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John Bolton, Discrete Sources, and the New Zealand Field-trip of 1948*

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Abstract

The field-trip to New Zealand by John Bolton and Gordon Stanley in 1948 was a crucial step in discovering the nature of discrete radio sources. This paper describes the circumstances surrounding the field-trip and also looks at other investigations in radio astronomy in New Zealand at that time.

1. Introduction

John Bolton was a world pioneer in radio astronomy. His early career at the CSIRO Radiophyics Laboratory was during the halcyon days of J. L. Pawsey (see Bolton 1982), when small close-knit research teams beavered away in an abundance of scattered field stations on what seemed like a never-ending variety of stimulating research challenges (for personal accounts see Christiansen 1984; Wild 1972).

One of Bolton's first major research challenges was to determine the true nature of 'radio stars', detected initially by Hey *et al.* (1946*b*) and, in the course of this investigation, he and Gordon Stanley were instrumental in establishing the Laboratory's two most easterly field stations—at Leigh and Piha, in that one-time extension of New South Wales known as New Zealand. This paper, which expands on Robertson (1992) and Orchiston (1993*a*), is about the New Zealand field-trip and other contemporary radio-astronomical investigations in that country.

2. The New Zealand Field-trip: A Brief Chronological Narrative

By the end of 1947, Bolton had recorded Cygnus A, Taurus A, Virgo A and Centaurus A, with evidence of possibly two further discrete sources. In Bolton's (1982) own words: '1947 had been a vintage year.' Yet one major problem remained: the true nature of these sources; accurate positional data were required so that possible optical correlates could be examined.

With this objective in mind, Bolton and Stanley discussed the nearest elevated coastal locations to Sydney which would permit observations of both risings and

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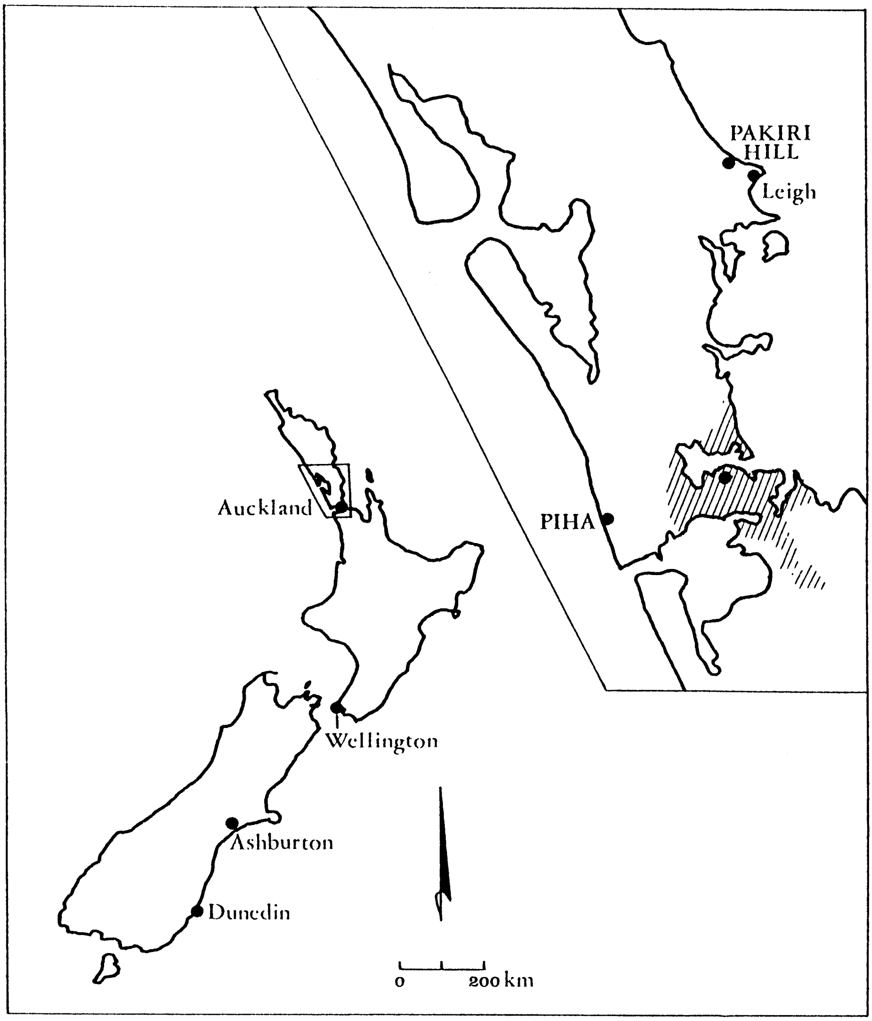

