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PERSONAL RECOLLECTIONS OF W.N. CHRISTIANSEN AND THE EARLY DAYS OF CHINESE RADIO ASTRONOMY

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Abstract: Between 1963 and 1998, Professor W.N. Christiansen visited China more than a dozen times, bringing valuable scientific information, expert guidance and all possible help to the young Chinese radio astronomy team. Here, the writer presents his memories of two typical, deeply-shared experiences, 'The Shahe Experiment' and 'The Making of the Miyun Meter Wave Aperture Synthesis Telescope', as expressions of the kind thoughts of a whole generation of Chinese researchers in astronomy.

Keywords: W.N. Christiansen, Prof. Ke, Chinese radio astronomy, the Shahe Experiment, the Miyun Aperture Synthesis Telescope

1 FOREWORD

Childhood memory is precious. The 'childhood'—or early days—of Chinese radio astronomy went through unusual trials and tribulations. The first team of Chinese researchers in radio astronomy, so very young at the time, and so deeply engulfed in stormy weather during their first steps, will hold dear in their memory the arrival of a senior colleague from the West. During this period, W.N. Christiansen (affectionately known by us as 'Prof. Ke', 'Ke' being the first of the five Chinese characters that transcribe his surname) made the long journey to us more than a dozen times (see Figure 1), and brought to us valuable scientific information, specialist guidance and assistance.

The memories of our discipline's infancy are still fresh with us, and our feelings cannot be expressed by ordinary words. Here, we recall a couple of the most typical events, as emissaries carrying the thoughts of an entire era.

2 RECOLLECTIONS OF THE SHAHE EXPERIMENT

Prof. Ke visited China for the first time in 1963. At that time, the Chinese Academy of Sciences' Beijing Observatory had a site in a Beijing suburb, Shahe, and the Radio Astronomy Section had installed there two cm-wave solar radiometers, copies of ones then in Soviet Russia.

In the early 1960s, our contact with Russia had fallen to a low ebb, and our contact with the West was nil. Members of our team at that time, with one or two exceptions, were all young people in their early 20s. In line with the whole of China, we subscribed to the slogans, 'Self-Renewal Through Self-Effort' and 'March Into Science'. However, electronics in China was just being born, and if we were to pull ourselves up by our own boot straps the only option that was technically feasible at all was working at meter wavelengths.

Figure 1: Beijing 1987. Professor and Mrs Christiansen with the then young Chinese team of radio astronomers.

Figure 2: View of the central part of the Chris Cross, looking west at sunset. This array comprised E-W and N-S arms each with 32 steerable parabolic antennas of 5.8m diameter. This was the world's first crossed-grating interferometer and it was used to produce daily isophote maps of solar emission at 1423 MHz (photography courtesy John Leahy).

After going over the problem again and again, we opted to start with solar observations at meter wavelengths, and we considered constructing a copy of the Chris Cross (Figure 2) which Professor W.N. ('Chris') Christiansen had erected at Fleurs near Sydney (Australia) in 1957 (see Christiansen et al., 1961; Orchiston and Mathewson, 2009).[1] In 1963, we were working on the 32 antennas specified in the project, having basically decided on the site for the antenna array, but we had not solved the key technical problem of the transmission lines. At that time, China still could not produce co-axial cables, and they were hard to import from Russia or from Eastern Europe. And, in particular, none of us had any idea on the overall technology of the antenna array. So, when we were told that Professor Christiansen, the inventor of the Chris Cross, was coming to visit us, it was like a happiness that had fallen from heaven.

Our joy was redoubled by a fact known to all: the Chinese scientific community at the time had been cut off from the West for more than a decade, as though we were sealed inside an hermetic wall. And this was the first time that a small door would open in this wall, and who should come through that door but the very man we most wanted to meet, Professor W.N. Christiansen!

