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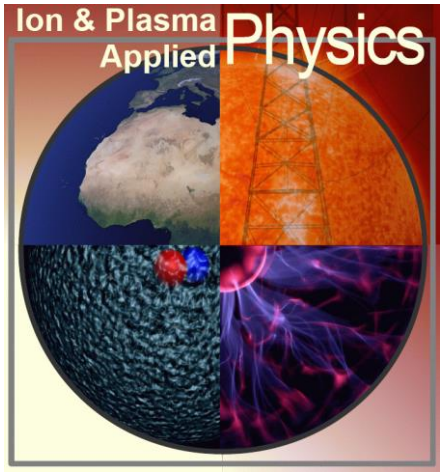

The

Innsbruck Experimental Plasma Physics Group

IEPPG

Institute for Ion Physics and Applied Physics
University of Innsbruck

The Innsbruck Experimental Plasma Physics Group (IEPPG), (January 2022)

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Institut für Ionenphysik und Angewandte Physik

- **Priv.-Doz.Dr. Codrina Ioniţă-Schrittwieser Senior Scientist (Head)**

- **Ao.Univ.-Prof. i.R. Dr. Dr. h.c.mult. Roman Schrittwieser, Senior Scientist (Deputy Head)**

- **DDr. Claudia-Teodora Konrad-Soare (Research Assistant)**

- **Dr. Florin Enescu (PhD student for physics)**

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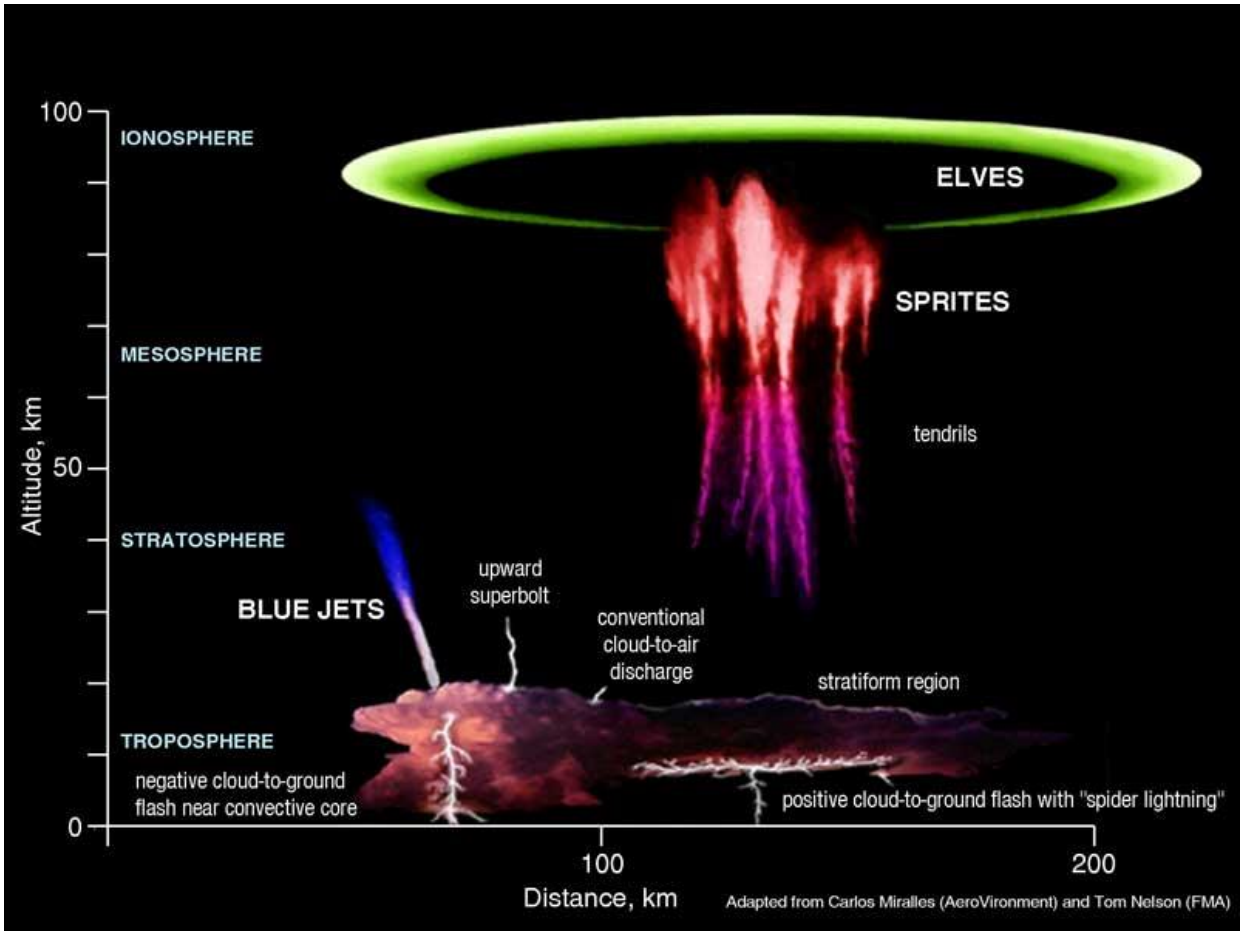
ΠΛΑΣΜΑ – PLASMA

