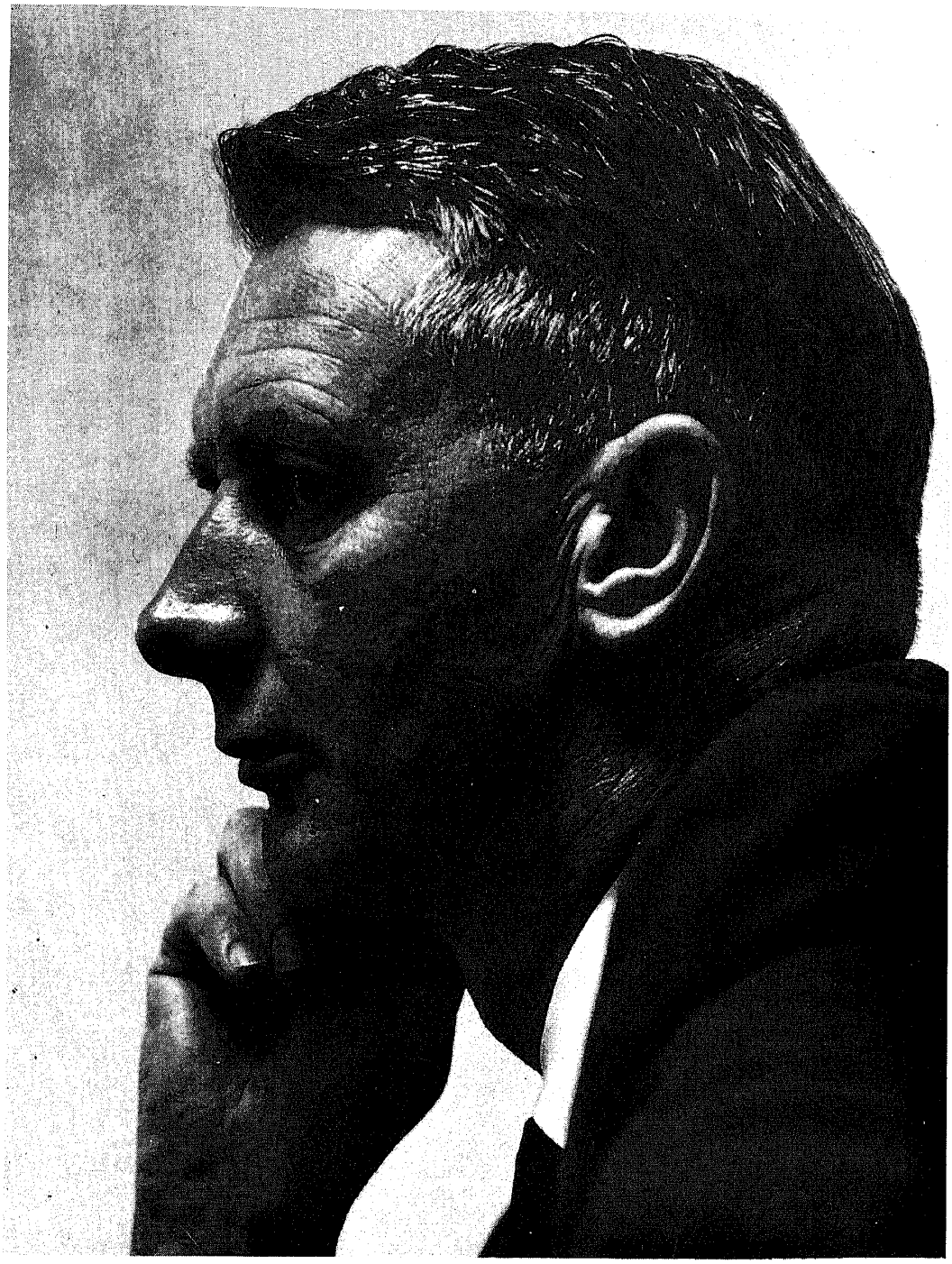
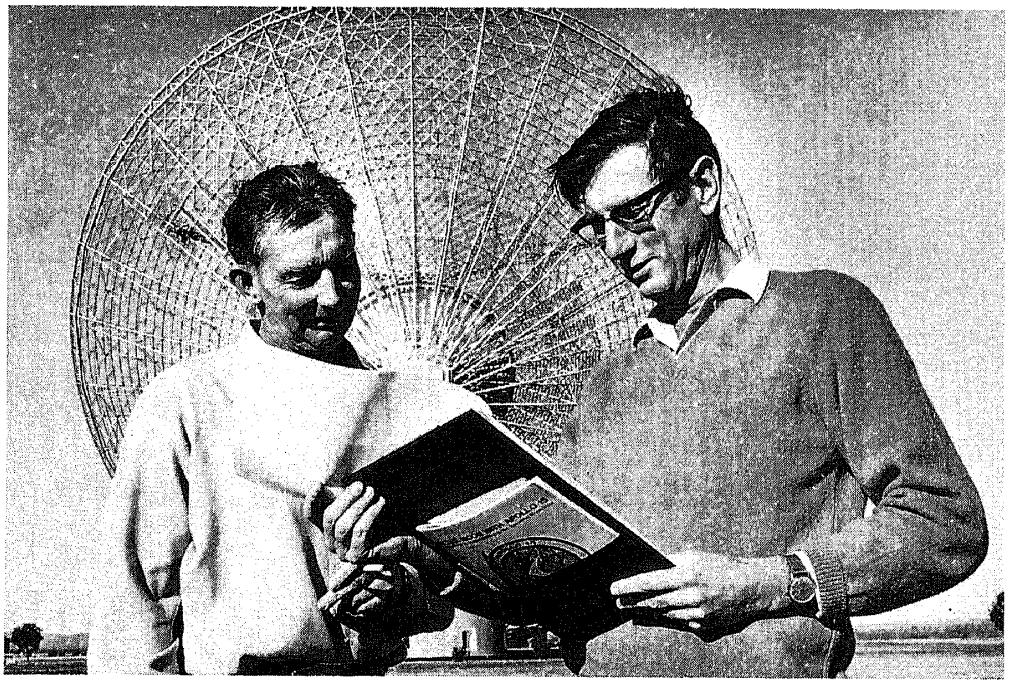