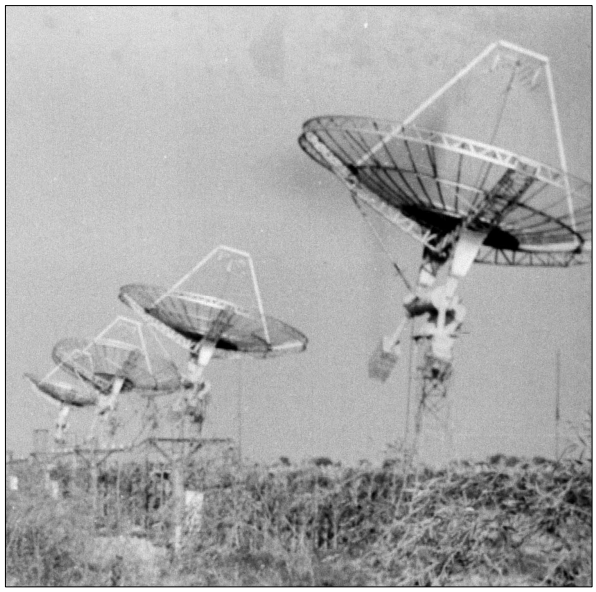

Figure 3: The four-antenna Shahe test array.

After a brief meeting, the Professor invited the author to visit Australia, and in 1964 Dr Wu Huai-wei and I took up this invitation and went to Sydney. At that time there were no diplomatic relations between China and Australia, so we stayed in Professor Christiansen's home and at the Hall of Residence at the University of Sydney.

During this trip, we made a point of visiting all of the radio astronomy establishments in Australia (but especially Fleurs), and we got an inkling of the scientific developments of the time and established many useful contacts. We discussed in detail with Prof. Ke ways of developing radio astronomy at the Beijing Observatory, and we arranged for Prof. Ke to visit us again in 1965 in order to help us with some of the technical challenges of the antenna array.

In 1965 we installed four 6-metre antennas at Shahe (Figure 3), so that we could carry out 'interim tests'. As soon as Prof. Ke arrived, he guided us to start building the twin wire transmission line system that he himself had specially designed, using a material which we could easily obtain at that time, copper wire. Two parallel copper wires of 4mm diameter made up the transmission lines, and the copper tubes that encased the wires were used to make an 'adder' that added up two radio frequency signals, and a connector that served as a 'matching transformer' between the cable and the copper tube. And there was the detector Prof. Ke himself designed for testing stationary waves. By left-right sliding movements of the adder the relative phase of the two signals was adjusted, thereby completing the 'two-two addition'.

When the Shahe Experiment was entering its final stage, China began sliding into a 10-year period of chaos, and all work was derailed, and even stopped completely at one stage. Nevertheless, by 1967 a meter wave 'Christiansen array' of 16 east-west elements was installed at the new Miyun Observing Station, and test observations produced the first one-dimensional maps of the Sun. Originally the aim was to erect a 32-element crossed-grating interferometer (similar to the Fleurs one), but we had to revise this plan and ended up with the 16-element array instead.

The realisation of the twin-wire transmission line system marked not only the completion of the new radio telescope, but equally important, it taught us (complete 'new hands' at the game) a profound lesson: by making the best of the situation, one can successfully carry out scientific research under difficult conditions. And this is precisely what we understood by the term 'Christiansen Style'.

3 THE MAKING OF THE MIYUN METER WAVE APERTURE SYNTHESIS TELESCOPE

After 1966, work at observatories throughout China stopped for a time, but the situation relaxed somewhat during the 1970s and from time to time we were able to carry out some work at the Miyun Observing Station. During this period, Prof. Ke came to China many times to bring us news of developments in radio astronomy abroad. And whatever little work we could do at the time always got support from him (on occasions he even brought us small electronics components that we needed). When in 1973 we heard the news that the Fleurs array was being converted into an

aperture synthesis instrument,[2] we felt that once work resumed at Miyun this would also be the best goal for our endeavour. During one of Prof. Ke's visits we discussed this idea in detail, and the Professor then made a move that was most extraordinary at the time: he proposed that China send two radio astronomers to Australia on a cultural exchange. As a result, in 1975 two members of the Miyun team, Drs Chen Hong-shen and Ren Fang-bin, spent eight months based in the School of Electrical Engineering at the University of Sydney where they learnt about the hardware associated with the analogue receiver system of the Fleurs Aperture Synthesis. This provided, ahead of time, useful preparation for our later work.

The year 1976 saw the end of chaos in China and order was gradually restored at Miyun. Our first task was to convert the Miyun array into an Earth-rotation aperture synthesis instrument. Originally 32 antennas had been constructed when we began making the Miyun array, but many of these found their way to various locations in China during the years of unrest. Fortunately, we managed to track down most of these surplus antennas and bring them back to the Miyun Observing Station, ending up with a 28-element east-west array (Figure 4), where the diameter of each aerial was increased from 6 metres to 9 metres.

