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Annex No. 10 to the MU Directive on Habilitation Procedures and Professor Appointment Procedures

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HABILITATION THESIS REVIEWER'S REPORT

on Habilitation Thesis presented by
Dr. JAN ČECH

Masaryk University
Faculty of Science
Department of Plasma Physics and Technology

entitled

DEVELOPMENT OF NON-THERMAL PLASMA SOURCES FOR FAST PLASMA TREATMENT OF MATERIALS

The topic of PhD Thesis presented by Dr. Jan Čech is meaningful and important and it presents a comprehensive overview of almost 20 years of the author's scientific activity in the field of non-equilibrium plasma discharges. The title of work is informative, the core of a thesis consists of 65 pages and it is written in English. It begins with the specifying of the research motivation and goals and it is structured to reflect the continuity and progression of the Author's research as a brief commentary on his selected scientific papers, with particular emphasis on two plasma sources: the Diffuse Coplanar Surface Barrier Discharge (DCSBD) and the CaviPlasma® technology. The additional list of thesis references is sufficient (98 positions) and contains works relevant to the topic.

From the first part of thesis it can be noted that Jan Čech's contribution to the development and diagnostics of DCSBD was substantial. The experimental investigations are characterized by the use of advanced non-invasive optical diagnostics, including ICCD imaging and optical emission spectroscopy, correlated with electrical measurements and numerical models. His work contributed to better understanding microdischarge dynamics related to electrode geometry effects, and temperature influence on the discharge behaviour. Moreover, the study on newly identified phenomena: the memory effect due to the residual heat accumulation and the charge relaxation event preceding the Townsend avalanche in the homogeneous regime in helium- are significant advances in the understanding of barrier discharge mechanisms. Performed experimental work of Candidate: well designed and sophisticated, contributed directly to the development of many industrial applications of DCSBD in wide pressure range for instance for the decontamination purposes.

Author is also co-inventor of innovative CaviPlasma® system for the plasma treatment of liquid, described in the second part of the thesis. CaviPlasma® can work with high flowrates (of several m^3/h). Proposed system was awarded national and international patents (already licenced) and its prototype was exhibited during Osaka Expo in 2025. It combines hydrodynamic cavitation and plasma discharge in a flowing liquid environment. Starting from the reactor design and testing the geometry and electrode materials, Candidate performed detailed diagnostics, revealing two primary operational regimes of the discharge (spark/glow) in the system. He characterized the generation of reactive oxygen species and quantified generated ROS. The results indicate that CaviPlasma® ranks among the most energy-efficient plasma-liquid systems, achieving hydrogen peroxide yields above 10 g/kWh.

For both described systems one can note excellent plasma diagnostic techniques and the ability to adapt them to challenging experimental environments involving transient, high-pressure discharges. The development of custom data-processing codes, synchronization of electric-optical measurements, and integration of numerical modeling to support experimental findings reflect a high level of methodological sophistication and independence. The Candidate's ability to bridge fundamental plasma science and technological applications is a notable strength of this work and results obtained by Dr. Jan Čech during his career are truly valuable contribution.

I have some questions for a Candidate: related to the topic of Habilitation Thesis:

1. Could you comment on the impact of humidity (in surrounding gas, or moisture content in plasma treated target) on the Diffuse Coplanar Surface Barrier Discharge (DCSBD) behavior?
2. What were the main challenges encountered when scaling up the CaviPlasma® system to industrial flow rates, is the discharge stable, what highest flow rates you can reach at the moment, do you see some limitations?
3. What are the most probable future application areas for both systems DCSBD and CaviPlasma®?

Scientific activity of Dr. Jan Čech is high and he is well known in plasma field as an earnest, dedicated and hard-working researcher. The habilitation thesis is based on 15 co-authored peer-reviewed papers in renowned international journals but according WoS database Candidate co-authored many other scientific contributions.
The publication list stated in the thesis also reflects the author's input, which is clearly identifiable and crucial for excellent quality of the published manuscripts.

Dr. Jan Čech publication record is fully consistent with the expectations for habilitation and reflects both sustained productivity and scientific recognition within the plasma physics community.

In conclusion: The work of Jan Čech demonstrates a high level of scientific maturity, methodological rigor, and independence. It provides both fundamental insight into the physics of non-equilibrium discharges and applied outcomes with clear industrial relevance such as industrial plasma processing, environmental remediation, and water treatment technologies. The development of the 3rd generation of CaviPlasma® systems with adjustable gas-phase composition demonstrates ongoing innovation spirit to expand and secure future perspectives.

In my opinion, work of Dr. Jan Čech is coherent, original and it is highly interdisciplinary. Candidate sufficiently documented his scientific achievements and his contribution to the development of Plasma Physics is undoubtful and well proven.

Thus, the habilitation thesis entitled "DEVELOPMENT OF NON-THERMAL PLASMA SOURCES FOR FAST PLASMA TREATMENT OF MATERIALS by Jan Čech fulfils requirements expected of a habilitation thesis in the field of Physics of Plasma.

I consider his work important and I sincerely support his efforts.

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