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USNO Astronomers Create New Catalog of the Fundamental Properties of Supermassive Black Holes that Comprise the ICRF

In a new paper published in the June 2022 issue of *The Astrophysical Journal Supplement*, astronomer Dr. Remington Sexton of the U.S. Naval Observatory has led the creation of a new catalog of the fundamental spectroscopic properties of the active galactic nuclei (AGNs) that comprise the International Celestial Reference Frame (ICRF). [1]

Since its adoption more than two decades ago, the ICRF has grown to include thousands of extragalactic radio sources with very long baseline interferometry (VLBI) observations, which allow multiple radio telescopes all over the world to act as a single radio observatory. Now in its third realization (ICRF3), the ICRF provides a celestial reference frame of unprecedented precision for use in critical domains such as astrometry, geodesy, and navigation. Paradoxically, however, relatively little has been known about the astrophysical nature of these objects apart from their positions and radio brightness.

This lack of physical information precludes many astrophysical investigations into the cause of position offsets between the ICRF and the new optical celestial reference frame, Gaia-CRF, a key research priority. One possibility is that these large optical-radio offsets can be attributed to radio jets, which can show extended emission at radio wavelengths, or be offset from the optical photocenters measured with *Gaia*, which for AGNs correspond to the accretion disk around the central supermassive black hole. "The ICRF is now at a point where a physical understanding of the fundamental nature of these objects will lead to an increased accuracy and precision in future ICRF realizations," said Dr. Sexton.

Using the enormous database of available spectroscopic data provided by the Sloan Digital Sky Survey (SDSS), important physical properties such as redshift, black hole mass, and emission line kinematics were determined for nearly 900 ICRF3 objects, with over 1,000 having AGN spectral type classifications. The catalog utilized a state-of-the-art, Bayesian spectral fitting algorithm that allows simultaneous fits of all spectral parameters of interest, along with robust uncertainty estimates, [2] which was developed at USNO specifically for studying the low- and high-redshift AGNs that comprise ICRF3.

Because of the variability of AGN emission due to black hole accretion processes that occur on short timescales, the objects that comprise the ICRF need to be monitored constantly for changes that may

affect the accuracy and precision of their positions. Plans are already underway for an extended spectroscopic catalog for all objects with VLBI data and from multiple archival sources in addition to data from SDSS. The USNO VLBI catalog is available to the public, and can be found at https://crf.usno.navy.mil/.

References:

[1] *The U.S. Naval Observatory VLBI Spectroscopic Catalog*
Sexton, R.O., Secrest, N.J., Johnson, M.C., & Dorland, B.N., 2022, ApJS, 260, 33

[2] *Bayesian AGN Decomposition Analysis for SDSS Spectra*
Sexton, R.O., Matzko, W., Darden, N., Canalizo, G., & Gorjian, V. 2021, MNRAS, 500, 2871