

# Czech Society for the Properties of Water and Steam

## Annual Report 2019

Submitted to IAPWS Executive Committee in Banff, Canada, September 30, 2019

### Steering board of CZPWS

Chair: Tomáš Němec (IT CAS, nemec@it.cas.cz), Vice-Chair: Josef Šedlbauer (Technical University of Liberec), Secretary: Jan Hrubý (IT CAS), Member: Radim Mareš (University of West Bohemia), Member: Milan Sedlář (SIGMA Research and Development Institute).

### CZPWS Meeting

Annual meeting of the CZPWS was held on June 26, 2019. A significant part of the meeting was devoted to CZPWS funding, in particular to ensuring the membership payments to IAPWS. Payment for 2018 has been granted by an anonymous individual. CZPWS expressed its gratitude. Payments for 2019, 2020, and 2021 are ensured by means of an international-cooperation grant by the Czech Ministry of Education, Youth and Sports led by T. Němec. Despite significant efforts, long-term funding of IAPWS membership has not yet been ensured.

### Research Activities

Surface tension and density of aqueous systems under supercooled conditions have been investigated at the Institute of Thermomechanics of the Czech Academy of Sciences. The experimental apparatus for the measurement of **surface tension** of supercooled aqueous mixtures [6] has been used to collect new data for the surface tension of seawater [1] and binary aqueous mixtures with sodium chloride and ethylene glycol [7]. The new data for seawater are in good agreement with the correlation by Nayar et al. [J. Phys. Chem. Ref. Data 43 (2014)] extrapolated into the supercooled region down to  $-25\text{ °C}$ , which is planned to become a new IAPWS standard for the surface tension of seawater. **Density** of cold and supercooled aqueous systems was investigated using a recently developed apparatus enabling high-accuracy density determinations up to pressure of 200 MPa [9]. Density of heavy water has been finalized [2]. Slight differences in isobaric expansivity from values computed from the recent IAPWS formulation (R16-17(2018)) have been found.

The problems studied in the SIGMA Research and Development Institute and the Centre of Hydraulic Research in the period June 2017 – May 2018 have been related mainly to the application of models of cavitation erosion during the hydrodynamic **cavitation** and models of cavitation instabilities to the problems of hydrodynamic pumps [5]. In cooperation with the Institute of Thermomechanics of the Czech Academy of Sciences, the Moscow Power Engineering Institute, the Technical University of Liberec, and the Wuhan University, experimental and numerical modelling of unsteady cavitation phenomena in water has been continued in the framework of international grant projects. Recent research is devoted to the influence of real water properties including the content of undissolved air on the pressure pulses excited by cavitation [4].

Thermodynamics of steam with special attention to supersaturated conditions has been studied by molecular simulations using polarizable force fields. Higher virial coefficients have been computed [3] and cluster distributions in steam have been studied [8].

### Publications

1. Vinš V., Hykl J., Hrubý J.: *Surface tension of seawater at low temperatures including supercooled region down to - 25 °C*, Marine Chemistry 213 (2019) 13-23.
2. Blahut A., Hykl J., Peukert P., Vinš V., Hrubý J.: *Relative density and isobaric expansivity of cold and supercooled heavy water from 254 to 298 K and up to 100 MPa*. J. Chem. Phys. 151 (2019) 034505.
3. Rouha M., Nezbeda I., Hrubý J., Moučka F.: *Higher virial coefficients of water*. J. Mol. Liq. 270 (2018) 81-86.
4. Sedlář, M., Soukal, J., Komárek, M., Volkov, A.V. and Ryzhenkov, A.V.: *Numerical Simulation of Interaction between Fluid and Vapor Structures in Multiphase Flow around Hydrofoil*. J. Appl. Math. Phys., in review.

### Conference Presentations

5. Sedlář, M.: *Cavitation phenomena in balancing drums of high-performance feed pumps*. PCC/PCAS/IRS Joint WG Meeting and Workshop, IAPWS Meeting, Kyoto, 2017.
6. Vinš V., Hykl J., Hrubý J., Hošek J., Fransen M., Šmíd B., Nikl Z.: *Seven years of measurement of the surface tension of supercooled water and aqueous mixtures at IT CAS*, 17th International Conference on the Properties of Water and Steam, Prague (Czech Republic), September 2-6, 2018.
7. Vinš V., Hykl J., Čenský M., Hrubý J.: *Surface tension of supercooled aqueous mixtures: Preliminary data for mixtures with alcohols and sodium chloride and for seawater*, 20th Symposium on Thermophysical Properties, Boulder (USA) June 24-29, 2018.
8. Hrubý J., Moučka F., Nezbeda I.: *Cluster distribution and nucleation in steam over a broad temperature range*. 17th International Conference on the Properties of Water and Steam, Prague (Czech Republic), September 2-6, 2018.
9. Blahut A., Duška M., Hykl J., Peukert P., Vinš V., Čenský M., Hrubý J.: *Measurements of density for supercooled ordinary water, heavy water, and seawater at high pressures*. . 17th International Conference on the Properties of Water and Steam, Prague (Czech Republic), September 2-6, 2018.