Fig. 1. New Zealand localities mentioned in the text.

settings of the sources. After considering and eliminating both Lord Howe and Norfolk Islands, they selected New Zealand, and the chief of the Laboratory, E. G. Bowen, enthusiastically supported a field-trip there. Not only did the Northland peninsula offer ideal observing sites within relatively easy access of Auckland, but also that city was home to university staff sympathetic to radio astronomy.

At the end of May 1948 an ex-Army radar trailer (see Bruce Slee' s photograph, Fig. 5, on p. 523), containing four 100-MHz Yagi antennas, a new receiver, recorders, chronometers and weather-recording equipment, was shipped to Auckland. Bowen had arranged with the New Zealand DSIR for logistical support for the expedition, which resulted in the New Zealand Army providing a truck that was used to haul the mobile field station to its first observing site, 'Pakiri Hill', a farm 10 km from Leigh and about 70 km due north of Auckland (not north–west as reported by Bolton 1982; see Fig. 1). The site was at an altitude of 300 m, overlooking the sea, an obvious prerequisite for a 'cliff interferometer' operating on the Lloyd's mirror principle. The coastline here ran from south–east to north–west, so that sources could be followed from the time they rose above the horizon. The Yagi array had a horizontal beamwidth of 12° and a vertical beamwidth of 30°.

Bolton and Stanley spent almost two months at Pakiri Hill and, from later accounts, seem to have found conditions there even more primitive than those experienced in more familiar field stations nearer Sydney. Bolton (1982) reminisces: 'Conditions were far from ideal; we had a long extension from an already overloaded power line and frequency variations caused variations in the chart recorder speed of at least 10%. The weather was sometimes appalling; on one occasion our barometer recorded a fall of 15 mm in 30 s, to be followed by a similar fall of 9 mm, 10 min later.' Accounts published in 1949 and arising from this expedition make no mention of these weather anomalies, and their impact, if any, on the observing schedule.

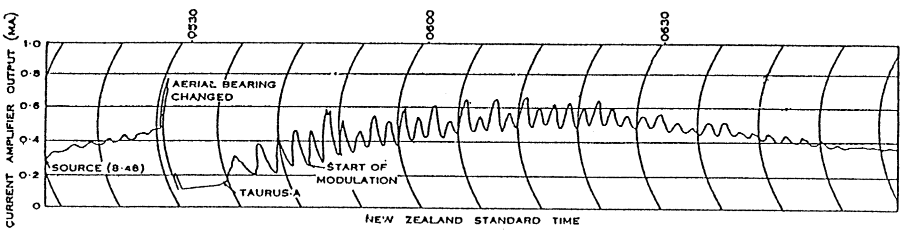

Fig. 2. Observation of Taurus A obtained at Pakiri Hill on 13 July 1948 (after Bolton and Stanley 1949).

Despite these distractions, by mid-July about thirty useable observations of Cygnus A and five of Taurus A were obtained (see Fig. 2). Bolton (1982) was later to note with some amusement: 'One of the first discoveries we made from observations of Cygnus-A at Leigh was that the Earth was curved!'

At the end of August the mobile field station was transferred to the 300-m cliff-top site of a former World War II radar station at Piha, 30 km due west of Auckland (not north as stated by Bolton 1982; see Fig. 1). This offered an excellent view of the western horizon, and Bolton and Stanley soon discovered that conditions here were vastly superior to those encountered at Pakiri Hill: 'The diesel plant for the radar station provided a supply of electricity stable in both voltage and frequency, our receivers performed faultlessly and the weather was perfect' (Bolton 1982). Over the next three weeks successful observations were made of Cygnus A, Taurus A, Centaurus A and Virgo A.