John Gatenby Bolton

1922 – 1993



Top: John Bolton on the structure of the Parkes dish installing the panels.
Bottom: Bolton and Wild at Parkes during one of the Apollo missions.

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Obituary

JOHN BOLTON – Astronomer Extraordinary

Astronomers all over the world would have been saddened to hear of the death of John Bolton in July this year. Not only was he one of the great pioneers who created whole new branches of the subject, but, for those who knew him personally, a friend of truly remarkable individuality. With his unlimited courage and penetrating intuition, and physically indefatigable when in intense pursuit of whatever he was after, John Bolton was a phenomenon that had to be experienced to be believed. So different was he from other scientists of his eminence that it was almost as if he did not belong with them.

Before World War II all information about the Cosmos had been obtained through the roughly half an octave window of the visible part of the electromagnetic spectrum. The half a century since then can truly be called the Golden Age of Astronomy when the field underwent a total transformation. The limits of the observable universe were pushed back beyond all reasonable expectations, and it was shown to be populated with surprisingly energetic galaxies radiating powerfully at wavelengths ranging over as many as fourteen orders of magnitude. As summed up by Paul Wild[1], Bolton's distinguished colleague and contemporary, "... it all began in 1948 when a 26 year old Yorkshireman named John Bolton with two colleagues discovered that three distant objects known from optical observations were extremely powerful emitters of radio waves. One, which Bolton called 'Taurus A' was located in our own galaxy: the Crab Nebula. The other two ('Virgo A and Centaurus A) were external galaxies. This discovery marked the beginning of the new era in which the universe could be explored by means of its high energy galaxies".

These revolutionary observations were made with equipment from World War II located on a cliff overlooking the sea in Sydney, Australia. John had opted to settle here at the end of the War because – according to one friend – "he had no desire to return to an England where a man from Yorkshire would find it hard to break into the academic community". Two other Yorkshiremen I got to know – through John – and admire as scientists, were Paul Wild, who like John also married an Australian and settled in Australia, and Fred Hoyle who as we all know, stayed in England, did break into the academic community with a vengeance, and to this day loves a fight.

John Gatenby Bolton was born in Sheffield on 5th June 1922. After going through his local grammar school, he won a scholarship to Trinity College, Cambridge. He graduated with honours in 1942 and joined the Royal Navy as a Radar Officer, but was soon recruited into radar research at the then secret Telecommunications Research Establishment (TRE). Among other famous figures in radio astronomy who also served time at TRE are Hey, Hanbury Brown, Bowen, Ryle and Lovell. In 1944 Bolton did get to sea on the aircraft carrier Unicorn in the Pacific where he even became involved in dangerous flight testing and survived a forced landing in a naval fighter.

