

## Tribute to E. Ulrich Franck (1920-2004)



E. Ulrich Franck, Professor Emeritus of Physical Chemistry at the University of Karlsruhe, died on December 21, 2004 at the age of 84. As a pioneer in high-pressure, high-temperature studies of water and aqueous solutions, Ulrich was a towering presence in the field of aqueous physical chemistry and its wide-ranging applications for over half a century.

Ulrich Franck was born on August 2, 1920, in Hamburg, Germany. He entered the University of Göttingen in 1939. His studies were interrupted by military service during the second World War. He graduated in 1946, and completed his doctorate at Göttingen in 1950. This university had a glorious past. For example, the crystallographer Gustav Tammann introduced the study of phase transitions in fluids and solids at high pressures when he became Walther Nernst's successor in 1903. Ulrich Franck's thesis adviser was

the calorimetry expert Arnold Eucken, and his thesis was on the transport properties of reacting gases. As a postdoctoral research associate in Göttingen, he became interested in the properties of aqueous solutions at high temperatures and pressures, thus bridging the fields of phase equilibria and solution chemistry that had grown apart from the beginning of the 20th century.

After a productive decade in Göttingen, in which he performed studies of thermal, transport and chemical properties of fluorine gas, and of dissociation of salts in high-temperature steam, he accepted an invitation from the Oak Ridge National Laboratory, USA, to extend work in aqueous solutions at high temperatures (March-October 1960). He was the first international scientist to do research at ORNL. He and his wife Elsbeth formed an enduring bond with Oak Ridge as they dealt with the challenges of transplanting a young family into a foreign environment. The friendships they established would continue and grow to include many generations of ORNL chemists and geochemists. Within that short period in 1960, Ulrich Franck designed and built a prototype high-pressure, high-temperature conductivity cell for electrolyte solutions, thus initiating a new line of research at Oak Ridge. Exciting years followed, full of discoveries in high-temperature aqueous solutions, with applications to problems in fossil and nuclear steam-power plants, geothermal energy, water desalination, geochemistry, and geology. Ulrich Franck's visit gave rise to many years of collaboration between scientists at Karlsruhe and Oak Ridge.

In the fall of 1960, the family returned to Germany, where Ulrich Franck had accepted the position of Professor and Director of the Institute for Physical Chemistry and Electrochemistry at the University of Karlsruhe. The Institute had been founded in 1900, and Fritz Haber was Ulrich Franck's perhaps most illustrious predecessor. Before the second World War, there had been research in the fields of electrochemistry, thermodynamics, and kinetics, including high pressure-high temperature chemistry.

In line with this tradition, Ulrich Franck established a first-class research laboratory for investigating thermodynamic, transport and electrochemical properties of high-temperature fluids. Ulrich Franck was a creative and fearless experimenter from his early career onward. He pioneered the development of visual cells for observing phase separation and Raman and absorption spectra of corrosive and hazardous fluids under daunting pressure and temperature conditions. He and his students were the first to observe liquid-vapor criticality in hydrofluoric and hydrochloric acid, sodium hydroxide, molten salts and molten metals. His breakthrough experiments with Heger on the dielectric constant of water and steam at high temperatures were basic to the understanding of the solvent properties of supercritical steam. He investigated the properties of this unusual solvent medium decades before the field became fashionable in the 1980s.

More than 80 students obtained their doctorates under Ulrich Franck's guidance. Several of them went on to establish prominent research groups at other German Universities, among them Michael Buback at Universität Göttingen, Friedrich Hensel [1] at Phillips-Universität Marburg, and Gerhard Schneider, at Ruhr-Universität Bochum.

Ulrich Franck's involvement with the International Association for the Properties of Water and Steam began early and lasted a lifetime. Several present and former IAPWS members worked in his institute as graduate students or postdoctoral associates. Under his guidance, Masahiko Uematsu developed the first wide-range equation-of-state based correlation for the dielectric constant of water and steam in 1980. Maria Laura Japas measured spectacular gas-gas equilibria in oxygen-supercritical water and in nitrogen-supercritical water in the mid-1980s. Many IAPWS members remember with fondness the gracious hospitality they received at the beautiful home that Ulrich and Elsbeth Franck built in Karlsruhe when he began his career at the university.