Greek: the *formed* or the *molded*,
related to the English words
plastic and *plaster*
The substance stars are made of!
The so-called fourth state of matter.

Plasma World

The plasma state is the normal state of matter



There are many more plasma phenomena in the atmosphere than just lightnings!*)

https://weather.com/news/news/transient-luminous-events-mysteries-sky-20130731

*) *"There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy."*

"Es gibt mehr Ding' im Himmel und auf Erden, als Eure Schulweisheit sich träumt, Horatio."

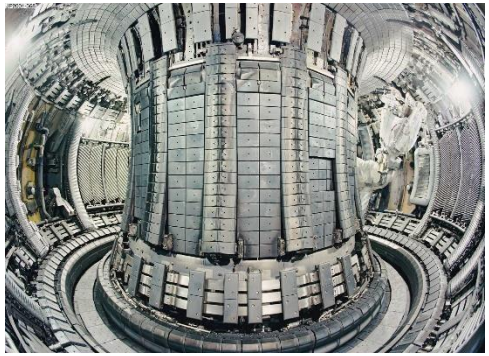
Hamlet, Shakespeare

Energy from plasma I

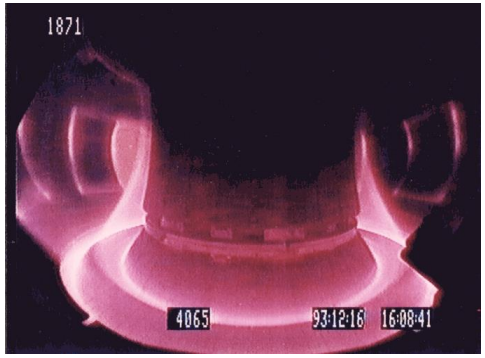
Nuclear fusion can (almost) only be realised in an extremely plasma

Fusions energy is the most a natural and clean form of energy!

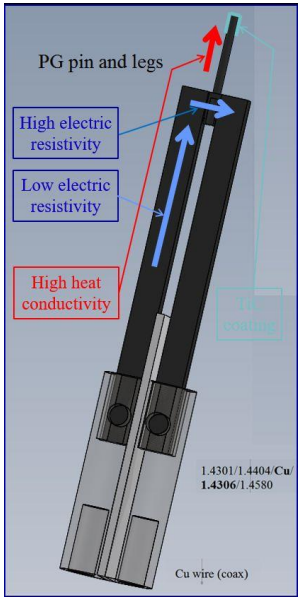
$$^{2}D_{1} + {}^{3}T_{1} \rightarrow {}^{4}He_{2}\ (3{,}5\ \text{MeV}) + {}^{1}n_{0}\ (14{,}1\ \text{MeV})$$



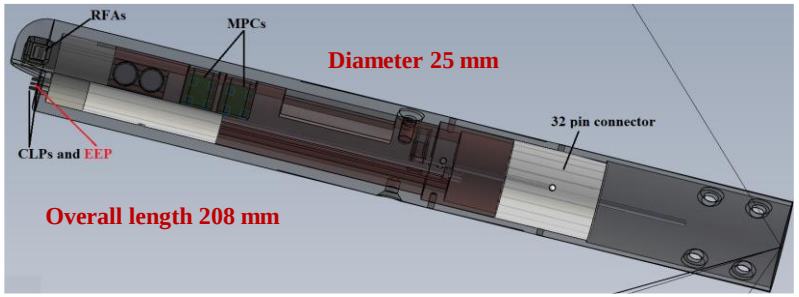
JET – Joint European Torus, the presently still largest fusion experiment in Culham near Oxford



