Back from the Dead: Restarted Black Hole Activity Discovered in a Giant Radio Galaxy (J1007+3540) Under Extreme Cosmic Pressure

A team of astronomers, led by Dr. Sabyasachi Pal and PhD student Shobha Kumari from India, has discovered a rare "giant" radio galaxy named **J1007+3540**. Using some of the world's most powerful telescopes including India's **uGMRT**, they have captured a rare moment in cosmic history: a monster black hole "waking up" after being silent for 100 million years. This galaxy is very gigantic, spanning over 3 million light-years. To put that in perspective, it is 50 times wider than our own Milky Way.

However, life for this galaxy is far from peaceful. It sits in the middle of a "galaxy cluster," a crowded neighborhood filled with searing-hot gas. This gas creates immense pressure, acting like a heavy atmosphere that tries to crush everything inside it.

By studying the radio waves emitted by this galaxy, scientists have uncovered a dramatic story of rebirth and survival. The images reveal a **"double-double"** structure—a pair of bright, fresh energy jets nested inside much older, fainter ones—which proves the central black hole has recently re-ignited after a long period of silence. As these new jets blast outward, they are locked in a struggle with their surroundings; the intense pressure from the hot gas in the galaxy cluster is actually pushing the jet's plasma sideways, creating striking curved shapes. This hostile environment has not only distorted the ancient plasma but is also stripping material away from the galaxy as it moves, leaving behind a wispy, millions-of-years-old trail known as a **"galactic wake".**

"This galaxy isn't just growing; it's fighting for survival," explains Dr. Pal. It acts as a natural laboratory for scientists to see how black holes turn on and off, and how they shape the universe around them. It's a violent, beautiful **"tug-of-war"** between the power of a black hole and the crushing weight of deep space.

The low-frequency **Band 3 (250–500 MHz)** image of J1007+3540 using uGMRT helped to trace the extended diffuse emission, clearly revealing the large-scale tail as well as the inner episodic jet and associated distorted outflow structures. The uGMRT image was further used to study the spectral properties of the source. In particular, the spatial distribution of the **spectral index** for the different parts of the structure helped to understand the ageing nature of the radio emission in the particular region.

This research signifies a major leap in our understanding of the cosmos, as the galaxy J1007+3540 represents a rare "perfect storm" where three extreme conditions meet: its colossal size, a re-ignited black hole, and crushing environmental pressure. By studying this unique system, scientists can finally observe the full life cycle of supermassive black holes—from how they power up to how they fall silent and eventually "wake up" again. Furthermore, it serves as a high-pressure cosmic laboratory, revealing how the harsh environment of deep space can physically sculpt a galaxy and influence its evolution, providing vital clues into the complex physics that govern the most violent corners of our universe.

This discovery was a global effort, involving researchers from India, and Poland. Apart from the lead authors Dr. Pal and Ms. Kumari, Dr. Surajit Paul from the Manipal Centre for Natural Sciences in India, and Dr. Marek Jamrozy, of Jagiellonian University in Poland also played an important part in this research. Their findings were recently

published in the ***Monthly Notices of the Royal Astronomical Society***, one of the leading astronomy journals.

DOI: https://doi.org/10.1093/mnras/staf2038

Contact:

Dr. Sabyasachi Pal (Principal Investigator): sabya.pal@gmail.com | +91 98364 17804

Shobha Kumari (PhD Student & Lead Author): kumarishobha.phy@gmail.com | +91 89184 28390

Surajit Paul (MAHE, Manipal): surajit.paul@manipal.edu | 9405510226

Marek Jamrozy (OAUJ, Poland): marek.jamrozy@uj.edu.pl

Ishwara Chandra CH (NCRA): ishwar@ncra.tifr.res.in | 9403136630

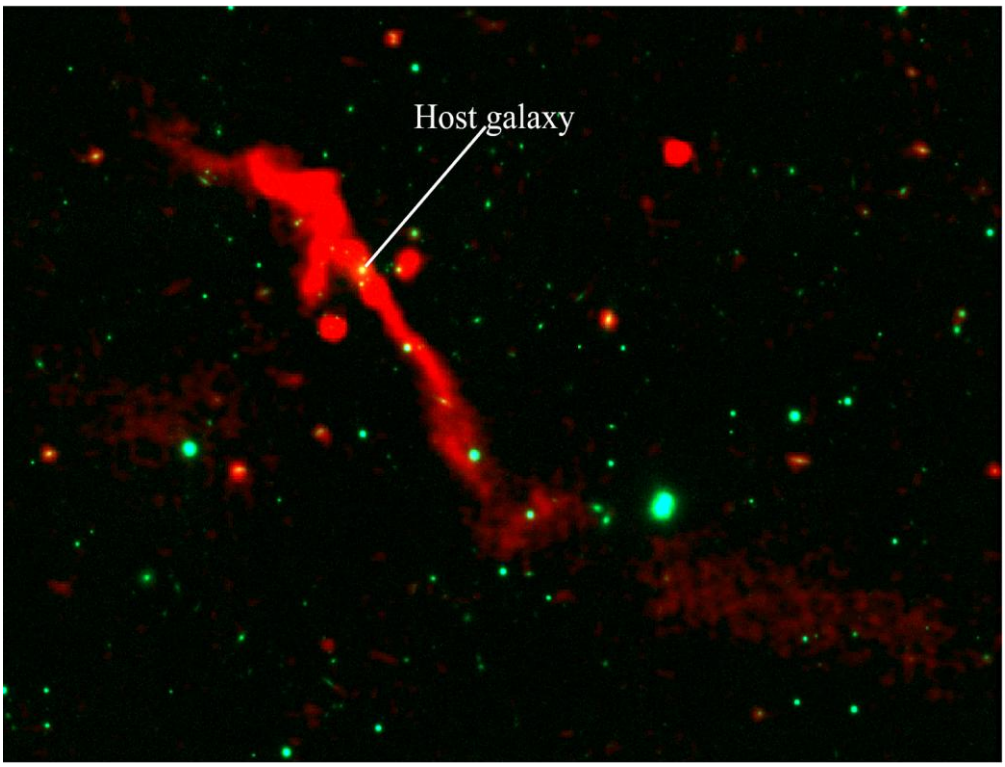

Figure: Low-frequency radio image of the giant radio galaxy J1007+3540 from LoTSS DR2 at 144 MHz. Here two stream of jets coming out from the center of the host galaxy is observable. The break in the jet signifies the collision between the jet itself and the surrounding cluster medium.