



Aalto University
School of Electrical
Engineering



The PLANETERRELLA

The polar light simulator

Cyril Simon Wedlund¹

with E. Kallio¹, T. Kärkkäinen¹, M. Alho¹,
J. Lilensten², M. Barthélemy², G. Gronoff³

¹ ELEC-Aalto University, Espoo, Finland

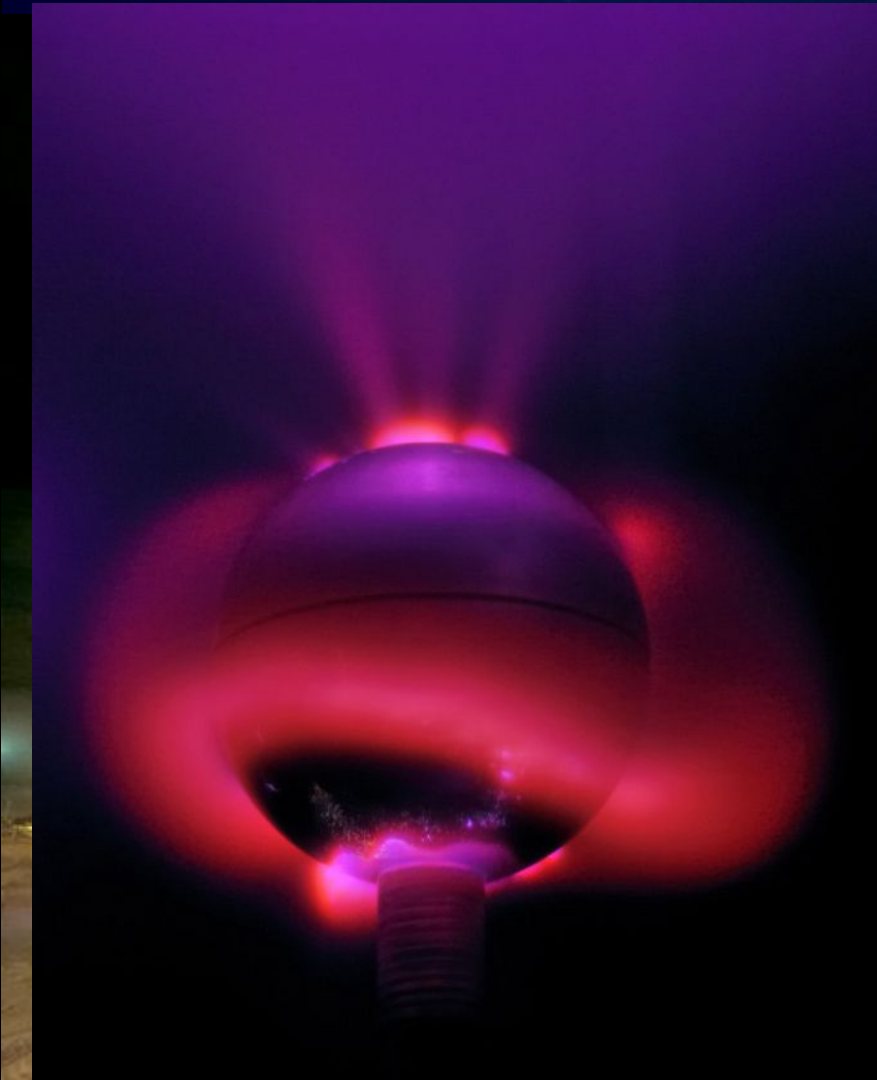
² IPAG-LPG, Grenoble, France

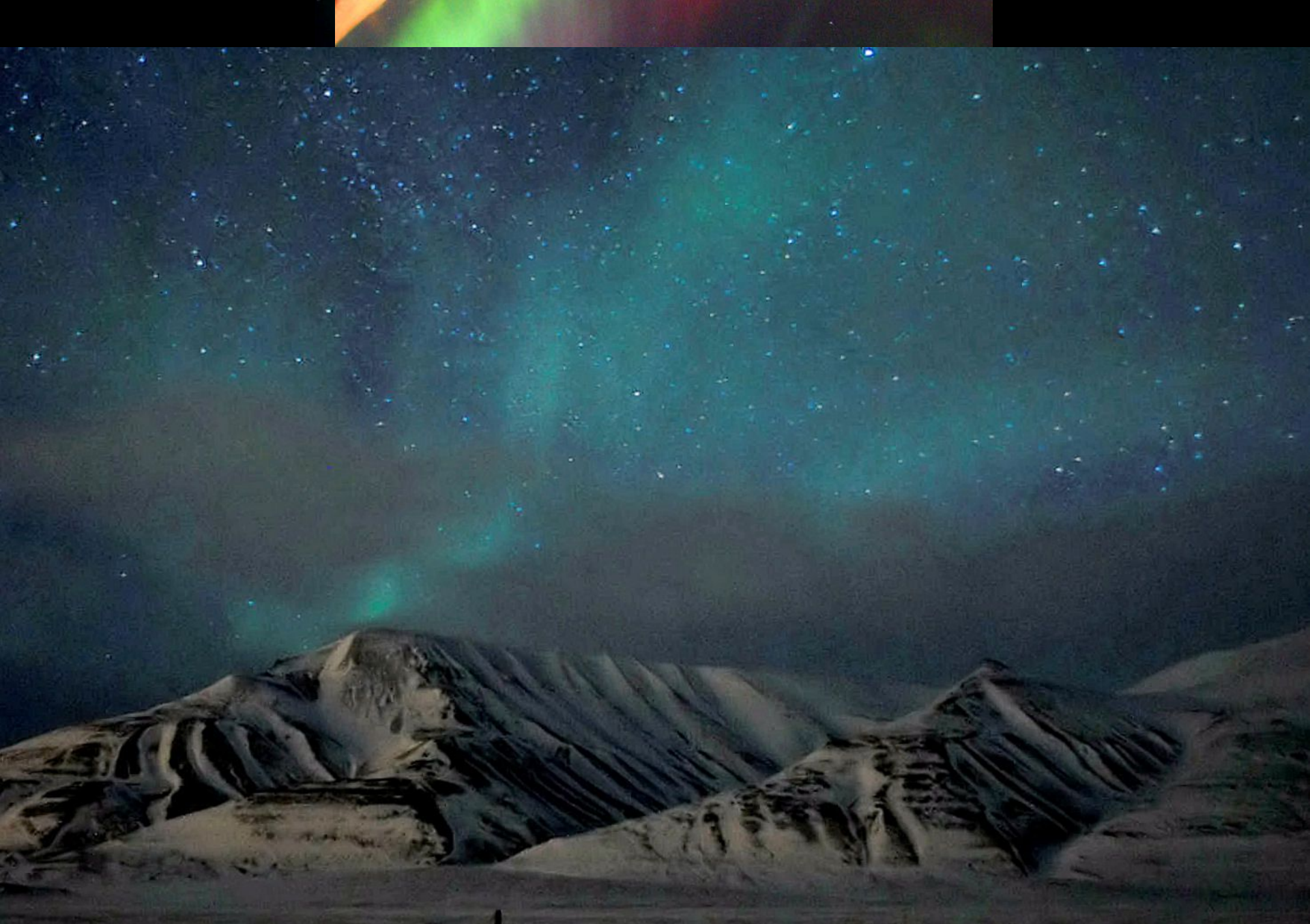
³ NASA LaRC, Langley, VA, USA



- From the aurora to the Terrella...

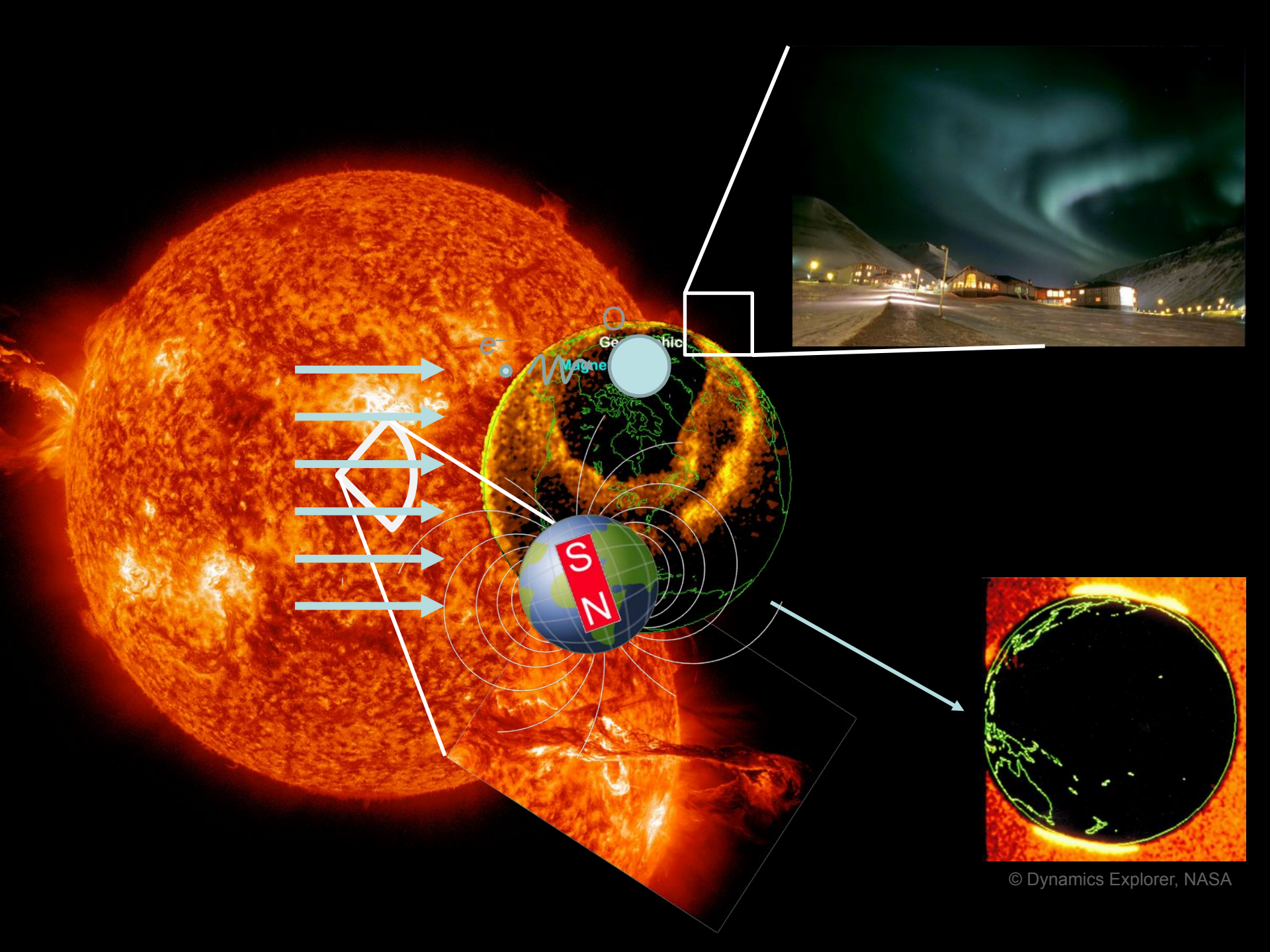
- Context
- K. Birkeland, the first space scientist
- The Terrella, Birkeland's polar light simulator