Ulrich Franck and his coworkers authored both invited and contributed papers to IAPWS conference proceedings. The Oak Ridge work with Bill Marshall (ORNL) resulted in the IAPWS guidelines on the electrical conductivity and ion product of water. The work with Uematsu was the basis for the first IAPWS release on the dielectric constant of water and steam.

Ulrich Franck remained an active experimenter, consultant and leader in this field until well after his retirement in 1988. Of his more than 200 publications, over 60 were published after this date.

With the rise of interest in supercritical fluids as solvents and reaction media, Ulrich Franck stepped forward as the most experienced leader in the field. The eye-catching picture he published on the cover page of *Chemical and Engineering News* in 1991 [2], of an oxygen flame burning in a pressurized methane-supercritical steam mixture, fueled the world-wide interest in supercritical water oxidation. Shortly before his death, he and Hermann Weingärtner summarized his views of the significance of this field [3].

Ulrich Franck maintained his ties with IAPWS throughout the years. He was a member of the PCAS (Physical Chemistry of Aqueous Solutions) working group, and a driving force behind the IAPWS Monograph *Aqueous Systems at Elevated Temperatures and Pressures* that recently appeared in print. He wrote the foreword for that book [4] while his health was already in serious decline, but he did live to witness and enjoy the appearance of the publication.

Ulrich Franck received ample recognition for his work. As early as 1958, he received the Medal of the Deutsche Gesellschaft für Chemische Apparatewesen (DECHEMA). This was followed by the Bunsen Medal of the Deutsche Bunsen-Gesellschaft in 1970, the P.W. Bridgman Medal of the International Association for High Pressure Research in 1981, the Yeram S. Touloukian Award of the American Society of Mechanical Engineers in 1988, and the Abraham Gottlieb Werner Medal of the Deutsche Mineralogische Gesellschaft in 1989. He was elected an IAPWS Honorary Fellow in 1992, and received the first IAPWS Gibbs Award at the 13th International Conference on Properties of Water and Steam in 1999. The Proceedings of that conference were dedicated to him. He was elected to membership of the Heidelberg Academy of Sciences in 1975, the Leopoldina Academy in 1978, and the Göttingen Academy of Sciences in 1991. He received an honorary doctorate from the Phillips Universität Marburg in 1992, and was an honorary member of the Bunsen-Gesellschaft. He was a guest professor at the University of California at Berkeley

in 1969-70, at the Universities of Tokyo and Kyoto in 1975, and at Cornell University in 1989-90. In 1979, he was a guest scientist at CNEA, Buenos Aires, Argentina.

The International Association for the Properties of Water and Steam recognizes with deep appreciation the many contributions Ulrich Franck made to the field of aqueous physical chemistry at high pressures and temperatures. With profound gratitude, IAPWS remembers his interest in and dedication to the work of the organization.

Johanna (Anneke) Levelt Sengers, NIST, USA

Donald A. Palmer, ORNL, USA

William L. Marshall, ORNL, USA

[1] F. Hensel, *Angew. Chem. Int. Ed.*, **44**, 1156 (2005), wrote the obituary for Ulrich Franck that was used as a reference for the present tribute.

[2] R.W. Shaw, T.B. Brill, A.A. Clifford, C.A. Eckert and E.U. Franck, *Chem. & Eng. News*, Dec. 21 1991, 26-38.

[3] H. Weingärtner and E.U. Franck, *Angew. Chem. Int. Ed.*, **44**, 2-22 (2005).

[4] E.U. Franck, in *Aqueous Systems at Elevated Temperatures and Pressures*, D.A. Palmer, R. Fernández-Prini, and A.H. Harvey, Editors, Elsevier, 2004, pp vii-ix.