Super-massive and supersonic black hole studied with the Sardinia Radio Telescope

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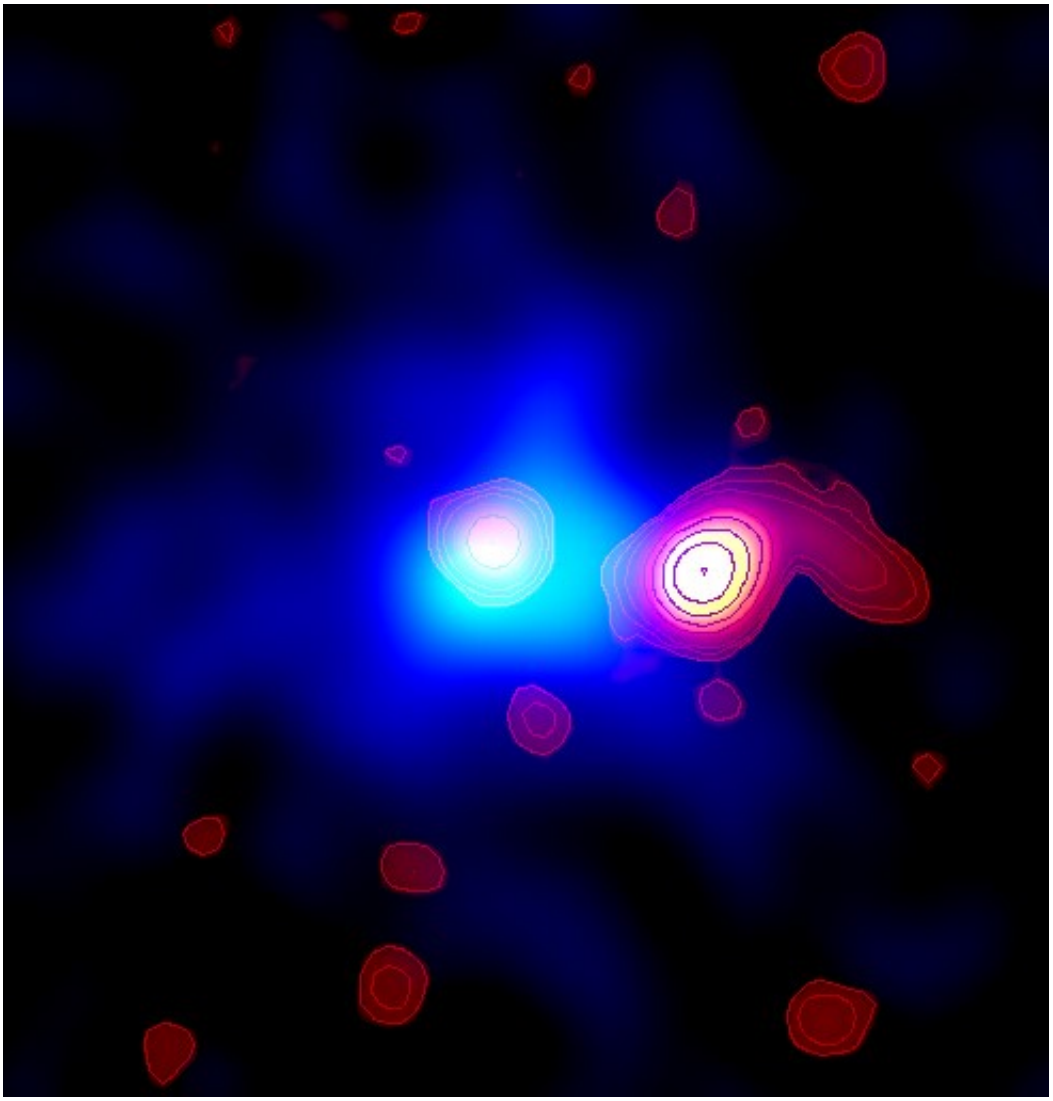


