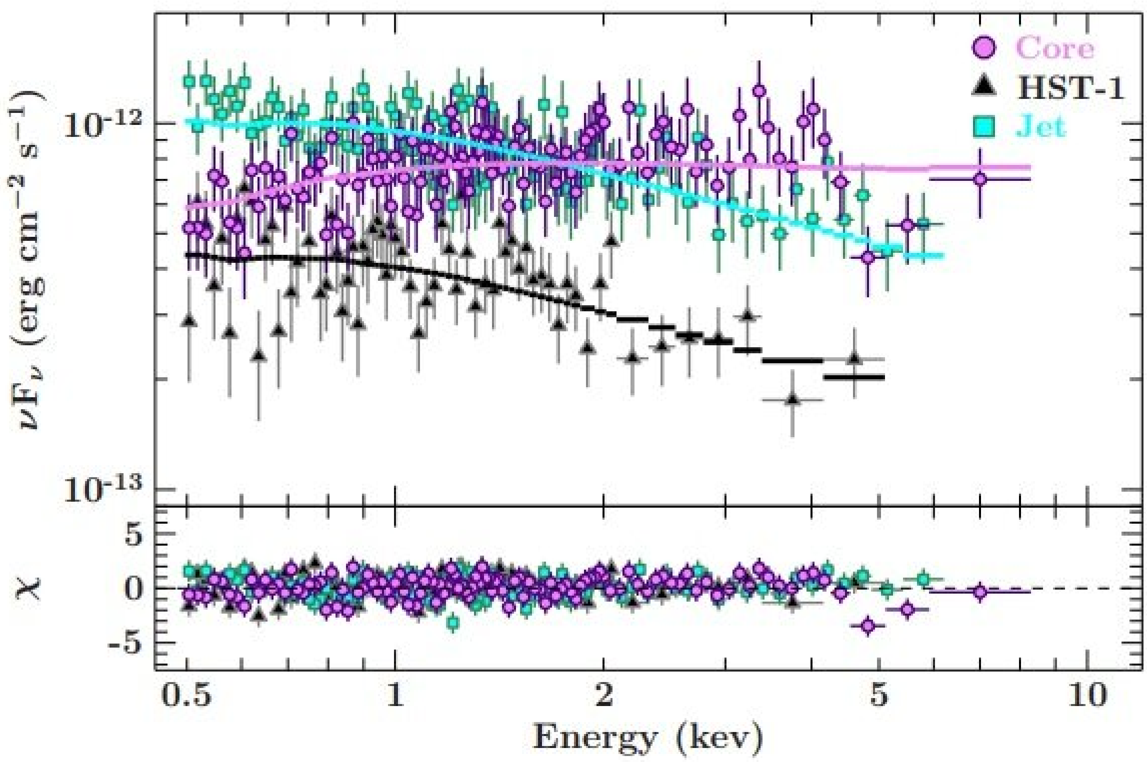
Astronomers investigate AGN jet in the Messier 87 galaxy

August 8 2019, by Tomasz Nowakowski



Combined X-ray spectra of M87. All three spectra are well fit by an absorbed power-law model. The core spectrum is harder than both the kpc-scale jet and HST-1. Image credit: Lucchini et al., 2019.

Astronomers have taken a closer look at the relatively nearby Messier 87 (or M87) galaxy to investigate the jet of its active galactic nucleus

(AGN). The new research, described in a paper published July 31 on arXiv.org, delivers important insights into the parameters of the jet, which could improve the understanding of AGNs in general.

AGNs are accreting, super-massive black holes residing at the centers of some galaxies, emitting powerful, high-energy radiation as they accrete gas and dust. These nuclei can form jets, having mostly cylindrical, conical or parabolic shapes, which are observed even on megaparsec scales.

Located some 53.5 million light years away in the Virgo cluster, M87 is a supergiant elliptical galaxy. It hosts one of the most well-known and remarkable jetted AGNs discovered to date. The jet of M87 is easily detected on a variety of physical scales, which enabled astronomers to obtain many high-quality images of this feature. This makes it a unique source to study the physics of jets in accreting black holes.

Now, a trio of astronomers from the University of Amsterdam, the Netherlands, led by Matteo Lucchini, has conducted another study of M87, focused on investigating the properties of its AGN jet. They analyzed the available dataset, mainly from NASA's Chandra and Fermi spacecraft, in order to unveil the jet's key parameters.

"In this paper, we employ a multi-zone model designed as a parametrization of general relativistic magneto-hydrodynamics (GRMHD); for the first time, we reproduce the jet's observed shape and multi-wavelength spectral energy distribution (SED) simultaneously. We find strong constraints on key physical parameters of the jet, such as the location of particle acceleration and the kinetic power," the astronomers wrote in the paper.

The study found that the location of particle acceleration occurs very close to the black hole, far closer to the central engine than the acceleration distance. Notably, high-resolution very-long-baseline interferometry (VLBI) images of the jet show a "pinching" of the outflow around this distance. This, according to the researchers, suggests that the initial injection of particle acceleration in the jet may be influenced by this pinching region.

Moreover, the astronomers matched their model's jet dynamics and shape with those inferred from direct imaging of the outflow through VLBI. This allowed them to find that the main contribution to the core's limited gamma-ray flux is due to inverse Compton scattering of the host galaxy's starlight, rather than synchrotron self-Compton (SSC).

Furthermore, the research found that in the case of M87, the radiating leptons need to be accelerated to very high Lorentz factors in order to extend the synchrotron spectrum up to the Chandra energy range. The study also revealed that the particle distribution in the jet is consistent with being isothermal, even beyond the dissipation region.

Summing up the results, the astronomers emphasized the importance of their study, noting that it could be fundamental for future investigations of M87 an other jetted AGNs.

"Our results have important implications both for comparisons of GRMHD simulations with observations, and for unified models of AGN classes. (…) Our results are particularly important in light of the upcoming observations of M87 with the Event Horizon Telescope, which provide even more detailed imaging of the regions near the black hole," the authors of the paper concluded.

More information: Matteo Lucchini, et al. The unique case of the AGN core of M87: a misaligned low power blazar? arXiv:1907.13408v1 [astro-ph.HE]: arxiv.org/pdf/1907.13408.pdf