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Press Release

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FOR IMMEDIATE RELEASE

USNO LEADS THE WAY IN ALIGNING THE SKY

On August 30th, the International Astronomical Union (IAU) adopted the International Celestial Reference Frame - 3 (ICRF3) as the standard reference frame for the celestial background. The IAU voted to adopt ICRF3 effective January 1, 2019, replacing the current reference frame, ICRF2, which had been adopted in 2009 by the IAU. ICRF3 is a "realization" of an idealized reference frame, tied to the center of mass of our Solar System. It is analogous to lines of latitude and longitude on the Earth extended into the sky--along with actual markers on the surface of the Earth to set those lines. These celestial reference points are used by all astronomers to determine positions and motions of celestial objects. The ICRF is used by Earth-orbiting spacecraft to determine their orientation (or direction of pointing), and by ground stations tracking space probes as they travel through the solar system. The ICRF is also used to measure the motions of the Earth in 3-dimensional inertial space with very high precision, making capabilities such as the Global Positioning System (GPS) possible.

As shown in Figure 1, the ICRF3 consists of 4536 extra-galactic "Active Galactic Nuclei" (AGN), which are the supermassive black holes in the center of distant galaxies. They are chosen because they are very bright in radio frequencies, and because they do not appear to wobble or move over time--that is, they are extremely distant and stable reference points. The ICRF3 includes, for the first time, observations in three different radio frequencies: S/X, K and X/Ka, making it the first multi-wavelength reference frame. This is important, as different frequencies support different types of users: the S/X band is used to determine the Earth's orientation, K is used primarily radio astronomers for astronomical measurements, and X/Ka is used by NASA, ESA, and other space agencies for solar system navigation.

The U.S. Naval Observatory (USNO) was critical in the development of ICRF3. USNO astronomers, led by Dr. Alan Fey of USNO's Fundamental Reference Frame Division, were part of the international, multi-organization working group that produced ICRF3. USNO also provided access to this group to the instruments required to make these observations. Fully two-thirds of

the S/X AGN were observed with the Very Long Baseline Array (VLBA) using time allocated by USNO, resulting in a five-fold+ improvement in accuracy for these sources. Furthermore, the entire northern hemisphere K-band reference frame was developed using USNO-provided VLBA time. USNO astronomers continue to work on ICRF3-related products, including a database of radio images of these distant AGN in order to distinguish "compact" sources from potentially problematic extended and variable sources.

“The USNO’s sponsorship of observing time on the Very Long Baseline Array (VLBA) has been critical to the improvements just adopted,” says Chris Jacobs of the Jet Propulsion Laboratory, Chair, ICRF3 Working Group from 2012-2015. “In the traditional 8 GHz band, USNO-sponsored time greatly improved the precision of the majority of sources. The work at the newly adopted 24 GHz band was only possible because of the USNO-sponsored time.”

In addition to leadership in the development of the new fundamental radio reference frame, USNO scientists were critical to supporting the new optical reference frame produced by the European Space Agency's Gaia space probe. The Gaia mission used a 2015 catalog of 1.4 million AGN identified by a USNO team led by Dr. Nathan Secrest (see Figure 2), as the foundation for their optical reference frame. Secrest, in a 2015 paper, used an innovative technique to identify AGN from infrared data taken by NASA's Wide Field Infrared Survey Explorer (WISE), tripling the known population of these important and enigmatic objects at the time and produced a dense, all-sky grid of AGN for the first time. It was this grid that was used by Gaia scientists to produce their high-accuracy reference frame.

USNO is the Department of Defense's Celestial Reference Frame (CRF) Deputy Manager. It is responsible for developing and maintaining the DoD's CRF to support DoD programs, and is also responsible for representing DoD's equities at international standard-setting bodies such as the IAU. Both the ICRF3 and infrared/Gaia work directly support USNO's DoD CRF responsibilities, and will provide improved capabilities for Earth orientation, satellite operations and other Navy and DoD users, as well as benefitting the international astronomical, astrophysical and geodetic research communities.

