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India's SARAS radio telescope gives clues to Universe's 1st stars & galaxies

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BENGALURU: Raman Research Institute (RRI) in Bengaluru on Monday said that in a first-of-its-kind work, using data from an Indian telescope, scientists have determined properties of radio luminous galaxies formed just 200 million years after the Big Bang, a period known as the Cosmic Dawn.

Pointing out that a number of telescopes, both ground and space-based, peering into the sky are aiming to capture the faint signals arising from the depths of the cosmos to better the understanding of our Universe, RRI said they used the Shaped Antenna measurement of the background RAdio Spectrum-3 (SARAS-3) telescope.

For the study, SARAS-3, indigenously designed and built at RRI, was deployed over Dandiganahalli Lake and Sharavathi backwaters, located in Karnataka, in early 2020.

"Researchers Saurabh Singh (RRI), Ravi Subrahmanyan from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, along with collaborators at the University of Cambridge and the University of Tel-Aviv, used data from SARAS-3 to throw light on the energy output, luminosity, and masses of the first generation of galaxies that are bright in radio wavelengths," RRI said in a statement issued here.

The TOI had first reported RRI and its collaborators' hunt for the first stars in December 2016 (see image), and subsequently about the deployment of SARAS-3 over Dandiganahalli Lake and Sharavathi backwaters earlier this year.

"Scientists study properties of very early galaxies by observing radiation from hydrogen atoms in and around galaxies, emitted

at a frequency of approximately 1420 MHz. The radiation is stretched by the expansion of the universe, as it travels to us across space and time, and arrives at Earth in lower frequency radio bands 50-200 MHz, also used by FM and TV transmissions. The cosmic signal is extremely faint, buried in orders of magnitude brighter radiation from our own Galaxy and man-made terrestrial interference," RRI said.

Therefore, it added, detecting the signal, even using the most powerful existing radio telescopes, has remained a challenge for astronomers.

"Results from the paper published in the journal Nature Astronomy on November 28, 2022, have described how even non-detection of this line from the early Universe can allow astronomers to study the properties of the very first galaxies by reaching exceptional sensitivity," RRI added.

The results from the SARAS-3 telescope are the first time that radio observations of the averaged 21-cm line have been able to provide an insight to the properties of the earliest radio loud galaxies that are usually powered by supermassive black holes, said Subrahmanyan, former director of RRI and currently with Space & Astronomy, CSIRO, Australia, and an author of the paper.

"This work takes forward the results from SARAS-2, which was the first to inform the properties of earliest stars and galaxies," he added.
Singh, one of the authors of the paper titled 'Astrophysical Constraints from the SARAS-3 non-detection of the Cosmic Dawn Sky-Averaged 21 cm Signal', said SARAS 3 has improved the understanding of astrophysics of Cosmic Dawn.

"It has shown that less than 3% of the gaseous matter within early galaxies was converted into stars, and that the earliest galaxies that were bright in radio emission were also strong in X-rays, which heated the cosmic gas in and around the early galaxies," Singh added.

In March this year, Singh, along with Subrahmanyan and the SARAS-3 team, used the same data to reject claims of the detection of an anomalous 21-cm signal from Cosmic Dawn made by the EDGES radio telescope developed by researchers from Arizona State University (ASU) and MIT, USA.

"This rebuttal helped restore confidence in the concordant model of cosmology that was brought into question by the claimed detection," RRI said.

"We have now got constraints on the masses of the early galaxies, along with limits on their energy outputs across radio, X-ray, and ultraviolet wavelengths," Singh noted. Further, using a phenomenological model, SARAS-3 has been able to put an upper limit to excess radiation at radio wavelengths, lowering existing limits set by the ARCADE and Long Wavelength Array (LWA) experiments in the US.

"The analysis has shown that the 21-cm hydrogen signal can inform about the population of first stars and galaxies," shared another author, Anastasia Fialkov from the Institute of Astronomy, University of Cambridge. "Our analysis places limits on some of the key properties of the first sources of light, including the masses of the earliest galaxies and the efficiency with which these galaxies can form stars," said Fialkov.

Further, since its last deployment in March 2020, SARAS-3 has undergone a series of upgrades. These improvements are expected to yield even higher sensitivity towards detecting the 21-cm signal. Currently, the SARAS team is assessing several sites in India for its next deployment.

"These sites are fairly secluded and pose several logistical challenges for deployment. However, they seem promising from science's viewpoint and, with new upgrades, seem ideal for our experiment," said Yash Agrawal, a PhD student and member of the SARAS team.