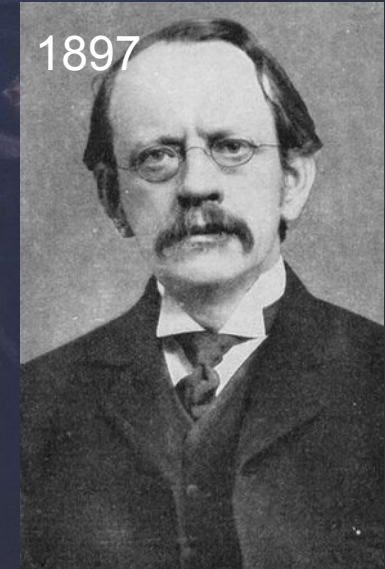
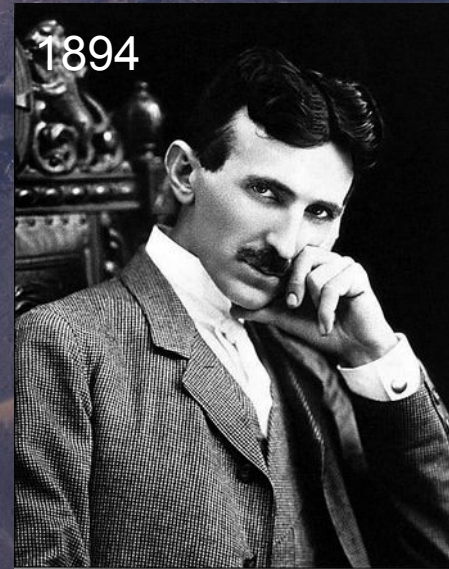
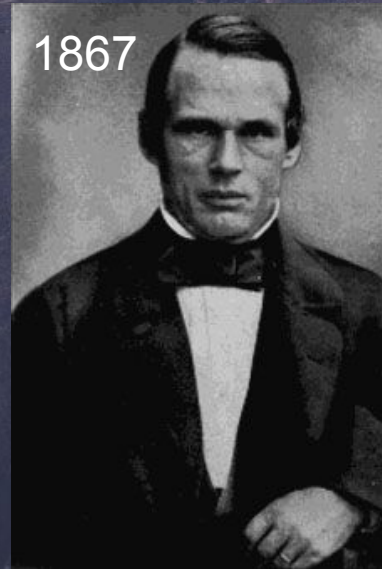
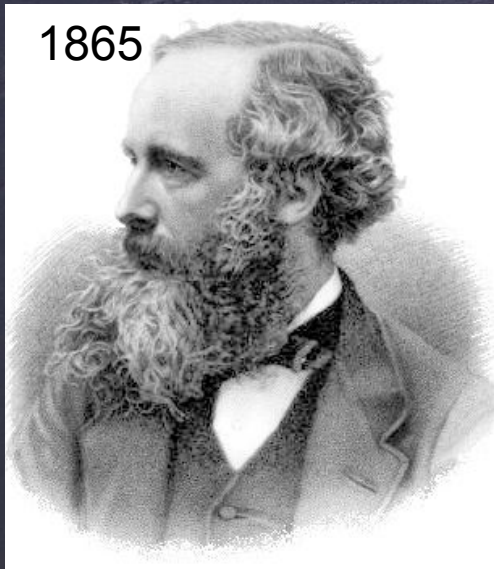
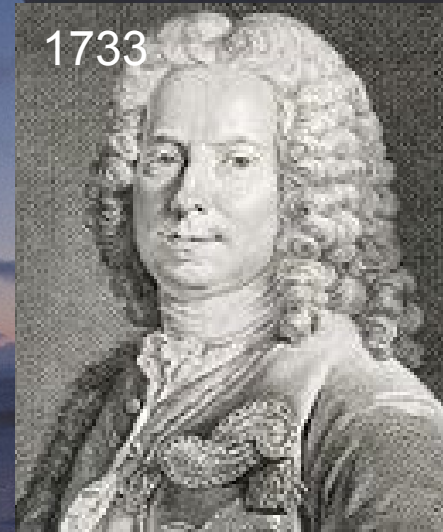
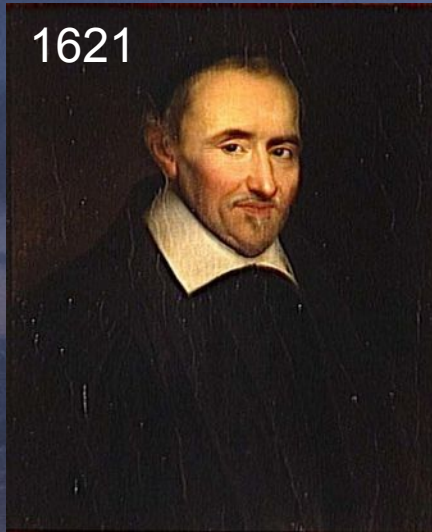
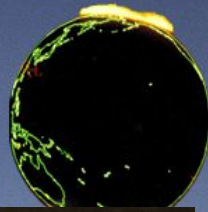
Dave Ewoldt, Oklahoma, Nov. 2003

So, what are the ingredients of the aurora?



Standing on the shoulders of
giants...

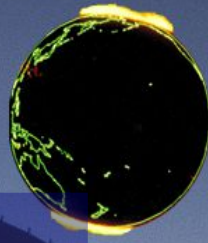
Unlocking the mysteries of the aurora





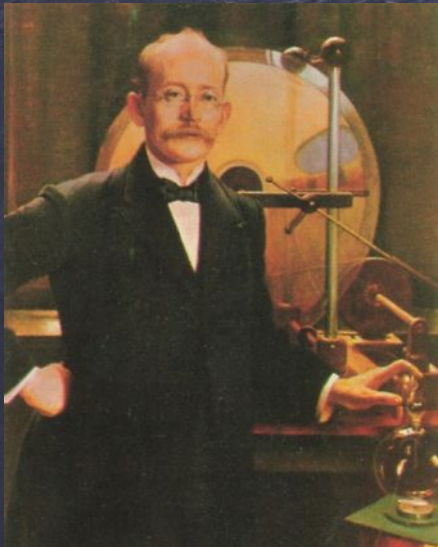
**The pioneer:
Kristian Birkeland (1867-1917)**

Birth of space physics

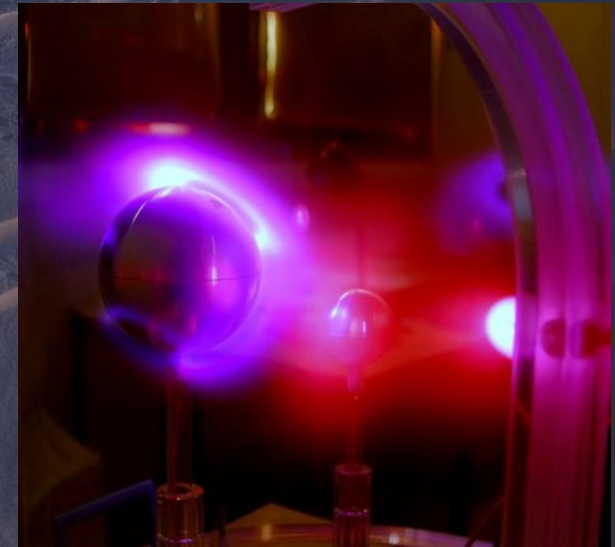


- **K. Birkeland: the first space scientist**
 - **1893** – First general solution to Maxwell's equation
 - **1896** – First experiments with discharge tubes
 - **1901** – start of the “**Terrella**” experiments
Polar expeditions with his students
 - **1908** – field-aligned currents, estimates of a current $\sim 10^6$ A, later confirmed by satellites

Oslo, 1902



Grenoble/Trieste, 2007



1106330796

NORGES BANK



200

TO HUNDRE
KRONER



200



KRISTIAN BIRKET AND 1807-1917

07002000

NORGES BANK

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TO HUNDRE KRONER

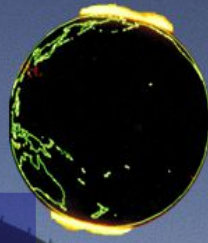


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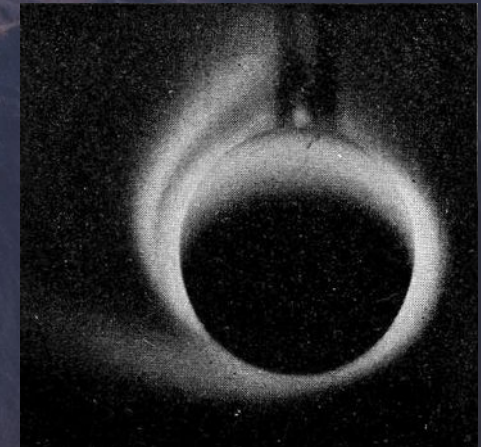
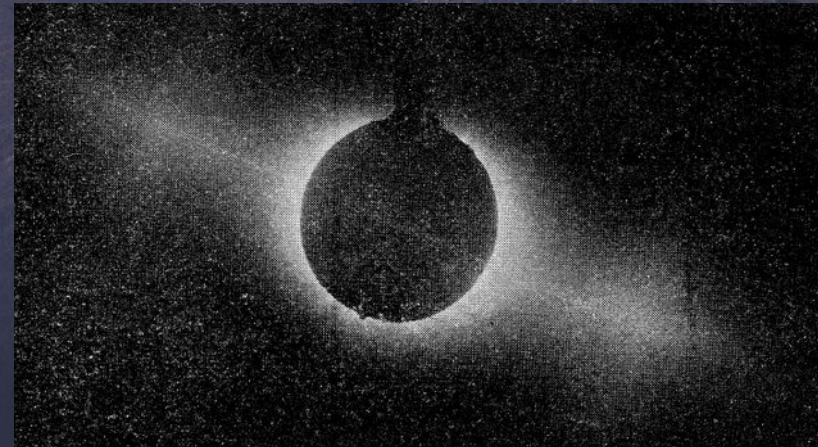
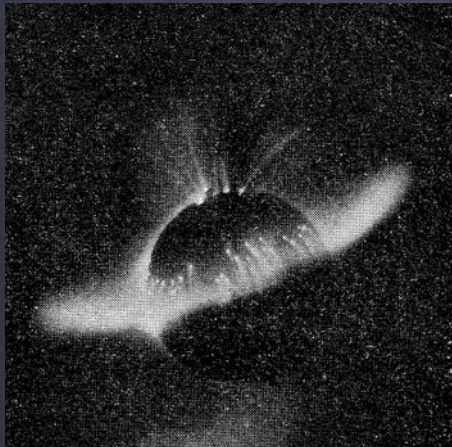
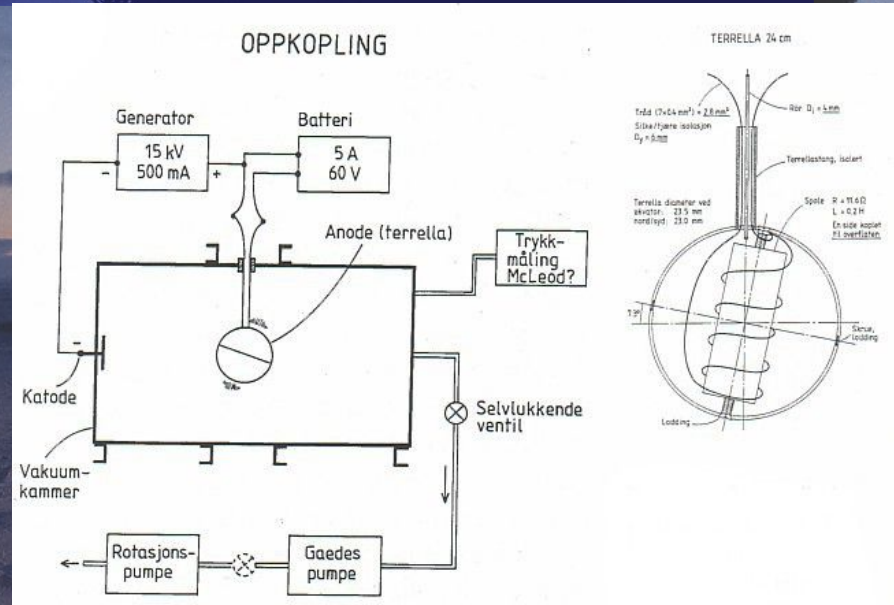
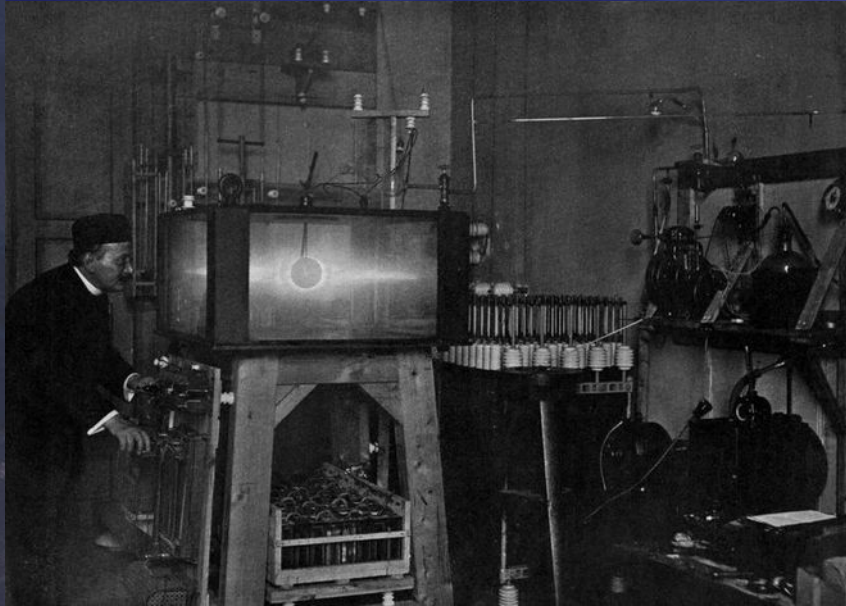


