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Motivation

Based on Dr. J. Lilén's bell-jar design and as part of the *Planeterrella European network*, we report here a revised design of a Planeterrella, which consists in a uniquely designed single-structure glass-aluminium vacuum chamber of cubic shape built 'in house' at Aalto University.

With code name *Terrella Cubica*, the aim is to support the current space physics cursus of the Aalto University Department of Electrical Engineering, by demonstrating plasma phenomena (auroral ovals, ring currents, etc.) usually only witnessed by instruments onboard space missions.

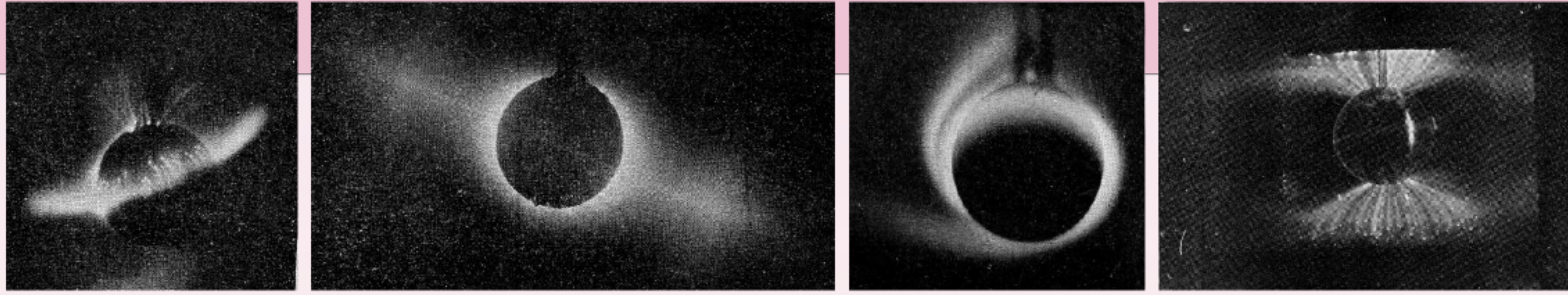
The ingredients of the experiment: From Birkeland's *Terrella*...

In 1902, the Norwegian physicist Kristian Birkeland started in Christiania (Oslo) a series of vacuum experiments to reproduce in the laboratory the auroral mechanisms he had theorised: he called them ***Terrella***, "little Earth", in honour of W. Gilbert's magnetism experiments.

The experiment is composed of:

- * **Vacuum chamber** capable of reaching ionospheric-like pressures ($\sim 10^{-3}$ mbar)
- * **Aluminium magnetised spheres**, with dipolar magnets (1 T), to mimic Earth and other planets
- * **High-voltage power supply** to mimic the electron flow (~ 1 kV, few mA)

When these spheres are placed in a partial vacuum, an electric discharge is introduced between the anode and cathode, simulating electrons precipitating along magnetic field lines in the rarefied gas, hence creating auroral ovals in the Southern and Northern hemispheres.



Birkeland's experiments in *The Norwegian Aurora Polaris Expedition 1902-1903* (1913)

... to the *Planeterrella* as a teaching tool for space plasma physics



First created at Grenoble University (France), the modern Planeterrella experiment has since been remade 17 times in universities in Europe and the US. It draws from Birkeland's heritage with many practical modifications that make it portable and accessible to Universities and public institutions. The main enhancement of the experiment is the use of several spheres to **recreate Space Weather phenomena** (Sun-planet or "exotic" star-exoplanet interactions). All vacuum chambers are bell-shaped and standardised.

Please visit us at:
<http://planeterrella.osug.fr/?lang=en>

The Planeterrella is organised as an international network bound by a Gentleman's agreement. Thanks to its success & several awards (EuroPlaNet, etc.) it has been seen and discussed by more than 20,000 people across the network.

