black hole.

"If a black hole absorbs a substance, there is a so-called accretion. Due to friction and heating, it causes radiation, which allows us to see the object indirectly and say that this is a black hole," explained Elena Seifina, the leading researcher of the SAI MSU. "If black holes do not have such a recharge, then we may not even suspect their existence."

To understand the nature of such "sleeping" black holes, astronomers led by Elena Seifina turned to several outbreaks from extragalactic sources. One of them, Swift J1644 + 57, was observed in 2011 simultaneously by several cosmic observatories (RXTE, Swift and Suzaku) in the X-ray and gamma-ray ranges.

At first, scientists thought that they were seeing another gamma-ray burst (GRB) similar to that observed in remote galaxies in the hardest range of the electromagnetic spectrum. However, the radiation of such flares usually disappears in a day or two, though the case of Swift J1644 + 57 was different. "The BAT tool at the Swift satellite was aimed at it and saw that two days later, the splash became even brighter. The whole outburst was observed for two years and then it went out," Elena Seifina explained.

Astronomers excluded the object from the GRB list and suspected that they were observing the tidal destruction of the star by a supermassive black hole. A star flying a short distance from a black hole undergoes tidal destruction. In this case, its matter does not fall onto the black hole at once, but forms a temporary accretion disk that glows brightly and can be seen from the Earth.

Previously, the only way to measure the mass of a black hole at the center of such accretion disks was to estimate the maximum luminosity of the disk, assuming that equilibrium is established between the pressure of electromagnetic radiation and gravitational forces in the disk.

In her doctoral thesis, Elena Seyfina documented observations of similar flares involving black holes both inside our galaxy and beyond, and reported that the X-ray spectrum tilt changes during the increase in luminosity. She found specific features of the spectrum that clearly indicated the presence of black holes in these objects. The scientists assumed that if the shapes (or the evolution of the shape) of the spectra of such flares are similar, then the processes occurring in them are also similar, and the normalization of the spectra is determined only by variable distances to the objects and their mass.

Noticing the similarity between the tracks (the dependence of the spectral tilt on the rate of accretion) of known objects and the tracks obtained in new extragalactic flares, the scientists suggested that they are also caused by stars torn by black holes. This allowed them to weigh invisible black holes in a new way, comparing them with galactic black holes of known mass.

Thus, a new method of weighing sleeping extragalactic black holes allows researchers to use data from known galactic objects like, for example, Cygnus X-1, with a black hole in the center. "Calculations showed that Swift J1644 + 57 contained a supermassive black hole with a mass of 7×10^6 solar masses. This is an object that we do not see, but which provides high luminosity due to its strong gravitational field and an accretion disk around it," explained Elena Seifina, the author of the paper.

Previously, the assessment of supermassive black hole masses also used ultraviolet, but for the new method, the X-ray range is sufficient. Scientists hope that the versatility of the new method will be helpful in assessing the mass of various extragalactic objects, such as the cores of Seyfert galaxies and others, where traditional methods do not work in principle.

More information: L. Titarchuk et al, Swift J164449.3+573451 and Swift J2058.4+0516: Black hole mass estimate using a tidal disruption event flare, *Astronomy & Astrophysics* (2017). DOI: 10.1051/0004-6361/201730869

Provided by Lomonosov Moscow State University