A million degrees hot deuterium plasma in the fusion experiment ASDEX Upgrade at the Max-Planck-Institute for Plasma Physics in Garching near Munich

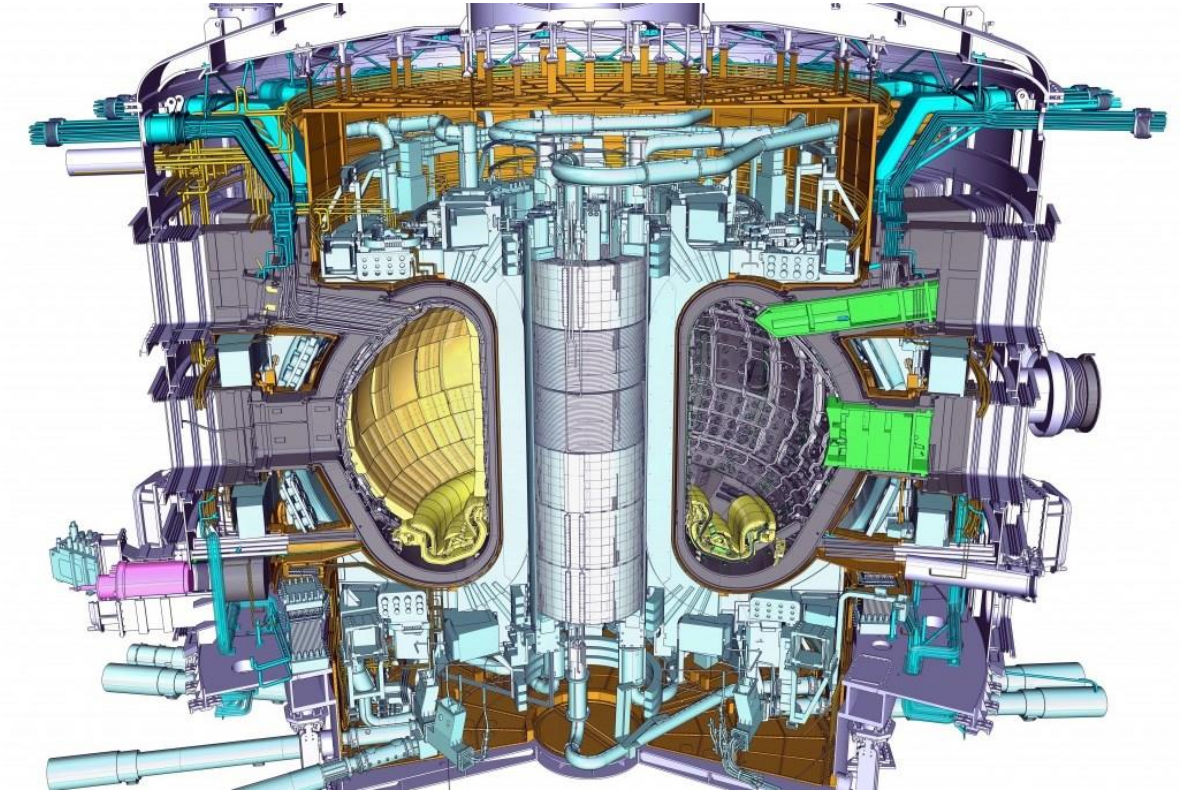


Although the plasma in a toroidal magnetic fusion experiment is extremely hot in the center, in the edge region we can still use conventional plasma diagnostics with plasma probes. Here a schematic of an electron-emissive plasma probe is shown which we have developed for use for instance in ASDEX Upgrade.



