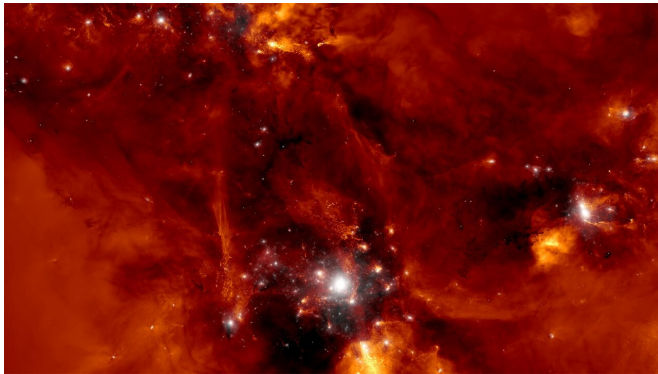


Forecasting the hunt for the first supermassive black holes

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Computer simulation of the formation of a proto-cluster of galaxies. Supermassive black holes may have had an important role in the formation of these structures in the early Universe. Credit: TNG Collaboration.

It is believed that the formation and growth of most galaxies across the history of the universe has been fueled by supermassive black holes growing together with their host galaxy as they collect matter to attain millions of solar masses. Chasing the early stages of these extreme objects is among the missions of future powerful telescopes.

A new and comprehensive estimate has now been presented in a study led by researchers of the Instituto de Astrofísica e Ciências do Espaço (IA). The study predicts the number of very young galaxies with active [supermassive black holes](#) at their cores that should have existed when the universe was less than 7 percent of its current age, and which are within the reach of future X-ray and [radio telescopes](#) already in the making. It was published in the *Monthly Notices of the Royal Astronomical Society*, and presented this week at the SPARCS IX meeting, where the science and technology of the future Square Kilometre Array (SKA) radio telescope are being discussed.

The results may guide the most effective observing

plans for SKA and for the ESA's Athena X-ray space observatory. Both observatories will be used to peer deep into the same period in the history of the universe explored by this study.

"Since there is a long wait until Athena and SKA will be available for science, there is time to modify their goals for the best," says Stergios Amantidis, of IA and Faculdade de Ciências da Universidade de Lisboa (FCUL), the first author of the paper. "For example, a past Athena white paper mentions a prediction of one order of magnitude fewer supermassive black holes than we found. They will use their result to make a preliminary plan for future surveys. Our results can now be used to improve the strategy and prepare more effective surveys."

The authors extend previous work done by others in the visible and X-ray part of the spectrum by adding predictions for radio and X-ray observations, and for the more distant universe. In this context, X-rays are produced by very hot matter spiraling extremely fast as it falls onto the black hole, and signal galaxies with their centres facing the Earth. Radio emissions, on the other hand, frequently signal galaxies viewed edge-on, and are produced by powerful jets of particles ejected away from the black hole's vicinity and interacting with the gas outside the galaxy.

Using eight computational models developed by other teams and applying current knowledge about galaxy evolution, the researchers predicted that in an area of the sky the size of the full moon, Athena will be able to spot X-ray activity from around 2,500 supermassive black holes at the cores of very young galaxies in the early universe. The results suggest that [radio emissions](#) will be less abundant at these early ages, but powerful telescopes such as SKA will still be able to identify tens of these sources in the same area of the sky.

The computational models were developed and fine-tuned using what observations of the environments

where galaxies evolve in the nearby universe. One of the models' limitations, evidenced by this study, is their poor capability to predict the few, highly luminous, active galactic centres already known to exist in remote epochs. Increasing the size of the simulations and the computational resources is necessary to overcome this limitation and to properly understand how the first galaxies and supermassive black holes appeared and evolved.

"This work puts into evidence the predictive powers of current state-of-the-art models of galaxy formation, and will guide us to make better use of the powerful telescopes being built," says José Afonso, of IA and FCUL, and second author of the paper. "At the same time, it also shows where our understanding of the first active [galaxies](#) still needs to be improved, something that will require all of our observational efforts during the coming years. The early [universe](#) is still largely hard to explain."

More information: Stergios Amarantidis et al.

The first supermassive black holes: indications from models for future observations, *Monthly Notices of the Royal Astronomical Society* (2019). DOI: [10.1093/mnras/stz551](https://doi.org/10.1093/mnras/stz551) , <https://arxiv.org/abs/1902.07982>

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