IUPAP C16 activities during the period 2021-2024

The IUPAP Commission on Plasma Physics (C16) was elected in October 2021 and served during a post-COVID period; its activities were thus conducted remotely (via the mailing list IUPAP-C16-Members@cern.ch) and Zoom meetings, apart from participation of representatives to IUPAP-supported conferences. The internal discussions were mainly devoted to: (i) C16 recommendations on IUPAP-sponsored conferences, and (ii) selection of the Early Career Scientists Prizes on Plasma Physics.

IUPAP-sponsored conferences held during the period

- **ESCAMPIG2022** - The 2022 Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases was held in Paris (France) on 11 – 15 July 2022, with 207 participants (including 52 women, i.e. 25.1%) from 29 countries (C16 representative: Ursel Fantz).
- **ICPP2020** - the 20th International Congress on Plasma Physics (ICPP2020) was held in Gyeongju (Korea). Initially planned in July 2020, and approved as IUPAP-sponsored conference in 2020, the congress was held from November 27 to the December 2, 2022. It gathered 262 participants, including 13.7% of women, from 26 countries, and provided the opportunity to award the 2021 Early Career Scientist Prize on Plasma Physics (C16 representative: S. Jacquemot).
- **ICPIGXXXV** - the 35th International Conference on Phenomena in Ionized Gases, approved as IUPAP-sponsored conference in 2021 and in 2023, initially scheduled to be held on 11 - 16 July 2021 in Egmond aan Zee (Netherlands), was finally organized from the 9th to the 14th of July 2023. 305 scientists attended the conference, among them 61 women (20%) (C16 representative: Ursel Fantz).
- **ESCAMPIG2024** – the 2024 Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases was held in Brno (Czech Republic) from the 9th to the 13th of July 2024. It gathered 192 participants, including 25% of women (48) and 33% of students (64), which can be considered as very promising for the future of the field. Conference early fees were kept affordable (from 530€ to 380€ for students) as recommended by IUPAP. The conference provided the opportunity to award the 2023 Early Career Scientist Prize on Plasma Physics and to listen to the prize talk on “A future perspective on modeling streamer discharges: longer time scales and other gases” (C16 representative: U. Fantz).

Reports from all these IUPAP-sponsored conferences have been submitted.

In addition, the 21st International Congress on Plasma Physics (ICPP2024) will be held in Ghent (Belgium) on 8-13 September 2024. The 2024 Early Career Scientist Prize on Plasma Physics will be there awarded (C16 representative: A. Das).

Sponsoring of conferences for 2025 was discussed within the Commission. Three applications were received and ranked, the Commission strongly recommending funding them all as topical conferences.

1/ 13th International Conference on Inertial Fusion and Scientific Applications (IFSA2025)
1/ 36th International Conference on Phenomena in Ionized Gases (ICPIGXXXVI)
3/ 9th Asia-Pacific conference on Plasma Physics (AAPPS-DPP)

In addition to nominal IUPAP support described above, the Commission supported the annual European Physical Society (EPS) Plasma Physics conferences through co-sponsoring of the PPCF/EPS/IUPAP PhD Student Poster Prizes.

- 2022
  - ***Bernardo Malaca*** (GoLP, IST Lisbon, Portugal) for "Superradiance from superluminal nonlinear plasma wakefields"
  - ***Francis Pagaud*** (Laboratoire de Physique, ENS Lyon, France) for "Plasma potential control in a weakly magnetized plasma column using negatively-biased emissive electrode"
  - ***Rui Torres*** (GoLP, IST Lisbon, Portugal) for "General relativistic particle-in-cell simulations of compact neutron star magnetospheres"
  - ***Nicholas Vivenzi*** (CNR, Univ. Padova, Italy) for "Non-linear visco-resistive MHD modelling of reversed field-pinch fusion plasmas: viscosity coefficient studies"
- 2023
  - ***Sophie Gorno*** (EPFL, Switzerland) for "Experiments and modelling to characterize the effect of connection length on power exhaust in TCV"
  - ***Radka Štefaníková*** (HZDR Dresden, Germany) for "Spatially resolved X-ray emission lines as a signature of electron dynamics in short-pulse solid-density laser-plasma interaction"
  - ***Michael Nastac*** (Oxford University, UK) for "Irreversible stochastic heating via phase-space entropy cascade in nearly collisionless plasma turbulence"
  - ***Swarnima Singh*** (Institute for Plasma Research, India) for "Experimental observation of a triple point for a complex (dusty) plasma"
- 2024
  - ***Aridai Bordón Sánchez*** (Universidad de Las Palmas de Gran Canaria, Spain) for "Spectroscopic and MHD modelling of strongly magnetized cylindrical implosions at the National Ignition Facility"
  - ***Ida Ekmark*** (Chalmers University of Technology, Sweden) for "Fluid and kinetic modeling of runaway electron seed generation during disruptions"
  - ***Julien Herbelot*** (Aix Marseille University, France) for "Electric field measurements in the presence of magnetic field with the EFILE diagnostic"
  - ***Thershi Siddarth Seebaruth*** (Sorbonne University, France) for "Simulations and experiments of shocks in weakly collisional plasma"

Early Career Scientist Prizes on Plasma Physics

In January 2022, the Commission drafted a ECSP call on Plasma Physics (used during the whole period of its mandate), specifying the documents required (a 3-page description of the work of the nominee, clearly mentioning key achievements and up to 5 major publications, a CV with a full list of publications and up to 3 reference letters). Selection procedure and criteria were also defined: quality and novelty of the scientific achievements of the nominee, impact of the scientific achievements of the nominee (citations, etc.), level of recognition reached by the nominee (visibility at conferences, record of invited talks, prizes) and opportunities opened by the nominee's research.

