New, highly accurate positions and motions available for millions of stars

March 28 2017

The United States Naval Observatory (USNO) has released a new catalog of over 107 million stars, the 5th USNO CCD Astrograph Catalog (UCAC5). This catalog of about 5.5 gigabytes of binary data is currently available from the German Astrophysical Virtual Observatory (GAVO) Data Center. It will soon be available from the Astronomical Data Center (CDS) in Strasbourg, France and its mirror sites. In addition to very precise positions, this catalog contains the most accurate "proper motions" ever measured for such a large number of stars. A paper by USNO scientists Norbert Zacharias, Charlie Finch, and Julien Frouard describing this research has been published in The *Astronomical Journal*.

To human eyes, the stars in the night sky seem to be "fixed," their relative positions unchanging over the course of an average lifetime. However, when examined more closely with high magnification, all stars are indeed moving with respect to each other. Most of this apparent motion is caused by the general rotation of our Milky Way Galaxy, which most stars follow. In addition, every star has some individual component of motion on top of the general flow. This includes our Sun, which takes our solar system and Earth along for the ride. As a result, as seen from Earth, most stars in our area of the Milky Way move a tiny distance across the sky each year. These "proper motions" typically amount to about half a degree (the apparent diameter of the Moon) across the sky in about 10,000 to 100,000 years.

Knowing the proper motions of stars is important to predict exactly where in the sky the stars will be at any given instant of time, something

the U.S. Navy and Department of Defense in general care about when using stars as points in a reference frame. Knowledge of stellar proper motions are also vital to learning about possible membership of stars in clusters and to understand the dynamics, history, and origin of the Milky Way's components including "dark matter," a currently hot topic in astrophysics.

The European Space Agency's Gaia astrometric survey satellite program began regular sky observations in July 2014 and recently published a first catalog of highly accurate positions of over a billion stars. For a subset of these stars, just over 2 million, an earlier space mission, Hipparcos, provided similarly accurate positions as observed near 1991. The long time baseline of about 25 years between these observations enabled astronomers to derive accurate motions of those stars.

The UCAC data were re-reduced using those 2 million Gaia stars to derive accurate positions of other, fainter stars at the UCAC observing epochs between 1998 and 2004. Combined with the accurate Gaia positions of 2015, the USNO scientists were able to derive proper motions of many millions more stars with accuracies similar to the Gaia + Hipparcos data. The errors on these proper motions are about 1.5 milli-arcseconds per year. This is equivalent to detecting an object moving an inch over the period of a year from a distance of 2,000 miles.

More information: N. Zacharias et al. UCAC5: New Proper Motions UsingDR1, *The Astronomical Journal* (2017). DOI: 10.3847/1538-3881/aa6196 , arxiv.org/abs/1702.05621

Provided by Naval Research Laboratory