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HIGHLIGHTING THE HISTORY OF JAPANESE RADIO ASTRONOMY. 4: EARLY SOLAR RESEARCH IN OSAKA

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Abstract: For about two years, from late 1949, Minoru Oda and Tatsuo Takakura carried out solar observations from Osaka, initially with a hand-made horn and later with a small parabolic antenna connected to a 3.3 GHz receiver, but they only published one short paper on this work. At about the same time, Ojio and others at Osaka City University presented the concept of a solar grating array at a meeting of the Japan Physical Society, but this was never built. In this paper, we provide brief biographical accounts of Oda and Takakura before examining their radio telescopes and the observations that they made. We also briefly discuss the proposed Japanese solar grating array.

Keywords: Japan, solar radio astronomy, Osaka University, Osaka City University, Minoru Oda, Tatsuo Takakura, solar grating array

1 INTRODUCTION

Japanese radio astronomy was launched on 9 May 1948 when Koichi Shimoda (b. 1920) observed a partial solar eclipse from Tokyo (see Shimoda, 1982; Shimoda et al., 2013), and by 1952 four different groups of Japanese researchers were actively pursuing solar radio astronomy, in Hiraiso, Osaka, Tokyo and Toyokawa (see Orchiston and Ishiguro, 2017). This short paper is about the Osaka initiative, which commenced in November 1949.[1]

For Japanese localities mentioned in this paper see Figure 1.

2 SOLAR RADIO ASTRONOMY AT OSAKA UNIVERSITY AND OSAKA CITY UNIVERSITY

2.1 Introduction

Radio astronomy blossomed in the years immediately after WWII, largely as a result of the development of radar during the War, and by 1950 Australia, Canada, England, France, Japan, New Zealand and the USA all had made valuable contributions, but with Australia and England the 'stand-out' nations (e.g. see Sullivan, 2009).

At the end of WWII

> The U.S. Initial Post-Surrender Policy prohibited research which might contribute to a revival of Japan's war-making potential; that included all activities relating to atomic energy. Research facilities were closed until the headquarters of the Supreme Commander for the Allied Powers (SCAP) could ascertain that their activities were of a "peaceful" nature. SCAP gave instructions to destroy or scrap "enemy equipment"—arms, war vessels, aircraft, and military installations. It exempted equipment considered "unique and new development" desirable for "examination, intelligence or research;" equipment deemed useful for U.S. army or naval operations; and equipment suitable for peacetime civilian use. (Low, 2006).

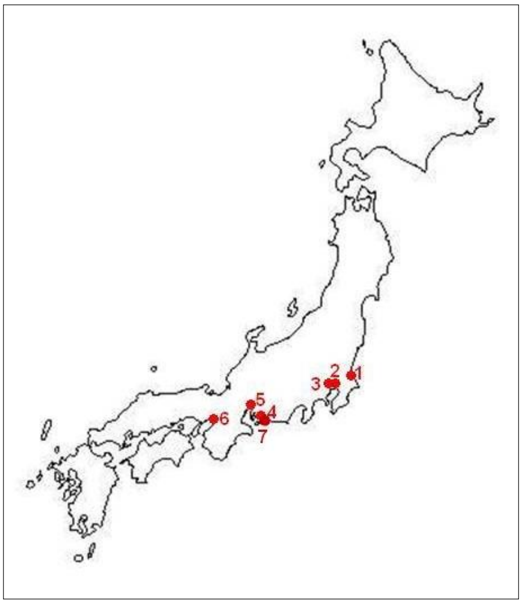

Figure 1: Japanese localities mentioned in the text. Key: 1 = Hiraiso; 2 = Tokyo University; 3 = Tokyo Astronomical Observatory (Mitaka); 4 = Toyokawa Observatory; 5 = Nagoya University; 6 = Osaka; 7 = Shimada (Map: Wayne Orchiston).

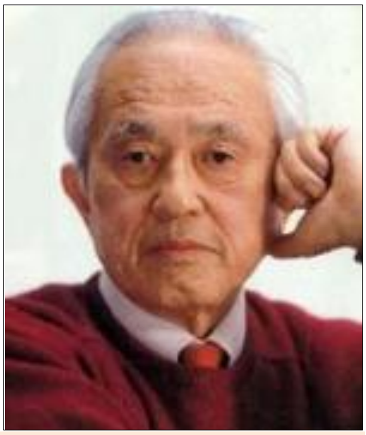

Figure 2: Professor Minoru Oda (www.casinapiova.va/content/academia/en.academicians/deceased/oda.html).

