Photonic integrated beamformers for broadband radio astronomy

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For the modern radio astronomy instruments wide instantaneous bandwidth is a characteristic of great interest. This can be a difficult requirement for a phased array antenna (PAA) employing a traditional electronic beamformer: the performance of the constituting components, mainly combiners and delay elements, limits the bandwidth of the total system. Photonic technology allows an overcome of this limit by providing wideband and continuously tunable combiners and delay elements, which are the basic building blocks for the so-called integrated optical beamforming network (IOBFN). The astronomical signals received from the antenna elements of the PAA are first amplified and then, using an array of electro-optical modulators, brought into the optical domain where they are delayed and combined, before being converted back to electrical domain via a detector.

A system demonstrator has been built and is currently under test in ASTRON, in the framework of a large Dutch project for integration of electronic and photonics (MEMPHIS). The system is a modified version of an aperture array demonstrator for SKA and is expected to give an operating instantaneous bandwidth a factor 10 higher than the one employing the electronic beamformer, for all observation angles. The beamformer is a single, silica-based optical –chip, employing optical ring resonators (ORRs) as true time delay units.

The use of optical filter-based SSB-SC modulation technique allows to widen even more the operating bandwidth of the system. Current studies aim to efficiently extend the capability of such a photonic system to produce multiple simultaneous beams by employing multiple optical wavelengths (multi-wavelength IOBFN).