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Karl Rawer: space research and international cooperation – Laudation on the occasion of the 100th birthday of Professor Karl Rawer

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Abstract. This laudation is given in honor of the 100th birthday of Prof. Karl Rawer which happens to coincide with the 45th anniversary of the International Reference Ionosphere (IRI). The ionosphere was discovered during Karl Rawer's lifetime, and he has dedicated his professional life to its exploration. World Wars I and II shaped his early life, but they also launched his career as one of the eminent geophysical scientists of the twentieth century. The paper looks back at Karl Rawer's life and his pioneering work and leadership in advancing and shaping the exploration of the ionosphere.

1 Introduction

Let me start with a quote: "It was chance and circumstances that gave me the opportunity to participate in shaping ionospheric and space science research during the 20th century", so reminisced Karl Rawer ten years ago when we celebrated his 90th birthday (Reinisch, 2004) here at the German National URSI Meeting. Heinrich Hertz's discovery of the propagation of centimeter length waves in 1888 and Guglielmo Marconi's transatlantic low and high frequency radio transmissions in 1901 started the explosive expansion of "wireless communication", and in the process led to the discovery of Earth's ionosphere. As early as 1902, Oliver Heaviside in England and Arthur Kennelly in the United States had independently postulated the existence of a "conducting layer" in the upper atmosphere in order to explain how radio waves can propagate long distances around the curvature of earth's surface. The Briton Hector Macdonald in Cambridge, the French mathematician Henri Poincaré in Paris, and the theoretical physicist Arnold Sommerfeld in München and electrical engineer Jonathan Zenneck in Braunschweig, they all worked on models for the surface diffraction of radio waves around the curvature of a large perfectly conducting sphere, although Zenneck's team also considered the effects of limited conductivity. The problem was that these surface diffraction theories explained the long-distance propagation in principle, but there were no numerical experimental data against which to test the theories. The situation changed after 1910 when the U.S. Naval Wireless Laboratory in Washington began conducting large-scale propagation studies that produced the Austin-Cohen formula for the specification of the electric field strength as a function of distance and wavelength λ. It soon became apparent that none of the surface diffraction theories had an exponential decay factor proportional to $\lambda^{-1/2}$ that the empirical Austin-Cohen formula predicted. It took another two decades to develop a first understanding of the basic principles of ionospheric physics and the propagation of radio waves in the ionospheric "magnetoplasma". The scientists and engineers of the time strictly adhered to the Humboldtian approach: "comprehensive and extensive fieldwork, careful preparation for expeditions, and meticulous collection of data" (Yeang, 2013). The Union Radio-Scientifique Internationale (URSI) which was founded in 1919 demanded this approach from its members, and Karl Rawer strictly followed it throughout his scientific career. His quest to fully understand and describe the physical processes that form the ionosphere and control its behavior always included experimental verifications of any theoretical model. Remote radio sensing as well as rocket and satellite measurements were the tools. Prof. Rawer, I bow in respect to you, you have been my teacher, and throughout my professional career I looked upon you as the ideal of a scientist and research leader. Your insistence on scientific rigor and

Figure 1. Karl and Waltraut Rawer hosting a party for the APW (courtesy Gerhard Schmidtke, Fraunhofer IPW, Freiburg).

honesty, and your caring sense of responsibility for your colleagues and coworkers became the example that I have tried to follow.

2 Karl Rawer's early years

Karl Maria Alois Rawer was born on 19 April 1913 in Neunkirchen (Saar). In his college years, he was fortunate to learn from eminent mathematicians and physicists, Gustav Mie and Gustav Dötsch in Freiburg, and Arnold Sommerfeld and Jonathan Zenneck in München. Prof. Zenneck who had started ionospheric echo sounding experiments in Germany had asked Karl Rawer to develop the theory for the reflection of vertically incident radio waves in the ionosphere for his doctoral dissertation. Being allowed access to the jewel of the mathematics institute, an *electrically driven mechanical calculator*, he was able to solve the problem of radio wave propagation in a stratified medium in a little more than a year's time, using hyperbolic and Epstein functions; he published the results in the *Annalen der Physik* (Rawer, 1939). From here on he was hooked in one way or other to ionospheric research and the computer as an analysis tool. During WW II, he was put in charge of developing ionospheric radio wave propagation predictions, working with Johannes Plendl and Walter Dieminger. At the end of the war in 1945, the Briton Roy Piggott escorted Walter Dieminger's Radiowave Research Team from its operational base in Austria to Lindau near Göttingen (Niedersachsen) in the "British Occupation Zone", Rawer's group followed the invitation by Yves Rocard in Paris to establish an ionospheric prediction service in Germany's "French Zone". A new ionospheric institute came to life first in Neuershausen, then in Breisach (Baden-Württemberg), i.e., close to Karl Rawer's academic origins in Freiburg and to his native Saarland. I was first introduced to Prof. Rawer in 1960 when he accepted me as a graduate student at the "Ionosphäreninstitut Breisach". This institute gave us students a first opportunity to see real scientists and researchers in action. Karl Rawer was born to lead and he did so by inspiring his coworkers and students, and by training young scientists from around the world. During my years in Rawer's institute I also witnessed how much his (late) wife Waltraut (see Fig. 1) and indeed his entire family have supported his professional career, and in turn how much he cared for his family.

