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Diagnostics for electric propulsion systems

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Plasma-based electric propulsion (EP) by various kinds of thrusters is a rapidly growing technology for engines of satellites and space probes for near-Earth and space exploration. In order to optimize such propulsion systems in different regimes (from a few μN to several N of thrust), the availability of suitable and proper diagnostics as well as modelling is of fundamental importance. The diagnostics include, for example, electric, spectroscopic, calorimetric and momentum measurements during the development and design in the lab and during real operation under space conditions.

Plasmas are generated by supplying energy to a volume containing a neutral gas, so that a certain fraction of free electrons and ions are generated from the neutral constituents. In technical plasma devices, the plasma is mostly generated in electrical discharges and the input energy is supplied in the form of electrical energy. The properties of non-equilibrium plasmas are discussed in many books and publications (see e.g. [1–5] and references therein), to which we refer the interested reader for further details. The generation and acceleration of ions away from the spacecraft to drive or affect it by momentum conservation are the crucial principles. Hence, topics of interest in this field of plasma research and application include aspects such as thrust measurements, plasma diagnostics, modelling and simulation of the involved species.

The topical collection "Diagnostics for electric propulsion systems" which was launched in 2021 contains eight original articles. This collection is a current review of design and operating experience of related diagnostics and control systems of various thruster concepts and missions. One paper describes "Global models for radio-frequency ion thrusters" by P. Dietz et al. [6] and one (more general) paper is on perspectives of "Cluster of Electric Thrusters for Astronautic and Robotic INPPS Flagship Space Flights to Mars and Europa moon" by F. Jansen et al. [7]. In the other six papers, which are related to suitable diagnostics for EP, optical methods are discussed in the article "Non-invasive assessment of plasma parameters inside an ion thruster combining optical emission spectroscopy and principal component analysis" by B.T. Nauschütt et al. [8] and in the paper "Single- and two-photon laser-induced fluorescence spectroscopy in rare gases for gridded ion thruster diagnostics" by C. Eichhorn et al. [9]. Furthermore, common and novel probe diagnostics in typical test environments are studied in the work "Thrust measurement and thrust balance development at DLR's electric propulsion test facility" by A. Neumann et. al. [10] as well as in the paper "Force probes for the development and testing of different elec-

tric propulsion systems" by A. Spethmann et al. [11]. Finally, in the contribution "In situ erosion measurement tools for electric propulsion thrusters: triangular laser head and telemicroscope" by C. Bundesmann et al. [12] a special method for determining the erosion of EP components is investigated and, in the article "An in-flight diagnostic package for spacecraft with electric propulsion" by T. Trottenberg et al. [13] a modern diagnostic setup for on-board measurements during EP operation is discussed.

All first authors of the several articles in this topical collection on "Diagnostics for electric propulsion systems" are from German Universities or research institutes, respectively. Thus, the compilation of the articles also reflects the current research activities in Germany in electric propulsion diagnostics under the support of the German and the European space agencies, DLR and ESA. The contributions are intended to summarize the accomplishments and current issues in a broad field in Germany. It should be emphasized that the papers focus on recent scientific and technological advances in this given area of EP diagnostics. The editor hopes that the present topical collection will find a large community of interested researchers and that the archival record contained in this collection will be useful as well.

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Author contributions
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References

1. von Engel A. Ionized gases. Oxford: Clarendon; 1955.
2. Raizer Y. Gas discharge physics. Heidelberg: Springer; 1991.
3. Lieberman MA, Lichtenberg AJ. Principles of plasma discharges and materials processing. New York: Wiley; 1994.
4. Hippler R, Kersten H, Schmidt M, Schoenbach KH. Low temperature plasmas. Weinheim: Wiley; 2008.
5. Goebel DM, Katz I. Fundamentals of electric propulsion: ion and hall thrusters. JPL Space Science and Technology Series. California Institute of Technology; 2008.
6. Dietz P, Reeh A, Keil K, Holste K, Probst U, Klar PJ, Volkmar C. Global models for radio-frequency ion thrusters. EPJ Tech Instrum. 2021;8:10.
7. Jansen F, Andreussi T, Brandt T, Cessaretti G, Ehresmann M, Grill J, Herdrich G, Funaki I, Girard N, Grundmann JT, Krejci D, Leiter H, Masson F, Maiwald V, Misuri T, Oriol S, Piragino A, Reissner A, Schanz L. Cluster of electric thrusters for astronautic and robotic INPPS flagship space flights to Mars and europa moon. EPJ Tech Instrum. 2023;10:10.
8. Nauschütt BT, Chen L, Holste K, Klar PJ. Non-invasive assessment of plasma parameters inside an ion thruster combining optical emission spectroscopy and principal component analysis. EPJ Tech Instrum. 2021;8:13.
9. Eichhorn C, Pietzonka L, Scholze F, Bundesmann C, Spemann D, Neumann H, Leiter H. Single- and two-photon laser-induced fluorescence spectroscopy in rare gases for gridded ion thruster diagnostics. EPJ Tech Instrum. 2022;9:2.
10. Neumann A, Simon J, Schmidt J. Thrust measurement and thrust balance development at DLR's electric propulsion test facility. EPJ Tech Instrum. 2021;8:17.
11. Spethmann A, Trottenberg T, Kersten H, Hey FG, Grimaud L, Mazzouffre S, Bock D, Tajmar M. Force probes for the development and testing of different electric propulsion systems. EPJ Tech Instrum. 2022;9:4.
12. Bundesmann C, Eichhorn C, Neumann H, Scholze F, Spemann D, Tartz M, Leiter HJ, Bnizdor RY, Scortecci F. In situ erosion measurement tools for electric propulsion thrusters: triangular laser head and telemicroscope. EPJ Tech Instrum. 2022;9:1.

13. Trottenberg T, Bansemer F, Böttcher S, Feili D, Henkel H, Hesse M, Kersten H, Krüger T, Laube J, Lazurenko A, Sailer D, Schuster B, Seimetz L, Spethmann A, Weis S, Wimmer-Schweingruber RF. An in-flight diagnostic package for spacecraft with electric propulsion. EPJ Tech Instrum. 2021;8:16.

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