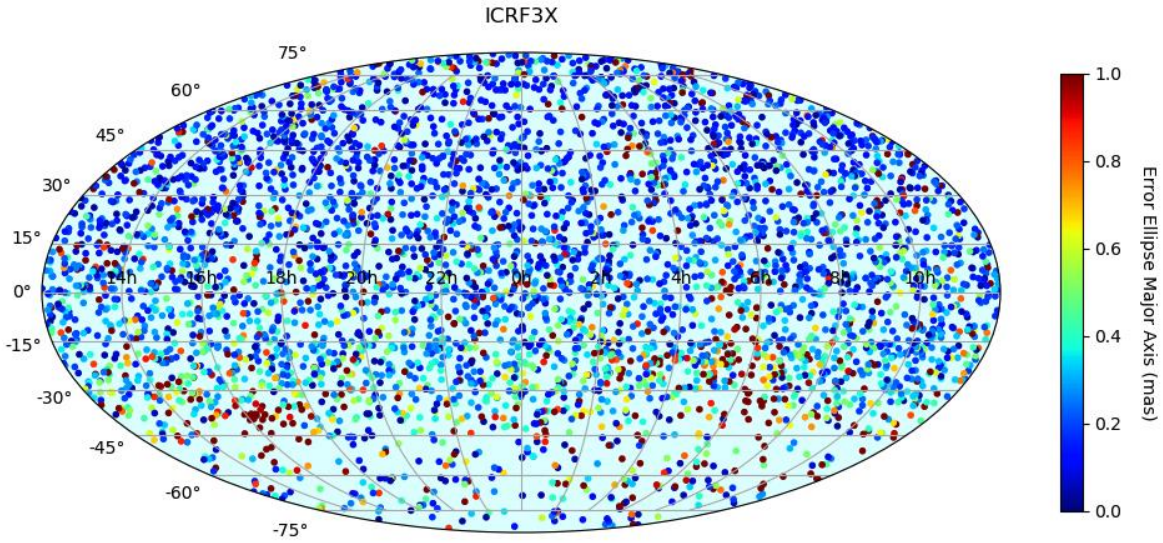

Figure 1. Distribution of the 4536 AGN high-precision radio sources that form the new ICRF3. Color indicates precision of AGN position (more blue = more precise).

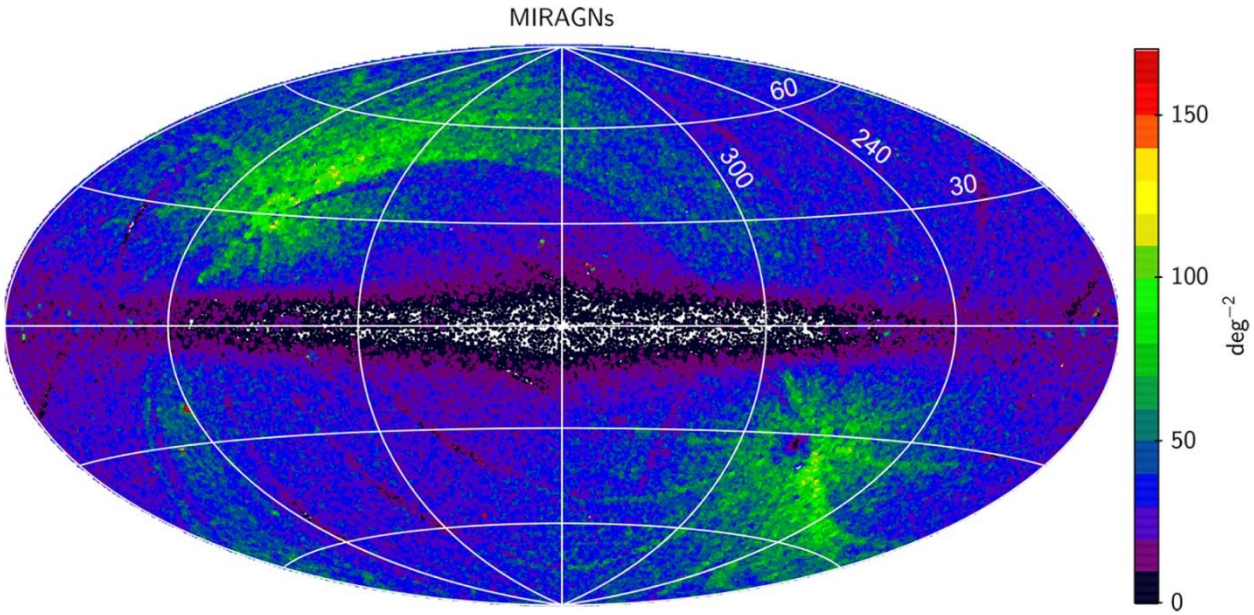

Figure 2. Mid-Infra Red Active Galactic Nuclei (MIRAGN) identified by Secrest team that formed the basis of the Gaia DR2 optical reference frame. Color indicates sources per square degree of sky. Galactic coordinates shown.