Indian and US satellites, AstroSat and Chandra, measure a black hole's spin rate

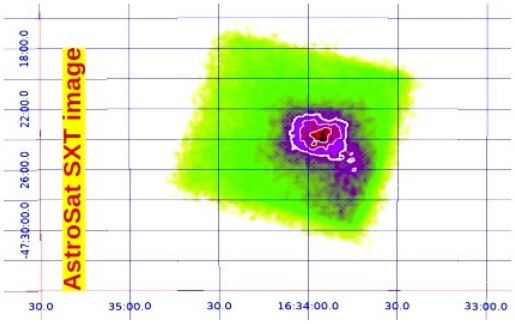
Using the X-ray data from two different satellites, AstroSat and Chandra, an international team of astronomers from multiple institutions, led by the Tata Institute of Fundamental Research (TIFR) in Mumbai, India, has measured the spin rate of a black hole in the binary stellar system 4U 1630−47.

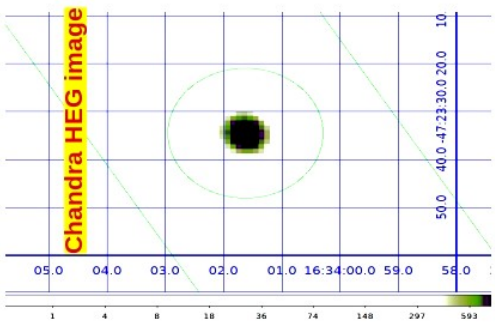
Relatively smaller black holes are exotic end states of massive stellar cores. The gravity of such a collapsing core is so strong that its entire mass is crushed into a point. This point, however, cannot be directly seen, because nothing, not even light, can escape from a region around it, thus justifying the name of the object. Surprisingly, astronomical black holes are the simplest known objects in the universe, because they can be fully characterized by only two properties, mass and spin rate. Therefore, measurements of these two properties are uniquely important to probe some extreme aspects of the universe, and the fundamental physics related to them.

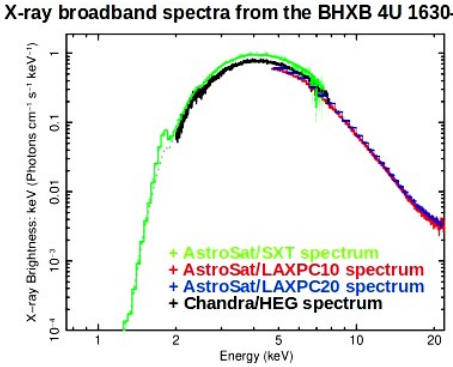
“Such measurements, especially of the spin rate, are very difficult to make, and can be done only by high-quality X-ray observations in the correct state of the binary stellar system, in which the black hole is gobbling matter from its companion star”, said the leading author Dr. Mayukh Pahari, who started this work at TIFR, before joining a Royal Society-SERB Newton International Postdoctoral Fellow position at the University of Southampton in UK.

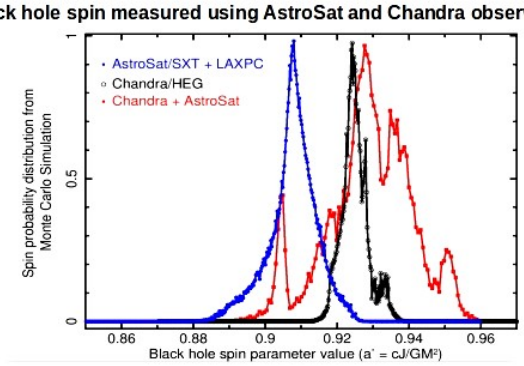
“The Soft X-ray Telescope (SXT) and the Large Area X-ray Proportional Counter (LAXPC) aboard the first dedicated Indian astronomy satellite AstroSat played a key role to measure the black hole spin rate, which was consistent with results from our contemporaneous Chandra satellite data”, said Prof. Sudip Bhattacharyya of TIFR, who is the Principal Investigator of the AstroSat SXT. “AstroSat was launched in 2015 by the Indian Space Research Organisation (ISRO)”, he added.

“From this first joint AstroSat-Chandra study of a black hole, that may lead to further such cooperations, we have found that the black hole in 4U 1630−47 spins very rapidly, with a rate not much less than the maximum possible rate, which makes it even more exotic”, said Prof. A. R. Rao of TIFR.









Caption: *Upper left panel*: AstroSat SXT X-ray image of the black hole cosmic source 4U 1630−47. *Upper right panel*: Chandra X-ray image of 4U 1630−47. *Lower left panel*: Shows, for all instruments, how X-ray brightness depends on the X-ray energy for 4U 1630−47. This dependence is used to measure the black hole spin rate. *Lower right panel*: Shows, for all instruments, the constraints on the black hole spin rate (~ 0.88−0.96). Note that the maximum possible spin rate is 1. [Figure credit: Mayukh Pahari].

The paper is accepted for publication in The Astrophysical Journal (https://arxiv.org/abs/1810.01275).

Sudip Bhattacharyya and A. R. Rao from TIFR (India), Mayukh Pahari, I. M. McHardy, Poshak Gandhi and Diego Altamirano from the University of Southampton (UK), Dipankar Bhattacharya and Gulab Dewangan from the Inter-University Centre for Astronomy and Astrophysics (India), Santosh Vadawale from Physical Research Laboratory (India), Stephane Corbel from University Paris Diderot and CEA Saclay and Observatoire de Paris (France) and Norbert Schulz from Massachusetts Institute of Technology (USA) contributed to this research work.