Aperture Synthesis Method and Two-Dimensional Imaging at Radio Wavelengths

Figure 1 - Interferometer by Christiansen and Warburton at Potts Hill, 21 km south-west of Sydney.

The development of the method of aperture synthesis is attributed to the team of Sir Martin Ryle of Radio Astronomy Group at Cambridge University who were preoccupied with analysing German radar equipment after the World War II. The early application of the principle of combining multiple antennae with the goal of constructing images at radio wavelengths, however, appears to originate in the work by Wilbur Norman "Chris" Christiansen and J. A. Warburton from 1953, both signing from the Division of Radiophysics at CSIRO. It is known Christiansen was radio astronomy pioneer and distinguished electrical engineer from Australia, and a variety of sources provide a good record of his accomplishments, such as Frater & Goss (2011). Very little information is available on Warburton, perhaps because the laboratory they have worked in was part of the classified research group involved in radar operations. The first synthesized two-dimensional image ever produced is made by that Australian pair. They recorded the "quiet" Sun at 21 cm wavelength with a 32-element interferometer aligned in the east-west direction that relied on the Earth rotation for scanning (Christiansen & Warburton 1953; 1955). Even earlier work on the synthesized unidimensional measurements of the solar flux using interferometer with two aerials is made by Stanier (1950). Virtually no information is available on him except that he was working in the same Cavendish Laboratory in Cambridge with Ryle. At that time, he was interested in measuring the brightening of the solar limb at ~60 cm wavelength and it is suggested his work gave impetus to Christiansen and Warburton to construct their array at Potts Hill – see figure 1 (Orchiston et al. 2011).

The chronology of the research in Cavendish Laboratory is itself a little convoluted. It looks like exactly the variable spacing interferometer used by Stanier in 1950 is considered to be the "simplest example" of aperture synthesis method, as described by J. H. Blythe – another representative of the Cavendish team. In his paper, he describes a pencial beam aerial for the study of H II regions in our Galaxy at low frequencies. In the acknowledgements section, Blythe mentions the original suggestion of the device was made by Ryle (Blythe 1957). His work refers to the not yet available publication that is said will provide a general account of the method. In that paper, Ryle & Hewish (1960) will return the reader back to the year 1953 when Ryle and Scheuer used a version of the instrument to study radio emission in the galactic plane. In their work that is mostly focused on the astronomical aspect the resolving power of the aerial system they used "does not depend on the size of the aerials, but simply on the greatest spacing used" (Scheuer & Ryle 1953). The date when the galactic surveys were done predates solar imaging of Christiansen and Warburton, however it should be safe to claim that aperture synthesis imaging originated in Australia while the first image from Cambridge appears only in 1962 in the work by Ryle & Neville. It appears both teams complemented each other well.

Astronomical imaging using aperture synthesis is important because it allows to overcome resolution problems, especially at long wavelengths such as radio and infrared, and later even involving the optical spectrum. Together with deconvolution algorithms, it is relevant to fields of research that require high resolving power. This includes studies of the magnetic filaments and complex gas dynamics in the Galactic center, search for exoplanets, observation of black holes and protoplanetary disks – virtually any branch of astronomy and cosmology benefits from the increased resolution data.

The more you increase the resolution, the more data you get per each degree of the sky, so it is crucial that storage, processing and analysis is done on an increased computing capabilities. The Pleiades Supercomputer, as described by Daniel Puser above, is an excellent example of how the two advancements converge.

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