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The Past, Present and Future of Phased Array Feeds in Radio Astronomy

Wim A. van Cappellen
ASTRON, the Netherlands Institute for Radio Astronomy, Dwingeloo, The Netherlands
e-mail: cappellen@astron.nl

Extended Abstract

How a new antenna concept was perceived, realized, and enabled large-area high-resolution surveys.

Reflector antennas with multiple beams traditionally use several electrically large feeds (such as horn antennas) to optimize the antenna efficiency. Consequently, the beams that they provide are widely separated on the sky, leaving large angular gaps "unused". Research in the late 1970s and early 1980s provided the notion that the electromagnetic fields in the focal plane of a reflector antenna carry all the information to observe a contiguous field of view that is much larger than the single beam of traditional feed antennas. At that time, it was still unclear how this idea could be applied, but the mental seed was planted. In the following decades, the puzzle was solved step-by-step, enabled by new technologies becoming available, such as antennas to densely sample the focal fields over a wide frequency range, low-noise amplifiers, and algorithms and computing platforms to efficiently process the information. Nowadays, the antenna concept of a fully sampling receiver in the focal plane of a reflector is known as a Phased Array Feed, and the first radio telescopes using Phased Array Feeds are in science operations.

The recent success of Phased Array Feeds in radio astronomy has generated interest in other domains, such as earth observation [1] and telecommunications [2,3]. The mobile fifth generation (5G) operates at higher frequencies. Compared to the previous generation, base stations require more antenna gain to compensate for the increased path-loss at mm-wave frequencies. Phased array feeds can deliver the required antenna performance while keeping the power dissipation under control.

The future of Phased Array feeds is bright, and their development continues in various domains. In radio astronomy, the results and promises of Phased Array Feeds align closely with the ambitious goals of the Square Kilometre Array [4]. Key challenges are to reduce costs of RF electronics, data transport and data processing, to lower the noise temperature, and manage the operational complexity. These developments will make future Phased Array Feeds even more competitive in large and smaller dishes, and at frequencies above the L-band.

References

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