3. Discussion

The principal scientific outcome of the New Zealand sojourn is well known (see Bolton 1955), and marked a significant advance in the fledgling discipline of radio astronomy. Armed with the vastly improved positions offered by the New Zealand observations, Bolton and his colleagues were able to suggest optical correlates for Taurus A, Centaurus A and Virgo A (see Bolton and Stanley 1949; Bolton *et al.* 1949), and these were eventually widely accepted by astronomers. However, the historian W. T. Sullivan (personal communication 1992) has been quick to point out that this initially was not the case: 'Publications and correspondence from that time indicate that the famous three optical identifications by BBS were treated much more as 'suggestions' over the next 2–3 years by all concerned, including Bolton. This was especially so because of the problems that Bolton had in determining systematic errors in his positions and because other likely optical objects of the same classes turned out *not* to be radio sources.'

The other notable result from the New Zealand field-trip involved the enigmatic 'source fluctuations' first reported by Hey *et al.* (1946*a*). While Bolton and Stanley were in New Zealand, Slee continued observing the target sources from Dover Heights in Sydney. These simultaneous trans-Tasman observations revealed that the puzzling source amplitude fluctuations were due to terrestrial atmospheric scintillations and were not inherent in the sources themselves (Stanley and Slee 1950). All in all, the New Zealand expedition was judged to be a great success.

The 1948 'radio stars' project also proved to be a field exercise in trans-Tasman cooperation. For Bolton and Stanley, travel was facilitated by ready access to the Army truck, and the DSIR also supplied a book of requisitions with which all bills were paid. They even provided a liaison officer to assist during the first two weeks of the field-trip (Bolton, personal communication 1992). Further cooperation came from the Department of Lands and Survey, whose staff accurately determined the height of the Pakiri site.

Bolton and Stanley also came to know Professor P. W. Burbidge, Dr K. Kreilsheimer and their graduate student Alan Maxwell, from the Physics Department of what is now the University of Auckland. This trio visited Pakiri Hill on at least one occasion (A. Maxwell, personal communication 1992), and Bolton (personal communication 1992) went to Auckland and lectured to Burbidge's students.

Bolton's visit was particularly opportune as Maxwell, for his Master's degree, was immersed in research on solar radio emission (Maxwell 1948) using twin Yagis mounted on a small 'receiver hut' on the roof of the Biology Department (Fig. 3). Although Burbidge had a passion for, and considerable knowledge of, astronomy, Maxwell's supervisor was Kreilsheimer who, on the other hand, was a 'radio science' specialist involved in upper atmospheric physics (A. Maxwell, personal communication 1993). After completing his thesis, Maxwell went to Jodrell Bank to study for his Ph.D., and then to Harvard College Observatory, where he was instrumental in establishing the Fort Davis Radio Astronomy Field Station (see Maxwell 1958).

Despite producing the first radio astronomy graduate thesis in New Zealand, Maxwell was not the first to carry out radio astronomical research there. This honour lay with Radio Development Board scientist Dr Elizabeth Alexander, who investigated enhanced solar radio emission during the second half of 1945 (Sullivan 1988; Orchiston 1993*b*). This, in turn, led to further solar monitoring by R. S. Unwin throughout much of 1947, during the 'Canterbury Project' based in Ashburton (Orchiston 1993*b*). A third radio-astronomy-related project from this period was by I. Thomsen, Director of the Carter Observatory in Wellington, who, in 1947–48, carried out an analysis of the correlation between sunspots and solar emission at metre wavelengths, and published his results in *Nature* (Thomsen 1948).

From the foregoing outline, it is apparent that considerable radio astronomical research had been conducted in New Zealand before the arrival of Bolton and

Fig. 3. Maxwell's steerable twin Yagis used for solar research in 1947–48.

Stanley (although very little published evidence exists), and that their Yagi array was not the first dedicated radio telescope in the country. (Indeed, Alexander had used a Yagi for solar observations from Piha in 1945.) However, they were the first to (i) investigate non-solar radio emission there, (ii) direct their researches at problems then perceived to be at the cutting-edge of science and (iii) publish their results swiftly and in a systematic fashion.

