Scanning Our Past From The Netherlands

Early Galactic Radio Astronomy at Kootwijk and Some Consequential Developments

During World War II, Prof. Dr J. H. Oort (Fig. 1), the famous Dutch astronomer and discoverer of the origin of our comets, was living in the countryside of The Netherlands. At that time it was an occupied country. He decided one day to ride his bicycle to visit the Observatory at Leiden University, which in fact had been closed for some time.

Halfway on this 120-km trip to Leiden, which is near the North Sea coast of The Netherlands, he got a flat tire and was forced to interrupt his trip at the residence of one of his promising students. With this student, the future Prof. Dr. H. C. van de Hulst (Fig. 2), he discussed potential new means, in addition to the well-known optical methods, to observe gaseous clouds in the galaxy.

I. Hydrogen Atom Emissions

At that time Karl Jansky and Grote Reber had already made their observations of radio noise emitted from the sun and from other sources within our galaxy, in 1932 and 1938, respectively. In 1944, Oort had already recognized the importance of radio waves for astronomical observations, and he quietly arranged a colloquium on radio waves from space at the Leiden Observatory. The young student H. C. van de Hulst explained to the limited audience the results of his study that neutral hydrogen atoms in the universe would emit a spectral line in the radio spectrum corresponding to a wavelength of 21.2 cm (or a rest frequency: 1420.4057 MHz), resulting from changes of the electron spin within hydrogen atoms.

Van de Hulst suggested that by using the Doppler principle, this effect could be a perfect means to determine the velocities in the structures of the galaxy. It was probably the first time that professional astronomers discussed the possibilities of radio astronomy. In the following postwar years, radio astronomy in Australia, England, and the United States led to many fascinating discoveries.

II. The Dish

Building a large radio telescope in The Netherlands just after the war, with a diameter of some 25 m necessary for the detection of weak signals, was financially not feasible. However, along the coast of the European continent a few of the 7.5-m Würzburg antennas, which had been part of a German radar chain, were still available (Fig. 3). Some of them were already in use for the study of radio propagation in the ionosphere. One of these antennas was made available to the new Stichting Radiostraling van Zon en Melkweg (Foundation for Radio Emission From the Sun and Milky Way, later The Netherlands Foundation for Radio Astronomy), a cooperation of universities and industry, with Oort being their first chairman. At that time, obviously, one had hoped to observe radio waves from only our immediate "neighborhood," e.g., the sun and the Milky Way at most. There was no expectation at that time of detecting radio waves from the farthest corners of the universe, as is common practice today.

The construction of a receiving station for the hydrogen-line experiment was started for practical reasons at Kootwijk Radio, in the center of The Netherlands, where a station of the Dutch PTT was located. This was a remote area, but uncomfortably close to high-power transmitting antennas. Halfway into the program to construct this system, a fire unfortunately delayed progress and forced the small crew, now with C. A. Muller (Fig. 4) in charge, to start all over again.

III. Worldwide Efforts

In the meantime, based on the prediction of van de Hulst, a small community of radio astronomers—H. I. Ewen and G. M. Purcell at Harvard University, Cambridge, MA, as well as W. N. Christiansen and J. V. Hindman in Australia—were working on an identical project, in mutual cooperation and exchange of ideas.

To satisfy the need for high sensitivity, a Dicke-type receiver was used, in which the (second) local oscillator frequency is periodically switched to a frequency corresponding to an adjacent frequency channel as reference. Comparing both signals by a synchronous detection system could indicate the presence of very weak signals. The presence of emissions from hydrogen clouds was confirmed on 11 May 1951, at approximately the predicted frequency, when the antenna was directed toward the Cygnus region. The result of the first survey is clearly shown in the depicted graph by manual tracking of that Cygnus area, corrected once every 2 min (Fig. 5). Actually, some six weeks earlier, Ewen of

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Fig. 1. Prof. Dr. J. H. Oort, the famous Dutch astronomer and discoverer of the origin of comets.