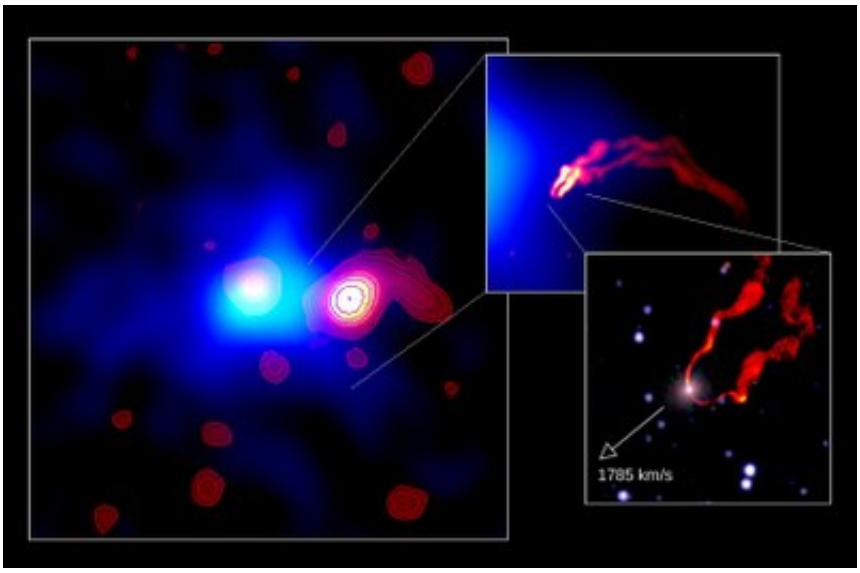
Credit: INAF

Using the brand-new Sardinia Radio Telescope (SRT), a giant parabolic dish of 64 meters diameter, a team of astronomers from the Italian National Institute for Astrophysics (INAF) and the University of Cagliari have produced a detailed image of a super-massive black hole proceeding at high speed towards the core of the distant cluster of galaxies designed as 3C 129. The results are going to be published in the scientific journal *Monthly Notices of the Royal Astronomical Society*.

The black hole sits at the center of an elliptical galaxy some at 300 million light years from Earth.

The black hole and its galaxy are in collision course with a nearby galaxy cluster, pulled by the gravitational force generated by the huge concentration of dark matter, galaxies, and hot gas. The radio images reveal that the black hole is actively accreting matter. Part of this material is not falling into the black hole but expelled into two streams of plasma that merge to form a spectacular tail much longer than the size of the galaxy itself.

"The phenomenon is quite likely a jet contrail," says Matteo Murgia researcher at the INAF - Astronomical Observatory of Cagliari, lead author of the study. "In the case of the black hole jets, the 'unburned fuel' consists of a plasma composed by mixture of high-energy electrons and magnetic fields that cools down by emitting radio waves. By comparing the new SRT observations with those performed with other radio telescopes, we were able to obtain for the first time a map of the age of this radio source and to conclude that the black hole is cruising at supersonic speed."



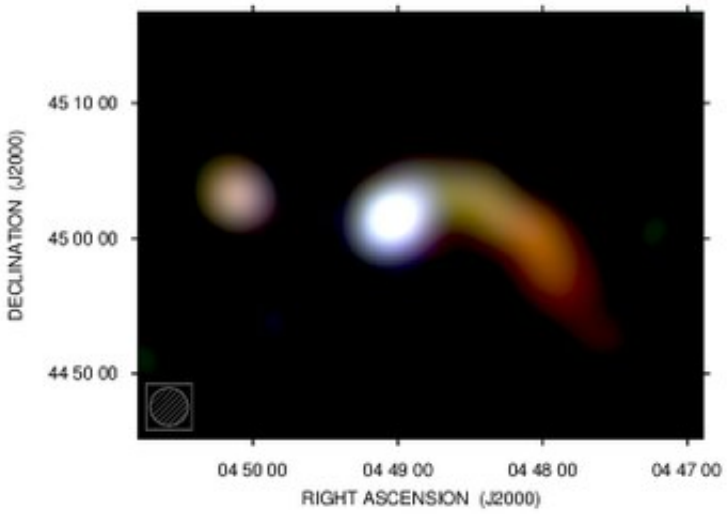
These false color images show the cluster of galaxy 3C 129 at radio, X-ray, and near-infrared bands. Left: superposition of the SRT image at 6.6 GHz (red) with the X-ray emission of the hot intracluster medium (blue). Top-right: Very Large Array image at 1.4 GHz. Bottom-right: high-resolution VLA image at 4.7 GHz (red) overlayed to an image of the black hole host galaxy in the near-infrared. Credit: NRAO; ROSAT satellite; the Two Micron All Sky Survey

In the Earth's atmosphere the sound speed is about 1,200 km/h, but in the 'atmosphere' of the cluster of galaxy surrounding the black hole, an ultra-rarefied gas at a temperature of tens of millions of degrees Kelvin, the sound speed is as high as 4 million km/h. The black hole is traveling at a speed as much as 1.5 times this limit.