Energy from plasma II

ITER (Latin „the way “, or „International Thermonuclear Experimental Reactor“, the future largest international fusion experiment of the world in Cadarache, France



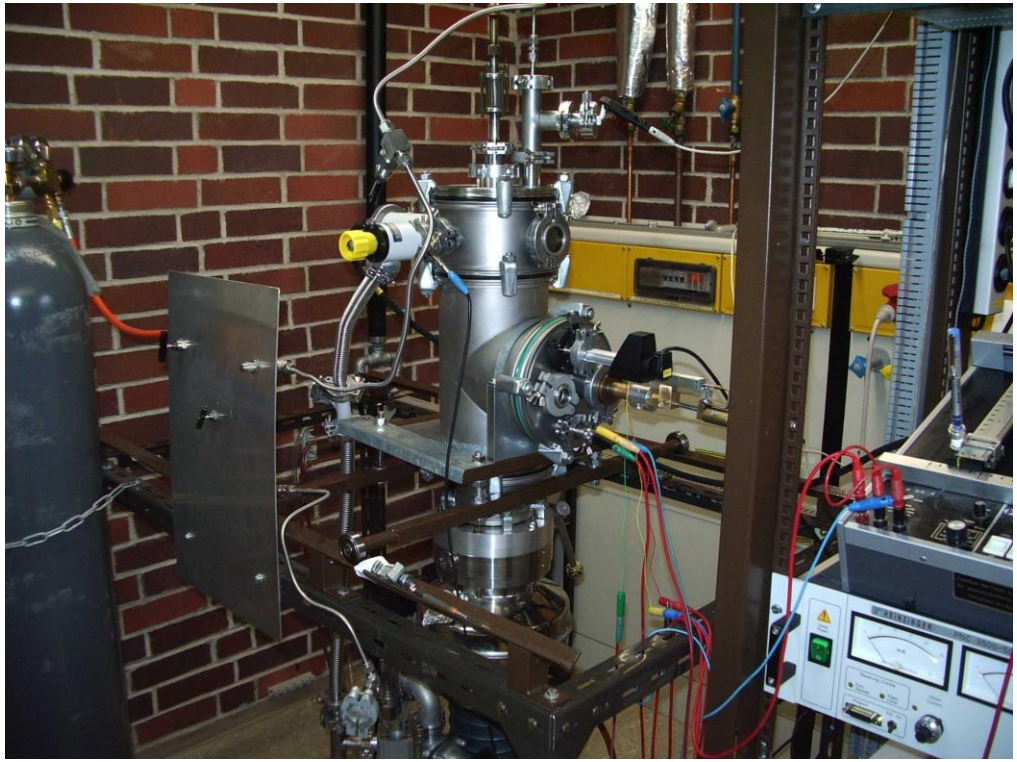
Schematic drawing of ITER

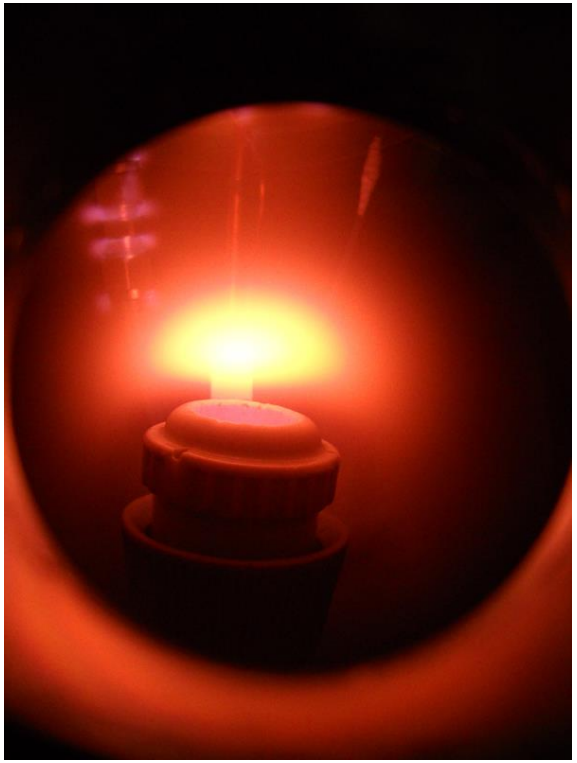
Future site of ITER in Cadarache, near Saint-Paul-lès-Durance, south of France.

ITER ad fusionem solum iter!