Fig. 2. Prof. Dr. H. van de Hulst first concluded that neutral hydrogen atoms in the universe would emit a spectral line in the radio spectrum, corresponding to a wavelength of 21.2 cm.

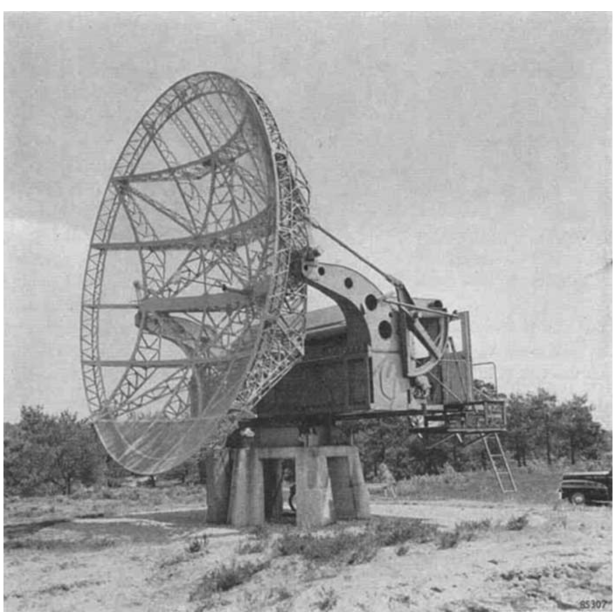

Fig. 3. Würzburg antenna at Kootwijk, The Netherlands.

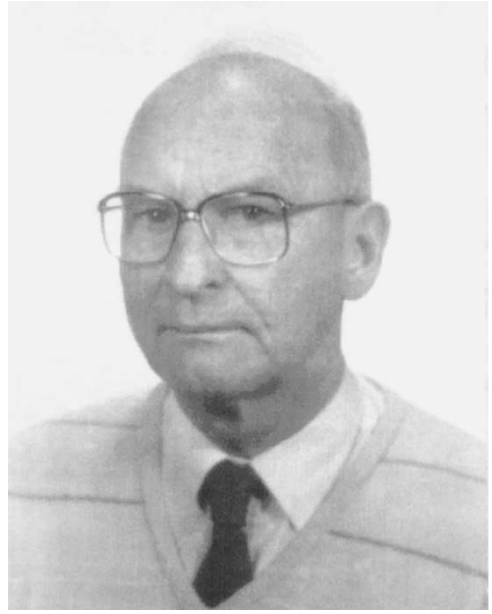

Fig. 4. Prof. Dr. C. A. Muller was in charge of the construction of the receiving station for the hydrogen-line experiment.

Harvard had already arrived at the same conclusion that detected the presence of the interstellar emissions by hydrogen, and Christiansen in Australia arrived at the same result a couple of weeks later.

These radio receivers turned out to be very effective instruments for astronomers, as for the first time it allowed the researchers not only to determine the position and the intensity, but in a later stage also the actual radial velocity component of neutral hydrogen clouds within the Milky Way.

IV. Kootwijk Measurements

In 1954, nearly full coverage of the Milky Way could be established by a coordinated effort of the three parties, each observing their specific "visible" section from their continent (Fig. 6).

The relative accuracy of the Kootwijk measurement corresponded at that time to approximately 1 °K. The tangential velocity component in relation to the center of the galaxy was still in discussion at that time, but it was clear that a spiral structure of the Milky Way in conformance with the optical observations of other galaxies was most likely.

The results of the Kootwijk measurements were a boost for the development of a new astronomical center in Dwingeloo, in the northern part of The Netherlands. The main instrument in Dwingeloo was a single paraboloid reflector with a diameter of 25 m. It was officially put into operation in 1956. The development of radio telescopes had started.