His son Bernhard who has chauffeured his father to Miltenberg is here to witness today's ceremony in honor of his father.

3 International outreach

Karl Rawer had recognized early on that ionosphere and space research in Germany can only advance in cooperation with the world community, but also that international science cooperation can build bridges between countries helping to foster peace in the world. In the early 1960s he was the first German after the end of WW II to be invited to lecture at the Sorbonne University as a Professeur Associé in collaboration with his friend Prof. Etienne Vassy. For many years he made weekly trips from Breisach to Paris. International travel was not as convenient as it is today and we students had great respect for Professor Rawer's strenuous schedule, and of course his international recognition. Rawer's URSI activities began in 1954, and he represented the German ionospheric research in the preparation for the International Geophysical Year, 1957/58. By that time, ionospheric sounding was done in many countries around the world, but there were no common rules for the scaling and interpretation of ionograms, complicating global ionospheric research. Eight ionospheric experts joined and formed the Worldwide Sounding Committee under the leadership of Allen Shapley. Two of the members, Piggott and Rawer (1961) published the results of the committee's work as the "Handbook for the Scaling of Ionograms". At the URSI General Assembly in Munich in 1966, Rawer was elected International Vice-Chair of Commission III (today Commission G) of URSI, and served as Vice-Chair and then Chair until 1972. Starting in the early 1950s, his institute developed scientific payloads for the newly developed French rocket "Veronique" for a first successful launch in 1954 in the French Sahara. His experience in space research and his connections to international research groups made Prof. Rawer the natural choice to take a leading role in the West-German National Committee of COSPAR. After the death of Julius Bartels in 1964, Rawer became its chairman. He vigorously exploited the opportunity that COSPAR offered to establish long lasting relationships between scientists from West and East across the cold war borders, but also with researchers in India and in hitherto neglected countries in the Far East and Africa. Although by inclination an experimentalist, he was a master in describing and documenting new results and in sorting existing knowledge. The first book ever published with the title "The Ionosphere" appeared in 1952 in German (Die Ionosphäre), and was translated into

English in 1956. In 1967 he published, jointly with Kurt Suchy, "Radio Observations of the Ionosphere" as Volume III/II in the Geophysics Series of the *Handbuch der Physik*. After Bartels's death in 1964, Karl Rawer became the editor of the series and issued the next five volumes of the series, III/III to III/VII.

In the late 1960s, the Space Science Committee in COSPAR decided to develop a "Standard Ionosphere Model", similar to the COSPAR International Reference Atmosphere for the thermosphere parameters (CIRA, 1961). Karl Rawer took on the challenge and chaired the COSPAR Task Force for the development of an *empirical* model of the ionosphere, the International Reference Ionosphere (IRI). When URSI joint the effort, the Task Force became an Inter-Union Working Group that started its work in 1968. A separate paper in this issue describes the IRI that Karl Rawer has hatched and then tutored for several decades.

4 Rawer's institutes

In spite of the difficult post-war conditions an ionospheric vertical incidence sounding station came to life in 1946 at Schloss Neuershausen near Freiburg under the auspices of the French Service Prévision Ionosphérique de la Marine (SPIM). This was the beginning of a long cooperation between French and German ionospheric prediction studies. Rawer then managed to establish the "Ionosphäreninstitut" in Breisach under the administrative control of the German postal service. This institute gained international reputation in the field of ionospheric radio wave propagation and forecasting, and the development of ionosondes in cooperation with research organizations in the USA and France, and joint measuring campaigns in Italy, Greece, Norway, and Africa. In cooperation with the Fraunhofer Society Karl Rawer then founded a separate institute in Freiburg, the Arbeitsgruppe für Physikalische Weltraumforschung (APW) with project funding from the Deutsche Forschungsgemeinschaft, NASA, and the European Space Agency Organization, ESRO. The launch of two successful satellite missions with APW instrumentation, AEROS in 1972 and AEROS-B in 1974, led to temperature and ion composition data that became an important input to the IRI. Soon the building in Freiburg became too small to house the expanding space research activities, and the Fraunhofer Society built an expansive institute in Freiburg-West, Karl Rawer was appointed the director of this Institute for Space Research (later renamed as Institute for Measuring Techniques), leading it until his official retirement in 1979.

Karl, we thank you for what you have done for science and humanity during your lifetime. Even after your "official retirement" you continued sharing your insight and energy with us, and your presence today here at the URSI Commission G Session is witness of that.

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