Aalto's *Terrella Cubica*, the first Nordic *Planeterrella*

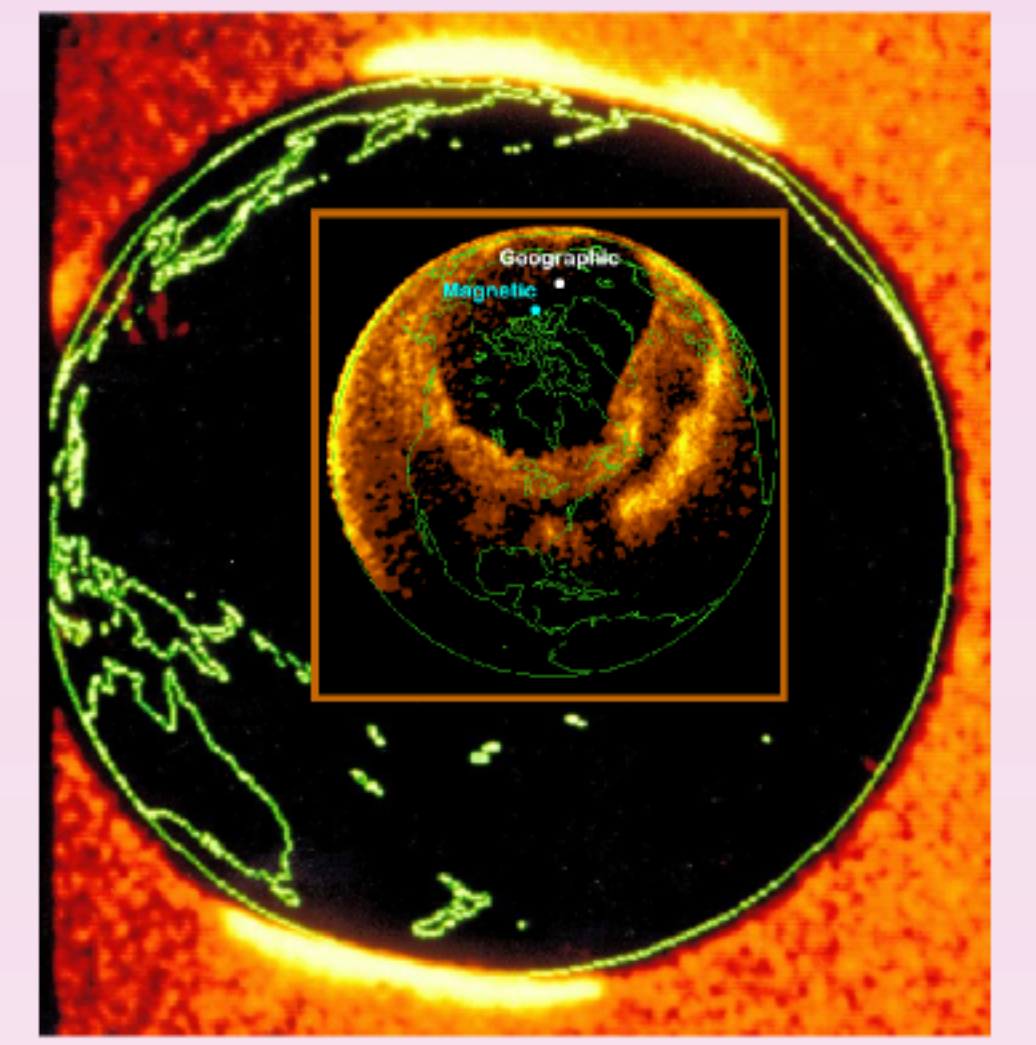
Stemming from the original cubic-shaped plasma chamber of Birkeland, we have built at Aalto University a new prototype within the *Planeterrella* agreement, called *Terrella Cubica* (see below).

The experiment has been entirely created on site at the University as a single aluminium structure. The small pieces (spheres, pedestals) as well as the base plate were created from off-the-shelf raw materials by machining and by 3-D printers. Neodymium magnets of 1 Tesla intensity are used in the current setup.

Tests are under way at Aalto University. **The experiment will be used to demonstrate basic phenomena encountered in planetary space plasmas** such as the Lorentz force, the Debye length, the formation of ring currents or of upper atmosphere VIS-UV emissions.



Aurora display above the EISCAT radar, Svalbard, Norway
(c) CSW



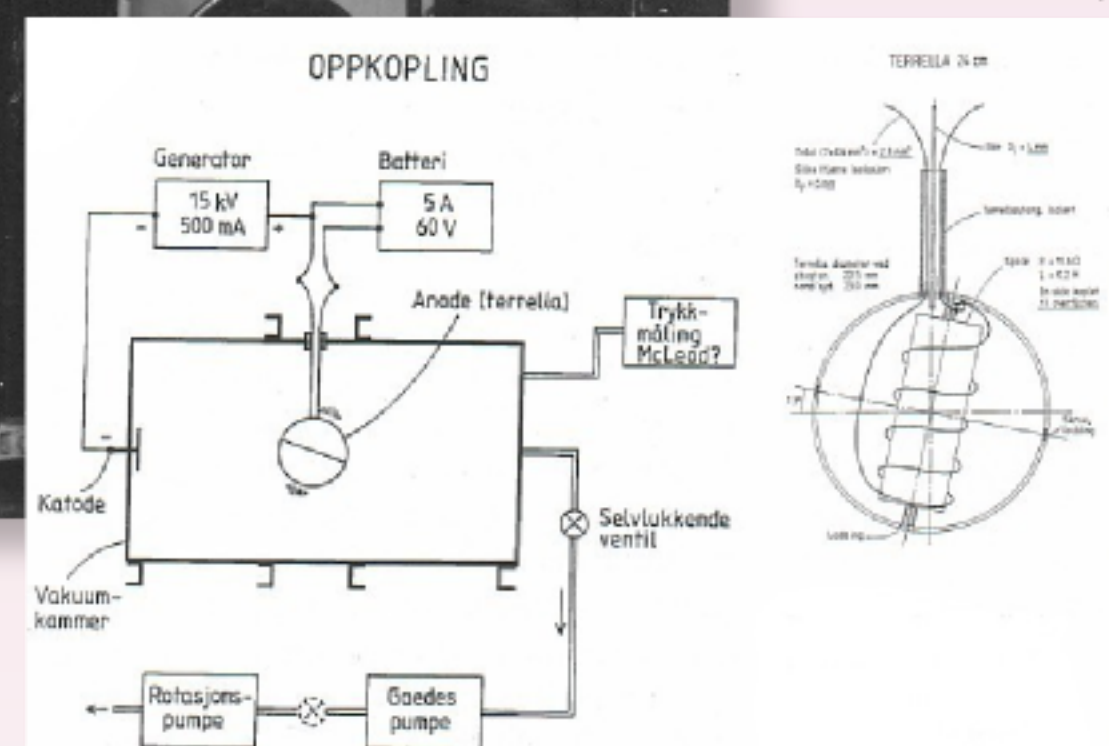
"The crowned Earth" seen by
Dynamics Explorer (c) NASA