Although radio astronomy was a non-military field of science and technology, its association with war-time radar research and development (as in other countries) meant that in Japan it was very difficult to obtain suitable equipment and stable power supplies for radio telescopes. The simplest option was to focus on 'solar noise studies' using modest instrumentation.

This is precisely what two young graduate students in the Physics Department at Osaka University did in November 1949 when they began researching solar radio emission, encouraged by their supervisor, a newly-appointed Professor of Physics, the cosmic ray expert Yuzuru Watase (see Oda, 1985). They were 26-yr old Minoru Oda (1923–2001) and 24-yr old Tatsuo Takakura (b. 1925).

After graduating with a B.Sc. in Physics from Osaka University in 1944, Minoru Oda was involved in magnetron research at the Shimada Naval Research Laboratory (see Figure 1) for the remainder of WWII, and this focus on microwaves provided his entré to radio astronomy. However, his commitment to this new field was short-lived, for in 1953 he went to the USA, and became involved in research on cosmic rays. After returning to Japan in 1956 he proceeded to build an international reputation in this field and subsequently in X-ray astronomy (Pounds, 2004). He achieved great success as Director of the Institute of Space and Astronautical Science (ISAS) and later the Reiken Institute (see Maddox, 2001), and long before he died (Figure 2) was widely regarded as the 'founding father' of space astronomy in Japan (Clark et al., 2001). One has to wonder if he would have achieved such international eminence had he remained in radio astronomy.

Tatsuo Takakura (see Figure 3) also worked on microwave radar during WWII (Takakura, 1985), but in stark contrast to Oda, he stayed true to radio astronomy throughout his career. After leaving Osaka City University in 1953 he joined the vibrant young radio astronomy group at Tokyo Astronomical Observatory (TAO) in Mitaka (see Nakajima et al., 2014), and remained there for the rest of his working life. At first he was devoted to solar research, but later he turned his attention to non-solar projects (see Takakura, 1985).

2.2 Osaka University

From November 1949 Oda and Takakura observed solar noise at 3.3 GHz using the hand-made metallic horn shown in Figure 4, which was supported by a damaged military searchlight mounting (Takakura, 1985). Apparently, the use of a horn rather than a parabolic dish was inspired by Japanese WWII radar technology. Much later, Takakura (1985: 163; our English translation) explained how this project came about:

Figure 3: A meeting of the Japanese National Commission V of URSI held at Toyokawa Observatory in 1954. T. Takakura is in the back row, third from the left. Also shown in the back row are some of Takakura's TAO colleagues: Akabane (2nd from the left), Suzuki (2nd from the right) and Hatanaka (extreme right). Oda is absent because by this time he was in the USA and no longer worked in radio astronomy (adapted from Tanaka, 1984: 345).

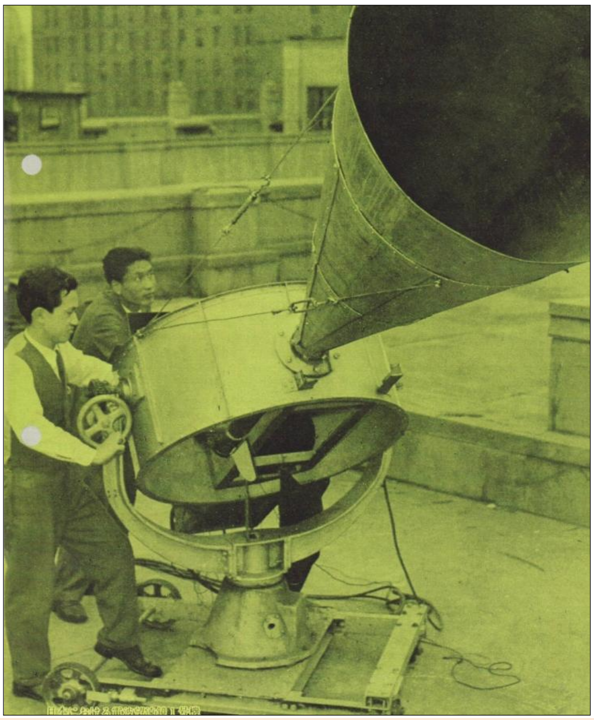

Figure 4: Oda (left) and Takakura (right) with their simple horn radio telescope at Osaka University in November 1949 (after Takakura 1985: front cover).