"A further peculiarity of this black hole – continues Matteo Murgia – is the presence of a shock wave in front of the galaxy, very similar to those associated to combat aircrafts. With some surprise, we found that the black hole speed we measured is exactly the one previously theorized to explain the presence of the shock wave."

The SRT is also capable to observe the radio sky in 'polarized light'. The

degree of polarization of the radio waves is an important source of information for the astronomers since can yield insights into the strength and orientation of magnetic fields in astrophysical objects. Close to the black hole the flow is turbulent and wavy with a very low polarized emission, but moving along the plasma wake the polarization level increases revealing highly ordered magnetic fields.

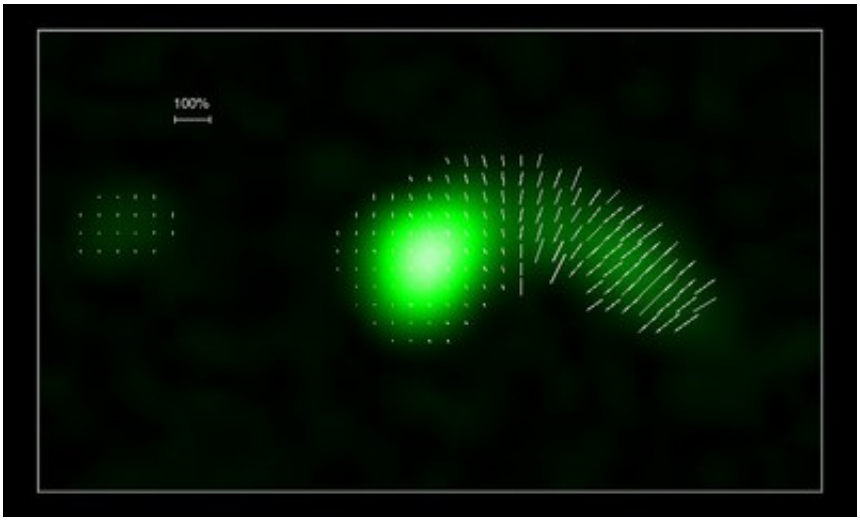


Three color composite images of 3C129 obtained at 0.3 GHz (WENSS; red), 1.4 GHz (VLA; green), and 6.6 GHz (SRT; blue). The color turns smoothly from bluish to redish as a result of the intense radiative cooling of the radio-emitting plasma wake. Credit: INAF

"This study is the first paper on a scientific results from the SRT", says Ettore Carretti, SRT Officer-in-Charge and co-author of the study. "It shows that the SRT is ready to produce high quality images of the radio sky even in polarization, that usually is challenging and left as last step to setup in a new facility. It is clear indication of the maturity of the telescope performance now ready to deliver the great and challenging science it was built for."

"The SRT is among the largest and most sensitive radio telescopes in the world and it is exciting to see early results being produced that verify its scientific performance. This will be the first of many new discoveries to come from this telescope", says Professor Steven Tingay, Head of the Radio Astronomy Section in the INAF Science Directorate.

"These fascinating images illustrate the capabilities of the SRT used in conjunction with the new state-of-the-art SARDARA backend", says Andrea Possenti Director of the Astronomical Observatory of Cagliari and PI of the SARDARA project, funded by the Sardinian Regional Government. "These results", underlines Possenti, "have been possible thanks to the joint efforts of the SRT Astronomical Validation team and the SARDARA backend developers, two tight-knit teams comprised of INAF scientists."



SRT image of 3C129 at 6.6 GHz in polarized light. The length of the line segments is proportional to the polarized intensity while their orientation represents the polarization angle. Credit: INAF

More information: M. Murgia et al. Sardinia Radio Telescope wide-band spectral-polarimetric observations of the galaxy cluster 3C 129, *Monthly Notices of the Royal Astronomical Society* (2016). DOI: 10.1093/mnras/stw1552

Provided by INAF