Forward – *Radio Astronomy by A.J. Higgs*

In September of 1968, the publishing firm of Thomas Nelson (Australia) invited the Australian Commonwealth Science and Industry Research Organisation (CSIRO) Division of Radiophysics to write a book on Radio Astronomy. Arthur John Higgs (1904—1991), then the Secretary of the Division, was assigned to draft the text. Higgs prepared a 14-chapter manuscript tentatively titled "*Radio Astronomy*"; however, the publisher decided not to proceed for unknown reasons. Many years later, while researching in the National Archives of Australia for his book, *From the Sun to the Cosmos, J.L. Pawsey, Founder of Australian Radio Astronomy* (Goss et al, 2023), Miller Goss located a copy of the manuscript (Higgs, 1969).

The manuscript provides an important insight into the development of Radio Astronomy from an Australian perspective. As Higgs explained in a 16 October 1968 letter to the publisher:

> *"My overall objective, however, would be to produce an interesting but authoritative account of Radio Astronomy at a semi-popular level which would be thoroughly up-to-date and different from other texts on this subject, in that it would draw largely from Australian material for illustrative purposes and record the significant contributions which Australia has made toward the development of this new and exciting field. This has not yet been adequately done."*

Higgs was uniquely placed to write such a text. He joined the Division of Radiophysics during WWII (1939—1945). After the war, he was present from the first steps in examining solar radio "noise" through the blossoming of radio astronomy in the 1950s and the building of the 64-m Parkes Radio Telescope and the Radioheliograph at Culgoora.

Higgs began his career as an ionospheric physicist at the Commonwealth Solar Observatory (later to become the Mount Stromlo Observatory) in September 1926 after completing a Batchelor of Science (BSc) at the University of Sydney. He had a specific interest in the properties of the ionospheric layers and radio propagation and also built equipment to use in photoelectric photometry (Frame and Faulkner, 2003: 39). He conducted measurements of atmospheric ozone from 1929 to 1932 and various experiments in conjunction with the Council for Industrial Research (CSIR) Radio Research Board including a study to confirm atmospheric effects associated with thunderstorms. In addition, he was involved in the confirmation of radio fade-outs related to solar flares (Martyn et al., 1937). Further, he explored these associations with R.G. Giovanelli, who was visiting Stromlo on a research fellowship from 1937—1939 (Higgs and Giovanelli, 1938). During 1938, Higgs made improvements to ionospheric sounding equipment at Stromlo to automate the collection of "soundings" eight times per hour and allowed the half-hourly data to be provided day and night to the Radio Research Board (Frame and Faulkner, 2003: 54). The data accumulated on the height, electron density and thickness of the ionospheric layers, and their variations with time of day, season and sunspot cycles would later prove a critical resource in help in forecasting maximum and optimal radio communication frequencies during wartime.

Higgs also worked closely with another Stromlo recruit, C.W. (Clabon) Allen, whose photometric atlas of the solar spectrum was arguably the Observatory's chief claim to fame in this period (Gascoigne, 1984: 597). Despite the outbreak of WWII, Higgs and Allen were able to travel to Victoria West, South Africa, to observe the 1940 Solar Eclipse. Allen undertook the astronomical observations, while Higgs carried out a series of ionospheric measurements (Pierce et al., 1940).

With the onset of WWII, Higgs was keen to contribute to the war effort. Given Higgs's experience in ionospheric research and involvement with the Radio Research Board, it was logical for him to join

the newly created and secret CSIR Radiophysics Laboratory, charged with developing radar in Australia. He would remain with Radiophysics for the remainder of his career. Higgs's relationship with Allen would prove critical in forging an early collaboration between astronomers at Stromlo and radio investigators at Radiophysics. Nowhere else in the world would such an early collaboration occur between optical and what would become radio astronomers (Sullivan, 2009: 137).

One of Higgs's first wartime projects was overseeing the design and build of automatic ionospheric recorders to improve the quality of prediction services for the military. These recorders, known as ionosondes, were installed in Sydney, Hobart, Brisbane, Townsville, Cape York, New Zealand, Fiji, and Christmas Island (Mellor, 1958: 506). One of the original ionosondes has survived and is now in the University of Queensland Physics Museum (https://physicsmuseum.uq.edu.au/ionospheric-recorder-type-y10d70890j28a).

By 1942, Higgs was appointed as a Research Officer with Radiophysics and moved to work developing a Mobile Coastal Defence CD radar, publishing its technical specification in December 1942 (Evans, 1970: Annexure 47, p18). He also wrote a technical summary of American Anti-Submarine and Air Intercept systems and, by June 1944, was promoted to Senior Research Officer. As the war progressed, he increasingly became involved in technical administration tasks.

At the end of WWII, Radiophysics pivoted to explore peacetime research. On 15 August 1945, Higgs, now Technical Secretary of the Division of Radiophysics headed by E.G. "Taffy" Bowen (1911—1991), was part of the senior team including Bowen, Pulley, Piddington, Pawsey, Eagles, Kerr, Payne-Scott and McCready. They met to discuss future research possibilities, one of which was exploring solar and cosmic noise observed during the war. This field of research would become known as radio astronomy. Over the next decade, Australia would become a world leader in this new field under the direction of the scientific leadership of Joseph Lade Pawsey (1908—1962).

