M U N I

HABILITATION THESIS REVIEWER'S REPORT

Masaryk University	
Applicant	Mgr. Zdeněk Bonaventura, Ph.D
Habilitation thesis	Modelling of Non-Equilibrium Electrical Discharges: Streamers and Determination of Electric Field from Optical Emissions
Reviewer	Carlos Daniel Pintassilgo, PhD
Reviewer's home unit, institution	Department of Chemical and Biological Engineering, Faculty of Engineering, University of Porto, Portugal

The habilitation thesis by Dr Zdenek Bonaventura is well-written and, in general, well-organised. It contains a concise description of the research work carried out by the applicant over the past two decades. The description is mainly divided into two parts, designated by A and B, containing each one selected papers dealing respectively with fundamental aspects of electric field determination in non-thermal (non-equilibrium) discharges and numerical modelling of streamers.

Part A comprises three papers (one from 2011, two others from 2018), being worth noting that two of them have more than 70 citations (source: Scopus database, May; info not reported in the document).

Part B contains seven papers, which are, in turn, divided into different groups, involving collaborations of Dr Zdenek Bonaventura with applied mathematicians (papers B1-B3), the effect of runaway electrons (papers B4 and B5), a Topical Review (B6) and (B7) the role of radiation transport to evaluate the role of photoionisation in streamers. Some papers in this second group also involve a relatively large number of citations, such as the case of paper B6, with almost 70 citations (source: Scopus database, May).

Besides a brief description of the content of each paper, the document also reports the corresponding percentage contribution of Dr Zdenek Bonaventura on different items, such as (i) Work contribution; (ii) Supervision; (iii) Manuscript and (iv) Research direction. Depending on the publication, these items range from 10 to 90%, illustrating Dr Bonaventura's capacities in the different components of research work. Moreover, in the list of papers concerning part A, a research contribution of 90% is pointed out, which reinforces the research skills of Dr Bonaventura in the important component of supervising work.

The list of publications reported in the document clearly shows a substantial track record (index - h of 24, a total of ~1600 citations, source Scopus database), involving co-authors from different groups and countries, as well as from different fields, such as mathematicians and experimentalists. This aspect is somewhat described in the Preface of the habilitation document, where Dr Zdenek Bonaventura reports some of the milestones in his professional path after his PhD, starting by the Université de Pau, France, passing by the Ecole Centrale and by the Ecole Polytechnique, France, the Technical University of Denmark, and more recently, IPP in Greifswald, Germany, as well as the Institute of Plasma Physics in Prague, Czech Republic, where he worked with Dr Milan Simek, clearly a word reference in experimental plasma physics. In the reviewer's opinion, these fruitful collaborations constitute an important added value to Dr Bonaventura's research.

The presentation of key papers and their concise content is complemented in two subsequent chapters with a much more detailed description of some of the fundamental physical bases, numerical procedures, and modelling results. While Chapter 1 focuses on streamer discharges, including the study of runaway electrons, Chapter 2 is dedicated to the determination of the electric field, with a numerical analysis of the reliability of the measurements of this crucial parameter in plasmas using optical emission spectroscopy.

Curiously, the presentation of these chapters does not follow the order of papers A1-A3 and B1-B7 reported at the beginning of the document. In other words, the papers of group B are related to Chapter 1, whereas the selected papers from group A constitute the basis of Chapter 2. Nonetheless, I find the content of these two chapters quite instructive, containing very good physics. In Chapter 1, fundamental aspects of streamer discharges, numerical methods for solving Poisson's equation, and photoionisation models are comprehensively discussed. Chapter 2 provides, in turn, significant results on the reliability of measuring the electric field from the ratio of optical emission bands of nitrogen, namely the second positive system and the first negative system. I find these results quite important to the low-temperature plasma community.

From the previous analysis and almost in conclusion, the present document clearly indicates that Dr Zdenek Bonaventura has carried out, over the past two decades, important and relevant work in plasma simulations. His expertise in fundamental plasma physics, accompanied by a solid background in numerical methods, has been the basis of important models capable of accurately describing different plasma sources.

Although not reported in the document, I would like to add to this report that Dr Zdenek Bonaventura was the chair of the Local Organising Committee of the Europhysics Conference in the Atomic and Molecular Physics of Ionised Gases (ESCAMPIG) held in Brno in July 2024. I had the opportunity to work quite closely with him for more than one year on the preparation of this Conference, as I was the chair of its International Scientific Committee (ISC). During this period, I could confirm not only his knowledge of different aspects involving modelling and experimental plasma discharges, but also how easy-going he is, which I believe to be a very good characteristic for a person in general and for a researcher in particular. One can infer this from the more personal notes in the first paragraph of the Conclusion and Outlook of the document.

Reviewer's questions for the habilitation thesis defence (number of questions up to the reviewer)

The document shows several results for the mobility and diffusion coefficients (figures 1.3, pg. 11) obtained from the solutions to the electron Boltzmann equation using Bolsig+ (which means under the usual two-term approximation) up to a value of the reduced electric field of 1000 Td. Isn't this upper value too large to use a Boltzmann solver based on the two-term approximation?

These values (and others) are obtained by considering the stationary solutions of the electron Boltzmann equation. How far does this hold for times shorter than ~1 nanosecond?

How do you handle, in general, the value of the gas temperature in your models? How reliable is the assumption of a constant value? For instance, if the gas temperature is found to be 500 K instead of 300 K, for a given pressure, this would imply a different gas number density N. How may this impact your calculations, namely in what concerns E/N?

Conclusion

The habilitation thesis entitled Modelling of Non-Equilibrium Electrical Discharges: Streamers and Determination of Electric Field from Optical Emissions by Dr Zdenek Bonaventura **fulfils** requirements expected of a habilitation thesis in the field of Plasma Physics.

Date: 8th June 2026 Signature: