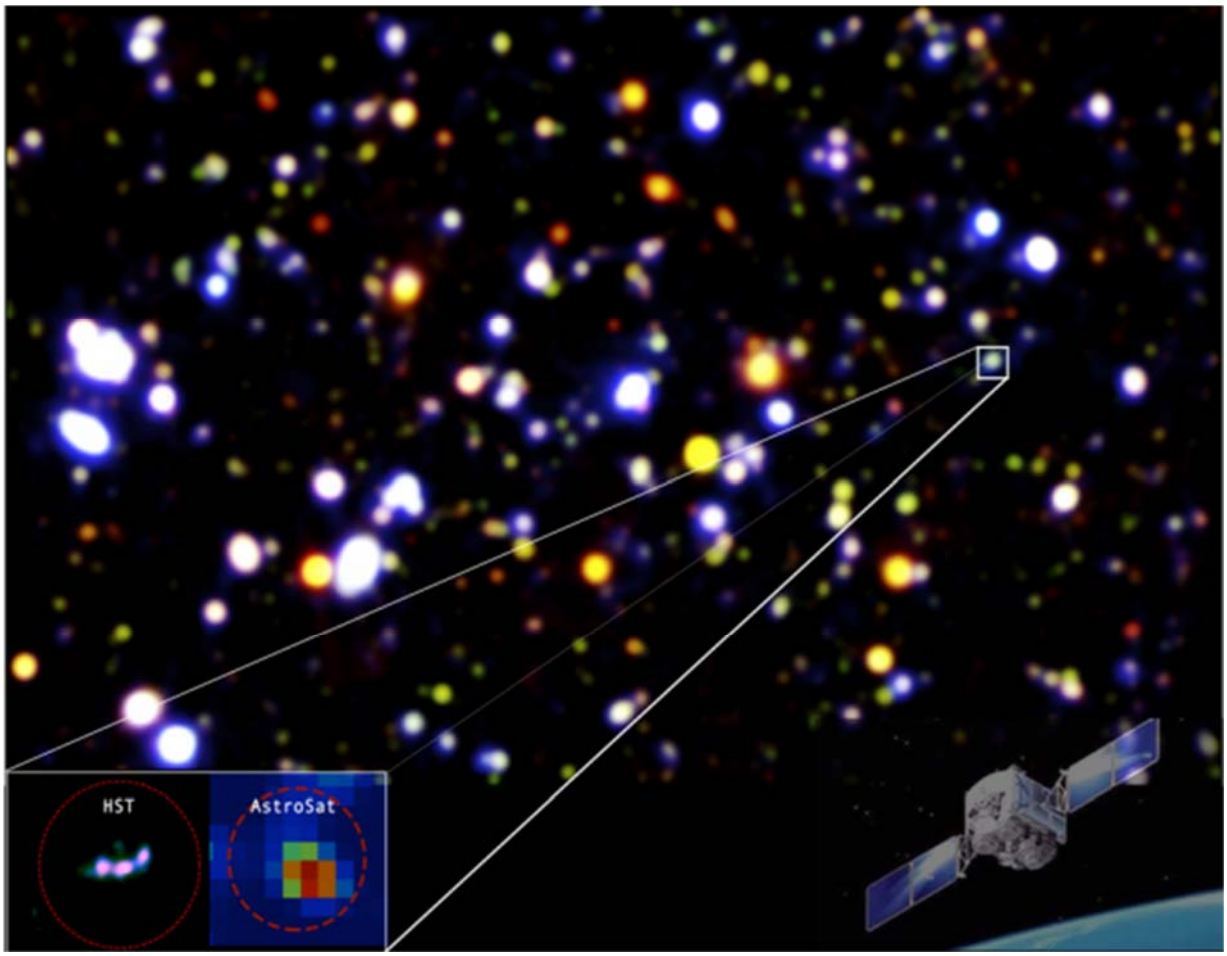
AstroSat caught a distant galaxy emitting extreme-UV photons *Tue, Aug 25, 2020*

A global team of scientists marks a major breakthrough

Key points:

- India's first multi-wavelength satellite, AstroSat, has detected extreme-UV radiation from a galaxy, called AUDFs01, 9.3 billion light-years away from Earth. At the time, our universe was forming stars at its peak rate. Such extreme-UV radiation has enough energy to break up a hydrogen atom into a proton and an electron and thereby played a key role in reionizing the early universe soon after the Cosmic Dark Age.
- The discovery was made by an international team of astronomers led by Kanak Saha, associate professor of astronomy, at the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune and was published on Aug. 24, 2020, by *Nature Astronomy*. This team comprises scientists from India, Switzerland, France, The USA, Japan and The Netherlands. Professor Akio Inoue of Waseda University represents Japan.