> One day in 1948, Minoru Oda happened to come to the lab where I worked, and said that he recently heard a rumour that a new field called radio astronomy had recently been born in overseas countries. He wanted me to work with him in this new field. This was my first opportunity to start research on solar radio astronomy.

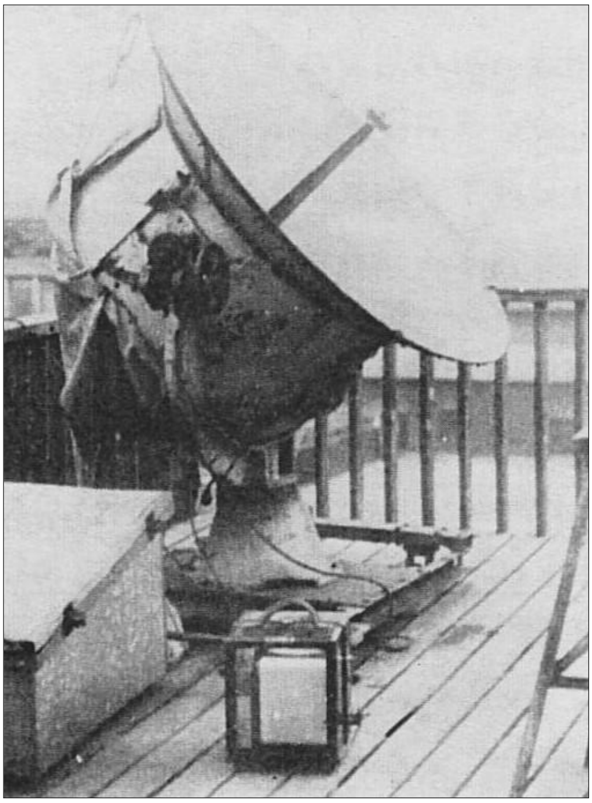

Figure 5: After they moved to Osaka City University Oda and Takakura replaced the horn feed with a 1-m parabolic reflector, and installed a new receiver, but they retained the chart recorder and the original mounting (after Takakura, 1985: 163).

As a result, the horn shown in Figure 4 was fabricated in the University's workshop, and Oda and Takakura found an abandoned 3.3 GHz radar receiver designed for use in submarines, and they modified it so that it coud be used with the horn. However, they did not know if the length and aperture of the horn were appropriate for a 3.3 GHz receiver (Takakura, 1985)!

We see that Oda and Takakura's decision to use a 3.3 GHz receiver also was motivated by their prior war-time experience working with microwave radar.[2] Towards the end of WWII the Imperial Japanese Army and Navy maintained metre-wave radar stations around the coasts of Japan (see Nakagawa, 1997; Nakajima, 1988), and the Navy also operated significant numbers of microwave radar units (Wilkinson, 1946a, 1946b). As we have seen, this to some extent lightened the burden of trying to source suitable electronic equipment during this difficult post-war period.

Takakura recalls that their initial attempts to detect solar radio emission with this simple radio telescope were frustrating:

> We used to manually point it [the horn] at the Sun, but could not detect any signal even after we had improved the sensitivity of the receiver. One day by mistake the antenna drifted away from the Sun, and then Oda noticed that the pen on the chart recorder recorded a strong signal … (Takakura, 1985: 163; our English translation).

Regrettably, they never suggested an explanation for this pointing error. Akabane (1986: 12–13; our English translation) also aludes to the difficulties that Oda and Takakura encountered at this time, prior to the introduction of the chart recorder:

> Since they pointed it [the horn antenna] on and off the Sun manually and read the needle of the current meter, I heard they spent lots of effort and time trying to detect solar radio emission …

Sometime in 1949—presumably towards the end of that year—Osaka City University established a new Faculty of Science and Technology, and Physics staff from Osaka University moved *en masse* to this innovative new facility, where Yuzuru Watase was appointed to a Chair in Physics (see Oda, 1985). Early in 1950 Oda accepted an Assistant Professorship in the same Department, and Takakura also transferred there, as a Research Assistant (Maddox, 2001; Takakura, 1985).

2.3 Osaka City University

Once settled at Osaka City University Oda and Takakura replaced the horn feed with the 1-m parabolic metal dish shown in Figure 5 (Tanaka, 1984), and they installed a new 3.3 GHz receiver (Takakura, 1985). They also constructed a metallic quarter-wave rotary polarization screen that was inserted directly in front of the dish when they wished to study the circular polarization of solar radio emission. In his report titled *Radio Astronomy in Japan*, Akabane (1986: 13) includes a photograph of this antenna with the polarization screen in place.

