In Memoriam
Grote Reber
1911–2002
Founder of Radio Astronomy

Grote Reber circa 1937

Although Karl Jansky discovered the existence of radio emissions from outer space as early as 1932, a decade passed before the scientific world began to take interest in it. During that barren period, one man, and one man alone, compelled by a great love of science and research, carried forward Jansky's initial work. That same man now recounts for us in his own words the pioneering experiments he conducted during his lonely vigil of the heavens.
Editor, Proceedings of the IRE, January 1958

In 1987, Grote Reber celebrates his Golden Anniversary in radio astronomy. While it is unlikely that his dedication to the field will be surpassed, his 50 years of radio astronomical observations is certainly unparalleled. As the pioneering works of Jansky and Reber were first reported in the Proceedings, it is apropos that the IEEE again welcome the contributions of Grote Reber to radio and plasma science.
Guest Editor, IEEE TRANSACTIONS ON PLASMA SCIENCE, December 1986.

***Abstract*—Grote Reber, amateur radio operator W9GFZ, died December 20, 2002 in Tasmania. He would have been 91 years old on December 22nd. Reber is acknowledged as the Father of Radio Astronomy and the inventor of the first true radio telescope. With the advent of space satellites, his greatest legacy may well be his invention of the parabolic dish, designed to receive nonterrestrial electromagnetic radiation, a concept that has revolutionized worldwide communication.**

I. Introduction

As a Radio Engineer and avid amateur radio operator in Wheaton, IL, in the 1930s, Grote Reber (1911–2002) was inspired by K. Jansky and the 1932 discovery of natural radio emissions from outer space. The concept of viewing space via radio signals inspired Reber to invent the first parabolic antenna specifically designed to study radio emission from space.

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Fig. 2. Reber's original radio telescope now placed outside the National Radio Astronomy Observatory (NRAO), Green Bank, WV. The author stands in front of the world's first parabolic dish antenna.

Analyzing the problem as an Engineer, Reber chose as his design a metallic parabola, for its wide wavelength reception capability. In 1937, using his own funds, he constructed a 9-m (31.4 ft) dish antenna in his backyard (Fig. 2). The strange structure attracted the attention of curious neighbors and became somewhat of a minor tourist attraction, he later recalled.

Using amateur radio theory and practice, he designed and built electronics that pushed the technical capabilities of the era, Reber succeeded in detecting "cosmic static" in 1938 near the amateur radio 2-m band (Reber's original equipment is now displayed in a memorial building, along side his original parabolic dish, at the NRAO).

From 1937 until after World War II, Reber was the world's only radio astronomer. In 1941, he launched an entirely new field of science: radio astronomy, by producing the first radio map of the sky.

He received the B.S. degree in engineering from the Illinois Institute of Technology, Chicago, in 1933. In 1962, he was awarded an Honorary Doctor of Science degree from Ohio State University, Columbus.

He worked in an Engineer for several radio manufacturers in Chicago from 1933 to 1947. He was a Radio Physicist at the National Bureau of Standards (now NIST) from 1947 to 1951. From 1951 until his death, he was associated with the Research Corporation conducting radio astronomy investigations in Hawaii and Tasmania. Reber also held an appointment with the Hertzberg Institute of Astrophysics, National Research Council of Canada, Ottawa. He was an Honorary Research Fellow of the Division of Radio Physics of the Australian Commonwealth Scientific and Industrial Research Organization.

Dr. Reber was a member of the American Astronomical Society. In 1962, he was the American Astronomical Society Russell Lecturer and also the recipient of the Bruce Gold Medal of the Astronomical Society of the Pacific. In 1963, Dr. Reber received the Elliot Cresson gold medal from the Franklin Institute of Pennsylvania, Philadelphia. In 1976, he received the Jansky prize of the NRAO and, in 1983, the Royal Astronomical Society's Jackson-Gwilt Medal [1]–[4].

As a scientific researcher and natural philosopher, Reber's publications were prolific [5]–[59]. His research appears in most of the world's radio science, plasma science, antenna science, astrophysics, genetics, agricultural, and geophysical journals, as well as the *Journal of the Franklin Institute*, *Nature*, *Science*, *Scientific American*, and *Sky and Telescope*.

II. Difficulties in Bringing Space Radio Observations to Astronomy

According to Reber [51]: "Several times I have been asked about the early lack of interest in radio astronomy by the astronomical community. In retrospect, there appear to have been two difficulties. First, the astronomers had a nearly complete lack of knowledge of electronic apparatus, viewing it as black magic. Second, and more important, the astrophysicists could not dream up any rational way by which radio waves could be generated, and since they didn't know of a process, the whole affair was at best a mistake and at worst a hoax." Comparing electronic technology to astrophysics, he commented: "I was in the middle of two groups not speaking the same language." Since he had crossed disciplines without a "formal" education in astronomy, all early work in radio astronomy, including that of Jansky, were primarily reported in the *Proceedings of the IRE* (IEEE) until 1940.