There is no evidence that the solar radio astronomy conducted by New Zealand scientists in 1947–48 generated any great public interest, yet the media were excited by the idea of two pioneering young radio astronomers from Sydney wishing to make non-solar observations in New Zealand in 1948. The publicity started when C. W. Allen stopped in Auckland en route to England, a week or so before Bolton and Stanley were due to arrive. Although primarily an optical astronomer, he had collaborated with colleagues at the Radiophysics Laboratory on solar work, and published a paper (Allen 1947). He was therefore in a position to know about the forthcoming field-trip, and sang its scientific praises in the pages of the *New Zealand Herald* ('Noises from stars', 22 May 1948). He mentioned the Leigh observing site (but not the Piha) and the advantages it offered over '... the Sydney headlands... where accuracy could not be attained.'

Three days later, on 25 May, a further news item also titled 'Noises from stars' appeared in the same newspaper, with statements by Harley Wood (Director, Sydney Observatory) about the Cygnus A radio source. In the article, A. J. Higgs (from the Radiophysics Laboratory) is quoted as saying that the Bolton and Stanley work '... was the most advanced in the world in this field.' Six days later on 31 May, Stanley's arrival in Auckland was briefly reported under the banner 'Scientist to study space noises'.

About two weeks after Bolton and Stanley arrived at Pakiri Hill, they were visited by a reporter from the *New Zealand Herald*, who subsequently produced an interesting feature article on June 25. In it, he rightly speaks of this pair of 26-year-olds as pioneers in radio astronomy, and identifies Bolton as an Englishman and Stanley as a New Zealander. He also reported on the response of the local population to these unusual intruders: 'The people of Leigh seem to have accepted the scientists with little comment. No one even seems to have climbed the hill to visit the strange-looking trailer with its four antennae pointing horizontally out to sea. Professor P.W. Burbidge... and several members of the Department of Scientific and Industrial Research have been the only ones, apart from inquisitive newspaper men, to have broken the research workers' steady routine. This peace, of course, is what they want and what they have asked for so that they can get on with their task. However, they proved willing enough to try to explain what they were doing.'

Bolton proceeded to discuss their observations of the Cygnus A source and, without knowing its origin, somewhat bravely postulated its distance as '... at least four [light] years and possibly thousands of [light] years.' We now know that a figure of 74×10^7 light years would have been closer to the mark.

Scientists are often called upon to justify pure research, and Bolton, showing considerable political acumen for one so young, rose admirably to the occasion when the reporter raised this matter: 'Mr Bolton replied in terms of Michael Faraday's analogy of a new-born baby—who can say what it will become? Mr Bolton pointed out that the study of radio echoes from the ionosphere layer encircling the Earth led to the development of radar, and investigations of properties of uranium led to the atomic bomb. The idea so far was not to use these radiations but to find out something about them.'

Through his lengthy article, the reporter offered an admirable insight into the exploits of the two radio astronomers. He concluded with the prophetic statement: 'However, whether the public will ever fully understand what has been done and how it will affect scientific progress are... questions whose answers are hidden in the future.' As it turned out, posterity was to assign this field-trip and the ensuing research results a principal place in the annals of radio astronomy.

It is a little surprising that the local media did not make more of Stanley's New Zealand origins, following the appearance of this article. Obviously, the ANZAC tradition was still prevalent, and issues of nationalism had yet to emerge. To all intents and purposes, Stanley was an 'Australian scientist' (as was Bolton).

After Bolton and Stanley's departure, almost a quarter of a century was to elapse before New Zealand was once more witness to work of international significance in non-solar radio astronomy. For about a decade from 1972, staff and graduate students led by Professor Paul Edwards from the Physics Department at the University of Otago, Dunedin, used meridian transit instruments operating in the 110–160 MHz range to investigate radio emission from flare stars and from the direction of the Galactic centre (Edwards 1975). But even this 'indigenous' New Zealand radio astronomy had a distinctive trans-Tasman connection, for Edwards was, by birth and training, an Australian.

Acknowledgments

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