

Investigation of Astrophysical Sources, Including the Sun, via Radio Interferometry Using AX-Offset D90 Antennas

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Extreme energy release in astrophysical sources, including the Sun, is associated with the acceleration and interaction of elementary particles—specifically, with the conversion of magnetic field energy. Consequently, the systematic study of radio emission from these sources with high angular resolution makes it possible to identify the mechanisms of particle acceleration, plasma heating during flares, and energy transport processes. This paper discusses the use of offset-focus parabolic mesh antennas (AX-Offset D90) to create the MEPhIst radio interferometer prototype and the scientific instrument itself. The MEPhIst radio interferometer will be based on two sparse-aperture antenna arrays with maximum baseline lengths of $l_{1\max} \approx 49$ m and $l_{2\max} \approx 61$ m. Each antenna field consists of two arrays with a special configuration and comprises up to 46 and 79 individual antenna elements (Main Antenna Modules—MAMs, based on the AX-Offset D90 antenna), respectively; the overall system dimensions are ~ 450 m, which will provide an angular resolution ranging from $\sim 0.12^\circ$ to $5.70 \cdot 10^{-3}^\circ$ in the frequency range of 0.3000–6.5000 GHz. The prototype system will also consist of two arms; however, each will comprise a T-shaped array of five MAM modules with an initial maximum baseline of $l_0 \approx 30$ m, which can be extended to $l_{01\max} \approx 53$ m and $l_{02\max} \approx 54$ m, respectively. This configuration simplifies the development of techniques for image reconstruction and object coordinate determination. The low weight and compact dimensions of each individual antenna module—based on the AX-Offset D90 design—will allow the system's antenna arrays to be mounted on the roofs of MEPhI buildings using surface-laid cable runs; this will significantly reduce equipment costs compared to interferometers based on traditional parabolic antennas (which require underground cabling due to the substantial mass and size of individual antenna units). A prototype antenna module is currently being developed and assembled at the Department of Experimental Nuclear Physics and Cosmophysics at NRNU MEPhI. Preliminary calibration has been performed at a frequency of 1.0009 ± 0.0001 GHz, and an increase in the received signal level has been demonstrated when pointing the antenna at the Sun. One of the primary scientific objectives of the MEPhIst radio interferometer will be to study the radio emission from both solar flares and the “quiet” Sun; this will enable further research into electron acceleration mechanisms, plasma heating during flares, and energy transport processes, as well as the detection and study of shock waves and the evolution of large-scale structures in the solar atmosphere. Another application of the facility will be the development of methods for monitoring solar activity in the radio range—specifically, continuing the comparative analysis of geomagnetic events identified using various indices. The MEPhIst radio interferometer can be used for Galactic research, including the study of the discrete radio source Sgr A, the Galactic radio halo, and neutral hydrogen clouds (HI line), as well as discrete sources and distributions in the HII (1415 MHz), H3 (1517 MHz), Na23 (1772 MHz), Al27 (1506 MHz), and OHI (1666 MHz) lines, among others; it also enables the analysis of emission properties in recombination lines. One of the primary objectives of the MEPhIst scientific facility will be to study the properties of transient sources both within our Galaxy and beyond: investigating radio pulsar period variations (including those located in the Galactic halo), examining the characteristics of non-stationary radio emission from magnetars, and studying radio bursts that fall within the instrument's field of view. Furthermore, the instrument allows for the study of emission characteristics in the neutral hydrogen (HI) spectral line at various redshifts, making it possible to establish the principles of the Gal_z scale—an initiative aimed at resolving the discrepancy in Hubble constant (H₀) values, which is a key challenge in modern cosmology. This unique new scale will

be employed for the first time, complementing existing scales based on data from supernovae (SN) and the cosmic microwave background (CMB).

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