It would not be until after World War II, when surplus radar equipment became available, that radio astronomy would blossom as a technical field.

III. Reber and Tasmania

A. Low-Frequency Radio Astronomy

The observation of celestial radio waves requires observation above the critical plasma density in the ionosphere (radio amateurs using the 160- and 80-m bands, as well as shorter wavelengths, generally count on high ionosphereic densities, both to produce skip in DX communication and to reflect cosmic static). At hectometer wavelengths the ionospheric density must be as low as possible ($< 1 \times 10^5$ cm^{-3}). The lowest electron density is near the minimum solar activity, during winter at night between latitudes of 40° and 50°, near the agonic line where compass points true north.

Reber found that the most auspicious places were near Lake Superior, MI, in the northern hemisphere, and Tasmania in the southern hemisphere. The former looks out on the northern sky and the periphery of the Milky Way, while the latter looks out on the southern sky and the center of the Milky Way, a region Reber found to be of considerable interest [45], [47].

While his original observations were at short wavelengths, 3300, 900, and 160 MHz, Reber's engineering background and knowledge of electromagnetic radiation mechanisms and plasma physics, turned him to very long wavelengths. The universe, 99.999% of observable matter being in the plasma state, must produce appreciable radiation that does not penetrate the ionosphere. Reber set out to detect and measure this, searching the sky at 144-m.

Reber calculated that a plasma of electrons and ions with a density of about 100 cm^3 would be sufficient to produce a temperature of 3.5×10^{-6} degrees Centigrade. He also noted the difficulties in making measurements. Reber noted that radiation from current-conducting plasma filaments [60] below 100 kHz would require observation from outside the Milky Way [52].

To measure these low-frequency waves, Reber moved to Tasmania, building his own solar heated house, where he would live 49 years to the remainder of his life. He made frequent visits to the United States and Canada in attempts to construct a low-frequency radio telescope array near the northern counterpart of Tasmania.

B. The 144-Meter Astronomical Array

Arriving in Sydney, Australia, on November 1, 1954, Reber proceeded to construct a 144-m (2045 kHz) antenna "farm." Located 5 miles north of Bothwell, Tasmania, his antenna was a circular array 1073-m (3520 ft) in diameter of 192 half-wave horizontal dipoles and a beam diameter of 7.1° at the zenith.

By use of phase-change taps, Reber could change the zenith angle up to 60°. Steering was only possible in a north-zenith south plane. East-west scanning was supplied by the Earth's rotation. With this array, he was able to produce a 144-m map of the southern sky showing a bright background corresponding to a 3.5×10^6 K blackbody with dimming at the center of the Galaxy and along the Milky Way [59], [61].

IV. Reber versus the "Standard Cosmology"

As an engineer, Reber, like others in his profession, viewed the big bang cosmology with great skepticism. He never missed an opportunity to point out the shortcomings of this cosmology, often citing his hero Hubble's doubts [4], [47]–[49].[1]

Reber recognized that in a cosmos of plasma, "there is no need for an expanding universe" [52]. Reber even gave a presentation to the Society of Amateur Radio Astronomers in Green Bank entitled 'The Big Bang is

[1]Interestingly, Reber's mother was E. Hubble's seventh and eighth-grade teacher.

Fig. 3. Skyline of Casablanca, Morocco. Nonsteerable miniatures of Reber's orginal parabolic antenna for the reception of nonterrestrial electromagnetic radiation as television.

Bunk.' In this regard, the Reber Stories are of great interest [1], as are his recounts with his close colleague J. Kierein.

Reber's original dish antenna now is on display at the NRAO. All of his scientific papers and records, as well as his personal and scientific correspondence, are held by the NRAO. These will be exhibited in the observatory's planned new library in Charlottesville, VA.

The NRAO Amateur Radio Club, Socorro, NM, located near the Very Large Array, now holds Reber's amateur call sign, W9GFZ. The call sign was used on the air for the first time since the 1930s on August 25, 2000, to mark the dedication of the Robert C. Byrd Green Bank Telescope.

V. Reber's Legacy

It is likely that Reber's legacy may not be in removing the optical "blinders" placed on astronomy since its inception, or in pioneering the study of the universe over much of its electromagnetic spectrum. Instead, it may be in the subsequent adaptation of "miniature-Reber" parabolic satellite dishes to mankind's communication needs "mushrooming" around the world (Fig. 3).

Each dish is a legacy to a most unlikely scenario, an Illinois boy in a farm town with a keen sense of technology and of the cosmos, whose studies of 'cosmic static' changed the nature of how mankind lives and communicates on Earth.

Little known and unannounced, Reber had been nominated for the Nobel Prize in Physics. Unfortunately, his "not being tied" to an Institute and his known "perchance for being a maverick," especially to the tenants of astrophysical hypotheses, were the unofficial reasons given for his not winning this prize and perhaps bringing him the universal recognition he deserved.[2]

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