Strangely, in their 1-page published report on the research that they did carry out, Oda and Takakura (1951) say nothing about polarization, just that

> Solar radio noise at 3300 m.c. was observed from April to Oct. 1950 for every two hours per day [i.e. two hours every day]. Attention was paid to the average intensity and its fluctuations during [the] two hours.

Although they recognised that "… the period of observations was too short to arrive at any decisive conclusions …" (ibid.), Oda and Takakura did offer "… some crude results …" The first of these was:

> The intensity of solar noise at 3300 m.c. *is approximately proportional to the whole disk sunspot number*, reported from the Tokyo Astronomical Observatory, and shows no clear relation to the central zone sunspot number or whole disk sunspot group number. (ibid., their italics).

They also noted fluctuations with a period of ~20 minutes regardless of the intensity of the received emission, and that

> The mean fluctuation of the intensity is approximately proportional to [the] square root of the intensity. (ibid.).

Towards the end of their short paper, Oda and Takakura (ibid.) suggested that:

> … it is most probable that the solar noise comes from the sunspots, but it should be noted that the period of a source is rather short. Then it may be supposed that the magnetic field in the sunspot might have [an] important role in the generation of radio waves.

This 1-page paper, or short communication, was the only publication issued by Oda and Takakura about their solar radio astronomy program, even though Tanaka (1984) indicates that they continued monitoring the Sun at 3.3 GHz for another 10 months—i.e. until August 1951. Tanaka (ibid.) also states that Oda and Takakura discovered there was a linear correlation between solar flux density and sunspot numbers, but he does not elaborate on this.

Perhaps Oda and Takakura did not write any further papers on their solar work because they felt there was nothing new to report. By 1951, radio astronomers in Australia (Lehany and Yabsley, 1949; Minnett and Labrum, 1950; Piddington and Hindman, 1949; Piddington and Minnett, 1949), Canada (Covington, 1947; 1948), England (Sander, 1947; Stanier, 1950), France (Laffineur and Houtgast, 1949) and the USA (Dicke and Beringer, 1946; Southworth, 1945) had published a succession of research papers on microwave solar radio emission, and Oda and Takakura would have been familiar with at least some of this literature.

They would have learnt that it was already well known that at frequencies above ~1 GHz burst

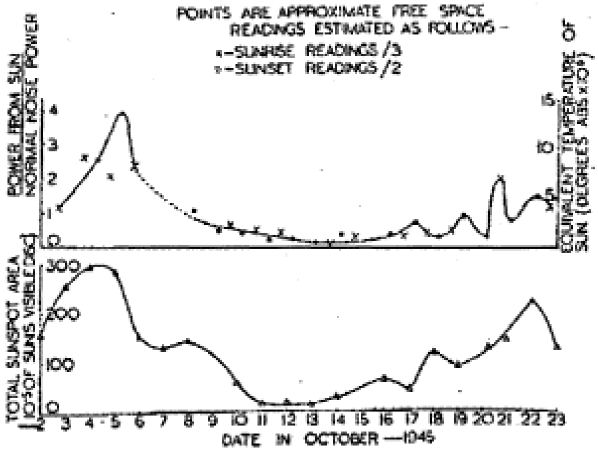

Figure 6: Plots of solar radio emission at 200 MHz (top) and total sunspot area (bottom) in October 1945 (after Pawsey et al., 1946).

emission was minimal and the solar flux density mimicked sunspot intensity. For example, in 1947 the Canadian, Arthur Covington began to regularly monitor solar radio emission at 10.7 cm (very close to the wavelength used by Oda and Takakura), and

> … this wavelength … turned out ideal as an index of solar activity, although its original choice [as in Japan] was dictated strictly by radar technology. Indeed, after only six months Covington (1948) could see his 10.7 cm data points rise and fall in perfect synchronism with the sun-spots .... (Sullivan, 2009: 213).

In fact, this correlation was first suggested by Pawsey et al. (1946), on the basis of October 1945 metre-wave data (Figure 6; cf. McCready et al., 1947), but it soon was confirmed to be a feature also of microwave solar emission—as shown in the lower two plots in Figure 7.

