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Coordinated observations using the world largest low-frequency radio telescopes and space missions

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Abstract

The positive possibilities of astrophysical objects studies(including the Solar system investigations) using coordinated observations with the largest existing and coming low frequency radio telescopes are shown. The observations of the Sun, Jupiter, Saturn, ant others with UTR-2, URAN, NDA radio telescopes, and WIND, Cassini and STEREO space missions at frequencies lower than 40 MHz have been carried out.

1. Introduction

Now we are witnesses of the rapid progress in the field of low frequency (LF) radio astronomy at frequencies less than 100 MHz. The astrophysical significance of such investigations becomes generally recognized due to unique opportunities opened by this branch of science. In the list of modernized and effectively operating instruments at decametric wave range are UTR-2 and URAN1 – URAN4 [1] (Ukraine, operating range of 8 – 32 MHz) and NDA [2] (France, 10 – 70 MHz). The Netherland – European new generation telescope LOFAR (10 – 80 and 110 – 240 MHz) is successfully being developed and have started to produce scientific data. The projects LSS [3] (France), GURT [1] (Ukraine), and LWA (USA) are also built now. So we can see that there is a powerful group of several tens of existing and developed big antennas each of them having from hundreds to several thousands of antenna elements and covering territory measured from several hundreds meters up to thousands kilometers. Coordinated and synchronous usage of these systems [2, 4] provides additional advantages in the astrophysical studies. This presentation illustrates such approach.

2. Advantages opened by coordinated use of a number of distant antennas

Evidently, it is very helpful for reducing or even removing hindering factors at LF radio astronomy to use multi-telescope observations which lead to a number of positive methodological and astrophysical results: 1) improvement of sensitivity by integrating around the area in coherent and non-coherent modes; 2) the broadening of observed frequency range because instruments usually differ in this point (at least we have 8 – 32 MHz plus 30 – 80 MHz); 3) improvements of identification from the point of ionosphere influence; 4) improvement of identification from the point of interference influence; 5) possibility of dispersion measurements with distant antennas by IPS in the solar wind and for ionospheric studies; 6) additional opportunities for determination of emission parameters (directivity) with distant antennas; 7) record base-line (~ 3000 km) for the selected VLBI experiments.

3. Examples of coordinated observations

Fig.1 illustrates one of negative factors which hinder LF observations and is connected with ionosphere influence (namely scintillations at ionoscheric irregularities). The dynamic spectrum measured towards 3C144 and AD Leo by UTR-2 is shown. The goal of this experiment was the search of bursts in LF emission from flare stars. We can see rather weak (~ 10 Jy) bursts but we have to consider the possibility that it could be produced by ionospheric scintillations when there is an radio continuum source in the telescope field of view. In order to resolve this problem we need to carry out simultaneous observations with distant antennas.

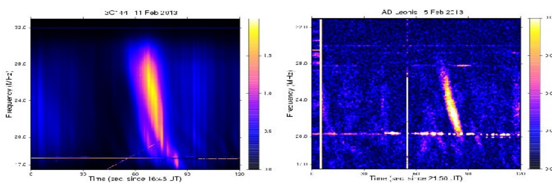

Figure 1:3C144 and AD Leo (UTR-2).

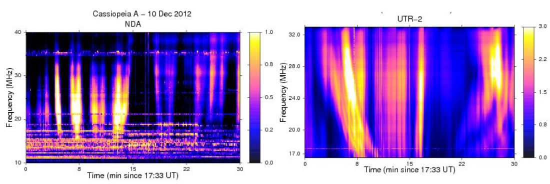

Figure 2:Cas A (NDA and UTR-2).

Fig.2 shows the results of synchronous observations of Cas A with UTR-2 and NDA. The complete decorrelation of ionospheric scintillations at distances ~ 3000 km is evident. This leads to more reliable identification of the burst emission. Synchronous observations of the Sun with UTR-2, URAN-2, and NDA are shown in Fig.3. The widening of the frequency observation band (8 – 42 MHz) has been achieved. Also the reliability of low intensity burst emission identification has been improved.

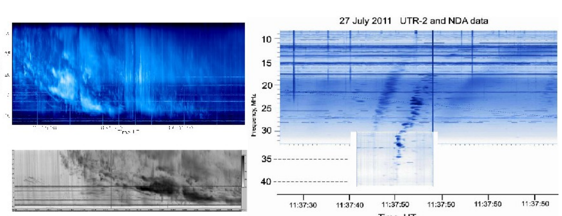

Figure 3: The Sun (UTR-2, URAN, and NDA).

4. Summary and Conclusions

Coordinated use of several big LF antennas (at least two ones) situated at distances from hundreds to thousands kilometers yields a number of positive methodological and astrophysical possibilities. Such approach is developed and tested at existing and future instruments including UTR-2, URAN, NDA, LOFAR, GURT, LSS, etc. Among promising investigation fields are studies of weak, variable, and transient radio emission in the Solar system and in other Universe regions. They are, for example, the Sun, ionosphere, interplanetary medium, Jupiter, Saturn, interstellar medium, flaring stars, exoplanets, pulsars, etc. As well, improving LF investigation efficiency can be provided by coordinated observations using big ground-based radio telescopes and space missions with inter-covered frequency ranges. Out-ionosphere observations (at LF < 10 MHz) and even at far side of the Moon jointly with ground-based instruments (which have much better sensitivities and spatial resolutions) considerably improves the quality and reliability of the corresponding studies [5], [6], [7]. Recently, such methods have been successfully realized with mentioned earlier telescopes and space missions WIND, Cassini, STEREO, in investigations of the Sun, Jupiter, Saturn, and others. The development of them are planned taking into account the future missions Juno, Solar orbiter, Far Side Explorer, etc.

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