In Australia Bolton joined the Commonwealth Scientific and Industrial Research Organisation (CSIRO) whose Radiophysics Laboratory was directed by E. G. (Taffy) Bowen. Radio emissions from the Sun had been discovered during the war and there was much activity investigating these by a group led by J. L. (Joe) Pawsey. There was no shortage of talent in the laboratory and among those who worked there at the time, and were to became famous later, were names like Paul Wild (already mentioned), Christiansen, Bernie Mills, Alec Little and Jack Piddington, besides a host of others almost as well known. To all of these scientists Pawsey was the father figure in Australian Radio Astronomy. Not so for Bolton however, one of whose first experiences was being ordered back to the lab by Pawsey when the latter unexpectedly visited the site and found the aerials not pointed at the Sun, because Bolton was looking for other radio sources.

Bolton was reassigned to assist Stanley to build equipment to go on an eclipse expedition to Brazil in the following year. It was a matter of great good fortune for astronomy that the expedition was called off and Bolton was 'released' to do what he pleased with the equipment they had built, and to avail of Stanley's services as well. They lost no time in moving the equipment out to the cliff-top site called Dover Heights, and so began a period of epoch making observations. Not withstanding the separation of Bolton from the solar group, his maiden publication in August 1947[2] deals with the first observations at three well separated frequencies (60, 100 and 200 MHz) of a solar outburst of Type II (as later designated by Wild). Bolton and coauthors correctly attributed the delays in arrival time with decreasing frequencies to the passage of a physical agency upwards through different levels of the corona. They estimated a velocity of almost 1000 km/s, close to that of auroral particles, and noted that an aurora was in fact observed in some parts of Australia a little more than a day after the outburst.

From then on it was radio sources, of which only one had so far been discovered, by Hey in England. The cliff top location of the Yagi antennas enabled the sea surface to be used as a 'Lloyd's mirror' to make a sea-interferometer providing an enormous increase in resolution. Fine interference fringes were observed on Hey's source fixing both its location in the constellation of Cygnus and an upper limit to its angular size of eight arc minutes. I may add in passing that it was the subsequent identification of this 'strong' radio source with a very dim optical galaxy some years later that made everyone instantly realise that the accessible radio universe would be far larger than the visible one.

Then followed the discovery of the three sources mentioned at the beginning. Determining their positions well enough to make the identifications was no simple matter. It involved shipping the equipment to New Zealand and towing it with an army truck to more than one location with a cliff of adequate height and appropriate orientation. Months of hard work later there was enough justification to write to three famous optical astronomers all of whom had an interest in the Crab Nebula – Jan Oort, Bengt Strömgren and Rudolf Minkowski. The letters provoked enthusiastic responses and led to cooperation and lifelong friendships. To quote Bolton "The identification of the Crab Nebula was a turning point in my own career and for non-solar radio astronomy. Both gained respectability as far as the 'conventional' astronomers were concerned"[3].

A project undertaken by Bolton which should find a place in any account of his career is the 72 ft hole-in-the-ground antenna built in 1951 for a survey of the region

near the galactic centre, which at the latitude of Sydney passed directly overhead. The excavation was done mostly by Bolton and Slee. Westfold, a Radio Astronomy theorist, also helped to dig, and Gordon Stanley trucked loads of ash from a powerhouse each week to stabilise the sand out of which the hole was formed. The reflecting surface was made from steel strips formerly used for binding packing cases, and performed adequately at the operating frequency of 160 MHz. It was interesting however that the 'site' for the hole was chosen not to be visible from the official working area of the Dover Heights station. All of the digging etc., had to be carried out in one's own time (lunch, after hours, etc) and in secrecy. Somewhere along the way Bowen was made aware of this exercise, and predictably, supported it. To be fair to Pawsey, after a first demonstration of the potential of this dish in early 1952, he too enthusiastically supported its upgrading to 80 ft in diameter and to 400 MHz in frequency. Observations with this improved version, made with Dick McGee led to Bolton's suggestion in 1953 that Sagittarius A was the nucleus of our Galaxy[4]. Three years later the IAU ratified the view making the position of this (radio!) source the zero of longitude in the new system of galactic coordinates.

