

Phased Array Feed for Reflector Antenna

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Abstract

A large class of radio astronomy observations require extended and large scale surveys. However, large reflector antennas used by radio astronomers have restricted field of view (FoV) which limits the survey speed. Conventionally, multiple optimized feeds have been used to increase the FoV, however, they do not produce overlapping beams and the off-axis feeds suffer efficiency degradation, resulting in reduced mapping efficiency. The Phased Array Feed (PAF) is another technology that can be used to increase the FoV. PAF consists of densely packed, electrically small feed arrays, each of which over illuminates the reflector. Signals from the array elements are combined to form multiple, overlapping beams with low spillover noise. A low-noise, multi-beam PAF system increases the survey speed of the telescope, enabling radio astronomers to make sensitive, large scale surveys. Developing a low-noise PAF, however, is difficult due to mutual coupling between array elements. Mutual coupling modifies the element radiation patterns. It also couples amplifier noise between signal paths. Therefore, detailed electromagnetic, noise and network modeling are needed to design a PAF for radio astronomy applications.

In this talk, I describe the development of a cryogenic PAF. This project was called the Focal L-band Array for the Green Bank Telescope (FLAG) – a collaboration between National Radio Astronomy Observatory, Green Bank Observatory, Brigham Young University and West Virginia University. A 1.4 GHz 19-element, dual-polarization, cryogenic PAF was developed for the Green Bank Telescope (GBT). I will describe the PAF instrumentation and the signal processing involved in forming beams with the system. Commissioning observations of calibrator radio sources show that this receiver has the lowest reported beamformed system temperature (T_{sys}) normalized by aperture efficiency (η) of any phased array receiver to date. The survey speed of the PAF with seven formed beams at the Nyquist separation is larger by a factor 7 compared to the single beam system on the GBT. I will then describe a model for the PAF system and compare its predictions with measurement results. Finally, I will present some observational results toward the pulsar B0329+54 and an extended H II region, the Rosette Nebula. The PAF system along with a real-time beamformer is currently being used for HI 21 cm observations of galaxies, study of Pulsar emission and to search for Fast Radio Bursts.

Bio

D. Anish Roshi graduated with an engineering degree in electronics and communications from the University of Kerala. In 1989, he joined the Tata Institute of Fundamental Research (TIFR), National Center for Radio Astrophysics, Pune as a Research Associate/Scientific Officer. At TIFR, he completed his Ph.D (Physics) specializing in Radio Astronomy (1999) and was appointed as a member of the faculty. He was a Jansky postdoctoral fellow at the National Radio Astronomy Observatory (NRAO), USA between 2000 and 2002. On completion of the post doctoral fellowship, Dr Roshi joined the Raman Research Institute (RRI), Bangalore. While at RRI, he was involved with several Astrophysics research and instrumentation projects. He led a team of engineers to build a digital receiver for the Murchison Widefield Array, located at Western Australia. In 2010, Dr. Roshi moved to the National Radio Astronomy Observatory (NRAO), USA. At NRAO, he was the System Architect and Project Scientist for the Versatile Astronomical Spectrometer that was built for the Green Bank Telescope (GBT). He was also the System Architect for the Phased Array Feed project. He is currently a Senior Observatory Scientist for Radio Astronomy at the Arecibo Observatory. His research interests include Galactic interstellar medium, massive star formation and radio astronomy instrumentation.