Svein Gjerdem
Sybil Johannsen

The First Space Scientist

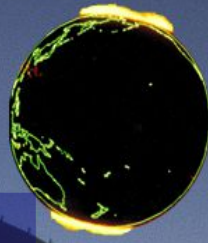


- Kristian Birkeland's terrella (1901-1917)

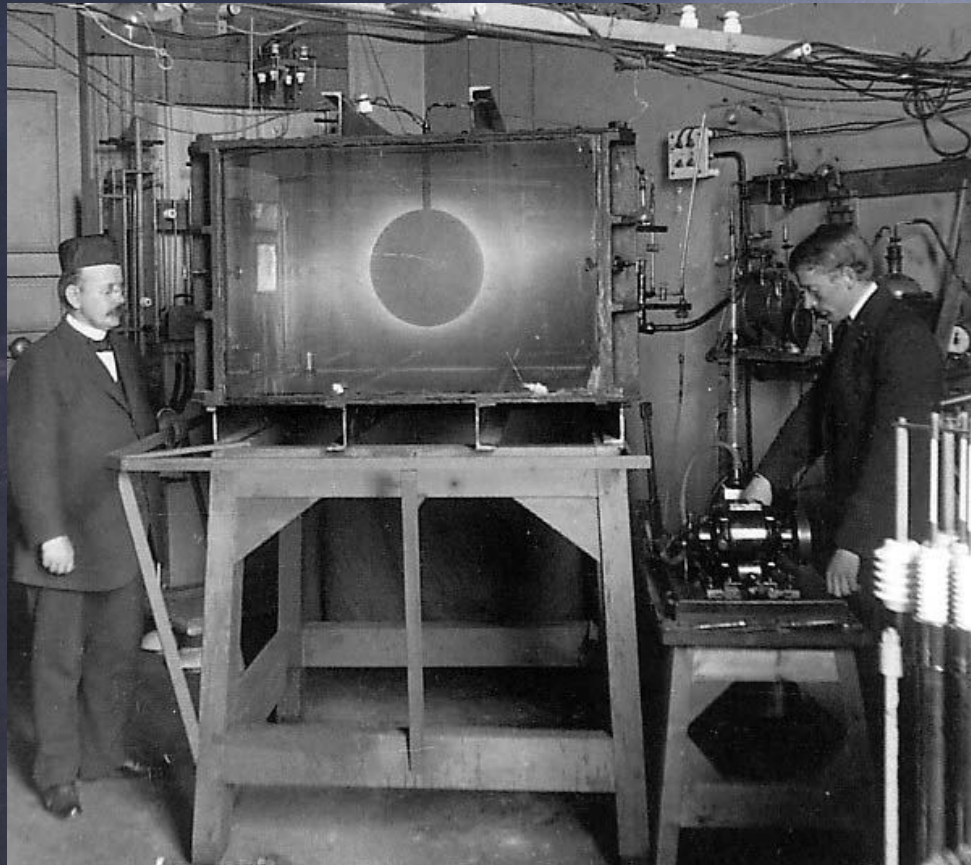


Birkeland, K., The Norwegian Aurora Polaris Expedition 1902-1903 (1913)

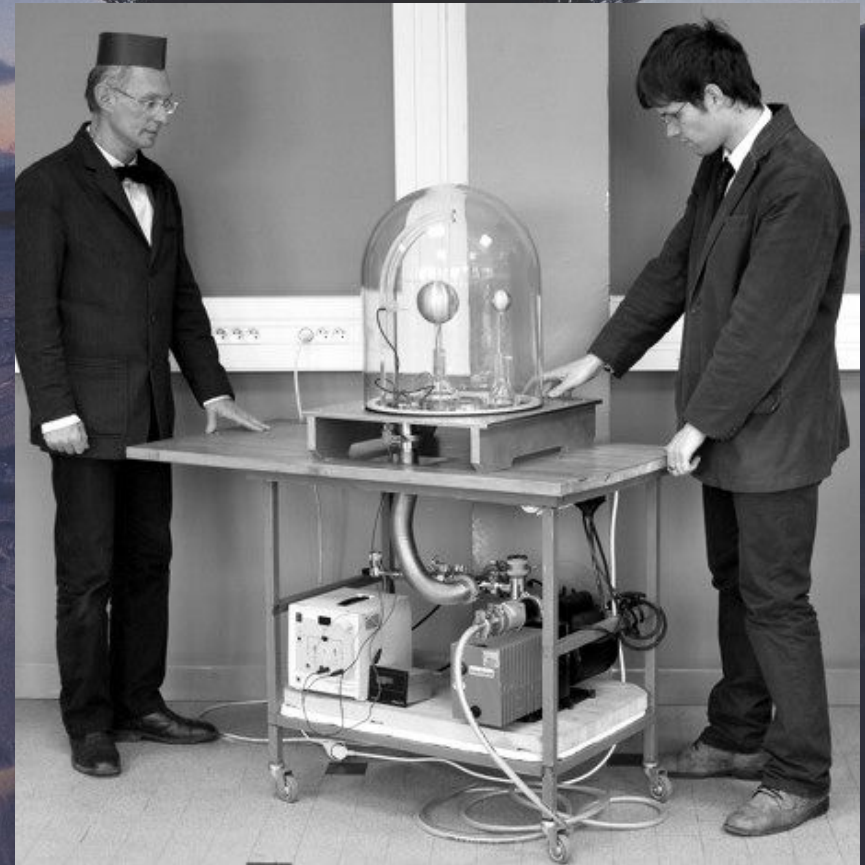
Towards the Planeterrella



- From the Terrella to the Planeterrella



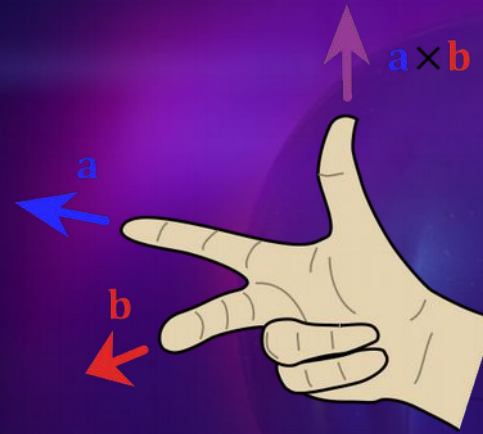
Oslo, 1912



Grenoble, 2012

Building of an aurora simulator

- First, a few tricks
 - Charged particles in a magnetic field



- Lorentz force:

$$\vec{F} \propto q \vec{v} \times \vec{B}$$

Building of an aurora simulator

• The how-to guide to the Planeterrella

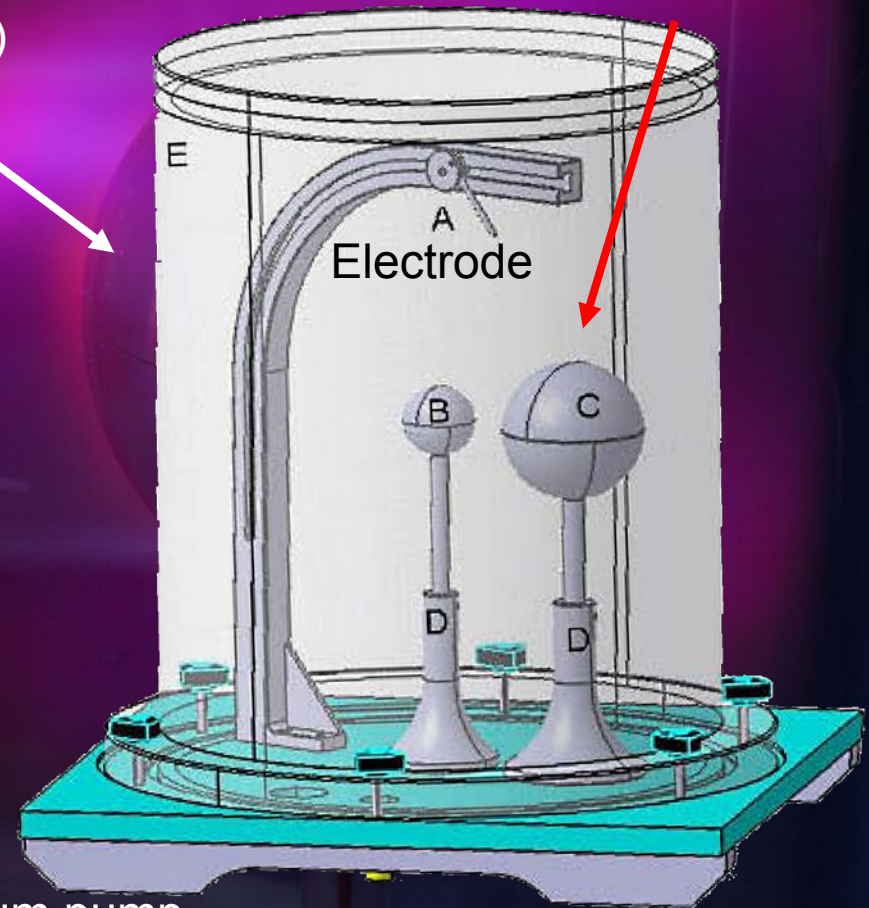
4. Magnetised spheres
aluminium
~ 1 Tesla