The making of the Miyun Aperture Synthesis Telescope was a gradual process. We started at a very low point, when the material conditions were difficult and the technological base was weak. But we had made preparations beforehand, and our target was clearly defined (as during the earlier Shahe period), so by making the best of a very difficult situation and bringing out our hidden potential we were able to keep forging ahead. The main problem at this time was the introduction of digital techniques and solving the complicated problem of data processing. Here, again, we had Prof. Ke's whole-hearted support. In 1979, he sent his research student, Dr C.K. Kwong, to Beijing to help set up a digital receiver, and in 1980 he again invited two Miyun colleagues, Drs Chen Hong-shen and Zheng Yi-jia to Sydney to familiarize themselves with the software and hardware of the Fleurs Synthesis Telescope.

At this point the blueprint of the Miyun Meter Wave Aperture Synthesis System was finalized, but it then took another four years to complete the experimentation, installation and testing.

The Miyun Aperture Synthesis Telescope consists of 28 antennas each of 9m diameter, divided into Array A (16 antennas) and Array B (12 antennas) arranged as shown in Figure 5), making up 192 interferometer pairs, with baselines 3do, 4do, ... 194do (where do = 6 m). The system works at two frequencies, 232MHz and 408MHz. At 232MHz, each cycle of 12 hours' observation gives an overall resolution of 3.8 × 3.8 arc min. csc δ, and a 'thermal noise limited' sensitivity of 0.05Jy (SNR= 6) covering a field of 8 × 8 square degrees.

Now, when we recall this series of efforts, we recognize it to be precisely what enabled the Miyun team to pass the starting line of technological modernization, and throughout this eventful journey, which lasted ten years, we benefited from the guidance and concern of our good teacher and friend, Prof. Ke.

The Miyun Meter Wave Aperture Synthesis Telescope was formally commissioned in 1984 (see Wang, 1986), and Prof. Ke made a special journey to take part in the appraisal of the Facility. He and other Appraisal Committee members are shown in Figure 6.

Figure 4: The Miyun 28-antenna Meter Wave Aperture Synthesis Array.