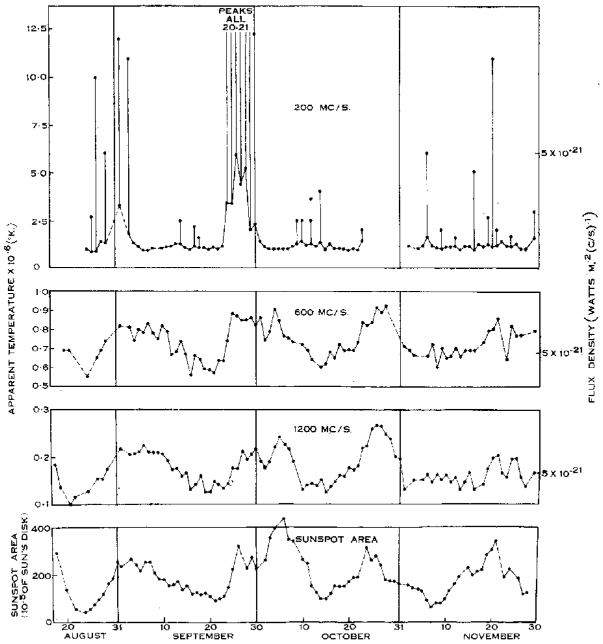

Figure 7: Variations in total sunspot area and solar radio emission at three different frequencies during a 4-month period in 1948. Note the obvious correlations at both 600 and 1200 MHz (after Lehany and Yabsley, 1949: 56).

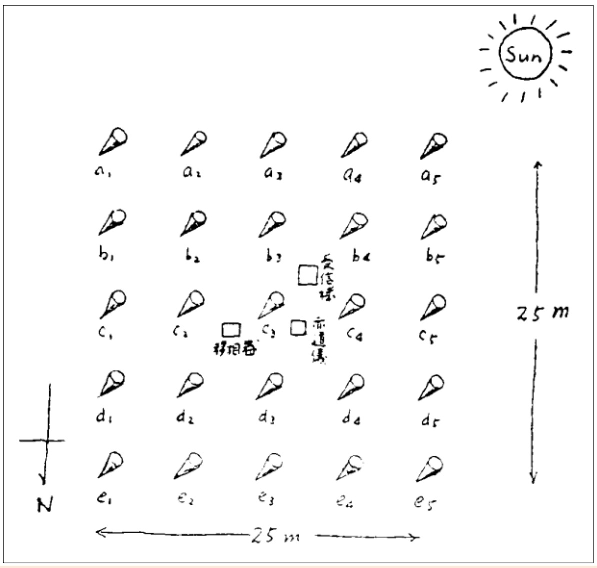

Figure 8: The solar grating array that was designed by Oda's group in 1950 but was never built (after Tanaka, 1984: 338).

Meanwhile, in 1946, Appleton and Hey (1946) in England and Martyn (1946) in Australia published papers on the polarization of solar radio emission, even if their studies focused on metre-wave emission. Presumably, Oda and Takakura did not obtain any new results that were meaningful at microwave wavelengths.

But another likely reason for Oda and Takakura's decision not to publish further papers was Oda's growing research interest in cosmic rays, at the expense of radio astronomy.[3] By this time it also was apparent that the optimal 'scientific mileage' in solar radio astronomy came from studying the metre-wave burst emission, and this became even more of a major international focus once Wild and his colleagues invented the solar radio spectrograph (see Wild, 1950a, 1950b; Wild and McCready, 1950) and could study solar bursts simultaneously across a wide range of frequencies. This somewhat reduced the research potential of single-frequency observations, and radio spectrographs quickly were adopted world-wide (including by Japan)

3 DISCUSSION

3.1 Takakura's Move from Osaka City University

When it became obvious that radio astronomy had no future at Osaka City University, Takakura was forced to move if he wished to remain in this field, or else he had to change his research direction and focus on cosmic rays. In choosing to continue in radio astronomy his options were limited: he had either to join Tanaka's vibrant Nagoya University group based at Toyokawa or Hatanaka's equally-impressive team at Tokyo Astronomical Observatory. At this time, both research groups were researching solar microwave emission (see Akabane, 1986; Nakajima et al., 2014; Tanaka, 1984), and for reasons that remain obscure Takakura chose to join the Tokyo group, where he went on to build a distinguished career as a radio astronomer (e.g. see Takakura, 1967; 1985).

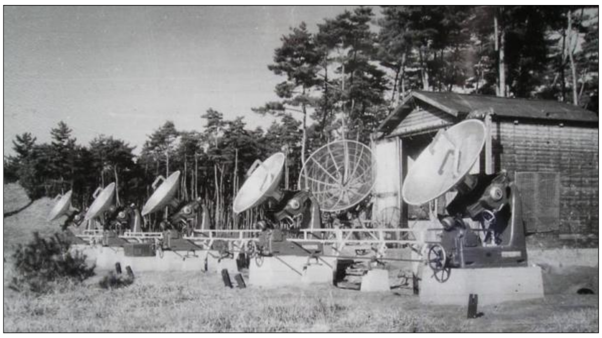

Figure 9: A view of the 4 GHz five-element grating interferometer installed at Toyokawa in 1953 (courtesy: Tanaka Family).