Plasma physics in Innsbruck I

Laboratory experiments I

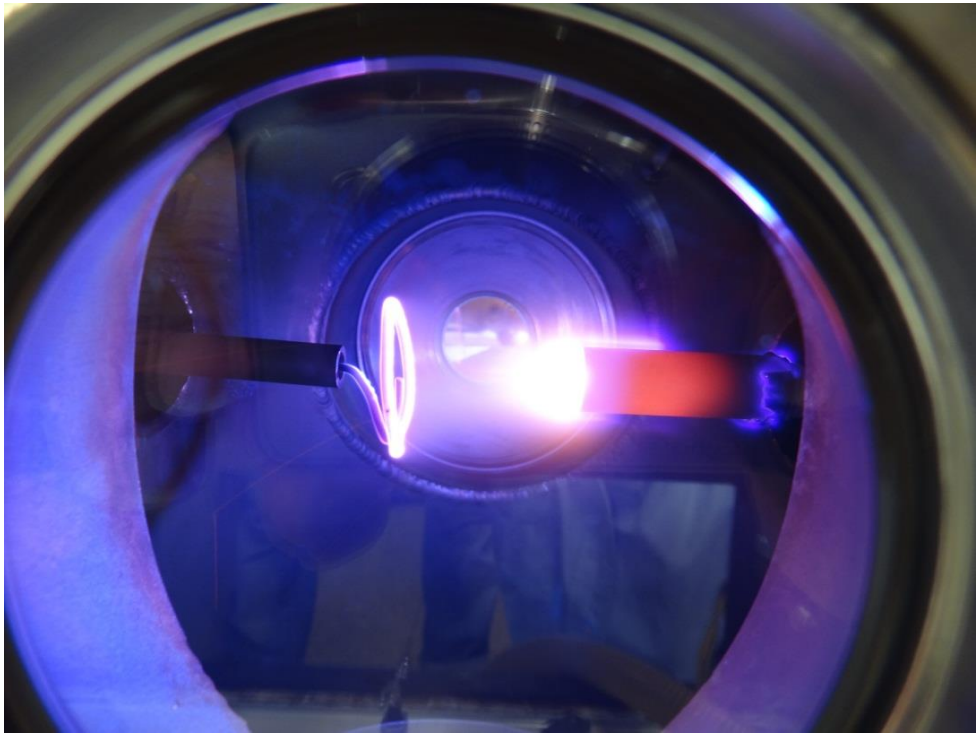


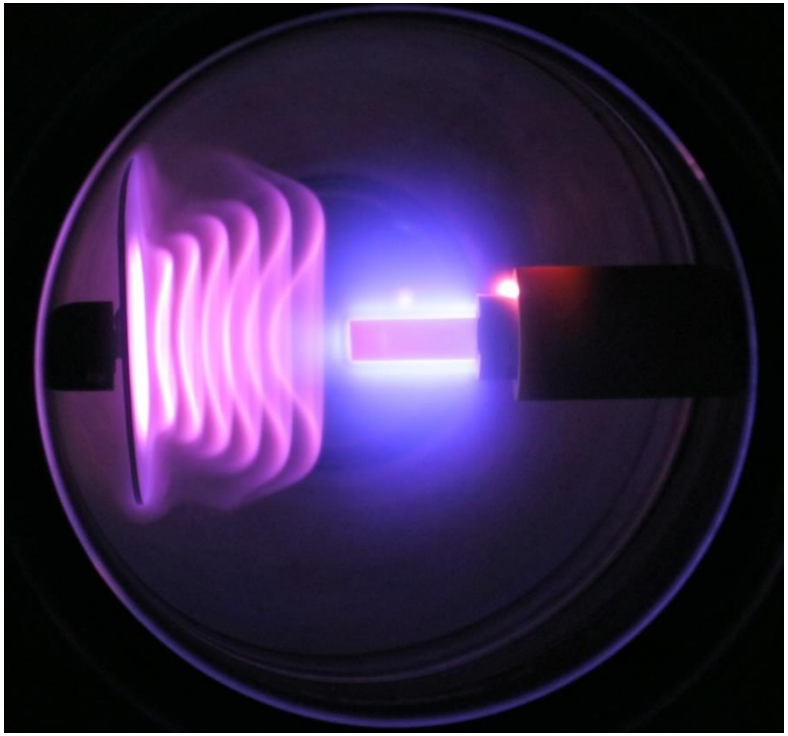


Hollow cathode (HC) experiment for producing a strong dense plasma by the pendulum effect in a cylindrical HC for various sputtering experiments. LHS: Experimental set-up; RHS: A typical hollow cathode discharge above the muzzle of the HC.