The next chapter in Bolton's story is set in the US where radio astronomy had been taking a back seat compared to the activity in Australia and England in the post war years. I have already mentioned TRE in England where Bolton worked for a while and where radar was developed. The corresponding centre in the US, set up much later, was the MIT Radiation Laboratories headed by Lee DuBridge. Here work on microwave devices and measurements was carried out by a battery of distinguished physicists – Bethe, Dicke, Pound, Purcell and Van Vleck, among hundreds of others. Taffy Bowen, already mentioned as the Chief of Radio Physics in Sydney was one of the key players in the drama of radar in World War II and was personally responsible for carrying an early sample of a 'magnetron' invented at Birmingham University across the Atlantic to the Radiation Laboratories. I mention this visit and Bowen's subsequent stay for some years at the Radiation Labs as it has a bearing on the Bolton story. The links of friendship Bowen forged then were crucial in obtaining generous financial support from foundations in the US for the Parkes 210 ft telescope to be built many years later. In return, Bowen arranged for Bolton to spend time at the California Institute of Technology where Lee DuBridge was President.

Bolton went to Caltech in January 1955 and in the six years before he returned to Australia in 1961, created the Owens Valley Radio Observatory which was quickly recognised as a world centre and which provided a much needed boost to radio astronomy in the US. Bolton's crew in this exercise came from all over the world – England, Australia, New Zealand, India, Canada and Norway if I have not forgotten any others. The graduate students were American and included Barry Clark, Ken Kellerman, Al Moffet and Bob Wilson. I was the Indian and was hired to maintain the radio equipment that Gordon Stanley had already built. In Bolton's own account[5] of the Owens Valley period he dwells on the education he received, from day one onwards, from Minkowski on the need for and importance of accurate radio positions as the only way to make identifications that would lead to progress.

The Caltech interferometer was unique and a forerunner of later instruments in having as elements large dishes operating at a frequency as high (at that time) as a GHz. It had the sensitivity and baseline to resolve a substantial fraction of the sources observed. Among the sources not resolved at the longest baselines was 3C295 which

was identified by Bolton with an object for which Minkowski with the Palomar 200 inch telescope got a redshift of 0.46, roughly three times the highest then known and a record which was to stand for fifteen years. There were many interesting discoveries made by members of Bolton's group during his years at Caltech, but his own interest in building the Owens Valley Observatory was, as he has stated himself, "to extend the observable scale of the universe to look-back times as great as the oldest stars in our own system"[5]. It was a unique and unforgettable experience to see Bolton go about this exercise in as cool and low key a manner as someone building a cattle shed or repairing a washing machine. He gave people tasks about which they may not have had a clue to start with. He never taught you how to do anything, as if that would have been a presumption. But his example and even more his expectation made people rise to heights that they would never have dreamt possible.

I have already mentioned 3C295, but the Caltech chapter of Bolton's story would be incomplete without a mention of 3C48. Quite simply, 3C48 was the first identification of a quasar which went public without a redshift in a paper presented at the Christmas 1960 meeting of the American Astronomical Society with the authors T. A. Matthews, J. G. Bolton, J. L. Greenstein, G. Münch and A. R. Sandage[6], the chronological order in which they were involved. Matthews was the Canadian with whom I shared an office, and who obtained a position for the radio source which beautifully fitted a 16th magnitude star. Spectra were obtained by Münch and Sandage and measured by Greenstein. After considerable tuition from Ira S. (not Taffy) Bowen, director of the Palomar Observatory, Bolton arrived at a possible fit for the lines at a redshift around 0.37 but a four angstrom discrepancy was unacceptable to the spectroscopists and stopped matters dead for about three years[5]. It was hence poetic justice that, as I shall recount shortly, Bolton played a vital part in the dramatic story of 3C273, hailed by most as the true first identification of a quasar.

To the surprise and disappointment of most of us working at Owens' Valley at the time, Bolton announced abruptly in late 1960 that he was returning to Australia to supervise the steelwork which had commenced on the 210 foot telescope that Bowen had been planning for years. This he did, not from the ground but from up on the structure. He also surveyed and reset every one of the more than thousand panels over an acre of surface. The telescope was commissioned in late 1961 and Bolton took charge as Director of the Australian National Radio Astronomy Observatory (ANRAO) to begin a third and equally spectacular phase of his career. Parkes attracted astronomers from all over the world including several of us who had worked with Bolton in California. Major contributions were made in almost every branch of radio astronomy of which there were a large number now. Bolton's lifelong interest in the discovery, classification and identification of radio sources found his greatest reward in these years. The Parkes Catalogue, in the making of which Bolton was personally involved, lists more than 8000 sources including several hundred quasars. Here too he had students among whom was Ron Ekers who went on to head the VLA and now the Australia Telescope.

