SHAO Analysis Center 2013 Annual Report

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Abstract This report presents the routine work and the pertinent research of the SHAO VLBI Analysis Center (AC) during 2013. The SHAO AC continued routine VLBI data analysis of 24-hour geodetic/astrometric observations to make products. The activities of SHAO AC in 2013 also included reduction of data from the Chinese VLBI Network (CVN), providing navigation for Chang'E-3 using the VLBI technique, and basic research in Astrometry, specifically theoretical discussions on the Celestial Reference Frame and the effect of aberration.

1 General Information

In 2013, one of the important activities at SHAO AC was real-time navigation by using VLBI for the Chang'E 3 satellite that launched on December 02, 2013. This work involved scheduling, observing, processing, and analyzing VLBI experiments, which lasted until early 2014. Our routine data analysis contained two parts: the IVS 24-hour sessions and the CVN experiments that aim to monitor the crustal movement of the Chinese mainland. In addition, research topics focused on the CRF and the astrometric effects that are outlined in Section 3. The members involved in these activities were Guangli Wang, Jinling Li, Minghui Xu, Li Guo, Liang Li, Fengchun Shu, and Zhihan Qian.

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2 Activities and Data Analysis at SHAO

SHAO is in charge of the CVN and is an Analysis Center of the IVS. Routine VLBI activities at SHAO included:

-The geodetic experiments and observations of MSP by the CVN

As usual, in 2013, the CVN conducted six 24-hour geodetic sessions which aimed at monitoring the CVN network and at determining the accurate position for the new 65-meter antenna in Shanghai, the TIANMA65. The experiment of MSP J1939+2134, with three CVN antennas — SH 25 m, UR 25 m, and KM 40 m — was on September 30, 2013. The calibrator of MSP J1939+2134 in our observation was J1935+2031, which has 1.5 degrees of separation from the pulsar and has a position precision of $\sim$ 0.1 mas. The CVN observation mode was fast-switching between the pulsar and calibrator with a cycle time of 180 s on the pulsar and 80 s on the calibrator, and the total recording rate reached 1024 Mbps.

-Post processing of the VLBI observations for the navigation of Chang'E 3 satellite.

We conducted the post processing of the VLBI observations for the navigation of the Chang'E 3 satellite, and obtained the differential group delay between the rover and the satellite with accuracy to a level better than 0.5 ns. The accuracy of the relative position of the rover and the satellite finally is at the meter level, based on the research of differential observations.

-Data processing and analysis of the CVN geodetic experiments

The relative work consists of the calculation of the delay and delay rate of CVN observations at every band, the resolution of group delay ambiguities, and the computation of ionosphere calibrations. In addition, SHAO is responsible for the generation of the VLBI group delay in NGS format and for the analysis of all CVN sessions by the software *shops*, which has been developed based on the software *OCCAM*6.1*E*(*Linux*) with modifications mainly in VLBI data process models.

-Regular data analysis of the IVS 24h sessions and product submission

We continued to routinely analyze all IVS 24-hour sessions using the CALC/SOLVE software, and we regularly submitted our analysis products (EOP, TRF, and CRF) to the IVS Data Centers. In order to contribute to the forthcoming ITRF2013 activity, we updated the geophysical and astronomical models, including the IAU 2006 nutation/precession, the ocean loading model, atmospheric pressure loading, the Vienna Mapping Function, and the antenna thermal deformation model.

3 Research Topics at SHAO

3.1 Validation of Solar Acceleration

In 2011 and 2012, we obtained the acceleration vector in the three components in the Galactic coordinate system (7.47±0.46, 0.17±0.57, 3.95±0.47) $mm{\cdot}s^{-1}{\cdot}yr^{-1}$ [1]. Traditionally, it was generally believed that the acceleration component in the direction normal to the Galactic plane was too small to be detected and that the acceleration vector should nearly point to the Galactic center, but our results showed that the vertical acceleration is notable. This year, we tried variant methods to validate this result. For example, we made two solutions with the same parameterizations and the same strategy except for a defining source, 2136+141. One solution took into account the effect of the acceleration on all sources, while another one took into account the effect of the acceleration on all except 2136+141. These two solutions treated the position of this source as a local parameter to obtain the time series of its position. Figure 1 shows the difference of these two time series, which demonstrates that the accordance between the predicted model and the time series obtained from VLBI data is quite well. The time series of the position of a single source clearly show the effect of the Solar acceleration, which demonstrates that the software and data are sensitive to the microarcsecond level.

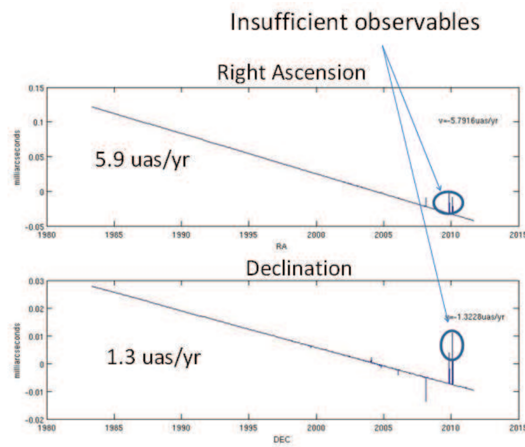

Fig. 1 The time series of 2136+141, obtained from two solutions.

3.2 The Aberration Effect

There was a groundbreaking step in the history of astronomy in 1728 when the effect of aberration was discovered by James Bradley (1693-1762). Recently, due to the variations in the aberrational effect of extragalactic sources caused by the Solar acceleration, the latter has been determined from VLBI observations with the uncertainty of about 0.5 mm/s/yr level. As a basic concept in astrometry with a nearly 300-year history, the definition of aberration is still equivocal and discordant in much of the literature. It has been under a continuing debate whether it depends on the relative motion between the observer and the observed source or only on the motion of the observer with respect to the frame of reference. We think that the aberration is essentially caused by the transformation between coordinate systems and is consequently quantified by the velocity of the observer with respect to the selected reference frame, independent of the motion of the source [2]. Obviously, this nature is totally different from that of the definition given by the IAU WG NFA in 2006, which is stated as “The apparent angular displacement of the observed position of a celestial object from its geometric position, caused by the finite velocity of light in combination with the motions of the observer and of the observed object” [3, 4]. The IAU’s definition has already led to some confusion and misunderstandings in the recent studies.

4 Plans for 2014

We will make a contribution to the ITRF2013 campaign and study the potentially systematic variances in the direction displacements of radio sources with the aim to improve the accuracy of their positions.

References

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