PRAGUE GA: 26th IAU GENERAL ASSEMBLY
Monday 14–Friday 25 August 2006
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HISTORIC RADIO ASTRONOMY WORKING GROUP SCIENCE MEETING #2 (WEDNESDAY 23 AUGUST)

"Radio Astronomy 50 Years Ago: From Field Stations to 'Big Science'"
Venue: Chamber Room

Organising Committee

Wayne Orchiston (Australia: Chair), Ron Bracewell (USA), Ken Kellermann (USA), Masaki Morimoto (Japan), Bruce Slee (Australia), Govind Swarup (India), Jasper Wall (Canada).

Program

14.00-15.30 **Session 3 (Chair: Wayne Orchiston)**

14.00-14.30 "The Beginnings of the U.S. National Radio Astronomy Observatory" (Keynote Paper)
Ken Kellermann and E.N. Bouton (National Radio Astronomy Observatory, USA)

14.30-14.50 "The 218-ft Jodrell Bank Transit Telescope and its Contribution to Radio Astronomy"
Andrew Quinn (James Cook University, Australia), Alastair Gunn (Jodrell Bank Radio Observatory, UK) and Wayne Orchiston (James Cook University, Australia)

14.50-15.10 "A True Radio Astronomy Pioneer: Cornell H. Mayer (1921-2005)"
V. Radhakrishnan (Raman Research Institute, India)

15.10-15.30 "Solar Radio Astronomy at Fort Davis, Stanford and Kalyan, 1956-1966: Personal Reminiscences"
Govind Swarup (Tata Institute of Fundamental Research, India)

15.30-16.00 **Afternoon Tea**

16.00-17.30 **Session 4 (Chair: Govind Swarup)**

16.00-16.30 "The Contribution of the Ex-Georges Heights Experimental Radar Antenna to Australian Radio Astronomy" (Keynote Paper)
Wayne Orchiston and Harry Wendt (James Cook University, Australia)

16.30-16.50 "The Development of Low Frequency Radio Astronomy in Tasmania"
Martin George and Wayne Orchiston (James Cook University, Australia)

16.50-17.10 "Discovery of the CMBR: Looking Back 40 Years"
Paul Boynton (University of Washington, USA)

17.10-17.30 "The Cosmic Microwave Background and Radio Astronomy"
Bruce Partridge (Haverfield College, USA)

Poster Papers

1 "The Contribution of the Potts Hill Field Station to International Radio Astronomy"
Harry Wendt and Wayne Orchiston (James Cook University, Australia)

2 “Owens Valley Radio Observatory, QSOs and Palomar”
Edward Waluska (James Cook University, Australia) and Marshall Cohen (Caltech, USA)

3. “Early Australian Pulsar Astronomy”
Peter Stark (James Cook University, Australia), Richard Wielebinski (Max-Planck-Institut für Radioastronomie, Germany) and Wayne Orchiston (James Cook University, Australia)

Publication of the Papers

In the Historic Radio Astronomy Series in the *Journal of Astronomical History and Heritage*.

Abstracts

“The Beginnings of the U.S. National Radio Astronomy Observatory”

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By the mid-1950s many of the scientific leaders in the United States had become concerned that the U.S. was falling behind the rapid developments in radio astronomy being reported from Australia and the UK. Not only were U.S. astronomers being left behind, but during the height of the cold war it was widely appreciated that many of the techniques used in radio astronomy had applications to communications and to military activities. However, the ambitious plan to concentrate radio astronomy resources in one large expensive facility was hindered by concerns, which continue to this day, about the negative impact of large research facilities on the independence of individual investigators.

In 1957, after a divisive struggle within the scientific community, the National Science Foundation named Associated Universities Inc. (AUI) which had no previous experience in astronomy, to build and operate the new National Radio Astronomy Observatory (NRAO) and provided initial funds to construct a ‘moderate-sized radio telescope’ in Green Bank, West Virginia. Building on their experience in operating large particle accelerators, AUI established NRAO as a world-class radio observatory open to all qualified scientists, independent of institutional or national affiliations, a practice now followed by many radio observatories throughout the world.

“The 218-ft Jodrell Bank Transit Telescope and its Contribution to Radio Astronomy”

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Jodrell Bank has been one of the leading observatories for radio astronomy for over fifty years. It has grown from being the University of Manchester’s botanical grounds to the expansive site for research, study and public interest it has become today. Over the course of its lifetime, scientists have employed a wide variety of instruments at Jodrell Bank, starting with old WW II Yagi aerials through today’s modern instruments of the Lovell telescope and the MERLIN/VLBI National Facility. There have been many changes over the years.