A global team of scientists made AstroSat stare at the galaxy which is located in the Hubble Extreme Deep field for more than 28 hours in Oct. 2016. But it took nearly two years since then to carefully analyze the data to ascertain that the emission is indeed from the galaxy.



Combined four-colour image of the AstroSat Uv Deep Field (AUDF). Red and green colours from HST while cyan and dark blue are from AstroSat. AUDFs01 is in the square box. Highlighted images in the boxes below are from HST and AstroSat. Image Credit: Kanak Saha (IUCAA).

Since UV radiation is absorbed by Earth's atmosphere, it has to be observed from Space. Earlier, NASA's Hubble Space Telescope which is significantly larger than UVIT did not detect any UV emission (with energy greater than 13.6 eV) from this galaxy because it is too faint. AstroSat/UVIT was able to achieve this unique feat is because the background noise in the UVIT detector is much less than the ones on HST – said the lead author. The excellent spatial resolution, and high sensitivity, a tribute to the hard work of UVIT core team over a decade, were key to the detection of this very weak source, said Shyam Tandon.

Astronomers have been looking for sources that reionized the early universe. The usual suspects have been the first astronomical objects, especially the newborn small galaxies. But observing ionizing radiation from these sources is next to impossible. The probability that a fraction of extreme-UV photons escape the host galaxy and caught by a telescope on Earth is practically zero, because these photons will be absorbed by the gas in the galaxy or the gas surrounding the galaxy or the matter between the galaxy and us.

But how some of these high energy photons manage to cross all the barriers and reach Earth is a mystery. The absorption in the intergalactic medium is so severe that it is impossible to observe ionizing photons in the reionization epoch directly. In the later epoch, the intergalactic absorbers decrease and we have a chance to detect such photons but it is still like a lottery, — said coauthor Akio Inoue, professor of Waseda University, Japan.

With UVIT observation, AUDFs01 became the first example of a galaxy with clumpy morphology and leaking ionizing radiation at 60 nanometers. AUDFs01 offers the first observational constraint in this extreme ultraviolet regime where stellar models are the most discrepant; with further detections, AstroSat will allow us to refine our scenario of cosmic reionization — said co-author, Anne Verhamme, professor at the Geneva Observatory, Switzerland.

AUDFs01 is in the middle of a redshift range (0.4 to 2.5) where previously no similar sources were detected. The galaxy is not only bridging the gap between the low and high redshift regime at present, but it is also the beginning of a new exploration of star-forming galaxies at extreme-UV wavelength. One can use large-aperture, ground-based telescopes like Keck, VLT, and Subaru for observations of ionizing photons in the universe of redshift larger than 2.5. But below this redshift, AstroSat becomes a unique facility. "Indeed, UVIT will play an important role in revealing insights to the epoch of reionization," said co-author Abhishek Paswan, a postdoctoral fellow at IUCAA. Anshuman Borgohain, a PhD student at Tezpur University and coauthor, said "It is a privilege to be a part of the team which has made this important discovery. The fact that we can do such outstanding work using Indian facilities is an inspiration for young scientists of the country."

Kanak Saha from IUCAA who lead this research said, "We knew it would be an uphill task to convince the international community that UVIT has recorded extreme-UV emission from this galaxy when more powerful HST has not." This discovery of AUDFs01 by AstroSat establishes that there is hope and perhaps, this is the beginning.

More about UVIT & AstroSat

AstroSat was launched on Sept. 28, 2015, by the Indian Space Research Organization (ISRO) and has onboard the UltraViolet Imaging Telescope (UVIT). The 38-cm diameter UVIT, which is capable of simultaneous imaging in far and near-ultraviolet bands with a wide field of view, was developed by teams from IIA, IUCAA, and TIFR from India, and CSA of Canada under the leadership of Shyam Tandon, ExEmeritus Professor, IUCAA. The development of all the instruments for AstroSat was strongly supported by ISRO.

Research Team (grouped together country wise)

Kanak Saha, Shyam Tandon & Abhishek Paswan (all from IUCAA, India); Anshuman Borgohain (Tezpur University, India); Anne Verhamme, Charlotte Simmonds & Daniel Schaerer (all from Geneva Observatory, Switzerland); Francoise Combes (Observatoire de Paris, LERMA, France); Michale Rutkowski (Minnesota State University-Mankato, USA); Bruce Elmegreen (IBM Research Division, USA); Debra Elmegreen (Dept. of Physics and Astronomy, Vassar College, USA); Akio Inoue (Waseda Research Institute for Science and Engineering, Japan); Mieke Paalvast (Leiden Observatory, The Netherlands)