3.2 The Osaka Solar Grating Array Concept

By 1950 it was apparent that there were three very different types of solar radio emission:

(1) Energetic non-thermal bursts and outbursts;
(2) Thermal emission from the quiet Sun; and
(3) A slowly-varying component, correlated with the total area of sunspots visible on the solar disk.

The second and third components dominated at microwave wavelengths, and in order to study these more effectively than a small single dish would allow Oda's group at Osaka City University independently developed the concept of a grating interferometer. This would operate at 4 GHz, and would be used to identify the locations of the sources responsible for the solar noise. The interferometer would consist of 25 circular horns each 50-cm in diameter and arranged in the configuration illustrated in Figure 8. This interesting concept was proposed in an 8-page paper that was presented at the annual assembly of the Physical Society of Japan in 1950 (see Ojio et al., 1950), but it was never acted on. Had it been, then possibly Japan rather than Australia may have hosted the world's first solar grating array (see Christiansen, 1953; Christiansen and Warburton, 1953; Wendt et al., 2008).

The 1950 Ojio et al. paper was never published and thus far our attempts to locate a copy of it have been unsuccessful, so we cannot provide technical details of this innovative radio telescope. If we do eventually track down this paper we will prepare a separate paper in this Early Japanese Radio Astronomy series just about this array.

Meanwhile, Professor Haruo Tanaka from Nagoya University was inspired by the Ojio et al. paper, which led him to construct Japan's first solar grating interferometer at Toyokawa in 1953 (see Figure 9). This interferometer, and other radio telescopes designed and constructed by the Toyokawa researchers will be the subject of a later paper in this series.

4 CONCLUDING REMARKS

For less than two years, starting in November 1949, graduate students Minoru Oda and Tatsuo Takakura monitored solar radio emission at 3.3 GHz, initially from Osaka University with a simple horn antenna and subsequently from Osaka City University with a small metallic parabolic reflector. Although they particularly wished to investigate the polarization of the solar emission, they ended up publishing just one short solitary research paper, which merely contained general comments about microwave solar emssion but nothing about its polarisation properties.

Oda then turned to other fields of astronomy, but Takakura was able to transfer to the vibrant Tokyo Astronomical Observatory radio astronomy group at Mitaka and make an important life-long contribution to solar and non-solar radio astronomy. The limited and short-lived Osaka experiments therefore served as his radio astronomical 'apprenticeship', and should be viewed in this light—notwithstanding the paucity of publications that he and Oda produced at this time.

5 NOTES

1. This is the fourth paper in a series that aims to document early Japanese radio astronomy. The first paper was an overview (Ishiguro et al., 2012), and it was followed by papers about the first solar radio observations made from Japan, by Koichi Shimoda in 1948 (see Shimoda et al., 2013), and a review of the early solar radio astronomy carried out at the Tokyo Astronomical Observatory (Nakajima et al., 2014).
2. Akabane (1986: 12; our English translation) notes that at this time Japanese scientists

   > … were stimulated by the news that US and Canadian physicists started observing celestial bodies in the microwave radio band …

   This was quite different from the early solar radio astronomy research conducted in Australia, England and New Zealand, which was at metre wavelengths.
3. This was nurtured by Professor Watase, and it is significant that when Oda went to the USA in 1953 he made this his sole research interest.

6 ACKNOWLEDGEMENTS

We wish to thank Ms Junko Oguri at the National Astronomical Observatory of Japan Library for providing copies of old research papers; the Tanaka Family for kindly supplying Figure 9; and Professor Ray Norris and Drs Peter Robertson and Harry Wendt for commenting on the original dfraft of this paper. The first author (WO) also is grateful to the NAOJ for helping fund this project.

7 REFERENCES

Akabane, K., 1986. *Radio Astronomy in Japan*. Tokyo, Japan Branch of the International Telecommunications Union (No. 58) (in Japanese).

Appleton, E.V., and Hey, J.S., 1946. Circular polarization of solar radio noise. *Nature*, 158, 339.

Christiansen, W.N., 1953. A high-resolution aerial for radio astronomy. *Nature*, 171, 831–833.