An often-overlooked instrument is the 218-ft above-ground transit telescope that was built in 1947 for cosmic ray research. However, its potential for radio astronomy was soon realized, and up until 1955 it was used to investigate Galactic and extra-galactic emission at 1.89m. This paper, which is based on a masters degree research project, describes this novel radio telescope and reviews its important contribution to astrophysics.

“A True Radio Astronomy Pioneer: Cornell H. Mayer (1921-2005)”

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While it is universally known that the patriarchs of radio astronomy, Jansky and Reber (despite their obviously European names) were American, there is a general impression that America’s contributions

faltered thereafter, and that the torch in the postwar years was carried by other countries. These were notably the UK and Australia, where many ex-WWII types became legends in the field.

Jansky's discovery was made at the very low frequency of 26MHz, and Reber's initial experiments suggested that much higher frequencies produced weaker or no signals. This led to a general feeling that the real action would be at metre wavelengths, which is where the UK and Australian groups concentrated their efforts and made headline news.

What was going on in this period, little noticed by the community then and probably unknown to the present generation, was work by another ex-WWII group at the Naval Research Laboratory in Washington, but at the very short wavelengths of centimeters. Connie Mayer was one of the leaders in this group, the significance of whose work would only be appreciated decades later. This is what I shall describe in this paper, which is dedicated to his memory.

"Solar Radio Astronomy at Fort Davis, Stanford and Kalyan, 1956-1966: Personal Reminiscences"

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Pioneering observations of the rapidly moving solar radio bursts made in Australia during 1945-1955 led to the establishment of the Harvard Fort Davis station in Texas in 1956, and this was used to obtain the dynamic spectra of solar radio emission in the 100-600 MHz frequency range. I worked at the observatory during 1956-1957 and discovered the Type U burst. In 1956 Bracewell started building a 32-element grating type cross antenna at Stanford in order to generate daily solar radio maps at 9.1 cm, and I joined him in 1957. Several pioneering contributions were made at Stanford between 1959 and 1963, and I will describe these.

Having gained enough confidence through my experience at the National Physical Laboratory, (New Delhi), CSIRO's Division of Radiophysics (Australia), Fort Davis and Stanford, I returned to India in 1963 with an ambitious plan to build a major radio astronomical facility for India. This eventuated in the form of the Kalyan 32-element grating interferometer, which was built in 1963-65 and used the 6-ft dishes from Christiansen's Potts Hill E-W grating array (which were donated by the CSIRO). With this new instrument we were able to demonstrate the presence of limb brightening of the radio Sun at 600 MHz.

Development of the Kalyan array led to the formation of an active radio astronomy group at the Tata Institute of Fundamental Research, the subsequently to the setting up of the Ooty Radio Telescope and later the Giant Metrewave Radio Telescope near Pune. The moral of this story: once you sit on a tiger it is difficult to get off, and the challenge continues (i.e. in this case, from field stations to 'big science')!

"The Contribution of the Ex-Georges Heights Experimental Radar Antenna to Australian Radio Astronomy'

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During the late 1940s and throughout the1950s Australia was one of the world's foremost astronomical nations owing primarily to the dynamic Radio Astronomy Group within the Commonwealth Scientific and Industrial Organisation's Division of Radiophysics. The earliest celestial observations were made with former WWII radar antennas and simpler Yagi aerials, before more sophisticated purpose-built radio telescopes of various types were designed and developed.

One of the recycled WWII antennas that was used extensively for pioneering radio astronomical research was an experimental radar antenna that initially was located at the Division's short-lived Georges Heights field station but in 1948 was relocated to the new Potts Hill field station in suburban Sydney. In this paper we describe this unique antenna, and discuss the wide-ranging solar, Galactic and extragalactic research programs that it was used for.

"The Development of Low Frequency Radio Astronomy in Tasmania"

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Within Australia, significant contributions to low frequency radio astronomy were made in the State of Tasmania after the arrival of Grote Reber in 1954. Whilst operating as an independent researcher, he teamed with Graeme Ellis from the Physics Department at the University of Tasmania and they built a 2.13 MHz array and carried out observations during a period of exceptionally low sunspot activity in 1955. In the early 1960s, Reber established a 2.085 MHz (144-metre wavelength) square-kilometre array in the central region of the State and used this to make the first map of the southern sky at this frequency. In addition, the University constructed low frequency arrays near Hobart, including a $650m^2$ array, which consisted of 2,000 dipoles and operated from 2MHz to 20MHz.

