PROBLEMS TO CONSTRUCT THE RADIO CELESTIAL REFERENCE FRAME USING VERA

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ABSTRACT. VERA, now under construction, is a Japanese differential VLBI network to measure the relative position of Galactic masers. Its target accuracy is 10 micro-arc-seconds on condition that an angular separation between the target and the reference sources is below 2 degrees. Because of this limit, VERA requires many reference sources. Required accuracy on the position of reference sources is around one micro-arc-second, because almost all of 10 micro-arc-seconds error is due to atmospheric effects. If one can use these reference sources to construct a radio reference frame, it may be possible to get a new one with accuracy of one micro-arc-second. However, it needs about 10000 sources of which positions and brightness distributions must be known to calculate source structure effects with accuracy of one micro-arc-second level. Survey of new VLBI sources and dense VLBI data on the u-v plane are indispensable.

1. OUTLINE OF VERA

VERA (VLBI Exploration of Radio Astrometry), a Japanese domestic D-VLBI (Differential or Delta Very Long Baseline Interferometer) network to measure the relative position of Galactic masers from some reference radio sources like quasars, is under construction at four sites in Japan. The 4 sites are Mizusawa (Iwate prefecture), Ogasawara (Tokyo Metropolis), Iriki (Kagoshima prefecture) and Ishigaki-jima (Okinawa prefecture). And its maximum baseline length is 2300 km. Each station has 20 m diameter antenna with two receivers that enable to make two beams simultaneously. Its target accuracy is 10 micro-arc-seconds on condition that the angular separation between the target source and the reference source is below 2 degrees.

Because of this angular limit, VERA requires many reference sources of which positions and brightness distributions (structures) are known precisely. Required accuracy on the position of reference sources is around one micro-arc-second, because almost all of 10 micro-arc-seconds error is due to atmospheric effects of the Earth. Although the reference sources used by VERA are limited around Galactic plane, they must be almost ideal sources for an accurate new celestial radio reference frame.

2. PROBLEMS ON NEW REFERENCE FRAME

Sensitivity of VERA is around 0.1 Jy. Sasao estimated that total number of radio sources over this intensity is about 5000 in the whole sky, and required number of reference sources

for VERA is 3000 (Sasao, 1999). However, this estimation of required number is based on the idea that there is one reference source in the circle centered at the target source with 2 degrees radius. In case of a reference frame, each reference source must be observed with at least another reference source to keep its precise position. On condition that each radio reference source is at the apex of equilateral triangles with 2 degrees sides, the number of sources is about 10000. Therefore the sensitivity of VERA must be improved. And, at present, there are only 2000 sources detected by VLBI. Therefore it needs active survey to increase number of known sources that can be detected by VLBI.

Usually, point like radio sources are selected as the reference points for geodetic and astrometric observations with current VLBI (including current D-VLBI). However, almost all radio sources are requested to be the reference sources for VERA, because there is not so enough number of sources as the reference of VERA. If the reference source is not point-like but has some structure, it needs structure correction to determine precise position of radio source (for example, Thomas, 1980 and Fujishita, 1983). Usually this correction is calculated from its map observed by VLBI (for example, Fey and Charlot, 1997).

Making maps from VLBI data is somewhat tricky technique. If VLBI observation can gain enough data in the u-v plane, a clear map is obtained only by direct inverse Fourier transformation. However, in case of VLBI, only a few Fourier components are observed and have no phase information. Direct inverse Fourier transformation is impossible. Therefore radio maps are made with a priori information, for example, radio brightness is not minus. This process is mathematically understood that one possible map is selected among many possible maps. There are many other maps that do not conflict with observed data. And there are various a priori assumptions, various mapping algorithms and various parameters which mapping software needs. Stability of the map using such variations is also in question. Dense VLBI data on the u-v plane is indispensable.

3. CONCLUDING REMARKS AND ACKNOWLEDGEMENTS

VERA is a powerful system to construct an accurate radio reference frame. However, it needs 10000 radio sources from the limit of its view. This needs almost all radio sources must be used as the reference sources. Therefore, survey of new VLBI sources, dense VLBI network to make a detail map of the reference sources, stable algorithm to draw a map free from used parameters are indispensable.

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