Plasma physics in Innsbruck II

Laboratory experiments II

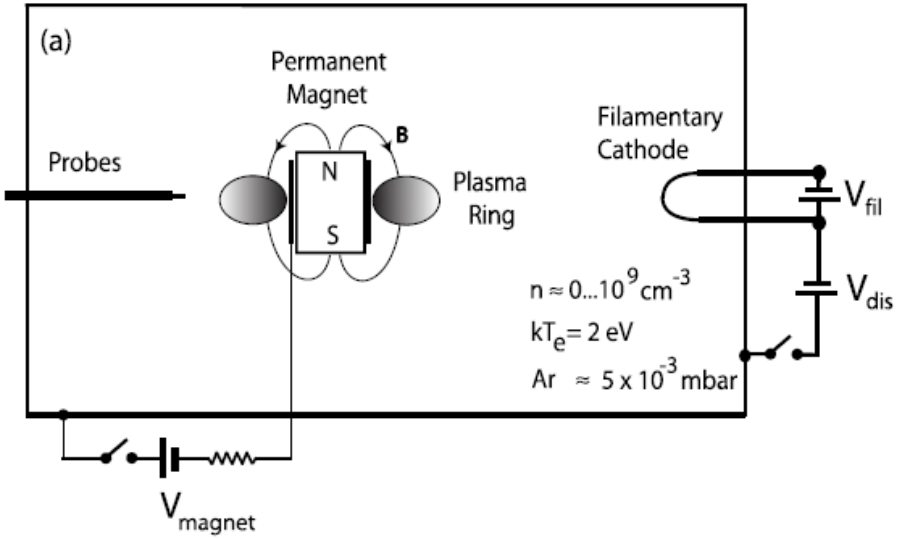


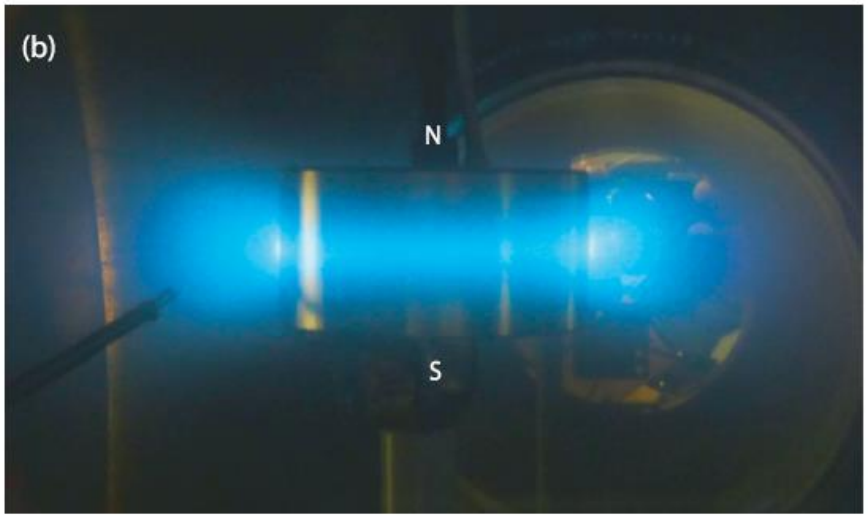


New plasma chamber with various space charge structures for investigation of their formation a behaviour.