Higgs remained Technical Secretary for the Division of Radiophysics until his retirement in 1969 at age 65. The role encompassed administrative support of all aspects of Radiophysics research, including rainmaking, air navigation aids, electronic computers, and radio astronomy. From this position, Higgs had a broad overview of all scientific developments in the Division and exposure to all key staff. In 1952, he was seconded for 18 months to head the CSIRO Scientific Liaison Office in Washington while a search for a new head was underway after the resignation of the incumbent. He then returned to Radiophysics in Sydney to resume his role as Technical Secretary.

Radiophysics ran a strict internal review process of all scientific papers before submission to journals for publication, and Higgs played a critical quality review role in this process. He was also involved in the oversight of the production of promotional material. For example, he appears in the credits for a 1968 short film on rainmaking research (https://csiropedia.csiro.au/rainmaking-1968/) as the "Scientific Director". He also wrote two chapters for the second edition of a *Text Book of Radar* (Bowen, 1954), produced by Radiophysics to summarise their wartime research efforts, and served on various international committees for the frequency allocation for radio astronomy and participated in lobbying efforts to ensure the preservation of crucial frequency bands for future research.

Over the years, Higgs often functioned as a wise council, smoothing some of the rough edges of Bowen's aggressive leadership style. He also helped facilitate the powerful

combination of Pawsey's research brilliance and Bowen's political and entrepreneurial skills that was in no small part critical to the Divisions success in the 1950s. Before the emergence of the human resources professional, Higgs also ended up performing this role, counselling staff and understanding the strength and weaknesses of individuals (Ryan, 1999). For example, in mid-1962, he visited New York and Boston and was in Washington when Pawsey was first diagnosed with brain cancer. He stepped in to play a liaison role in helping Pawsey and his family until he could return to Australia (Goss et al., 2023). Pawsey died later that year, on 30 November 1962, in Sydney.

Higgs retired from Radiophysics in 1969, reaching the retirement age of 65. While he had started work on the manuscript in 1968, it is clear from the archives that he continued to work on it during his retirement until at least mid-1970. Whether the publishers changed their minds, Higgs lost interest in the project, or a combination of the two is unclear. Chapter 13 – "*Is the Universe expanding?",* is missing from the archives and may never have been prepared. By the 1970s, the debate on the nature of redshifts had settled on the expanding universe hypothesis, so Higgs may have considered that including a chapter on alternative theories, such as steady-state cosmology, was no longer warranted.

While Higgs retired in 1969, he continued his scientific interest and involvement throughout the 1970s, including serving on the editorial committee of *The Australian Physicist*, published by the Australian Institute of Physics. He passed away in 1991, coincidentally in the same year as his long-time boss at Radiophysics, Taffy Bowen.

The surviving manuscript provides a survey of the state of radio astronomy in 1968 from a uniquely Australian perspective. It begins with a brief history and then examines the state of knowledge, instruments and techniques using many examples from Australia within an international research context. The chapters cover the origins of cosmic radio waves, instruments and methods, the nature and distribution of radio sources, the Sun, Solar Systems sources, exploding stars, hydrogen-line emission and galactic structure, extragalactic HI, including the large and small Magellanic Clouds, interstellar molecules, cosmic magnetic fields, quasars, pulsars, and radar astronomy.

While providing a comprehensive survey of the topic, there are two surprising omissions. First, there is no mention of the Australian discovery of the discrete radio source (Sgr-A) at the galactic centre (Piddington and Minnett, 1951; McGee and Bolton, 1954), which was the first indication of an unusual object located there. Secondly, there is no coverage of Christiansen's development of the earth-rotational synthesis technique, which he used to produce a 2-D image of the Sun (Christiansen and Warburton, 1955). The development of the method was significant as it now underpins most modern radio astronomy imaging techniques. While Radiophysics did not pursue the method further, Martin Ryle's group at Cambridge leveraged the development of digital computers to make the earth-rotational synthesis technique practical for imaging. Ryle would later receive a Nobel Prize (1974) for his observations and inventions, particularly the aperture synthesis technique. Perhaps, in 1968, Radiophysics did not yet appreciate the significance of these two contributions. Christiansen had left the group in 1960, and no one else in Radiophysics had continued work on aperture synthesis for cosmic research, focusing instead on the 64-Parkes telescope. The significance of the Sgr-A discrete source was also perhaps overlooked as the highly

successful work elucidating the galactic structure focused on HI research. Also, the manuscript was written before the realisation that the power source of quasars was massive black holes at the nucleus of galaxies and that black holes exist at the centre of virtually all massive galaxies.

Although the manuscript itself is not a history, anyone interested in the history of the development of radio astronomy will find it a fascinating read and a clear summary of the state of science in the late 1960s.

Harry Wendt
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