1. Vacuum jar (plexiglas)

2. HV generator
(0.5-1 kV)

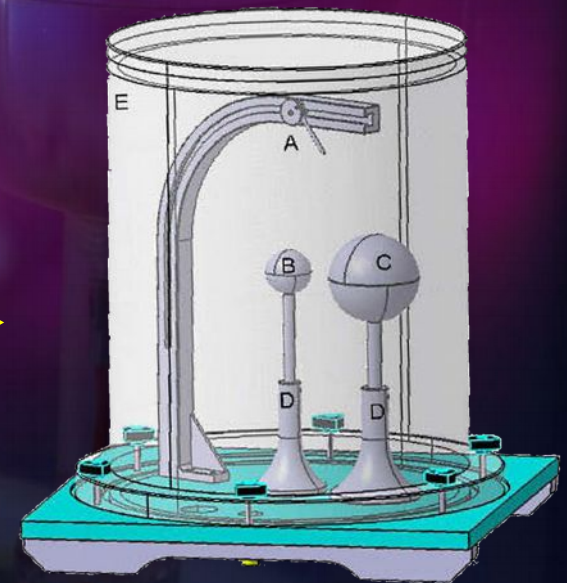
3. Primary vacuum pump
~ 1 Pa ($\sim 10^{-2}$ mbar)

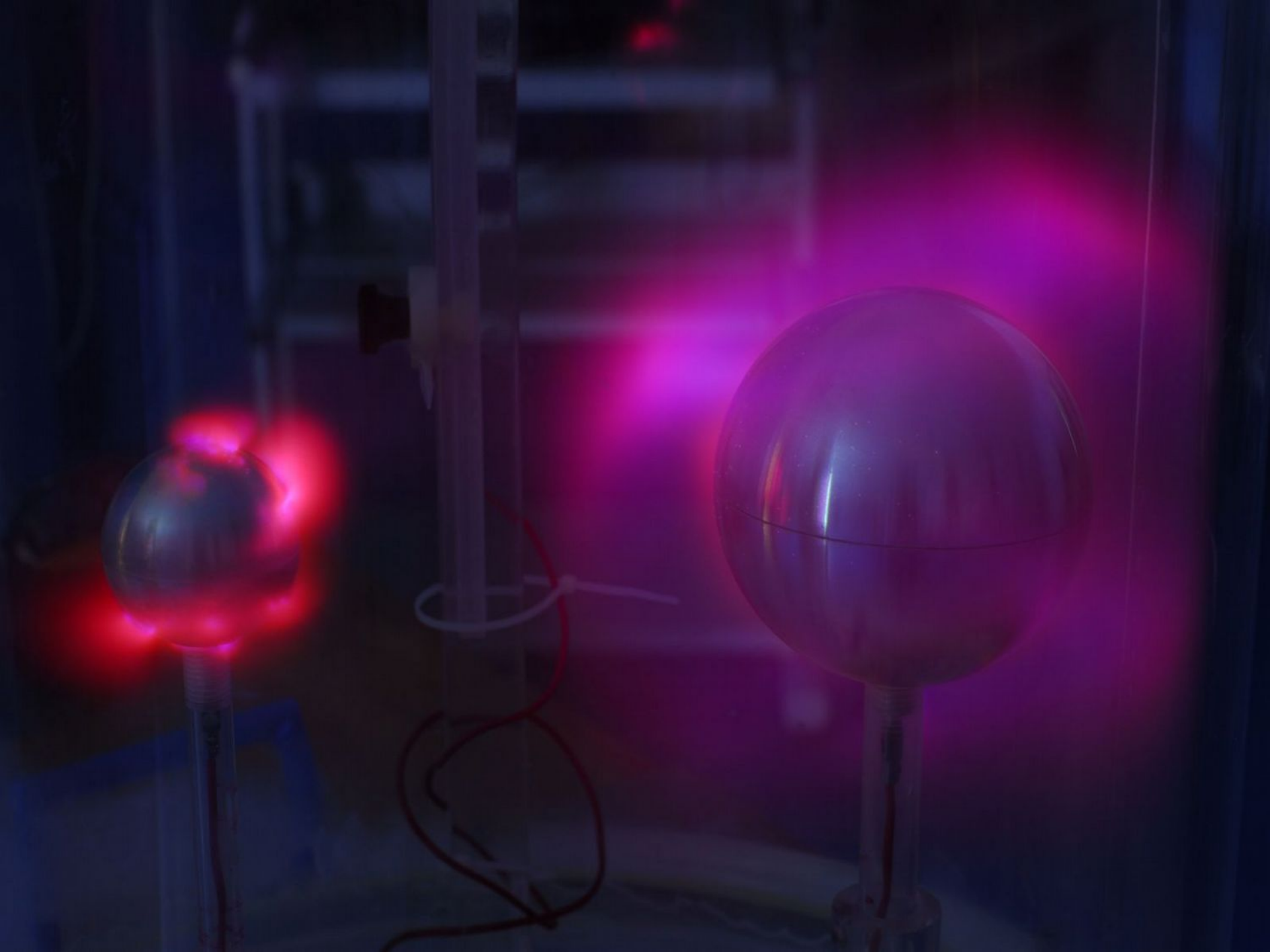


Building of an aurora simulator

- Earth as a Terrella - Analogy and scales

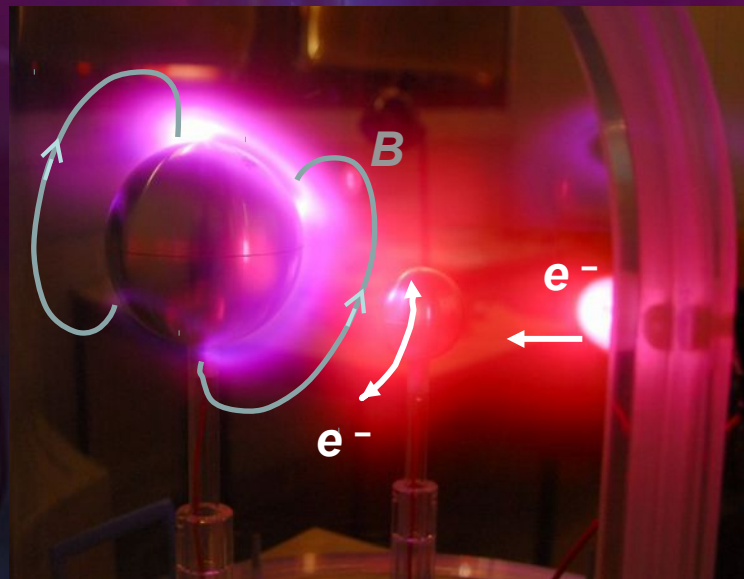
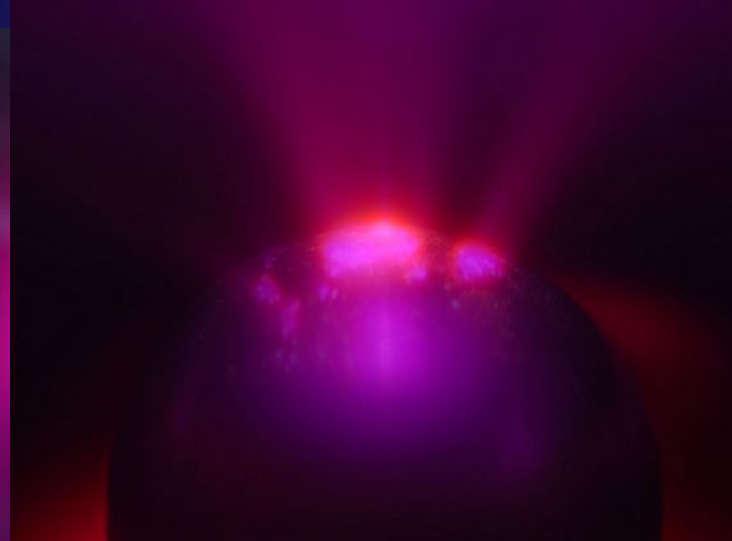
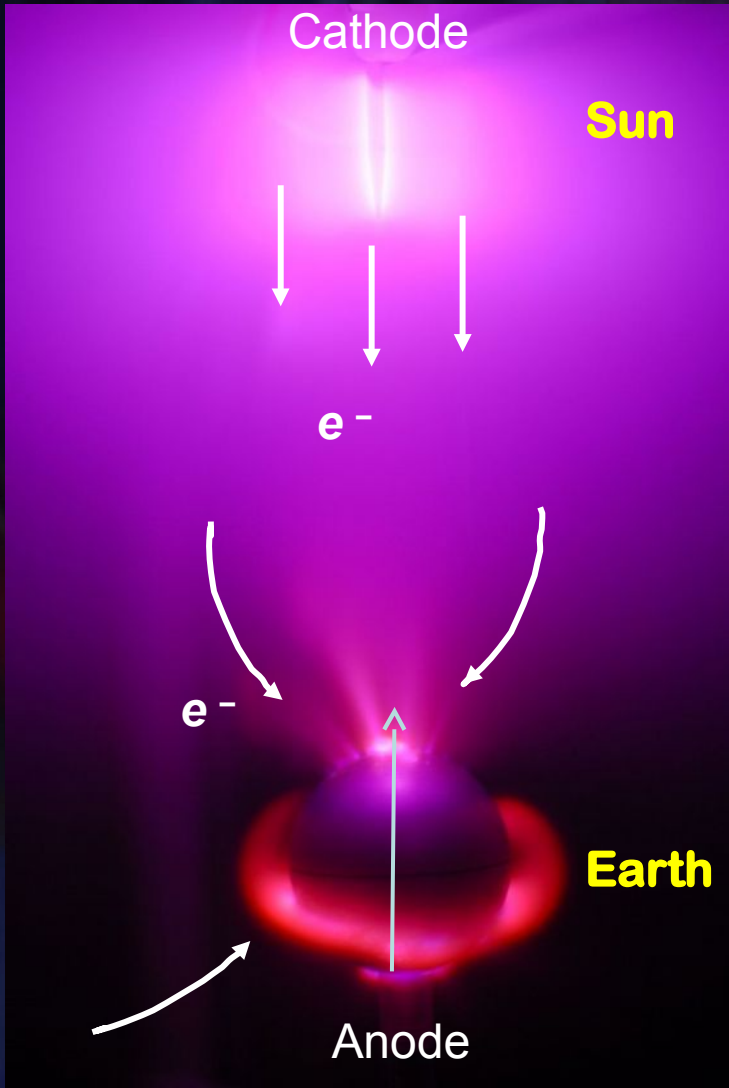
	Terrella	Earth	
✂ Planet \varnothing (m)	0.1	$12 \cdot 10^6$	x
✂ Energy of e^- (keV)	~ 10.5 -5		✓
✂ Vacuum (bar)	10^{-5}	10^{-5} (h = 100 km)	✓
✂ Magnetic field (T)	1	$50 \cdot 10^{-6}$	x