Plasma physics in Innsbruck III

Laboratory experiments III

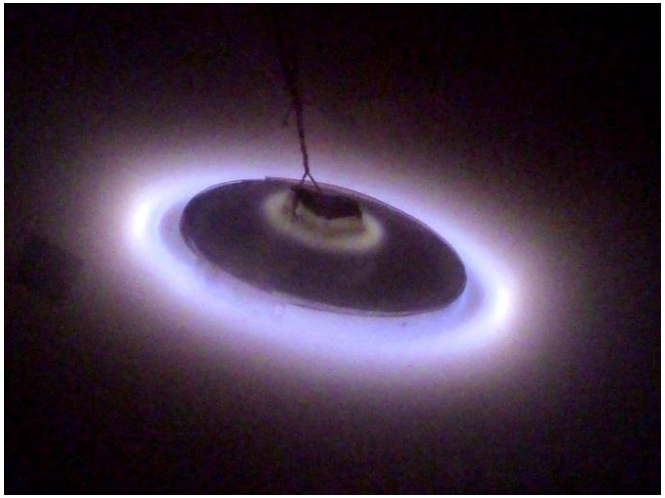


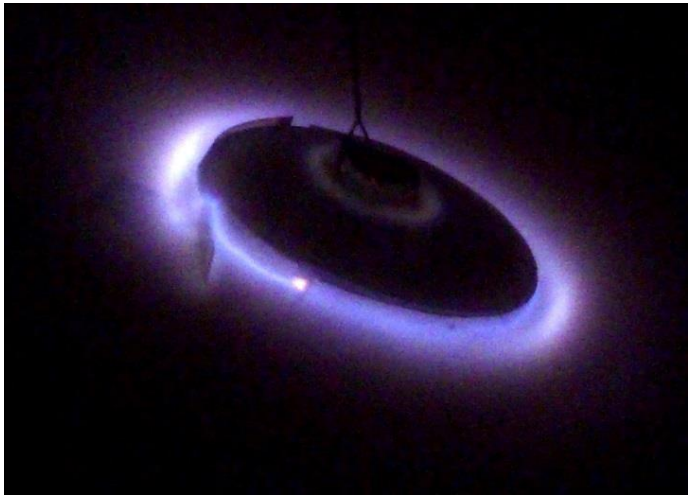


Experimental set-up (left panel) and plasma ring in the equatorial plane of a cylindrical permanent dipole magnet biased at -400 V in argon at pressure $p = 5 \times 10^{-3}$ mbar (Nd magnet, 5 cm diam., 2,5 cm length and 0,4 T maximum).

Plasma physics in Innsbruck IV

Laboratory experiments IV





Space charge structures on biased permanent magnets:

These are no UFOs!

Plasma physics in Innsbruck V

Laboratory experiments V

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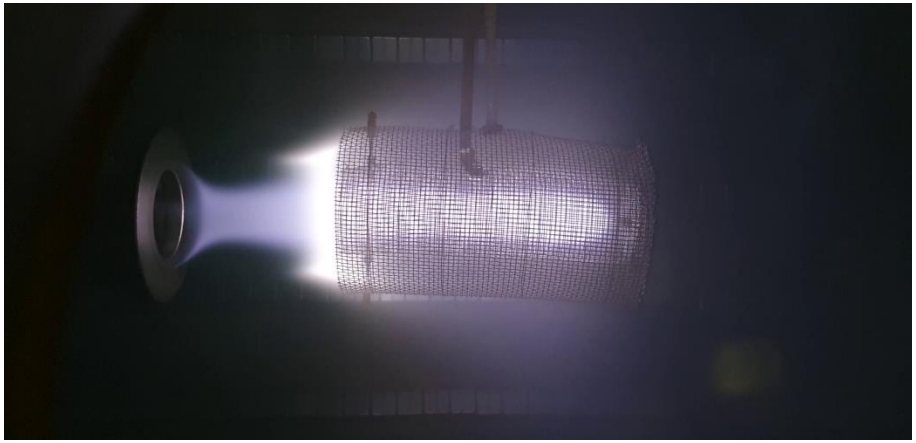
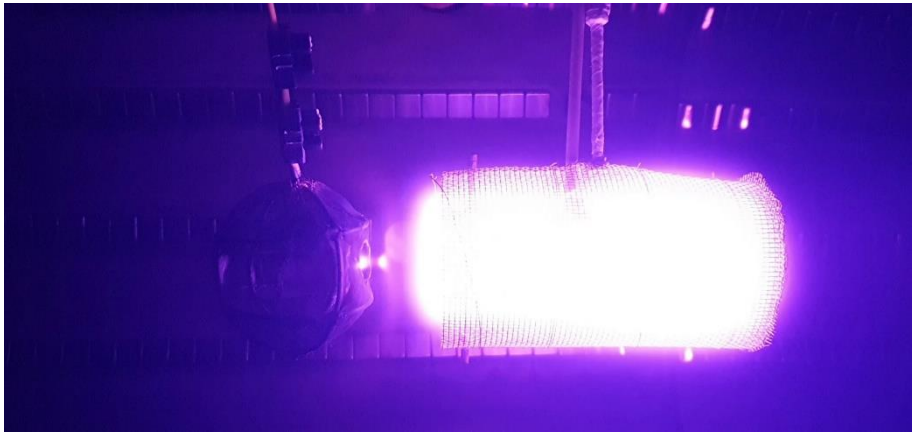
Double concentric cylindrical gridded electrode