Prof. Birkeland in his laboratory (c) Nasjonalbiblioteket, Billedsamlingen, Oslo

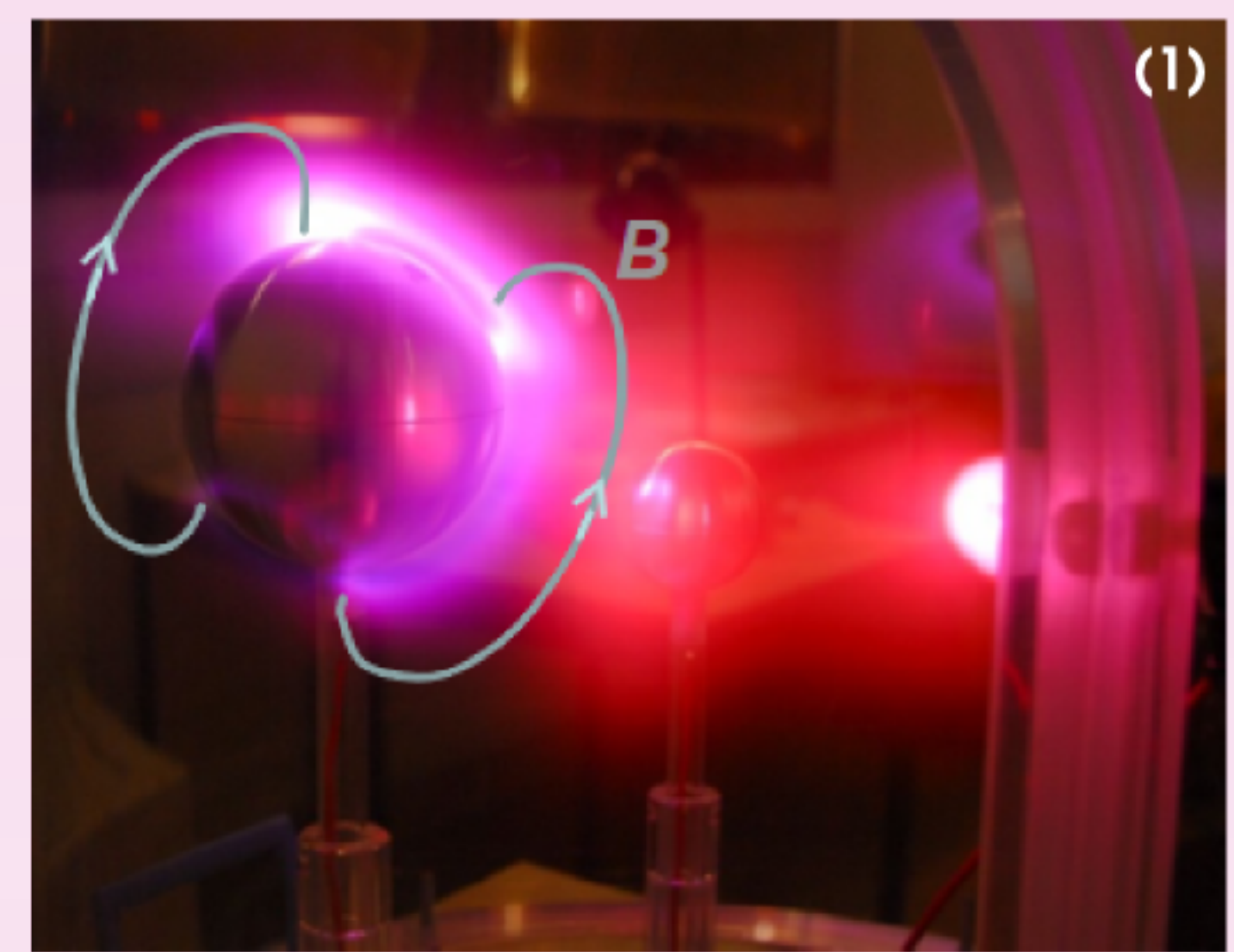