- 2022
  Ten nominations (40% of female nominees) were received, of extremely high quality as recognized by the whole Commission. A first round (by email) allowed selecting 2 nominees for a second round of discussions during a Zoom meeting. The 2022 prize was awarded to **Marija Vranic** (IST, Portugal) for "her outstanding contributions on the understanding of the interplay between classical and quantum effects in extreme ultra-intense laser-plasma interactions, on the underlying computational methods, and on the applications for plasma-based secondary sources of energetic particles". The prize has been presented at a seminar given at the *Laboratoire pour l'Utilisation des Lasers Intenses* (LULI, France) on February 13, 2023, by the chair of the Commission.

- 2023
  Four high-quality nominations (including one female nominee: 25%) were received. A first round (by email) allowed the selection unambiguously of one nominee. The 2023 prize was awarded to **Jannis Teunissen** (CWI, Netherlands) for "the development of a suite of numerical codes to simulate streamer discharges in full 3D with their intricate inner structure, including their interactions and branching statistics, in agreement with experiments, as well as for contributions to codes and predictions for relativistic MHD in astrophysics, and to machine learning for space weather".

- 2024
  Six nominations were received (with, unfortunately, only one female nominee: 17%). A first round (by email) allowed pre-ranking them for a second round of discussions during a Zoom meeting. The 2024 prize was awarded to **Vinícius Njaim Duarte** (PPPM, USA) for "elucidating the mechanism behind the nature of the nonlinear response of Alfvénic waves in fusion experiments, and for the advancement of collisional plasma kinetic theory that led to a self-consistent transport theory, established from first principles and successfully applied to the dynamics of fusion plasmas and self-gravitating systems".

Links with other Commissions and Working Groups

Considering the strong links existing between plasma physics and accelerator science (e.g. in beam dynamics, ion sources, new acceleration techniques), the C16 chair is associate member of the IUPAP Working Group on Accelerator Science (WG14).

Moreover, the C16 chair is co-chair of the International Committee on Ultrahigh Intensity Lasers (ICUIL – IUPAP Working Group 7), these powerful light sources being key drivers for extreme plasma physics, a topic well represented within C16, for instance by the 2022 Early Career Scientist Prize. Such a co-chairmanship is behind the creation of the ICUIL prize for early career scientist, awarded for the first time in 2024.

It is interesting to note that this prize was awarded to Yan Wan for outstanding contribution to the field of laser-plasma-based electron acceleration, at the frontier between the three IUPAP components: C16, WG7 and WG14.

Scientific highlights

The C16 mandate was marked by remarkable achievements in plasma physics that is important to mention, as they will shape - positively or not - the future of the field.

- The long-term goal of achieving ***laser fusion*** ignition – i.e. producing more fusion energy than laser energy invested - was reached on December 5, 2022, at the Lawrence Livermore National Laboratory (USA) on the National Ignition Facility (NIF) thanks to huge improvements in target design and manufacturing precision. This achievement followed obtaining the first burning plasma (in which the fusion reactions themselves are the primary source of heating in the plasma: the so-called alpha heating) in fall 2020. Since then, a record for neutron yield has been set on July 30, 2023, when the NIF laser delivered 2.05MJ of laser energy on target resulting in 3.88MJ of fusion energy output.
- The second deuterium-tritium experimental campaign (DTE2) at the Joint European Torus (JET) in December 2021 resulted in the first direct observation of the fusion fuel keeping itself hot through alpha heating. The third and final campaign (DTE3) in October - November 2023 led in a ***magnetically-confined fusion*** energy record output of 69MJ during a single 5-second long pulse, however without any energy gain; it allowed primary exploring fusion processes and control techniques under similar conditions to and in preparation for future fusion power plants. JET was permanently shut down on December 20, 2023, after 40 years of operation that provided major contribution to the development of fusion energy.
- An unprecedented discovery in ***solar plasma physics*** was published in 2024. For the first time, plasma waves from a solar flare were observed to be focused by a coronal hole, a phenomenon reminiscent of gravitational lensing in astrophysics.
- These last years were finally marked by the emergence of a large number of private start-ups in the field of nuclear fusion. The 2024 Fusion Industry Associations reports at least 45 companies, with very diverse technological approaches, working to commercialize fusion energy around the world thanks to private investments and public-private partnerships.