Recent experiments at the Innsbruck Plasma Physics Laboratory: wide variety of space charge and plasma potential structures under different experimental conditions – various biases and gas pressures.

Such experimental setups will be investigated for their potential applicability as **plasma thrusters**.





Themen für das Bachelorseminar und eventuell weiterführend (I)

Sommersemester 2022

1. **Grundlegende Eigenschaften eines DP-Maschinenplasmas (Double Plasma Machine)** mit eigenen Sondenmessungen im Innsbrucker Plasmaphysiklabor unter Anleitung.
2. **Plasmadiagnostik mit Sonden,** Theorie und experimentelle Ausführung, eventuell Mitwirkung am Einsatz von Plasmasonden im ASDEX Upgrade oder anderen Fusionsexperimenten (Buch: R. Hippler, S. Pfau, M. Schmidt, K.H. Schoenbach, Eds., "Low temperature plasma physics", Wiley, 2001; 6. Kapitel von S. Pfau und M. Tichy).
3. **Raumladungsschichten in Plasmen,** Schichten an Grenzflächen, Doppelschichten in Plasmen (Buch: Francis F. Chen, "Introduction to Plasma Physics and Controlled Fusion", Vol. 1, Springer-Verlag 1984; Skriptum "NSCS" R. Schrittwieser, C. Charles, Plasma Sources Science and Technology **16** (2007) R1–R25, doi:10.1088/0963-0252/16/4/R01).
4. **Ladungsträger in magnetischen und elektrischen Feldern** (Buch: Francis F. Chen, "Introduction to Plasma Physics and Controlled Fusion", Vol. 1, Springer-Verlag 1984).
5. **Entladungen bei Atmosphärendruck,** Dielektrische Barriereentladungen (Dielectric Barrier Discharge – DBD) u.ä. Buch: M.A. Liebermann & A.J. Lichtenberg, „Principles of Plasma Discharges and Materials Processing“, John Wiley & Sons, Inc.,1994.

Themen für das Bachelorseminar und eventuell weiterführend (II)

Sommersemester 2022

6. **Atmosphärische Entladungen**, Blitze, Elmsfeuer, Rote Kobolde, Blue Jets, Elfen, u.ä. (Literatur: E.M. Bazelyan & Y.P. Raiser, „Lightning Physics and Lightning Protection“, Institute of Physics Publishing, 2001; V.A. Rakov & M.A. Uman, „Lightning: Physics and Effects“, Cambridge University Press, 2003.)
7. **Plasmatriebwerke,** eine Übersicht, eventuell Mitwirkung an Experimenten im Innsbrucker Plasmaphysiklabor unter Anleitung.
8. **Weltraumplasmen,** von der Magnetosphäre zu den Polarlichtern.
9. **Kernspaltung/Kernfusion**, von Wasserstoff bis zu Transuranen, (Buch: W. Demtröder, "Experimentalphysik IV, Kern-, Teilchen- und Astrophysik", 3. Auflage (!!), Springer-Verlag, 2010, vor allem: 6. Kapitel).
10. **Magnetischer Einschluss von Fusionsplasmen**, (Buch: Francis F. Chen, "An Indispensable Truth, How Fusion Power Can Save the Planet", Springer-Verlag, 2011, XVII, 433 p, http://www.springer.com/physics/particle+and+nuclear+physics/book/978-1-4419-7819-6).
11. **"Kalte Fusion",** Dichtung und Wahrheit: welche Methoden sind wenigstens physikalisch nicht unsinnig, welche beruhen zumindest auf einem interessanten physikalischen Effekt, welche sind Unsinn? (Myonenkatalysierte Fusion, Bläschen-„Fusion“.