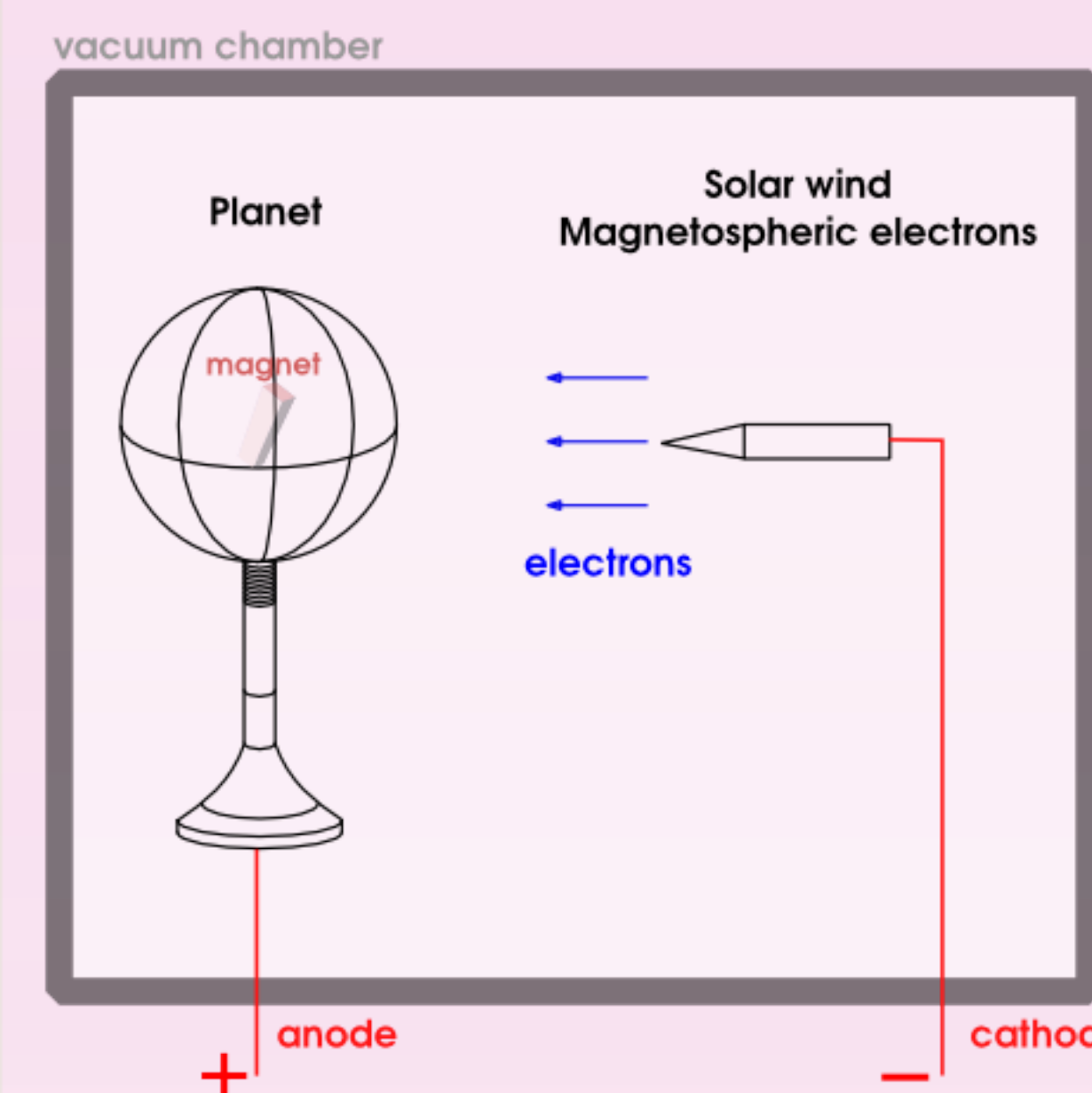


Norwegian
200 NOK
bank note,
a tribute to
K. Birkeland,
"the first space
physicist"

