Report from
the Short Term Mission – STM

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Report:

1. Topic

Large reflector antennas used for radio astronomy suffer from surface deformations due to gravity, wind and thermal loads. These deformations distort the optimum parabolic shape for the reflector and produce a reduction of aperture efficiency, which can be very critical at millimeter wavelengths.

Microwave holography is a radio technique to measure the reflector surface accuracy through far-field sampling of the antenna beam with the help of a radio-source in the sky and mathematical field transformations. A good radio-source is a geostationary satellite, whose beacons are very powerful, providing high SNR, and their position is almost fixed in the sky.

Yebes Observatory has a long-time expertise in microwave holography, as staff of this institution contributed to the improvement of the IRAM 30-m surface accuracy, in the surface evaluation of the ALMA antenna prototypes in Socorro (NM, USA), in the optimization of the Yebes 40-m dish and in the holography measurements of the 32-m Medicina radio telescope in preparation for the Sardinia Radio Telescope.

This expertise has been profited by the Max-Planck-Institut für Radioastronomie in order to measure the surface accuracy of the 100-m radio telescope in Effelsberg. Therefore, it was proposed to perform holography measurements of the 100-m radio telescope through collaboration between Max-Planck institute and Yebes Observatory.

These measurements allow the determination of the actual surface status of this telescope and help to decide on a procedure to improve its surface accuracy.

The results can be promoted as a RadioNet activity through the publication of a paper and other RadioNet partners can consider the use of a similar approach to improve the aperture efficiency of their radio telescopes.

2. Proposed and Performed Work

It was proposed to perform holography measurements of the 100-m radio telescope surface to evaluate its current surface accuracy.

This work was done with the help of the Ku-band holography receiver available at Effelsberg and the holography backend (70MHz downconverter and FFT analyzer) available at Yebes Observatory. This backend was shipped to Effelsberg in due time.

In addition, particular software was developed/adapted in order to write the data files. It merges antenna positions and FFT analyzer data to generate suitable FITS files that are read by the Yebes holography data reduction and analysis software, which was tuned to include the geometrical parameters of the 100-m telescope.

An EUTELSAT satellite at 31º elevation was used as radio source for these measurements.

After system set-up, far-field maps of the telescope beam were measured. Then, a problem with antenna position information was detected, as it was not being read properly by the new software. Finally, this problem was solved and good maps could be measured. However, the size of the measured beam maps could not be very large (16x16 pixels only, with 0.5 seconds integration time each) because the tracking of the satellite during OTF maps was not accurate enough, and an important drift in telescope pointing was observed. As a result, the resolution of the computed surface accuracy was very coarse (9 m) which is too large to allow the derivation of panel adjustment for surface improvement. It has to be considered that the size of a typical panel is in the range 1 – 2 m, so the number of pixels for a good adjustment map should be 128x128.

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Therefore, the telescope tracking of geostationary satellites has to be very much improved. It was not possible to do this task during the STM, due to the limited time for the activity, and because the 100-m schedule had other compromised observations too.

New holography measurements should be scheduled after the improvement of satellite tracking. Then, larger maps could be measured to derive a high-resolution surface map suitable for panel adjustment and surface optimization.

3. CROSS-DISCIPLINARITY

This activity has provided an exchange of hardware and software knowledge between two RadioNet institutions in a very specific technique like microwave holography. In fact, nowadays, it is the most accurate and fast technique for the surface characterization of large dishes (> 15 meters in diameter).

In addition, it is a technique that can be implemented in other RadioNet observatories for the improvement of their radio telescope aperture efficiency.

4. IMPACT

As mentioned in section 2, an inaccurate telescope tracking of the satellite impeded to measure high-resolution beam maps from which suitable panel settings can be derived.

In order to solve this issue, Effelsberg staff will work in the development of an accurate algorithm to determine satellite pointing angles versus time which will be included in the radio telescope control software.

Once this is solved, new holography measurements will be scheduled in order to measure high-resolution beam maps without pointing drifts. From these measurements, the surface accuracy will be computed and panel adjustments derived.

The results of this activity will improve the surface accuracy of the largest steerable radio telescope in Europe. Its surface improvement will provide higher aperture efficiency of the telescope, provided better quality data, and hence will reduce the valuable integration time required for radio astronomy observations.

Similar measurement systems could be implemented using commercial equipment in other RadioNet observatories.

5. PUBLICATIONS

- *In case of future publication - please provide additional information: place & date. Remember to insert the acknowledgment of the RadioNet support:*

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