Pune University scientists' model reveals previously undetected structures in the Universe

(Savitribai Phule Pune University Press release)

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A team of astrophysicists led by Dr. Surajit Paul from SP Pune University have come up with a new model that shows, observations to be conducted with the upcoming world's largest radio telescope - the Square Kilometer Array (SKA) - will allow scientists, for the first time, to detect the diffuse matter in Cosmic Filaments - previously unseen structures that link galaxy clusters in the Universe. This calculation was presented at two international conferences – SPARCS meeting 2016 and SKA annual meeting-2016 - that took place in Goa during 3-11 November where this breakthrough research has been published as featured news by the SKA organisation.

The structure of the Universe is thought to be web like long interconnected filaments that are made up of diffuse hydrogen, which are connected by the nodes made of large galaxy clusters. Galaxy clusters are the biggest known and observationally verified structures in the universe till date, even light needs millions of years to cross such an object. These objects emerge when thousands of galaxies like our milky way come together through gravitational attraction. Filaments are 10 to 100 times longer than galaxy clusters itself. Filaments are actually connecting galaxy clusters, channel the gas into the clusters, thus contributing to their growth. These filaments remained undetected yet and scientists have been working on this issues for at least last two decades. The calculations by Dr. Paul and team by invoking new models predict that they will indeed be observable with the upcoming SKA telescope.

Caption: Dr. Surajit Paul talking to us at his office.

The discovery of the filaments could shed light on one of the most enduring problems in modern Astrophysics - that of the missing baryons. Baryons make up the light emitting mass that enables us to see the objects like star, nebula, milky way etc. As per current understanding, only 5% of the total

energy mass distribution in the Universe should come from baryons; the rest being dark energy (71%) and dark matter (24%). However, when observing the Cosmic Microwave Background – the faint imprint of the early Universe - we find that between then and now, half of the baryonic matter - that is matter that thermally interacts and emits light - has seemingly disappeared and cannot be detected.

Scientists' models predict these filamentary structures should be there, however they have not been seen in observations of any light wavelengths until now. "The reason is possibly this material is very diffuse and very cold, so, emits very little radiation and is hard to detect with the currently available facilities" said Dr. Paul. “It is also true that, no previous theoretical model could predict their obvervability with certainty. Uniqueness of our model is that, we have realised the importance of presence of turbulence in the filaments that can amplify the cosmic magnetic field and accelerate ambient electrons to generate considerable amount of emission in radio wavelengths” he added. SKA being extremely sensitive, will be able to detect them for the first time, as their calculations show.

Computation done by Prateek Gupta and Reju Sam John, who are working under Dr. Paul for their PhD thesis, show that the first phase of SKA Telescope would be able to see the filaments closest to massive galaxy clusters, where they inroad into the cluster medium. Turbulence is very high in this region leading to particle re-acceleration and amplification of strong magnetic field. "Eventually, when second phase of SKA will be up and running, we hope to detect entire filaments connecting clusters together", Dr. Paul says.

This pioneering research show there could be more matter quietly tucked away in these previously undetected filaments than in all galaxy clusters. "We expect that the detected filaments will account for 30 to 40% of the missing baryon" adds Paul. "so detecting them would go a long way in solving this persisting problem.

Square Kilometre Array (SKA) is the world's largest telescope under construction in two places in Australia and South Africa which detects the radiation in radio waves, just like GMRT, but, much more powerful. India is also a core member of this project. Dr. Paul, who is also a faculty associate at the Inter University Centre for Astronomy and Astrophysics (IUCAA, Pune) told that "the simulations works for this research was performed using High Performance Computing facility at IUCAA and it took 3 months to finish. If the same amount of calculation is done with a high power desktop computer, it would have taken more than 100 years,” Dr. Paul mentioned. "We are very much thankful to IUCAA HPC facility that enabled us to do this cutting edge research" as he acknowledged.

Dr. Surajit Paul’s team for this research consists of Ph.D. students – Prateek Gupta and Reju Sam John, as well as his collaborators from the Centre for Astronomy, IIT, Indore – Dr. Abhirup Datta and Dr. Siddharth Malu. This research has been funded by Department of Science and Technology (DST) under DST INSPIRE Faculty research grant.

Web links :
https://www.skatelescope.org/news/highlights-from-the-ska-science-conference-in-goa
https://www.periscope.tv/w/1yoJMDBoMbpGQ
http://timesofindia.indiatimes.com/city/pune/Observing-previously-undetected-structures-in-the-Universe/articleshow/55392748.cms
http://www.deccanchronicle.com/science/science/141116/indians-may-help-solve-mysteries-of-universe.html
Talks given at SPARCS and SKA meeting on 5th and 10th November 2016:
http://www.ncra.tifr.res.in/ncra/news-events/sparcsprogramme.pdf
https://indico.skatelescope.org/event/391/picture/15.pdf