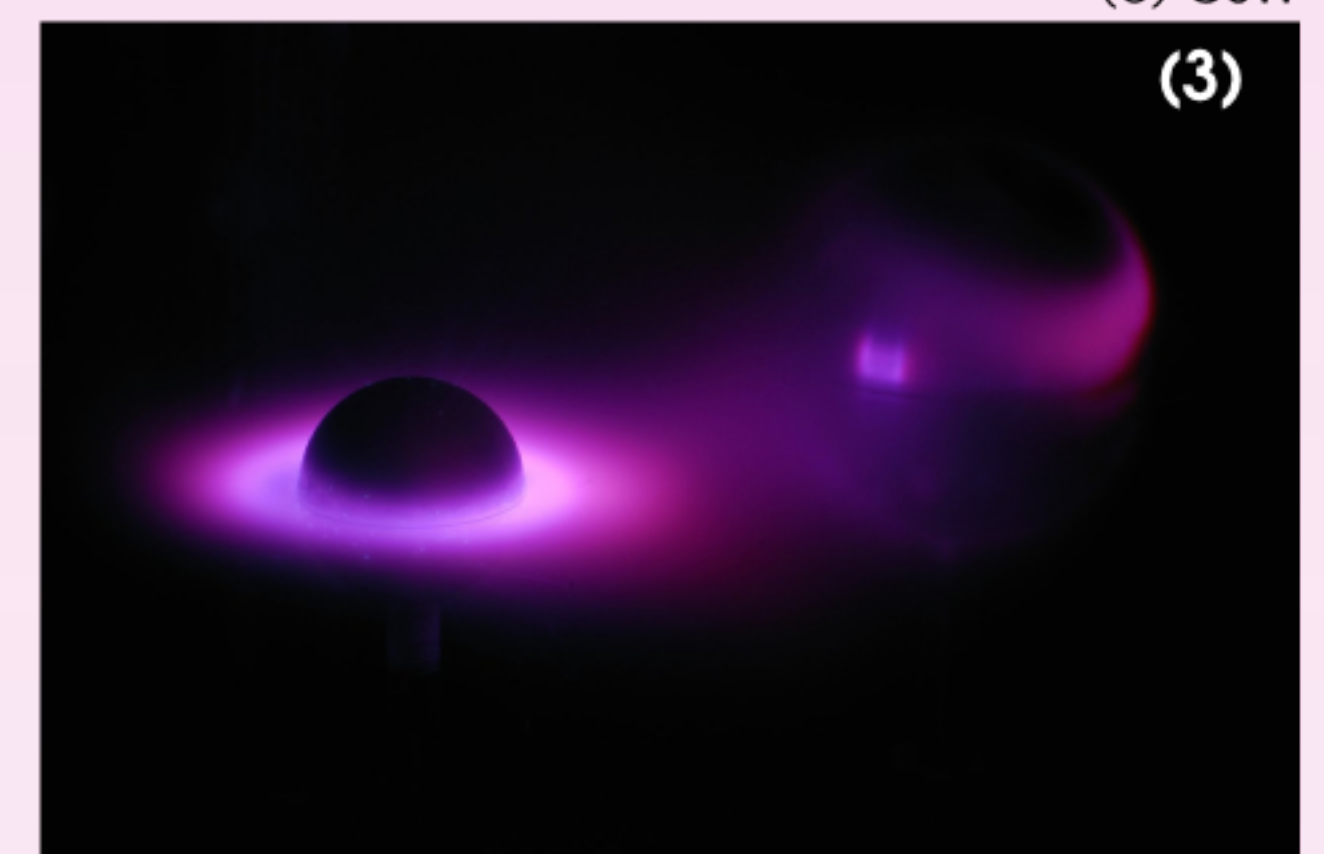
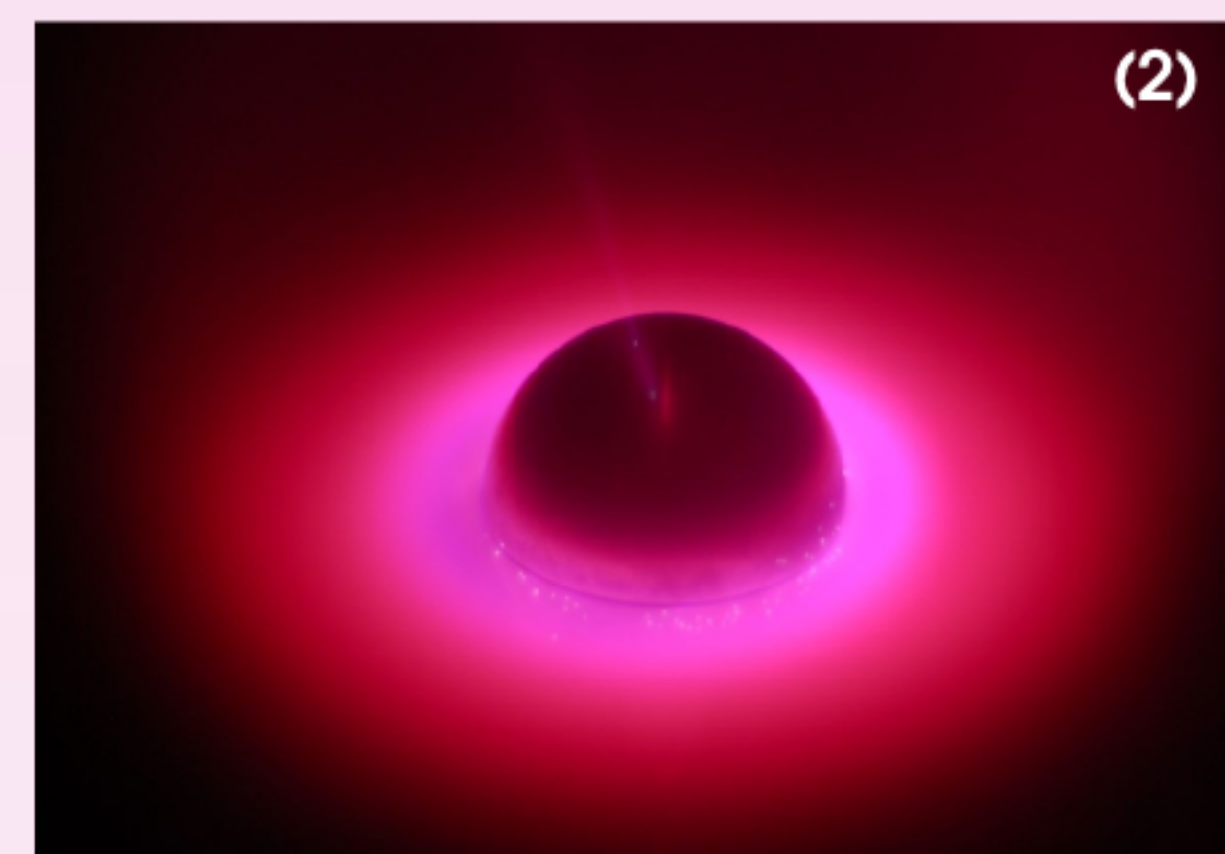