The Planeterrella in action

- Auroral oval mode



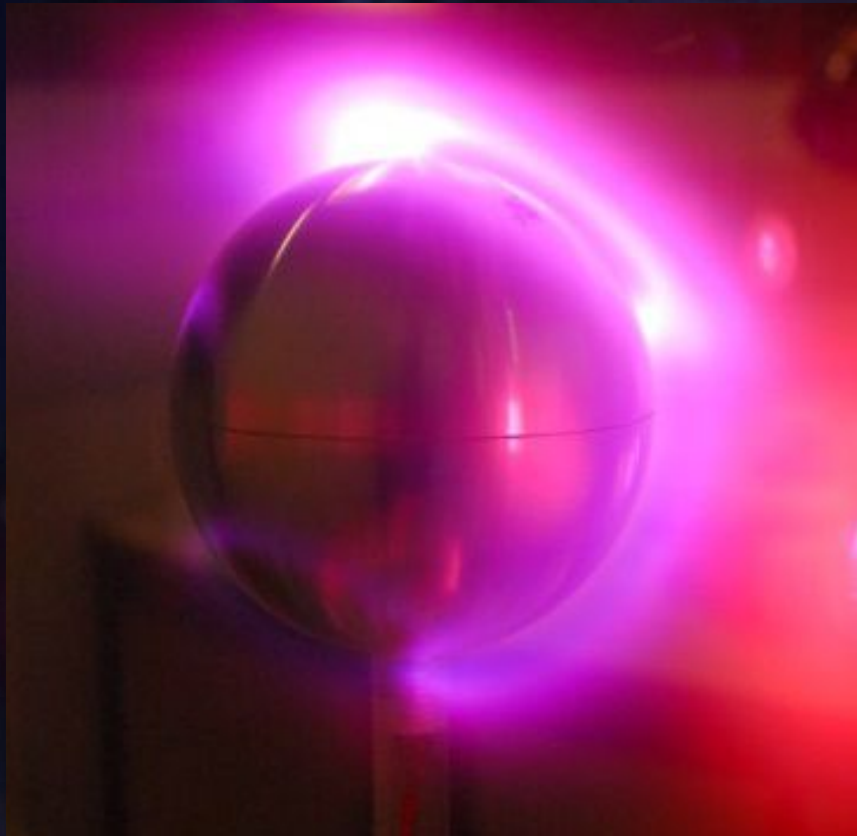
The Planeterrella in action

- Auroral oval mode

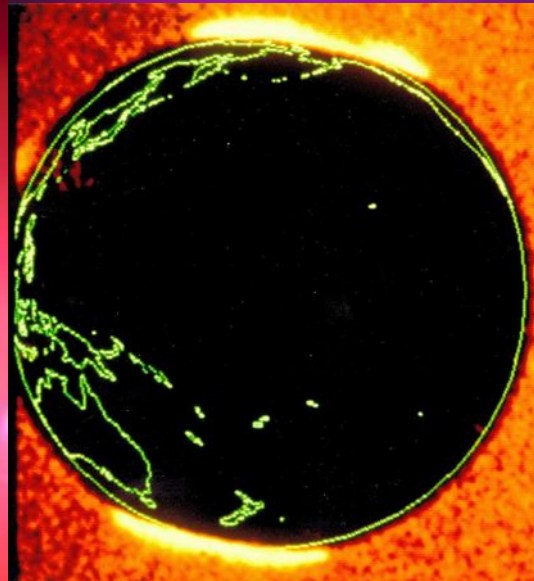


The Planeterrella in action

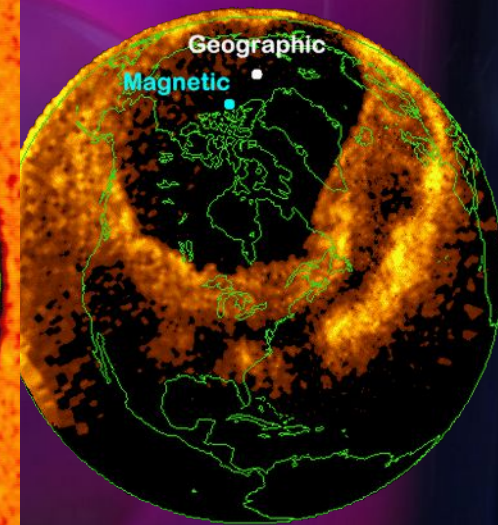
- Auroral oval mode

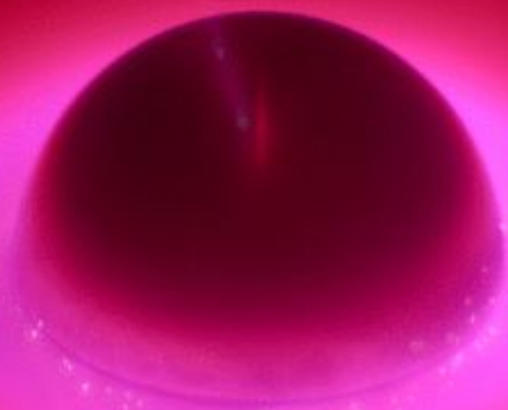


Planeterrella experiment
'aurora mode'



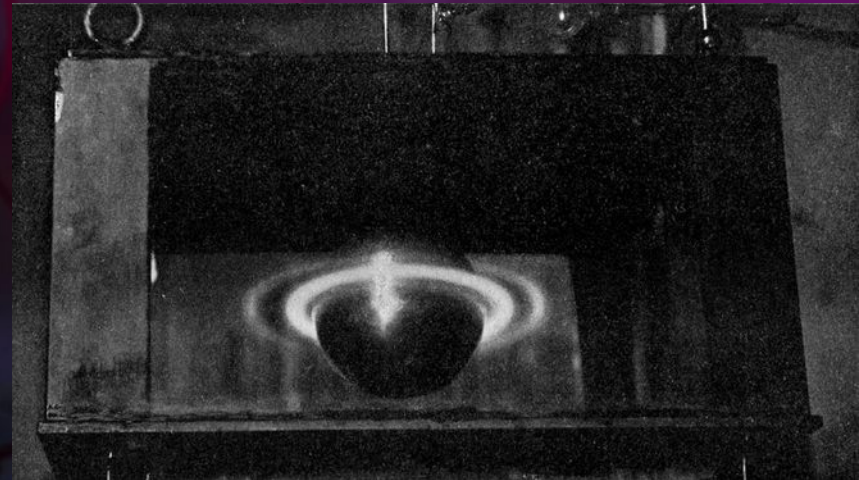
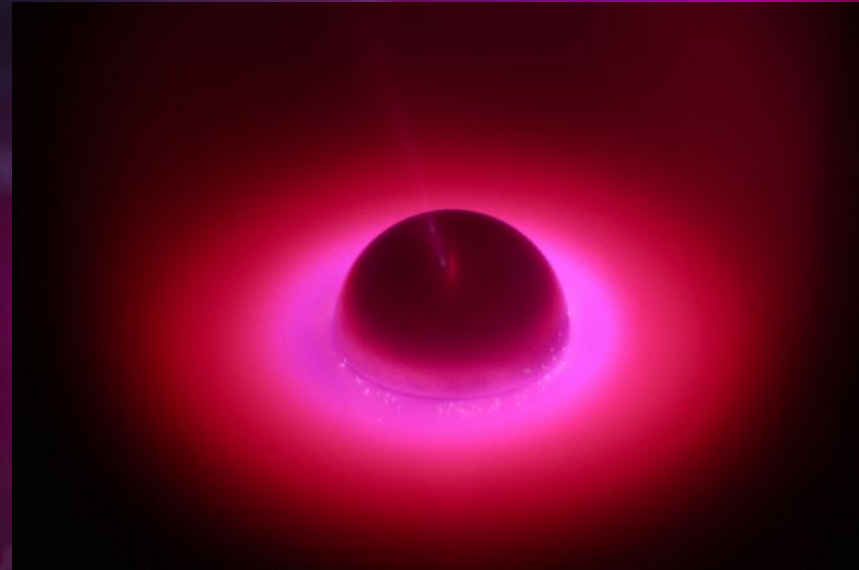
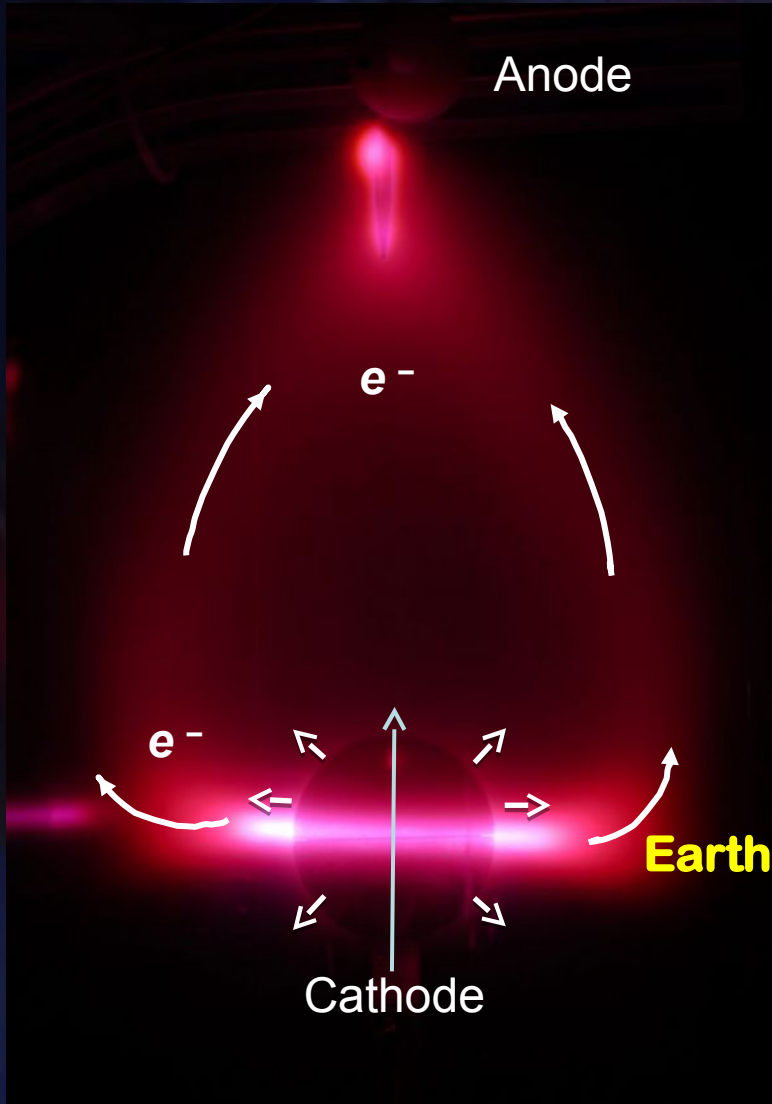
Satellite image of Earth
(Dynamics Explorer, NASA)