Christiansen, W.N., and Warburton, J.A., 1953. The distribution of radio brightness over the solar disk at a wavelength of 21 cm. Part I: a new highly directional aerial system. *Australian Journal of Physics*, 6, 190–202.

Clark, G., Nagase, F., and Linsley, J., 2001. Minoru Oda. *Physics Today*, 54(9), 74–75.

Covington, A.E., 1947. Micro-wave solar noise observations during the during the partial eclipse of Novem- ber 23, 1946. *Nature*, 159, 405–406.

Covington, A.E., 1948. Solar noise observations at 10.7 centimeters. *Proceedings of the Institute of Radio Engineers*, 36, 454–457.

Dicke, R.H., and Beringer, R., 1946. Microwave radiation from the Sun and Moon. *Astrophysical Journal*, 103, 375–376.

Ishiguro, M., Orchiston, W., Akabane, K., Kaifu, N., Hayashi, M., Nakamura, T., Stewart, R., and Yokoo, H., 2012. Highlighting the history of Japanese radio astronomy. 1: An introduction. *Journal of Astronomical History and Heritage*, 15, 213–231.

Laffineur, M., and Houtgast, J., 1949. Observations du rayonnement solaire sur le longeur d'onde de 55 centimètres. *Annales d'Astrophysique*, 12, 137–147.

Lehany, F.J., and Yabsley, D.E., 1949. Solar radiation at 1200 Mc/s, 600 Mc/s, and 200 Mc/s. *Australian Journal of Scientific Research*, A2, 48–62.

Low, M.F., 2006. Accelerators and politics in postwar Japan. *Historical Studies in Physics and the Biological Sciences*, 36, 275–296.

McCready, L.L., Pawsey, J.L., and Payne-Scott, R., 1947. Solar radiation at radio frequencies and its relation to sunspots. *Proceedings of the Royal Society*, A190, 357–375.

Maddox, J., 2001. Obituary: Minoru Oda (1923–2001), *Nature*, 410, 888.

Martyn, D.F., 1946. Polarization of solar radio-frequency emissions. *Nature*, 158, 308.

Minnett, H.C., and Labrum, N.R., 1950. Solar radiation at a wavelength of 3.18 centimetres. *Australian Journal of Scientific Research*, A3, 60–71.

Nakagawa, Y. (translated and edited by L. Brown, J. Bryant and N. Koizumi), 1997. *Japanese Radar and Related Weapons of World War II*. Walnut Creek (CA), Aegeen Park Press.

Nakajima, H., Ishiguro, M., Orchiston, W., Akabane, K., Enome, S., Hayashi, M., Kaifu, N., Nakamura, T., and Tsuchiya, A., 2014. Highlighting the history of Japanese radio astronomy. 3: Early solar radio research at the Tokyo Astronomical Observatory. *Journal of Astronomical History and Heritage*, 17, 2–28.

Nakajima, S., 1988. The history of Japanese radar development to 1945. In Burns, R. (ed.). *Radar Development to 1945*. Hitchin, Peter Peregrinus Ltd. Pp. 245–258.

Oda, M., 1985. Cosmic Ray School of Osaka University/ Osaka City University—for the memory of late Profes- sor Yuzura Watase. In Sekido, Y., and Elliot, H. (eds.). *Early History of Cosmic Ray Studies: Personal Reminiscences-with Old Photographs*. Dordrecht, Reidel. Pp. 219–224.

Oda, M., and Takakura, T., 1951. A study on solar noise at 3,300 m.c. *Journal of the Physical Society of Japan*, 6, 202.

Ojio, T., Takakura, T., and Kaneko, S., 1950. A plan for the localization of solar sources on the solar surface by 5-column 5-row electromagnetic horns. Preprint of the 5th Annual Assembly of the Physical Society of Japan, November 5, 5C7, 1–8 (in Japanese).

Orchiston, W., and Ishiguro, M., 2017. The early development of radio astronomy in Japan. In Nakamura, T., and Orchiston, W. (eds.). *The Emergence of Astrophysics in Asia: Opening a New Window on the Universe*. New York, Springer.

Pawsey, J.L., Payne-Scott, R., and McCready, L.L., 1946. Radio-frequency energy from the Sun. *Nature*, 157, 158–159.

Piddington, J.H., and Hindman, J.V., 1949. Solar radiation at a wavelength of 10 centimetres including eclipse observations. *Australian Journal of Scientific Research*, A2, 524–538.