V. Radio Interferometry Matures

During the second half of the 20th century, radio interferometry became a standard technique in radio astronomy besides the "classical" single-dish instruments. In Westerbork, not far from Dwingeloo, an earth-rotation

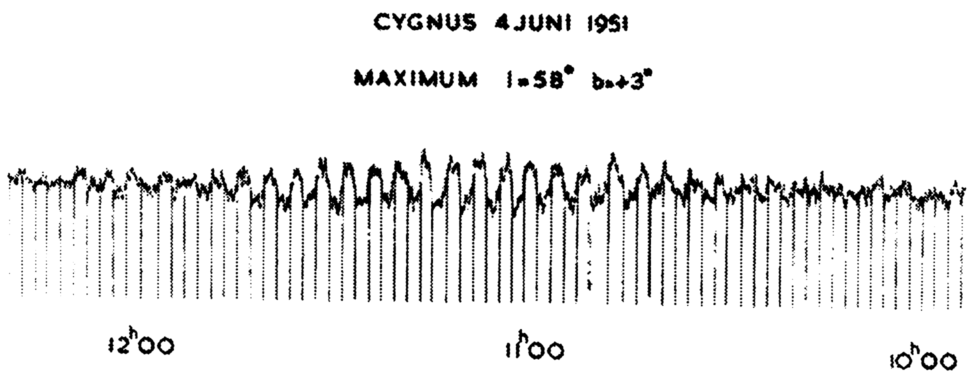

Fig. 5. One of the first hydrogen line observations for a drift curve through the Cygnus region.

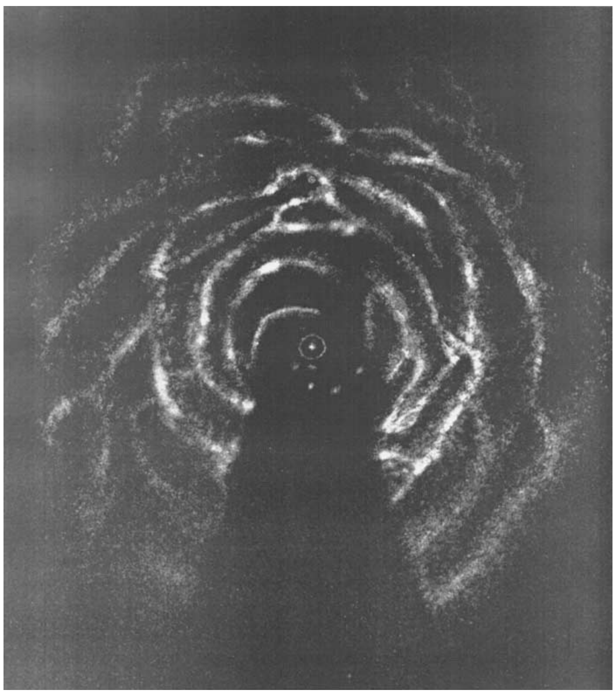

Fig. 6. Artist's illustration of the galactic system as seen from the north galactic pole, prepared from the 21-cm line observations by The Netherlands Foundation for Radio Astronomy of Leiden University and the Division of Radiophysics Common Wealth Scientific and Industrial Research Organization, Sydney, Australia. The density contrasts are accentuated for better perception.

synthesis interferometer telescope was put into operation in 1970. This telescope consists of fourteen 25-m paraboloids on an east–west baseline of 3 km. The angular resolution achieved by this instrument corresponds with that of a single-dish instrument of 3 km diameter. A further development was that of very long baseline interferometry: signals from cosmic origin are received by telescopes separated by even more than several thousands of kilometers, i.e., located in different continents and even located in space. These signals are later correlated with each other to produce a single image with an angular resolution corresponding to that of an instrument of the dimensions of the longest distance in the network. The radio observatory at Dwingeloo hosts the European correlator center.

Thus, Oort, van de Hulst, and Muller started a promising tradition, adding new wisdom to noisy cosmic signals.

Where does the state of the art stand today? The latest development is the LOFAR project, a very widely distributed antenna system that has been recently started and will be finalized in 2006. This system will cover an area of approximately 350 km in diameter and uses direct fiberglass communication lines to its center.

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