NEWS! From the
NAVAL OBSERVATORY
U.S. NAVAL OBSERVATORY 3450 MASSACHUSETTS AVE., NW WASHINGTON, DC 20392-5420

U.S. Naval Observatory

Press Release

For Immediate Release

Information contact:
Dr. Nathan Secrest
Astronomer, Celestial Reference Frame Department
U.S. Naval Observatory
nathan.j.secrest.civ@us.navy.mil

USNO Astronomer Leads Study that Questions Structure of the Universe

In a new paper published in the October 2022 issue of *The Astrophysical Journal Letters*,[1] an international team of cosmologists led by astronomer Dr. Nathan Secrest of the U.S. Naval Observatory report the results of the first joint analysis of the large-scale structure of distant radio galaxies and quasars, demonstrating that it is significantly inconsistent with theoretical predictions.

Radio galaxies are primarily active galactic nuclei (AGNs)—supermassive black holes at the centers of galaxies releasing energy from the matter falling into them—that emit powerful jets of charged particles moving extremely close to the speed of light. These jets are luminous sources of radio emission and can be detected across the universe by radio telescopes such as the Very Large Array (VLA) in New Mexico. Quasars, also AGNs, are the more powerful counterparts of radio galaxies, converting enormous amounts of matter into energy, and are particularly easy to spot in the infrared with telescopes such as the orbiting Wide-field Infrared Survey Explorer (WISE).

Importantly, there is little overlap between these two populations of AGNs: radio-luminous AGNs are typically found in large elliptical galaxies with old stars while quasars are found more broadly in disk galaxies with younger stars. This means that radio galaxies and quasars each provide an independent measure of the structure of the universe on the largest scales—hundreds of millions of light years—where the standard model of cosmology, called ΛCDM (“Lambda cold dark matter”), requires that the universe look the same everywhere, with no over- or under-abundance of matter in any direction. Any apparent deviation from this picture should entirely be due to our solar system’s motion with respect to the large-scale universe, which induces an imbalance akin to the Doppler effect. A precise value of our solar system’s motion is inferred from the same imbalance seen in the cosmic microwave background (CMB) radiation—the relic radiation from the universe’s earliest moments—providing a benchmark to test the structure of the universe on the largest scales.

By jointly analyzing radio galaxies and quasars, Secrest and his team showed that there are significantly more of both types of AGN in one direction—and significantly less in the opposite direction—than should appear to be the case given our solar system’s motion with respect to the large-scale universe. Importantly, the statistical significance of this result is enormous, amounting to about a one-in-threemillion chance of being a false positive. For comparison, the more widely known "Hubble tension", in which the expansion rate of the universe deduced from measurements of the nearby universe and that inferred from the properties of the cosmic microwave background are in significant disagreement, has a statistical significance of about one-in-forty thousand.[2]

The consistency between radio galaxies and quasars demonstrated in the current study strongly argues against these results being due to instrumental or other systematic errors, building upon and strengthening the results of a breakthrough study published last year, also led by Secrest, that used only WISE-selected quasars and found a similar level of disagreement from theoretical predictions.[3] "To be clear, the current cosmological model, ΛCDM, has been remarkably successful in describing the structure and evolution of our universe," says Secrest. "Nonetheless, there are an increasingly large number of anomalies and inconsistencies with ΛCDM, such as the well-known 'Hubble tension'. Our results, demonstrating that the apparent large-scale distribution of radio galaxies and quasars is at odds with theoretical predictions, are at least as significant as the Hubble tension, underscoring the need to build upon the successes of ΛCDM and deepen our understanding of cosmology and the nature of the universe."

[1] *A Challenge to the Standard Cosmological Model*
Secrest, N.J., von Hausegger, S., Rameez, M., Mohayaee, R., Sarkar, S. 2022, ApJL, 937, 2

[2] *Cosmic Distances Calibrated to 1% Precision with Gaia EDR3 Parallaxes and Hubble Space Telescope Photometry of 75 Milky Way Cepheids Confirm Tension with ΛCDM*
Riess, A.G., Casertano, S., Yuan, W., Bowers, J.B., Macri, L., Zinn, J.C., Scolnic, D. 2021, ApJL, 908, 1

[3] *A Test of the Cosmological Principle with Quasars*
Secrest, N.J., von Hausegger, S., Rameez, M., Mohayaee, R., Sarkar, S., & Colin, J. 2021, ApJL, 908, 51