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Pioneer of ocean thermodynamics: IOW researcher Rainer Feistel receives Fridtjof Nansen Medal 2018

On April 9, 2018, Rainer Feistel, physicist at the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) until 2014, received the Fridtjof Nansen Medal 2018 of the European Geosciences Union (EGU) at its general assembly in Vienna. The EGU, with about 12,500 members Europe's leading association for geoscientists, honoured Feistel's ground-breaking work in the field of ocean thermodynamics. Particularly by defining the thermodynamic properties of seawater by means of a Gibbs function he created for the first time stringent thermodynamic foundations in oceanography, from which other scientific disciplines such as climate research and engineering also benefited significantly.

On the occasion of yesterday's medal award ceremony, the EGU laudation honoured the medallist with the following words: “Feistel's work has not only fundamentally changed the approaches to ocean thermodynamics, but also the way, in which fundamental theories should be applied consistently and translated into general practice. Furthermore, he was a pioneer in how to communicate such fundamental theories within and especially beyond his own discipline. Only in this way could his ground-breaking work find its way into every corner of ocean and climate research and decisively advance progress in thermodynamics in all scientific and technical disciplines in which water plays a role.”

“The leading thermodynamic properties of a fluid are determined by the relations, which exist between volume, pressure, temperature, energy, and entropy. But all the relations existing between these five quantities for any substance may be deduced from the single relation existing for that substance between volume, energy, and entropy.”

This is Josiah Willard Gibbs’ conclusion reached in 1873, which, as a variation of the law of conservation of energy, represents one of the core theses of physical thermodynamics and lead him to formulate his famous fundamental equation, the so-called “Gibbs function”. From it one can in fact mathematically derive everything that a scientist or engineer would like to know about water (or about any other pure substance or mixture) and its thermodynamic properties in various contexts: freezing and evaporation point, heat of fusion, density, speed of sound and much more.

However, this has not been that easy for a long time. Before the general availability of good computer capacities in the form of PCs, the Gibbs function, which for seawater involves calculations with over 100 coefficients and more than 200 interactions, was – above all – a theoretical concept describing consistent physical logic in the relationships between the five thermodynamic parameters. For practical applications, a collection of formulas for some selected properties was used that were significantly less complex and therefore could be analysed without the aid of computers. But these formulas are not consistent and not complete as a logical system, so that the respective calculations always contained a certain amount of error and were therefore problematic.

These deficiencies became apparent to IOW physicist Rainer Feistel, when in 1990, on the occasion of the modernisation of the international temperature scale, he wanted to update the thermodynamic property equations used in marine research with the new ITS-90 standard. Another weakness of these equations was that they accounted for the salinity of seawater only by

the provisional measure of “practical salinity” determined by conductivity, instead of the much more precise “absolute salinity”, which indicates the actual total mass of dissolved sea salt.

Therefore, Feistel – with energy and perseverance – set about to “thoroughly clean up” all these inconsistencies, which was now possible thanks to the newly available computer technology. For it was clear to the IOW researcher that water in all its forms – ice, liquid, vapour, sometimes mixed with sea salt, sometimes mixed with air in the atmosphere – is one of the key factors in both, in oceanography and in the Earth's entire climate system. A new highly precise, consistent and comprehensive thermodynamic standard concept in geophysics and climate research was therefore essential for all modelling – whether of ocean currents or future climate change scenarios – as well as for direct observations using a wide variety of measuring instruments.

In a series of publications, Rainer Feistel first formulated a consistent Gibbs function for seawater, from which all thermodynamic properties can be derived for the first time by comparatively simple mathematical calculations. As a logical consequence, a Gibbs function for ice followed and, in cooperation with other researchers, the thermodynamic description of humid air. This resulted in a complete thermodynamic description of all water components of the climate system – from the upper atmosphere to the deepest layers of the oceans.

Today, Feistel's Gibbs function is the internationally recognised definition of the thermodynamic properties of seawater known as the standard TEOS-10 (short for "Thermodynamic Equation Of Seawater – 2010). One of the reasons for this was that the physicist and oceanographer consistently established contacts beyond the boundaries of his own discipline with all kinds of experts who deal with issues, in which the thermodynamics of water plays a role: chemists, meteorologists, atmospheric researchers, engineers and standardisation organisations.

Rainer Feistel (*1948 in Warnemünde, Germany) studied physics at the University of Rostock where he received his doctorate in 1976. Subsequently, he went to the Lomonossov University in Moscow (1978-79), where he worked scientifically on self-organisation and evolution. Back in Rostock, he received his university teaching qualification in Theoretical Physics in 1979. In 1981 he was awarded the Gustav Hertz Prize of the GDR Physical Society for his innovative work in the field of self-organising systems. In the same year he went to Humboldt University in Berlin as a lecturer in Theoretical Physics. He spent two years (1986-88) of his Berlin lectureship teaching at the University of Asmara in Eritrea. After his return, Rainer Feistel worked for 25 years (1989 until he retired in 2014) as a physical oceanographer at the IOW and, respectively, its predecessor, the Institute of Oceanography Warnemünde of the Academy of Sciences of the GDR. In 2013 Feistel was named an Honorary Fellow of the “International Association for the Properties of Water and Steam”. Currently he is still scientifically active, for example in the international committee for the properties of seawater (http://www.teos-10.org/about_JCS.htm), and publishes scientifically on physical oceanography, thermodynamics, self-organisation and information theory.

The **European Geosciences Union** (EGU, www.egu.eu), based in Munich, is the most eminent association for geoscientists in Europe with more than 12,500 members from all over the world. As a non-profit organization, its goal is to promote excellent research “for the benefit of humanity” in the geosciences as well as the earth system and space sciences. The Annual General Assembly is the largest and most important conference of European geosciences. There, outstanding scientists are honoured for their work in various fields of research. The Fridtjof Nansen Medal pays tribute to outstanding achievements in marine research and has been awarded to 23 scientists since 1996.

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