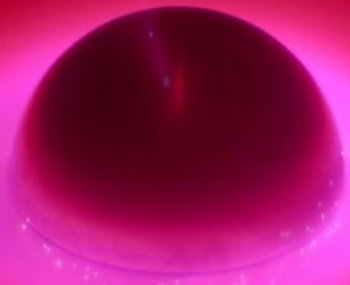
The Planeterrella in action

- 'Ring current' mode



The Planeterrella in action

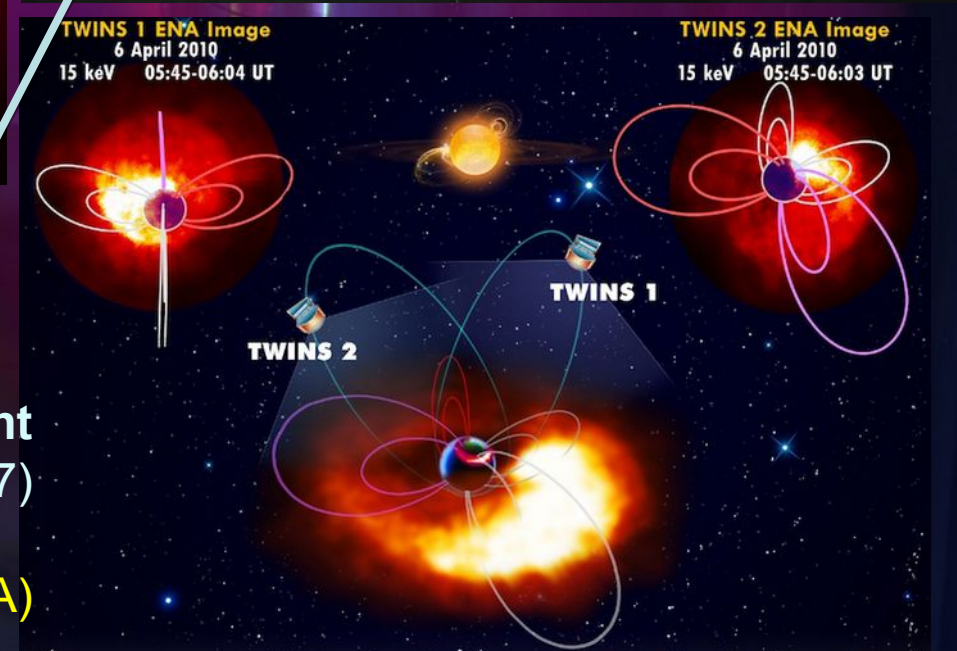
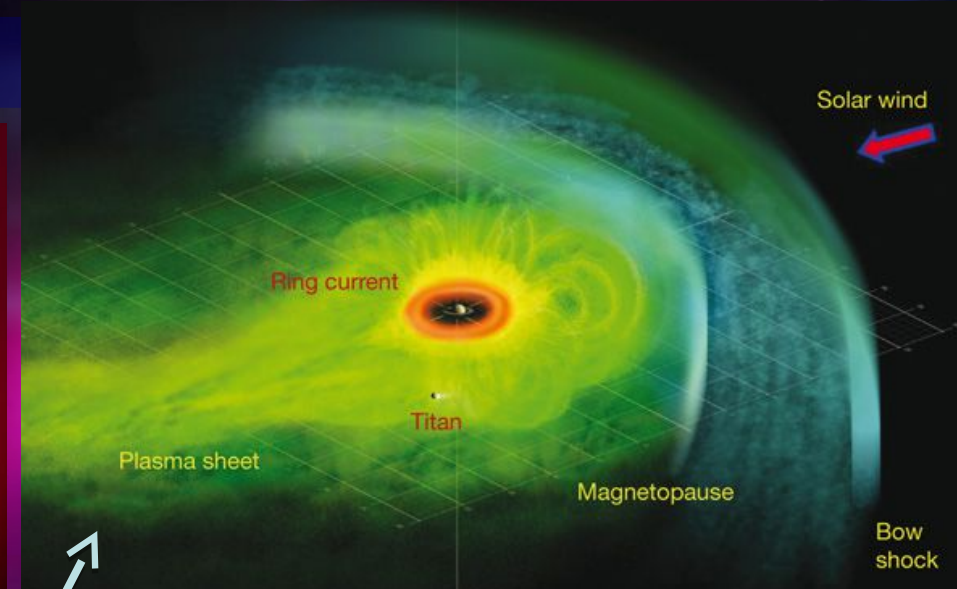
- 'Ring current' mode



Planeterrella experiment
'ring current mode'

Artist rendition of Saturn's ring current
(Krimigis et al., 2007)

Current goal of mission TWINS (NASA)



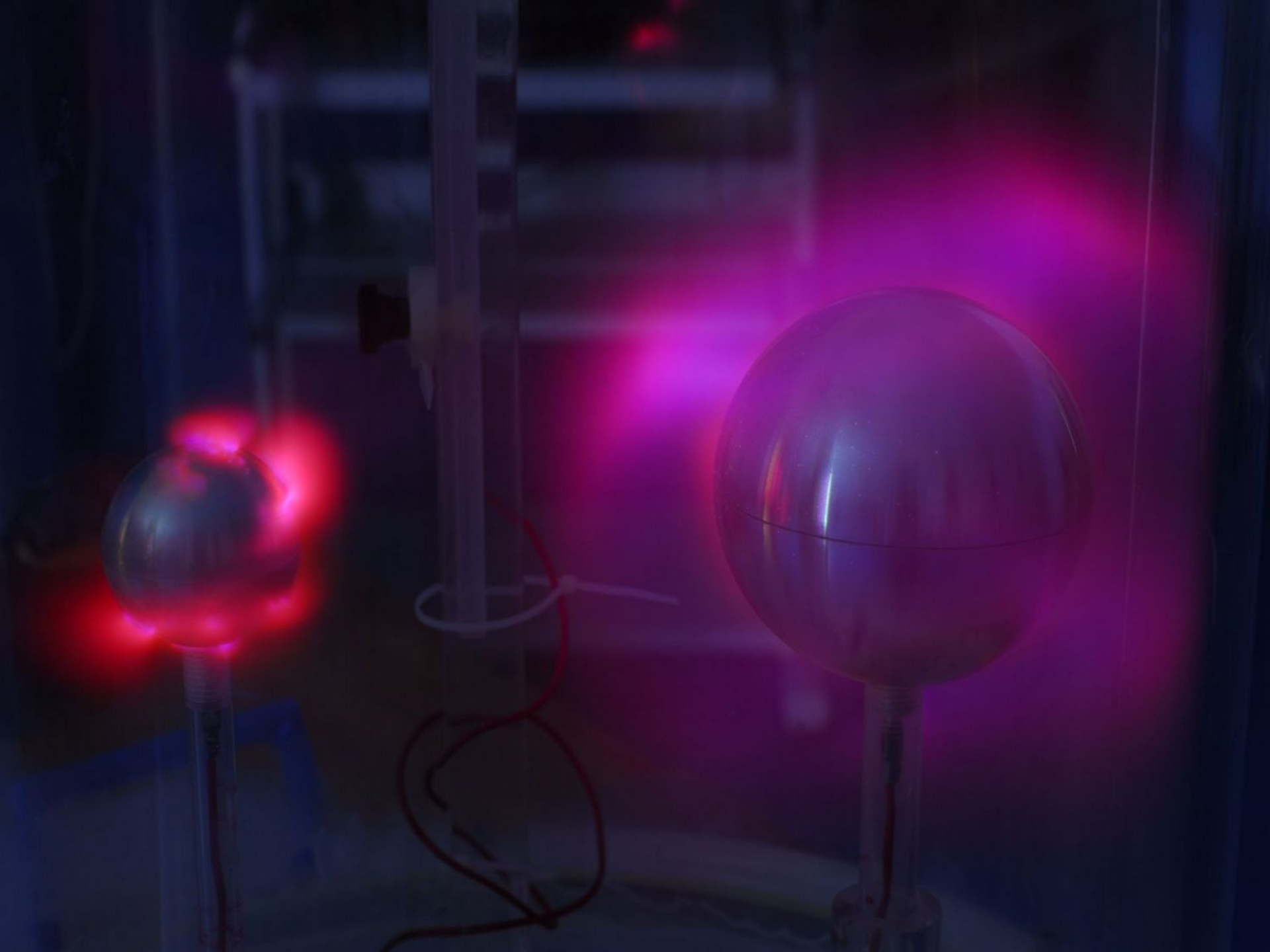
- Join us at:

- <http://planeterrella.osug.fr/?lang=en>

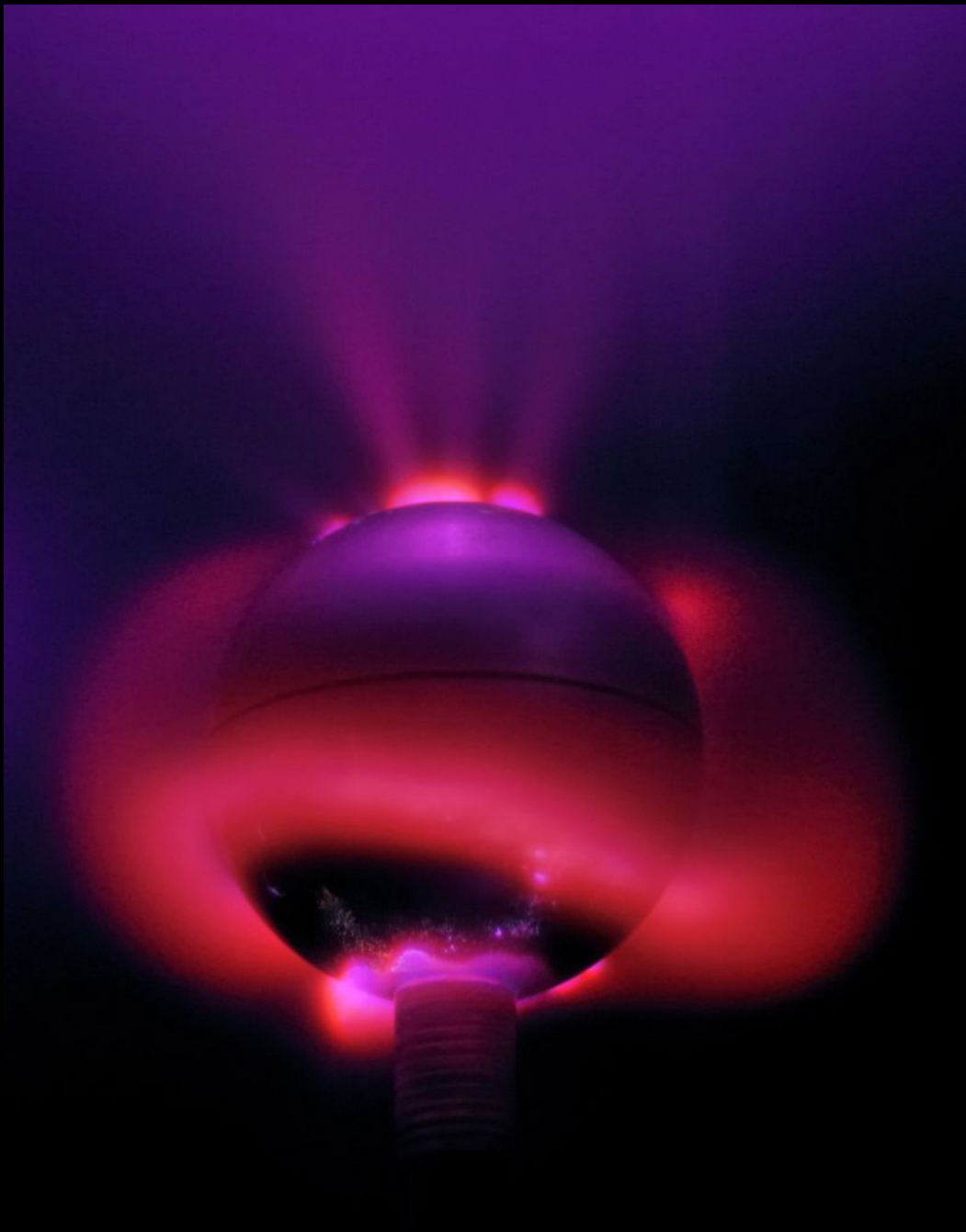
and

- <http://space.aalto.fi>



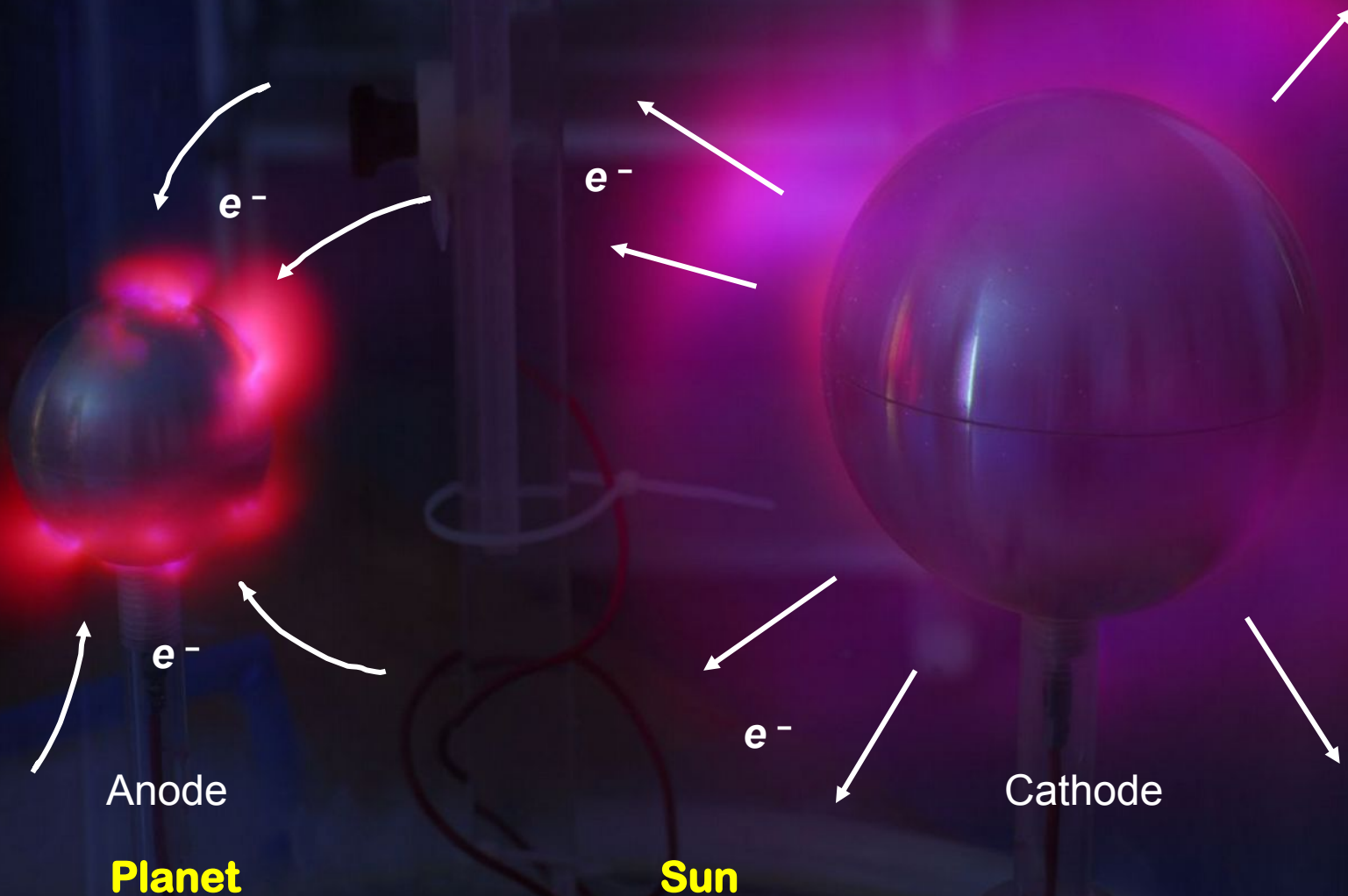






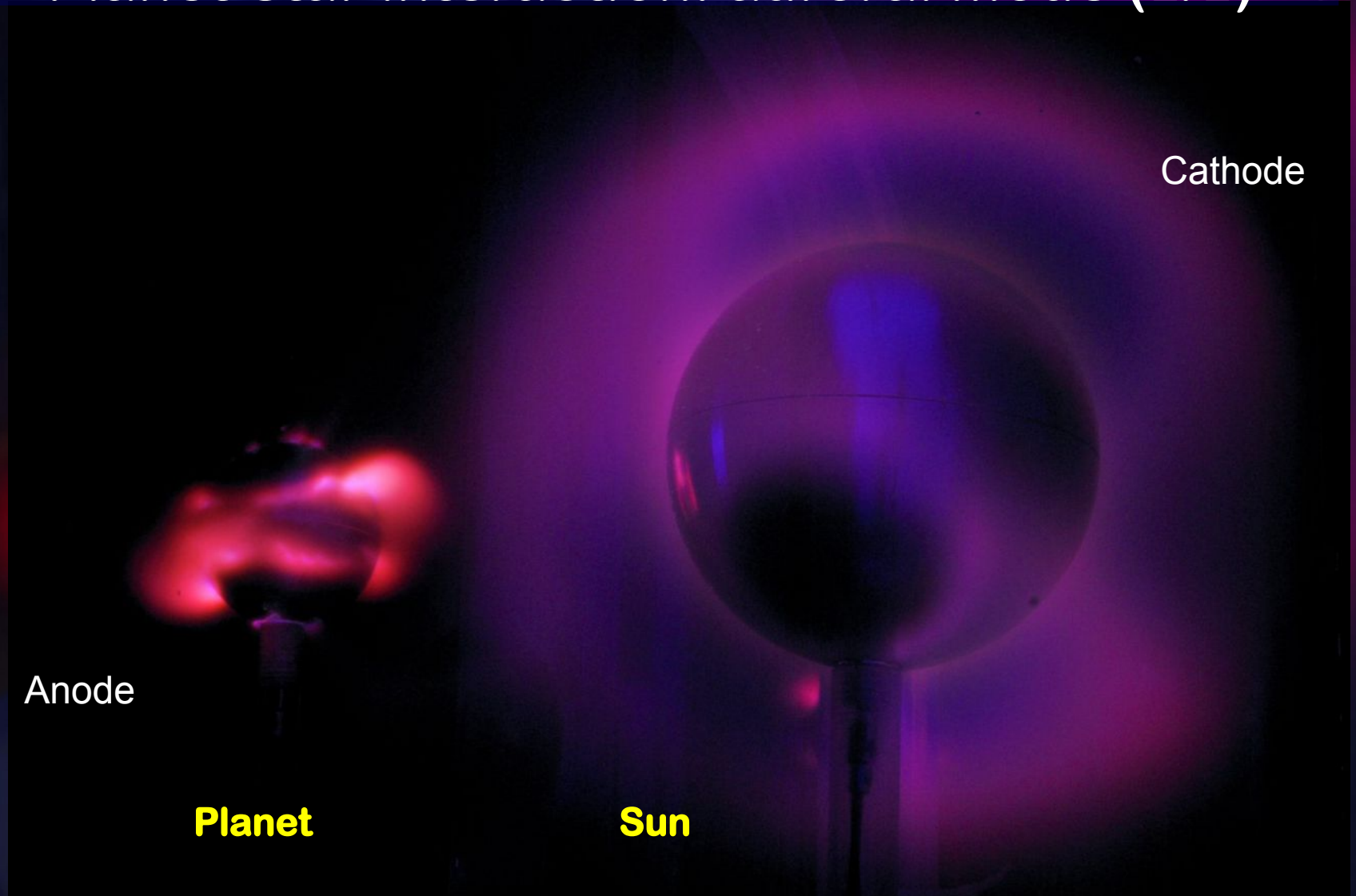
The Planeterrella in action

- Planet-star interaction: auroral mode (1/2)



The Planeterrella in action

- Planet-star interaction: auroral mode (2/2)

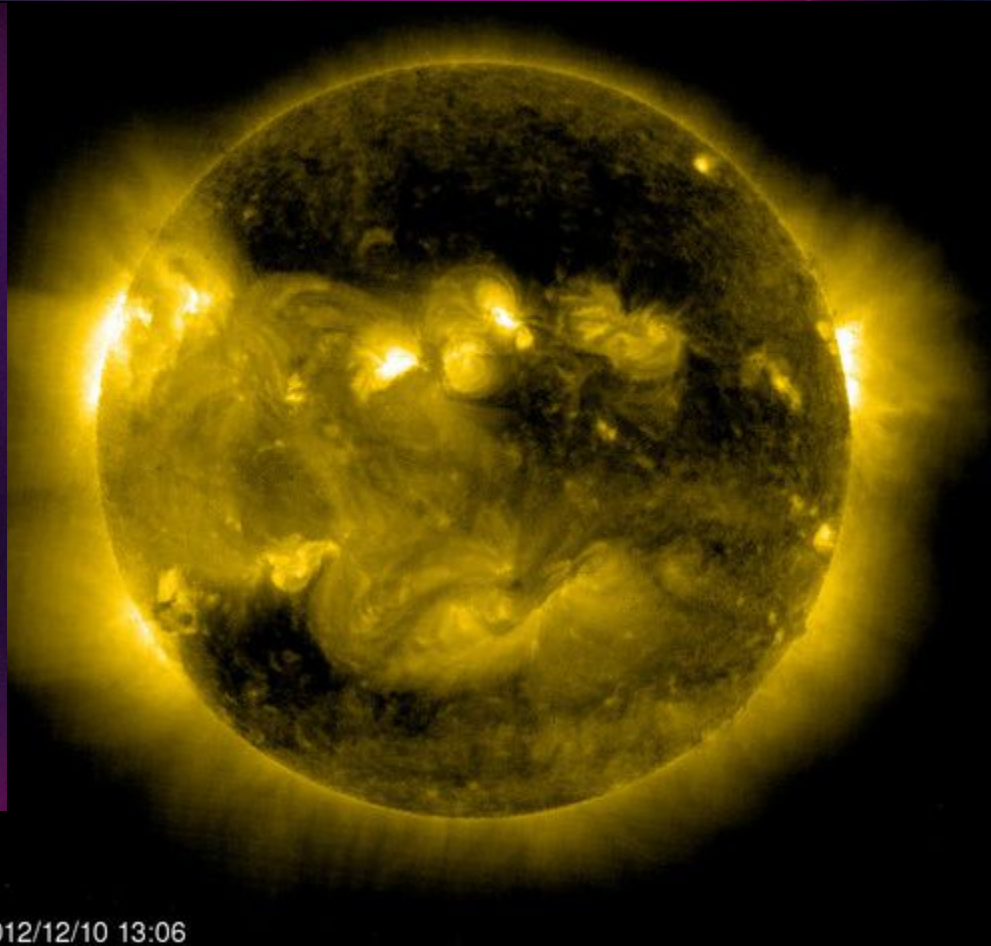


The Planeterrella in action

- Planet-star interaction: auroral mode (2/2)