As hinted earlier, Bolton and the Parkes dish were essential elements in the drama of the identification of the source 3C273 as a quasar. Cyril Hazard who had pioneered the lunar occultation technique of determining accurate positions for radio sources at Jodrell Bank happened to be in Australia in Hanbury Brown's group at Sydney University. He was invited by Bolton to take part in observations at Parkes of occultations of the radio source 3C273, several of which had been predicted for 1962.

It was typical of Bolton to figure out that the most critical of these occultations would require an extension of the existing zenith angle coverage of the telescope, and that this could be achieved by grinding off a considerable amount of metal from the bearing housings. I was not there to witness it, but knowing John, I can picture him with the grinder, hand-rolled cigarette hanging from his lip, knee braced against a girder and grinding away in a shower of sparks. In any event the observation was spectacularly successful and as a final touch to the drama, Bolton and Hazard each carried a record and travelled on different planes to Sydney. Minkowski who was on a visit to Australia at the time communicated the position to Maarten Schmidt who established the redshift as 0.158, considered astoundingly large for an object that looked like a star. This was the breakthrough and it led Greenstein and Matthews to believe the 'redshift' of 0.37 obtained earlier for 3C48 and to publish it in a paper following those on 3C273[7].

The Parkes telescope also played an important part in several of NASA's Apollo missions. Not many may know that Neil Armstrong's first steps on the moon seen all over the world, live on television, came via Parkes. Another, and unplanned occasion was when a sudden emergency on another of the Apollo missions required Parkes to come on line in a matter of hours. It just so happened that I was to have observed that night, and had to quickly clear the focus cabin of the pile of equipment that I had spent all day assembling. In a situation of such urgency, kicking someone off the dish required no effort, but to quote the London Times "Bolton, typically, left nothing to chance. With the Australian sun beating down, he stood, stop watch in hand, rehearsing teams of his perspiring staff in hand-cranking the axis gearing of the 1000-ton dish at rates correct to follow the spacecraft should mains power fail".

The great importance of the discovery of the three radio sources described at the beginning was not a little due to Bolton's identification of them with optical objects. More than anyone else, Bolton brought radio and optical astronomy together, through constant interaction with the best optical astronomers of his time, through the use of optical telescopes himself for identification purposes, and through efforts to set up major facilities like the Anglo Australian Telescope and the UK Schmidt Telescope. He was among the earliest to recognise the unity of astronomy across all wavelengths.

Several changes took place at the Radio Physics Division in the period 1971–72. Bowen retired as the Chief of the Division and his place was taken by Paul Wild. John Bolton retired as Director of ANRAO but continued in Parkes as Astronomer at Large until 1981 when after a heart attack he decided to retire and move to a coastal resort in the warmer climate of Queensland. Many honours came his way as they should have, some a little belated like the Bruce Medal of the Astronomical Society of the Pacific. It was awarded to Bolton in 1988, when his health had already deteriorated to the point of ruling out travel to the US, but it was carried and presented to him at a special ceremony held in Australia. I am happy to point out that the Indian Academy of Sciences which publishes this journal elected Bolton an honorary fellow in 1973.

No one who came in contact with Bolton would have failed to notice that determination was his main characteristic. This came through in sport even quicker than it did in other areas. Whether in table tennis, snooker or golf, once he had decided that he would win, it did his opponent little good being a much better player in other circumstances. Bolton's power of concentration was phenomenal and his resolve unshakeable. Pity the bureaucrat who tried to get in his way.

I consider myself very fortunate to have associated over many years with a person of such integrity and strength of character. I believe that it did good to all of us who had this privilege. Most people who have known Bolton paint him as harshly intolerant of mediocrity and poor judgement. I think this was true, but only if it interfered directly with his plans or actions, when most of us would react the same way too. Bolton was a fearless individual, who could be ruthless when needed, but I always thought of him as a fair and friendly person and one who together with his wife Letty kept open house to all of us who had ever worked with him. He was more than a great pioneer in science; he was an extraordinary man.

V. Radhakrishnan
Raman Research Institute
Bangalore.

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