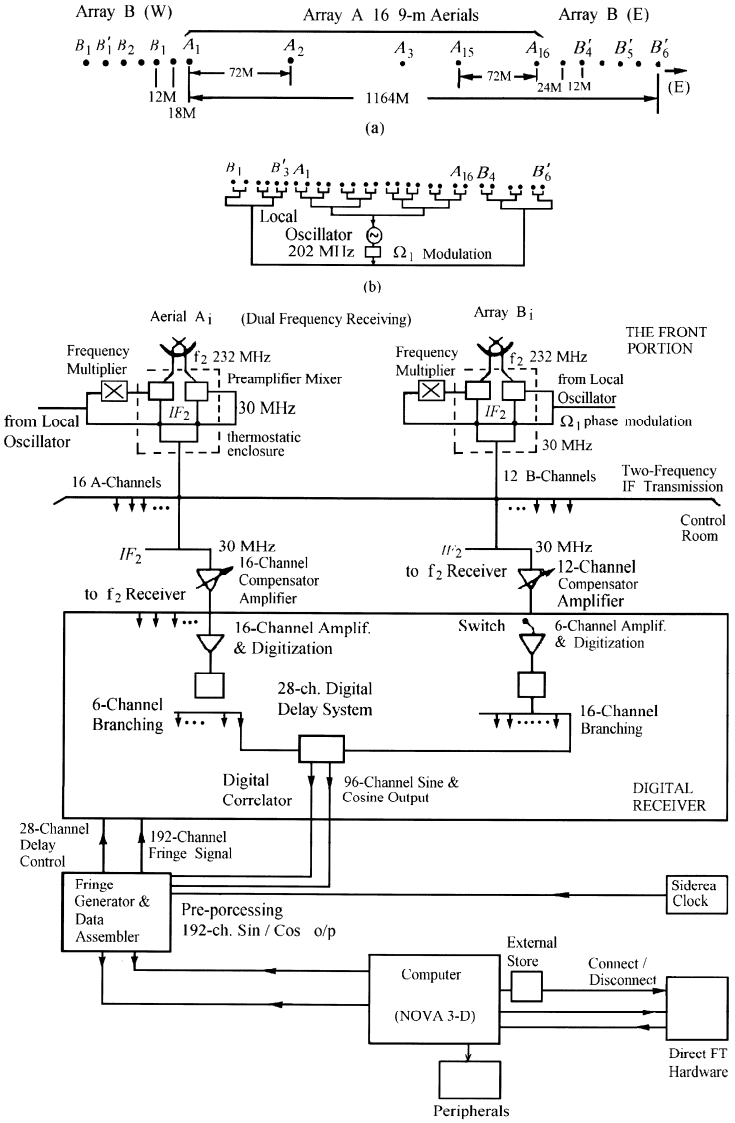

Figure 5: A structural overview of the Miyun Aperture Synthesis Telescope system.

4 PROF KE AND THE CHINESE ACADEMY OF SCIENCES (CAS)

Although just two examples may not do full justice to the history of 'Prof. Ke and China', which spanned more than a third of a century, these two examples are typical, and are so deeply and indelibly impressed in our memories that they serve to illustrate the impact of his strong personality on our hearts and his contribution to the establishment and growth of radio astronomy in China. Over thirty-plus years, he became familiar with all of China's astronomical institutions and their radio astronomy divisions. Besides Beijing Observatory, the Purple Mountain Observatory, Shanghai Observatory, Yunnan Observatory and the Urumqi Astronomical Station all kept records of the many lectures and visits by Prof. Ke, and of the numerous astronomers (and not just radio astronomers) from various places in China who visited Australia over the years and enjoyed kind hospitality and concrete help from Prof. and Mrs Ke. Furthermore, Prof. Ke encouraged other Western radio astronomers to come to China, and many of them—including Rob Frater, Miller Goss, George Miley, Bruce Slee and Richard Wielebinski—have established deep friendships with us. Like Prof. Ke, many of them made personal efforts to help China move out of isolation and rejoin the international astronomical community. Prof. Ke also, through his personal influence in international academic circles, did much to help return China to such international organizations as the IAU, URSI and the ICSU.

Prof. Ke's deep friendship towards China was not confined to the Miyun radio astronomy team, or even to the Chinese astronomical community. His academic distinction and his sincerity elicited widespread respect and admiration in the wider scientific community. Apart from his aforementioned dealings with astronomers, especially the younger ones, many scientists from our older generations, including Go Moruo, Y.H. Woo and Chou Peiyuan, became close personal friends of his. Figure 7 is an historically-significant photograph. It was taken in the 1960s and although rather 'formal', it records some of these 'older scientists'—who were not very old then—in company with Prof. and Mrs Ke.

In recognition of his long and important contribution to Chinese astronomy, in 1996 Professor Christiansen was elected a Foreign Member of the Chinese Academy of Sciences.

Figure 6: The Appraisal Committee of the Miyun Meter Wave Aperture Synthesis Telescope.

Figure 7: Professor and Mrs Christiansen with Go Moruo, the first President of the Chinese Academy of Sciences (sixth from left), Y.H. Woo, physicist and Vice-President of the Chinese Academy of Sciences (fourth from left), Chou Peiyuan, physicist and President of Peking University (third from left) and the astronomer Tcheng Mao-lin (second from left).

5 CONCLUDING REMARKS

I would like to conclude this short article with two photographs taken during the Ninth Assembly of Members of the CAS in 1998 (Figures 8 and 9 on page 38), for this was to be the last of the many occasions when Prof. Ke was with us (since 1963).

Let these solemn records convey from all of us—friends in a country that he loved—our deepest feelings for him as we look on the passing of history.

6 NOTES

1. Christiansen was on the staff of the CSIRO's Division of Radiophysics in Sydney when the Chris Cross was built, but in 1960 he moved to a Chair in Electrical Engineering at the University of Sydney.
2. For details of the Fleurs Synthesis Telescope see the various papers in the September 1973 special issue of the *Proceedings of the Institution of Radio and Electronics Engineers Australia* (Vol. 34, No. 8).

Figure 8: Professor Christiansen (front row, second from left) at the Ninth Assembly of Members of the Chinese Academy of Sciences in 1998, during his last visit to China.

Figure 9: Professor Christiansen speaking at the Ninth Assembly of Members of the Chinese Academy of Sciences.

7 ACKNOWLEDGEMENTS

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