This paper reports on a doctoral research project that examines the history of low-frequency radio astronomy in Tasmania).

"Discovery of the CMBR: Looking Back 40 Years"

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On 13 May 1965, Arno Penzias and Robert Wilson submitted a letter to the Editor of the *Astrophysical Journal* briefly outlining the technical details of a meticulous measurement of the excess temperature of empty sky at 4,080 MHz. In the page-and-a-half note they were careful not to speculate on the cause of this effect. Thirteen years later, each was awarded a share of the 1978 Nobel Prize in Physics for the discovery of the Cosmic Microwave Background Radiation. How did this modest, obscure announcement of 'excess temperature' lead to the celebration of a profound revelation of the nature of the physical universe and a watershed for the empirical foundation of 21st century cosmology? The key is a companion *Ap.J*. letter submitted on 7 May 1965 by Robert Dicke's group at Princeton.

In this paper I will review the unfolding of this fascinating interplay between the conduct of ordinary science and the gift of serendipitous discovery, and conclude by reviewing the microwave and cryogenic technology of the late '40s and early '50s and suggesting that the CMBR could have been revealed more than a decade earlier if either of two major players had only read one or two of the journal publications of the other.

"The Cosmic Microwave Background and Radio Astronomy"

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The cosmic microwave background (CMB) was predicted by physicists (Alpher, Gamow and Herman), discovered by telecommunication engineers (Penzias and Wilson) and interpreted by physicists in Bob Dicke's group. Many of the dozen or so scientists who set out to make the initial measurements of the spectrum and isotropy of the CMB had backgrounds in physics rather than astronomy (and I was one of them). Astronomy, including conventional radio astronomy, initially played only a restricted role in CMB studies. I suggest some reasons why, and explore how radio astronomy came to influence and enrich work on the CMB. This presentation may complement Paul Boynton's more extensive history of the discovery of the CMB.

"The Contribution of the Potts Hill Field Station to International Radio Astronomy" [Poster Paper]

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During the 1950s Australia was one of the world's foremost astronomical nations owing primarily to the dynamic Radio Astronomy Group within the Commonwealth Scientific and Industrial Organisation's Division of Radiophysics. Most of the observations were made at the network of field stations maintained by the Division in or near Sydney, and one of the most prominent of these was located at Potts Hill, the site of Sydney's major water-distribution reservoirs.

This poster paper reports on a doctoral research project, and outlines the amazing range of radio telescopes developed at the Potts Hill field station; the types of solar, Galactic and extragalactic research programs to

which they were committed; and the pioneering young men and women who played a key role in the early development of radio astronomy.

"Owens Valley Radio Observatory, QSOs and Palomar" [Poster Paper]

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The Owens Valley Radio Observatory (OVRO), located 250 miles north-east of Los Angeles, was constructed in the 1950s and is operated by the California Institute of Technology. The early research that was done using two 90-foot antennas as an interferometer, focused on the determination of the precise position for radio sources. This research led to collaborative studies of various extragalactic sources, including Quasi-Stellar Objects (QSOs), by astronomers from both the OVRO and Palomar Mountain, where the 200-in Hale telescope is located.

Research has already been conducted on the history of the OVRO, the Palomar telescope, and the discovery of QSOs. What has not been investigated is the relationship that developed from the collaborative efforts of astronomers from OVRO and Palomar. This poster paper reports on a doctoral research project that examines the discovery of QSOs at the OVRO and how this work impacted on the operating relationship between Caltech and the Carnegie Institution of Washington, and ways in which it affected later scientific research conducted by the Caltech radio astronomers.

"Early Australian Pulsar Astronomy" [Poster Paper]

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Serendipitous discoveries have played a key role in the evolution of science, and one that stands out in astronomy is Jocelyn Bell's identification of the first pulsar, CP 1919, in 1967.

Just two weeks after the initial announcement in *Nature*, radio astronomers associated with the CSIRO's 64m Parkes Radio Telescope began observations of this lone PSR, and quickly expanded their single-frequency observations to an investigation spanning the frequency range 85-2,700 MHz. Over the next few years a great deal of research was done on the properties of pulsars using the Parkes Radio Telescope and the Culgoora Circular Array. However, neither instrument was suitable for pulsar searches, which quickly became the domain of the University of Sydney's Molonglo Cross radio telescope. This survey instrument *par excellence* made many new discoveries, and by the end of 1971, 53% of all known PSRs were Australian finds.

This poster paper reports on a doctoral research project that critically examines the discovery and investigation of pulsars at Molonglo, Parkes and Culgoora during the period 1968-1978.