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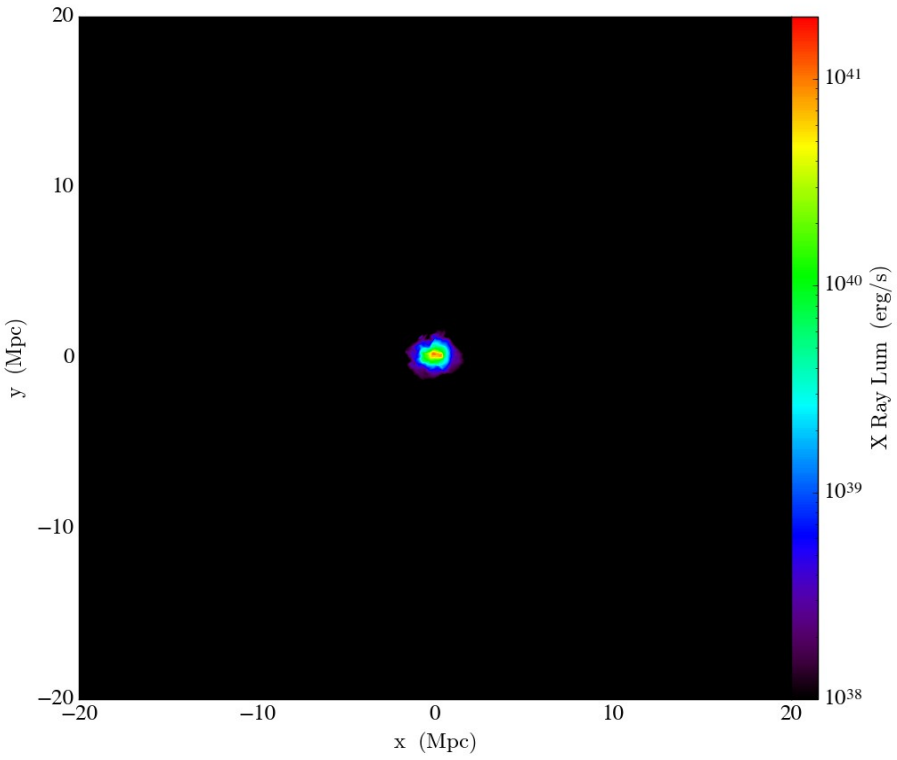
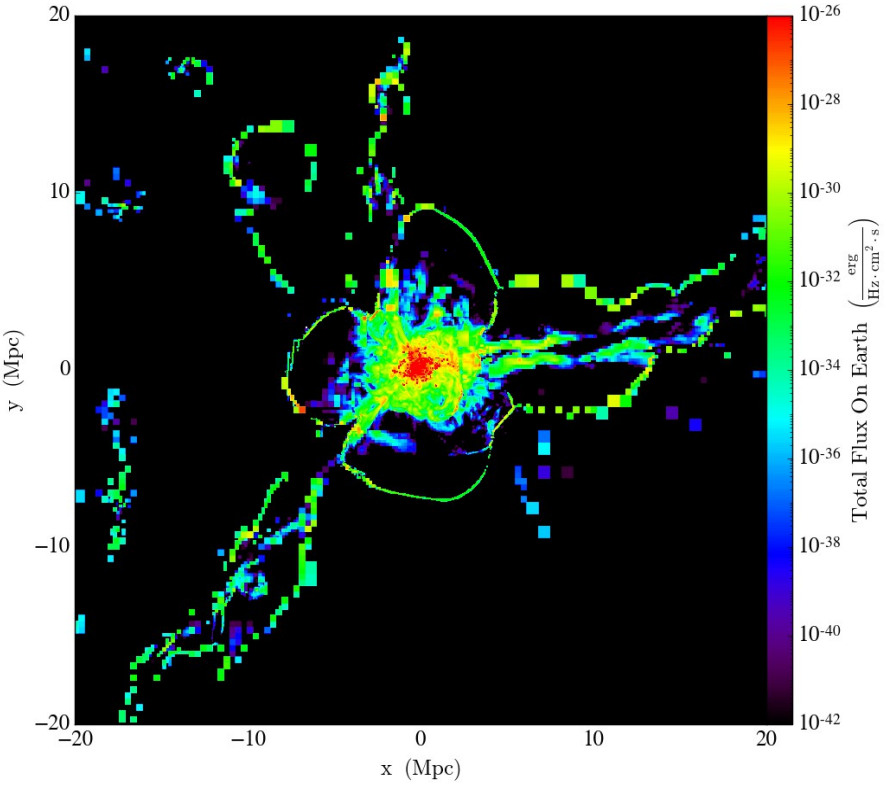
Images:



Caption : 1. Simulation of the X-ray emissions of a galaxy cluster. It shows the possible detectable emissions with current X-ray telescope facilities.



Caption : 2. Simulation of radio emissions **from the same cluster** and additional filaments that are predicted to be detected. The SKA1 would be able to detect the region immediately around the cluster and SKA2 would detect the filament structures extending beyond it.