Birkeland's
experimental
set up
(Brundtland,
1997)

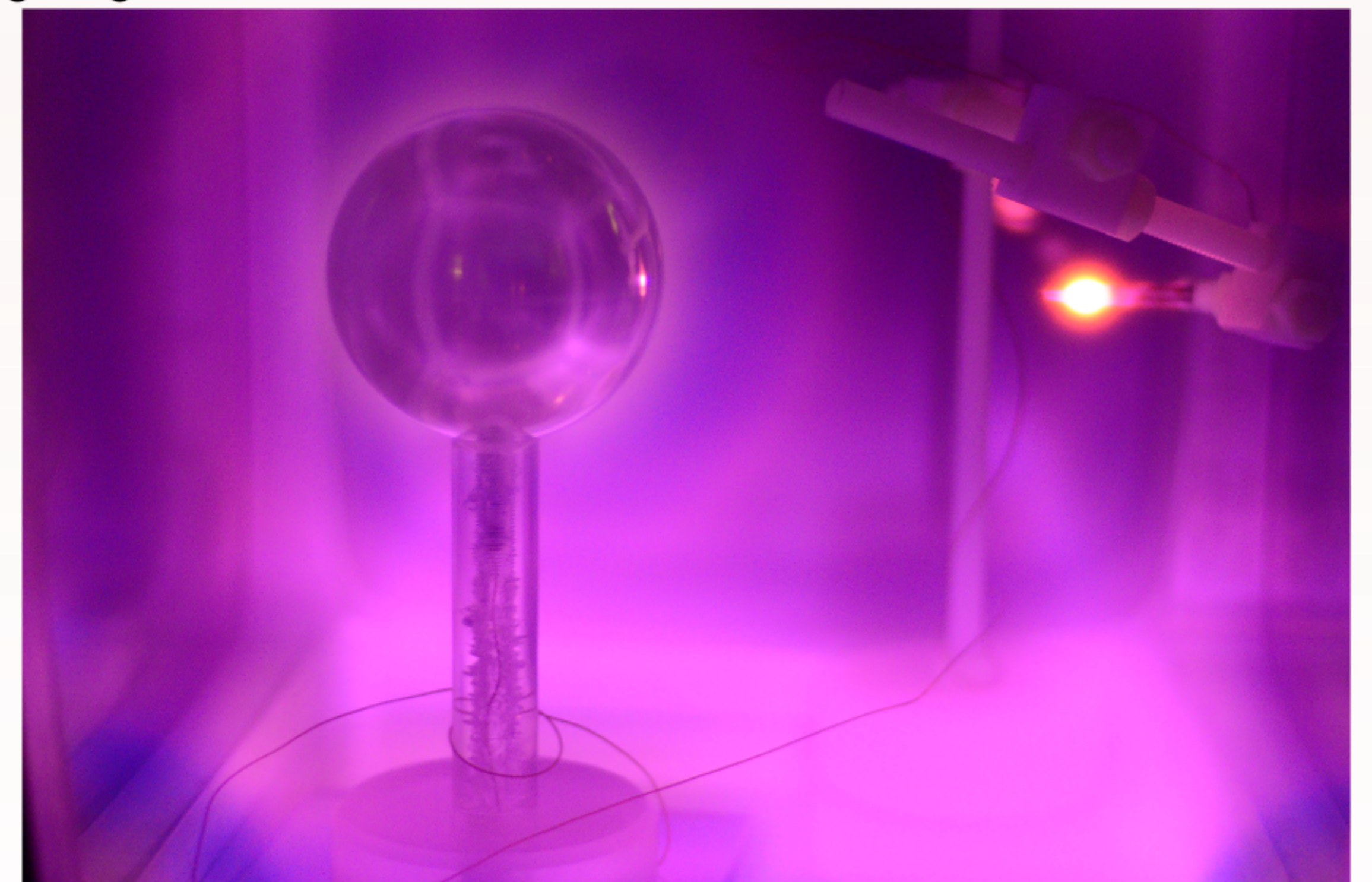
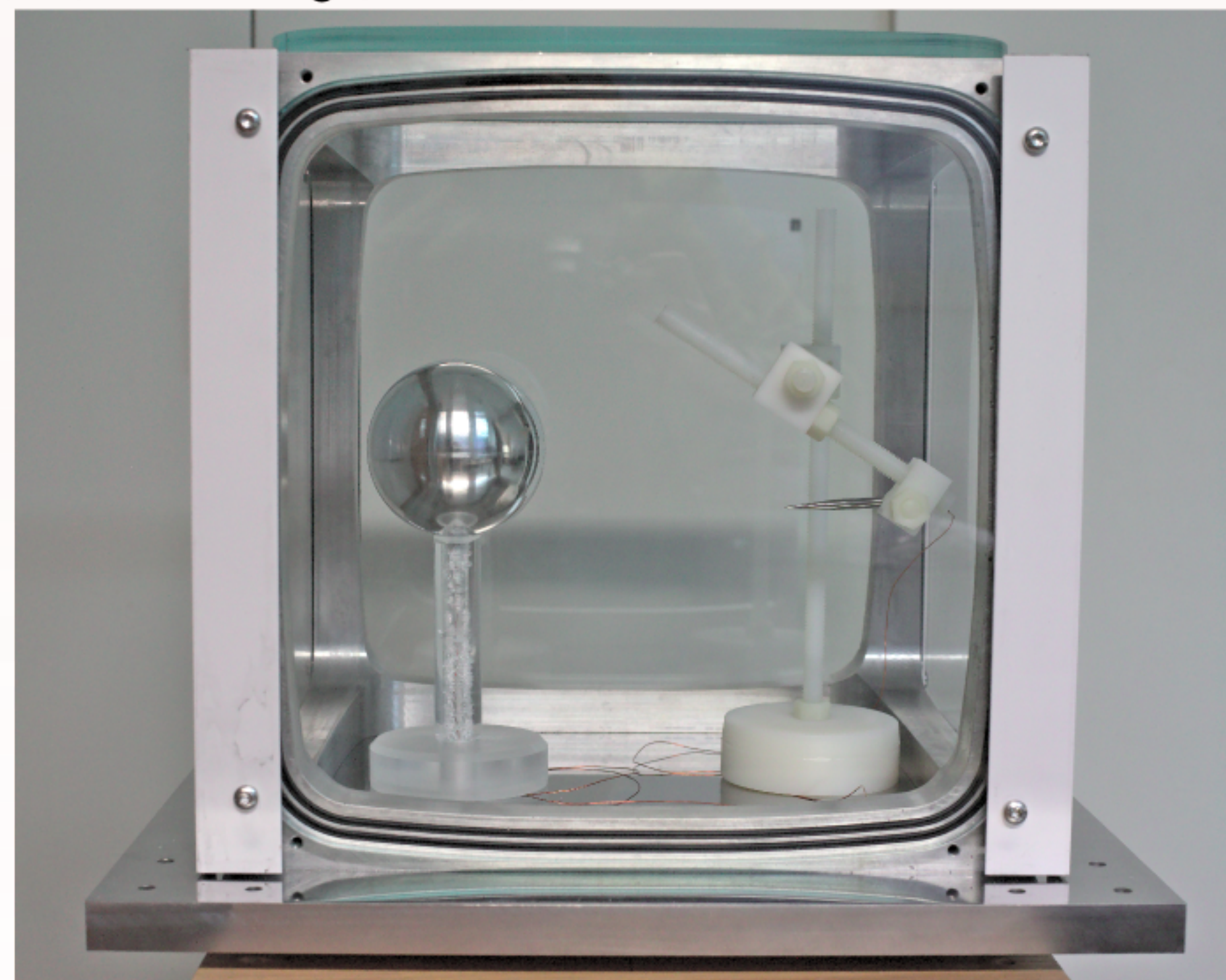
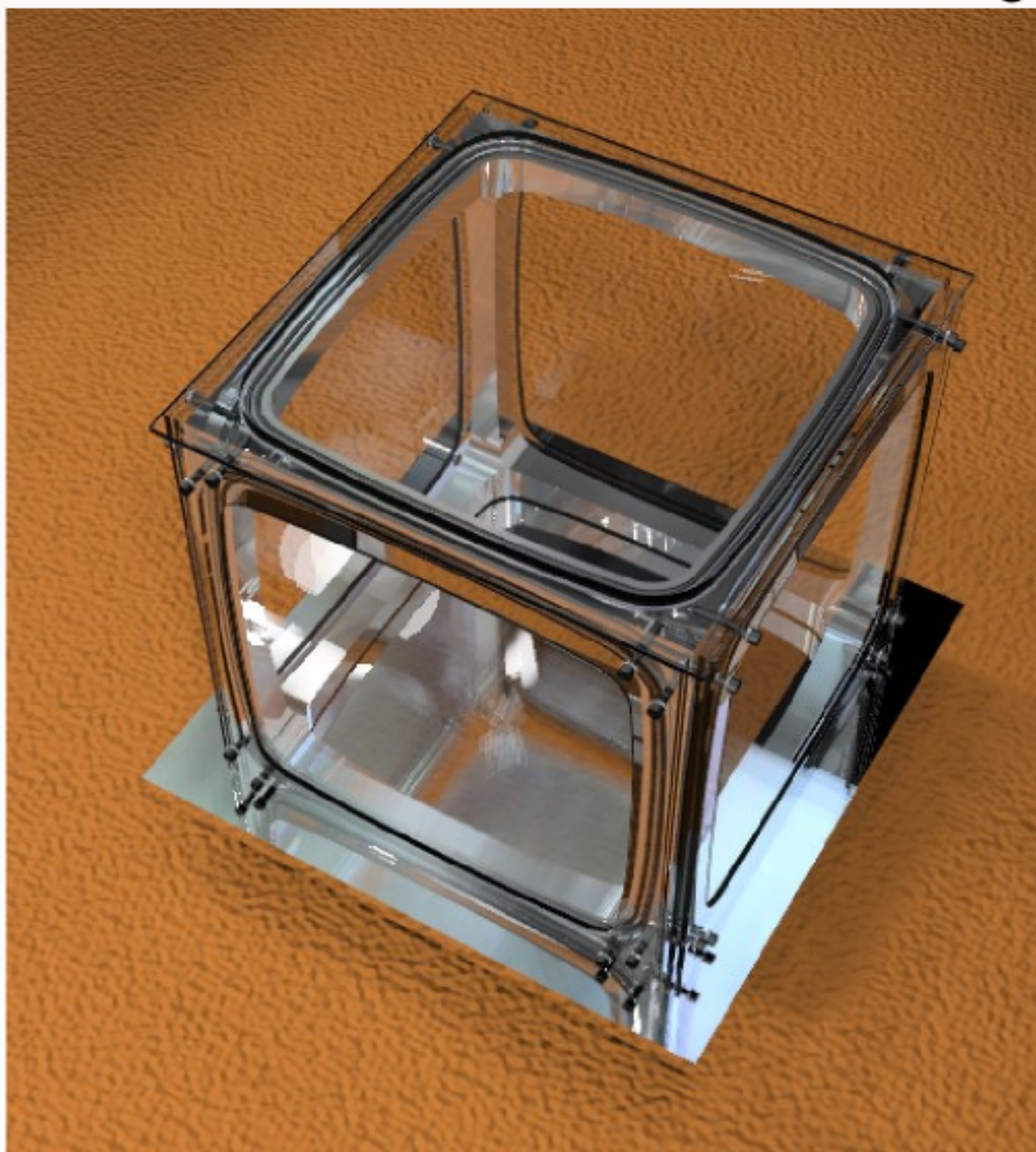
Experimental setup of all Planeterrellae



The original *Planeterrella* auroral simulator at Grenoble University
(1) Earth (2) Ring current configuration (inverted polarities) (3) Exoplanet-stellar disk binary interaction
(c) CSW



The Aalto *Terrella Cubica* from 3-D design (left) to building (middle) and first vacuum test with discharge (right) (c) CSW and TK



Further reading

Brundtland, T., The Laboratory Work of Professor Birkeland in The Auroral Observatory, University of Tromsø, 1997.
Rypdal, K. and T. Brundtland. The Birkeland Terrella Experiments and their Importance for the Modern Synergy of Laboratory & Space Plasma Physics. *J. Physique IV*, 1997, **07** (C4), 113-132.
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Lilén, J., M. Barthélemy, C. Simon, P. Jeanjacquot, and G. Gronoff, 2009, The Planeterrella, a pedagogic experiment in planetology and plasma physics, *Acta Geophysica*, **57**, 220.
Lilén, J., et al., 2013, The Planeterrella experiment: from individual initiative to networking, *Journal of Space Weather and Space Climate*, **3**, AA07.
Gronoff, G., and C. Simon Wedlund, 2011, Auroral formation and plasma interaction between magnetized objects simulated with the Planeterrella, *IEEE Trans. Plasma Science*, **39**, 2712.