STARTING WITH A SPLASH

In December 1962, some nine months after the Parkes Telescope commenced operation, NASA sponsored a conference in New York on *The Physics of Non-Thermal Radio Sources*. John Bolton was invited to attend and report on the first observations from Parkes. Instead, he sent me, and my report began with the words: 'Of the current observing programs on the CSIRO 210 ft radio telescope at Parkes, the program to measure the polarization of radio sources has produced the most unexpected results'.

From the early days of radio astronomy, it had been known that the emissions from the sun are often highly polarized, however attempts to detect any polarization of the emissions from discrete sources, or the galactic background had failed. The suggestion that the emission from these sources was generated by the synchrotron process received a boost in 1954, when, following Shklovskii's proposal that both the light and the radio emission from the Crab Nebula were synchrotron emission, the *light* was found to be highly linearly polarized. But it was another three years before observers at the US Naval Research Laboratory detected polarization in the *radio* emission from the nebula, measuring 7% linear polarization in the 3 cm emission.

The first detection of polarization in the radio emission from an *extragalactic* source came early in 1962, when the group at the US Naval Research Laboratory measured 8% linear polarization in the 3 cm radiation from Cygnus A. Significantly they found that the degree of polarization was much less at the somewhat longer wavelength of 10 cm. This suggested that perhaps appreciable polarization would be found only at the shortest wavelengths, which might explain the failure of the earlier attempts to detect polarization, which had all been made at longer wavelengths.

I believe the successful studies of the polarization of the microwave emission from Jupiter made at Caltech, had led John Bolton to make provision for polarization studies at Parkes. The first Parkes detection of polarized radio emission from a source other than Jupiter was made by Ron Bracewell (visiting from Stanford University), Brian Cooper and Tom Cousins. This was during some unscheduled observations early in 1962, when an experimental 10 cm receiver was being used to test the performance of the dish at this short wavelength. (The dish had been designed to work well at wavelengths of 21 cm and longer. These tests showed that it still worked well at a wavelength as short as 10 cm). Strong linear polarization was found in the radio emission from the peculiar southern galaxy, Centaurus A.

Marc Price and Brian Cooper then made measurements of Centaurus A at longer wavelengths. They not only found polarization at these longer wavelengths, they also found that the direction of the linear polarization changed systematically with wavelength, the change in angle being proportional to the square of the wavelength. This rotation of the plane of polarization, the *Faraday Effect*, was attributed to propagation through ionized interstellar gas pervaded by a magnetic field.

Soon after the detection of linear polarization in Centaurus A, Frank Gardner and John Whiteoak discovered linear polarization in other radio sources, and by July 1962 they were reporting detections for eight sources. Suddenly a new area of study had opened up. Linear polarization in extragalactic sources was at last being detected, confirming the synchrotron origin of the emission, and measurements of the Faraday rotation were providing information on the number of electrons and the strength of the magnetic field along the path from the source to the earth. And incidentally the discovery of strong Faraday rotation explained the earlier failures to detect polarization at longer wavelengths: the radiation was depolarized by variable Faraday rotation across the face of the source.

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In early 1962 Cyril Hazard, from the University of Manchester, who was spending a period at the University of Sydney, visited John Bolton at the Radiophysics Laboratory, and showed us recordings he had made at Jodrell Bank of the *lunar occultation* of the weakish radio source 3C 212. *Occultation* is one of those delightful words that litter the astronomical literature; for *occultation* read *eclipse*. Cyril had realised that observing lunar occultations of discrete radio sources could provide valuable information. Timing the disappearance of a radio source behind the moon, and then its reappearance, provides a means of accurately locating the source on the sky. Furthermore, the patterns of decrease and increase of the received radio emission as the edge of the moon passes over the source can delineate the size and shape of the source. In the case of 3C 212 the pattern Cyril had recorded as the source disappeared behind the moon was a classical *diffraction pattern,* showing that the angular size of the source was very small indeed.

Having had some success with this technique at Jodrell Bank, Cyril now came to tell John of predictions that one of the stronger radio sources in the sky, 3C 273, would be occulted a number of times during 1962, and that for several of these occultations the source should be above the horizon of the Parkes Radio Telescope. He asked if he could use the Parkes dish to observe these events. Cyril observed the occultations of 3C 273 at Parkes and the observations were extremely successful, largely, it must be said, thanks to John Bolton's assistance. In the papers reporting the observations John's name does not appear as an author, but it was he who made sure there were no problems. As he delighted in telling, for one of the occultations he ground away a part of the telescope so that it could be tipped the extra few degrees needed to be sure of observing the emergence of the source from behind the moon.

Cyril Hazard was a man of ideas, but his execution of these ideas could sometimes attract that natural nickname of 'Hap Hazard'. Some years later, in Puerto Rico, Cyril invited me to witness an occultation they planned to observe at the Arecibo Observatory. I arrived at the observatory to find everything very quiet. There was none of the frenzied activity one would expect in advance of an attempt to record a once-in-twenty-years event. It turned out that Cyril had forgotten to convert Universal (Greenwich) Time to local time and that the occultation had already occurred!

There was no formal report of Cyril's observations of the 3C 273 occultations given at that December 1962 New York meeting: the paper reporting the results was still in preparation. However, news of the observations had travelled by the grapevine and Al Moffet referred to them in his presentation, which gave me the opportunity to show the slides I had brought of the recordings of the August and October events. Analysis of the occultation records defined the position of the source on the sky, and the shape of the radio emitting area, with great accuracy. The optical counterpart was identified immediately: like the radio source, the optical object had a peculiar shape. It looked like a star with a jet issuing from it. One more example to add to the four cases already known of very small diameter radio sources whose optical counterparts looked like stars - the so-called 'radio stars'. But less than a month after the New York meeting Maarten Schmidt recorded the spectrum of the optical counterpart and showed the object to be the core of a galaxy far beyond the Milky Way, a galaxy with a redshift of 0.16, the first recognised *quasar*. A rapid re-assessment of the spectra of the other four 'radio stars' led to the recognition that they were also galactic cores with high red-shifts, with 3C 48 the most distant at a redshift of 0.37.

Anyone interested in the history of science would be fascinated to read a paper presented at that New York meeting that does not appear in the Proceedings. In a long presentation Jesse Greenstein discussed the optical spectra of the four previously known 'radio stars'. For each of them he managed to find an explanation of the spectral features in terms of normal Milky Way stars. The paper is not mentioned in the published proceedings of the meeting, and the lengthy paper that Jesse had submitted to the Astrophysical Journal was withdrawn after Maarten Schmidt's discovery. Fortunately for the history of science, Maarten has assured me that he has preserved a copy of Jesse's paper.

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