Piddington, J.H., and Minnett, H.C., 1949. Solar radiation of wavelength 1.25 centimetres *Australian Journal of Scientific Research*, A2, 539–549.

Pounds, K., 2004. Obituaries: Minoru Oda. *Astronomy & Geophysics*, 45, 2.40.

Sander, K.F., 1947. Radio noise from the Sun at 3.2 cm. *Nature*, 159, 506–507.

Shimoda, K., 1982. After Dinner Talk: Two reflectors made in 1930. In *13th Okazaki Conference 1982* (31–35). Tokyo, Institute for Molecular Science, Publication No. 10.

Shimoda, K., Orchiston, W., Akabane, K., and Ishiguro, M., 2013. Highlighting the history of Japanese radio astronomy. 2: Koichi Shimoda and the 1948 solar eclipse. *Journal of Astronomical History and Heritage*, 16, 98–106.

Southworth, G.C., 1945. Microwave radiation from the Sun. *Journal of the Franklin Institute*, 239, 285–297 (erratum, 241, following page 166).

Stanier, H.M., 1950. Distribution of radiation from the undisturbed Sun at a wave-length of 60 centimetres. *Nature*, 165, 354–355.

Sullivan, W.T. III, 2009. *Cosmic Noise. A History of Early Radio Astronomy*. Cambridge: Cambridge University Press.

Takakura, T., 1967. Theory of solar bursts. *Solar Physics*, 1, 304–353.

Takakura, T., 1985. Thirty-five years in solar radio astronomy. *The Astronomical Herald* 78(6), 163–167 (in Japanese).

Tanaka, H., 1984. Development of solar radio astronomy in Japan up until 1960. In Sullivan, W.T. III (ed.). *The Early Years of Radio Astronomy. Reflections Fifty Years after Jansky*. Cambridge, Cambridge University Press. Pp. 335–348.

Wendt, H., Orchiston, W., and Slee, B., 2008. W.N. Christiansen and the development of the solar grating array. *Journal of Astronomical History and Heritage*, 11, 173–184.

Wild, J.P., 1950a. Observations of the spectrum of high-intensity solar radiation at metre wavelengths. II. Outbursts. *Australian Journal of Scientific Research*, A3, 399–408.

Wild, J.P., 1950b. Observations of the spectrum of high-intensity solar radiation at metre wavelengths. III. Isolated bursts. *Australian Journal of Scientific Research*, A3, 541–557.

Wild, J.P., and McCready, L.L., 1950. Observations of the spectrum of high-intensity solar radiation at metre wavelengths. I. The apparatus and spectral types of solar burst observed. *Australian Journal of Scientific Research*, A3, 387–398.

Wilkinson, R.I., 1946a. Short survey of Japanese radar—I. *Electrical Engineering*, 65, 370–377.

Wilkinson, R.I., 1946b. Short survey of Japanese radar—II. *Electrical Engineering*, 65, 455–463.

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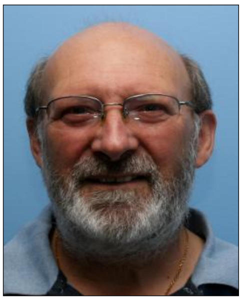

years Wayne worked at the CSIRO's Division of Radiophysics in Sydney and later at its successor, the Australia Telescope National Facility. He has published on the history of radio astronomy in Australia, France, Japan, New Zealand and the USA. Wayne was the founding Chairman of the IAU's Working Group on Historic Radio Astronomy. He has supervised five Ph.D. theses on the history of radio astronomy. Currently he is the Vice-President of IAU Commission C3 (History of Astronomy). In 2013 he was honoured when minor planet 48471 Orchiston was named after him.

Dr Tsuko Nakamura was until very recently a Professor at the Teikyo-Heisei University in Tokyo, where he taught Information Sciences since 2008. Prior to that, he worked at the National Astronomical Observatory of Japan for many years. His research interests lie in observational statistics of very small asteroids and in the

history of Japanese astronomy, and he has published more than fifty papers in this latter field. His books include *Five Thousand Years of Cosmic Visions* (2011, in Japanese, co-authored by S. Okamura), *Mapping the Oriental Sky*, *Proceedings of the ICOA-7 Conference* (2011, co-edited by W. Orchiston, M. Sôma and R. Strom) and *Highlighting the History of Astronomy in the Asia-Pacific Region*, *Proceedings of the ICOA-6 Conference* (2011, co-edited by W. Orchiston and R. Strom). Tsuko is the Chairman of the Executive Committee of the International Conference on Oriental Astronomy.

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