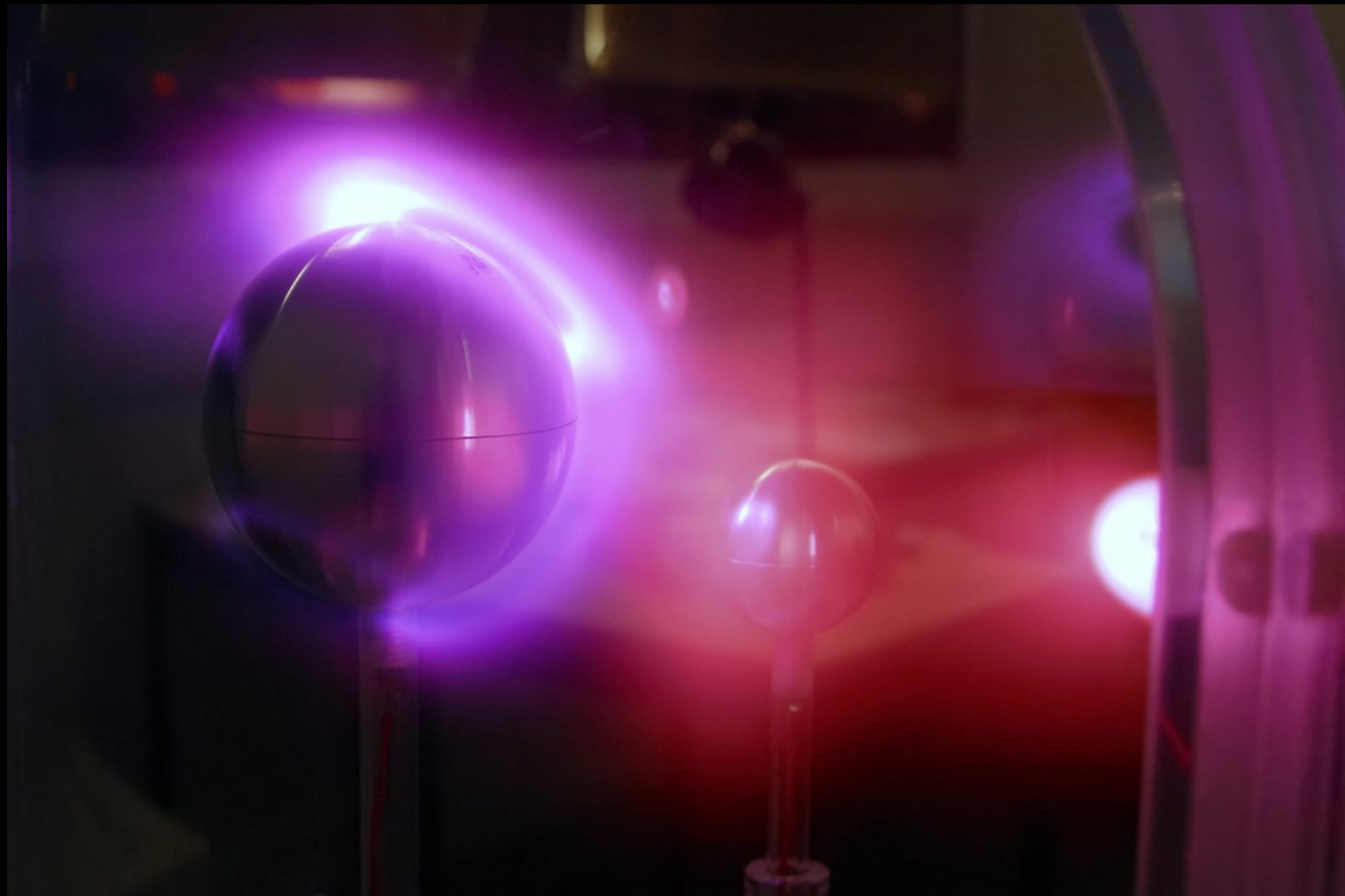


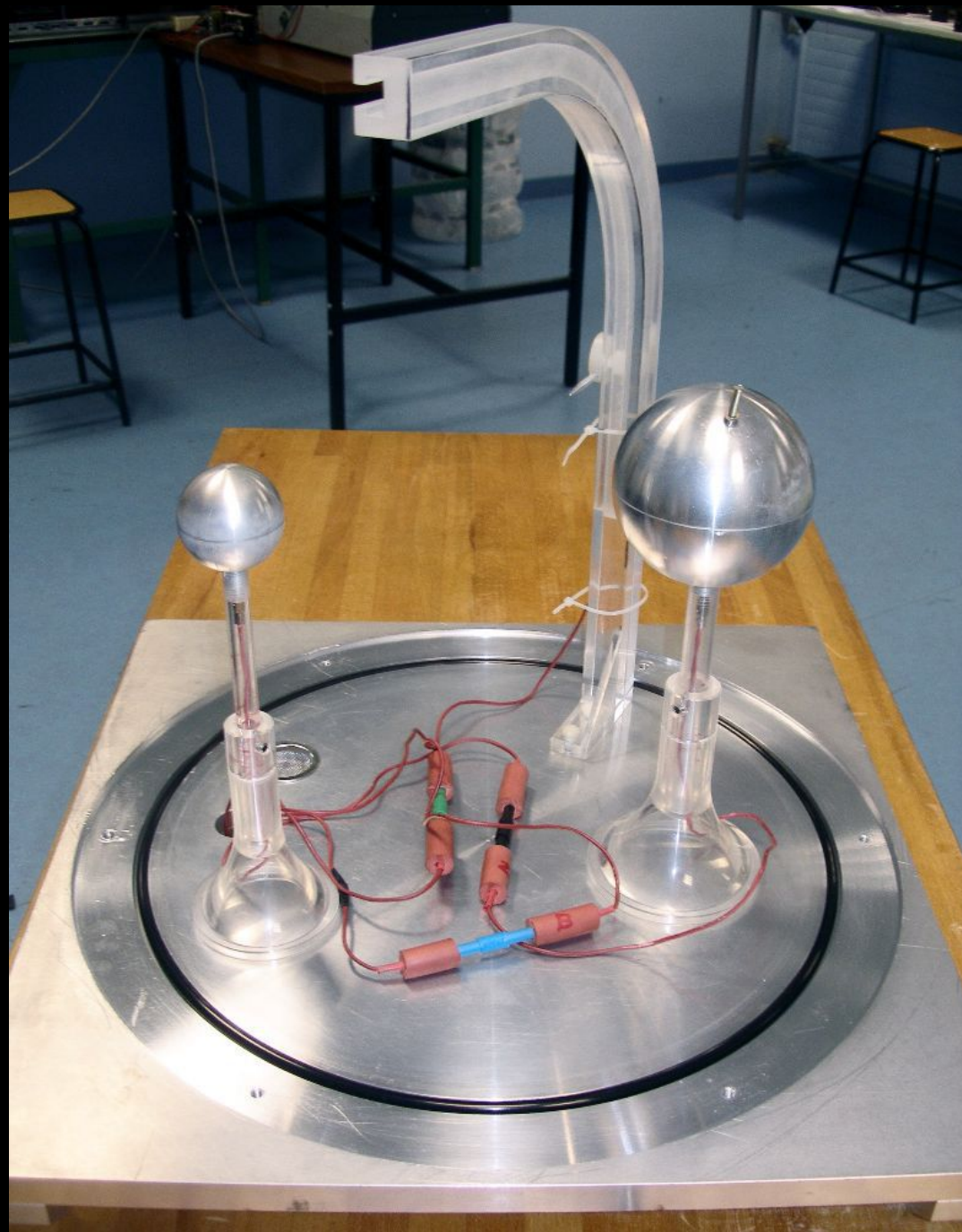
Planeterrella experiment
'solar coronal hole mode'

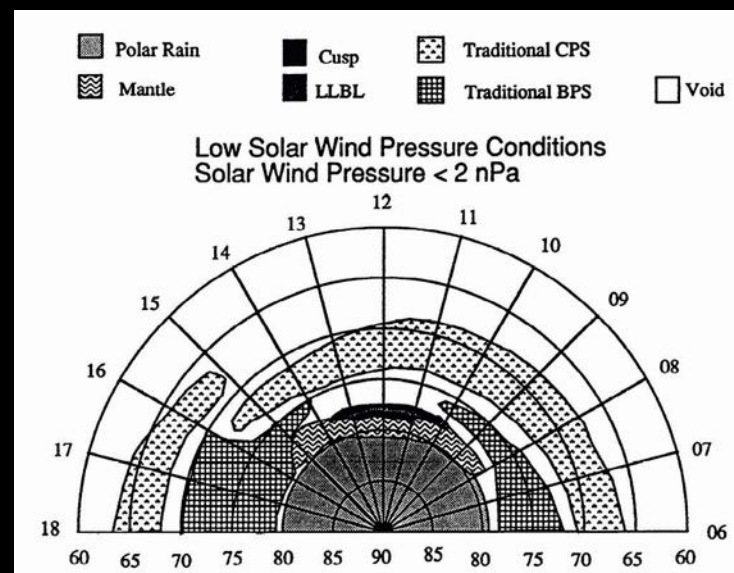
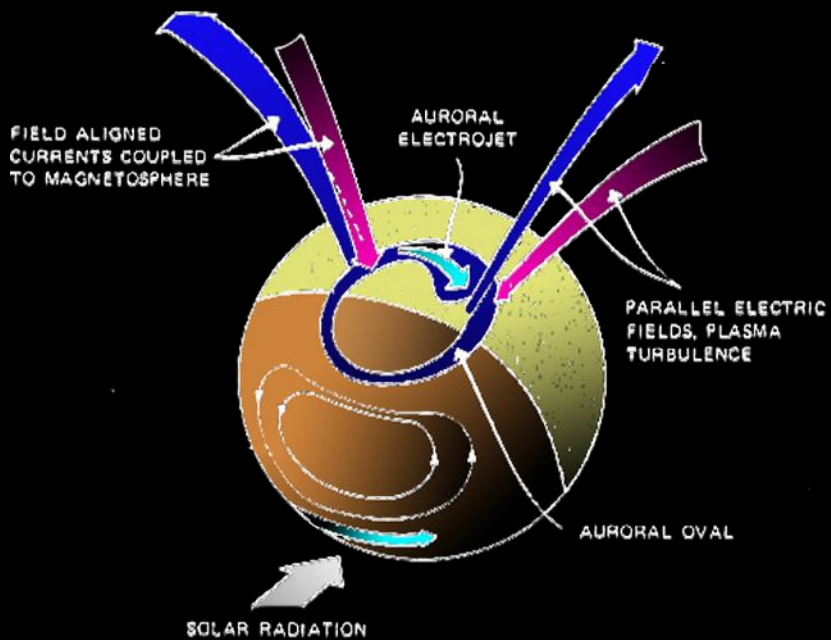
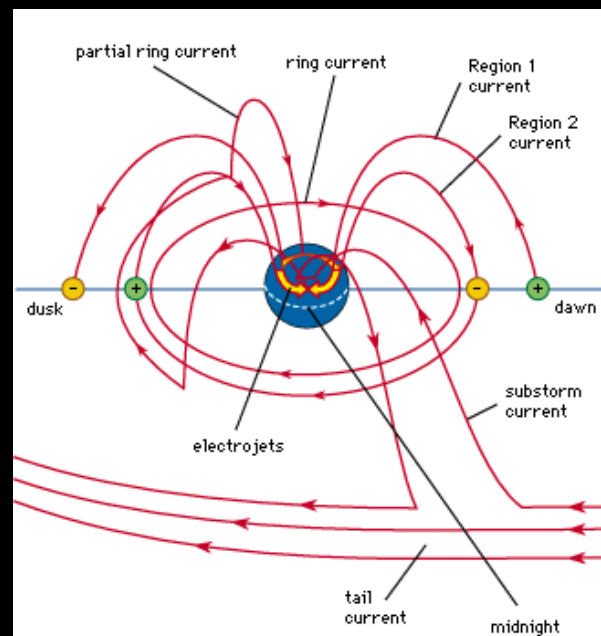
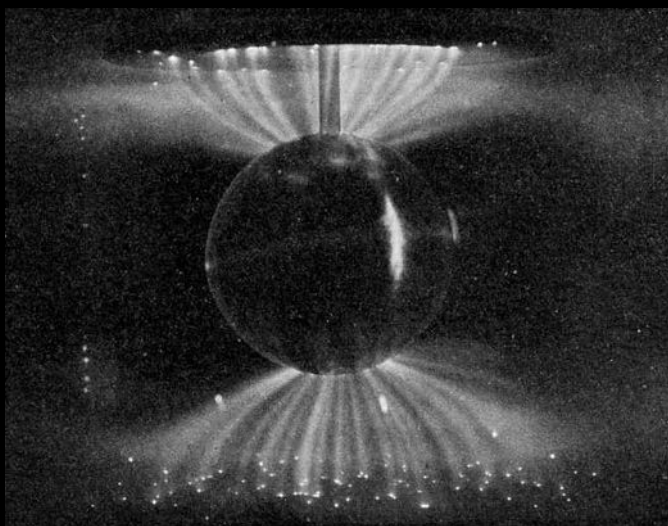


2012/12/10 13:06

Satellite image of the Sun
(SOHO EIT, ESA)







Configurations of the Planeterrella

- Uranus-like interaction?

