

A Terrella Device for Simulating Aurora-Like Phenomena in a Box

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Abstract A Terrella device was developed and setup in Trieste in 2006 to be used as an experimental training device during practicum sessions of the Advanced International School on Space Weather at ICTP. The Terrella consisted of a vacuum chamber, where an aluminum sphere with an embedded permanent magnet bar mimics the Earth (Terrella) and its magnetic field, and a system of electrodes is set to a high potential difference to generate an electron flow (particle wind) that ionizes the residual air around the sphere. This results in aurora-like glowing patterns whose geometry is dependent on the orientation and distance of the bar magnet, so that various configurations can be experimented. This Terrella device proved to be an effective tool not only for academic but also for outreach purposes. We will briefly present both applications, focusing in particular on the latter, and on the planned use for IHY EPO activities.

Keywords Terrella · Aurora · Solar–terrestrial relations · Heliosphere · International Heliophysical Year

1 Introduction

The Terrella (small Earth) was conceived as a magnetized sphere made of lodestone to simulate the terrestrial magnetism by the English physicist William Gilbert in 1600. In

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1896 the Norwegian physicist Kristian Birkeland set up a device using a Terrella subject to electrical discharges in a vacuum chamber to demonstrate why the auroral lights appear in regions centered at the magnetic poles. His experiments are documented e.g. in Birkeland (1908), where he describes a new vacuum-box of 320 l with floor and ceiling made of 12 mm steel plates, the pillars between of bronze, and the sheets of plate-glass at the sides 30 mm in thickness. The experiment showed the “zodiacal-light ring”; it required little magnetising of the globe (11.3 cm in diameter), but a great discharge-current (up to 100 mA).

In 2005, Lilensten started experimenting with Terrella devices for education and public outreach (EPO) purposes, following the pioneering work by Bruntland (1998). He proposed the development of a Terrella device in Trieste to be used for a practicum at the ICTP school on Space Weather held in 2006. Hence, a prototype Terrella was developed in a joint effort by INAF-Astronomical Observatory of Trieste, INFN-Division of Trieste and Physics Department of the Trieste University under the local supervision of M. Messerotti and the remote guidance of J. Lilensten.

2 The Terrella Device Built in Trieste

The Terrella device built in Trieste is illustrated in Fig. 1 and can be briefly described as follows. A molecular vacuum pump creates a moderate vacuum (2×10^{-1} mmHg) in a chamber made of a bell-shaped glass housing. Inside the chamber, an acrylic glass holder hosts an aluminum sphere (the Terrella) wired at the top and a copper electrode at the middle point of a leg, which are fed by a high-voltage power supply (600–850 V, 0.7–2.0 mA). A neodymium–iron–boron permanent magnet bar (Residual $B = 1.21$ T) is housed inside the sphere to simulate the Earth’s magnetic field. The sphere can act both as cathode and as anode by changing the electrical setup of the system. In this way, various experiments can be carried out according to the selected configuration. Upon switching the power supply on, the electron flux generated at the electrode is channeled to the magnetosphere of the Terrella, where it ionizes the residual gas atoms in two annular regions in the proximity of the magnetic poles, which faintly glows by fluorescence much as in planetary auroral phenomena.

3 EPO Applications in Trieste

An application in high level education was performed during the ICTP-COST-USNSWP-CAWSES-INAF-INFN International Advanced School on Space Weather (Abdus Salam International Centre for Theoretical Physics, Trieste, 2–19 May 2006),¹ where a practicum on experimenting with Terrella was managed by J. Lilensten and C. Simon for attending PhD students, Post-Docs and young scientists. An application for public outreach occurred during the Open Day at the Miramare Science Campus² on Saturday, 16 September 2006. In the scientific booth n. 12 dedicated to illustrate the research in Bioastronomy and Space Weather, the Terrella device was used to illustrate the solar-terrestrial relations and their relevance for the life emergence and evolution also in other planetary and exoplanetary environments. Another application for public outreach consisted in an exhibit in the

¹ http://cdsagenda5.ictp.trieste.it/full_display.php?ida=a05201

² <http://openday.ictp.it/>

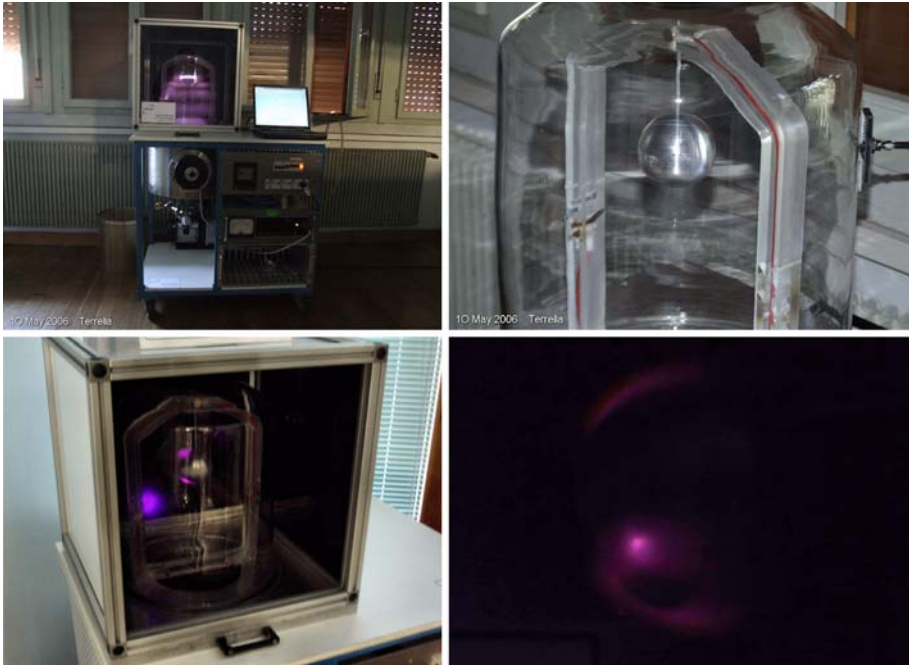


Fig. 1 Overview of the Terrella device (*top left*). Details of the aluminum sphere, the electrode and the insulated holder under the glass housing (*top right*). The protection housing (*bottom left*). Detail of the faint polar rings (*bottom right*)

framework of the national meeting organized by the INFN-Trieste Division from 1 to 6 October 2007 on Communicating Physics,³ open to the communication specialists as well as to the students and to the general public.

All the above applications show the flexibility of the device, which can be successfully used to explain at different levels of complexity the planetary environments and their coupling with the central star via a hands-on exhibit.

4 Conclusions

A Terrella device has many potentialities for teaching physics at all levels as well as for educational and public outreach purposes due to its high visual impact in simulating at a basic level the response of the Earth and, in general, of magnetized planets to heliospheric perturbations. Anyway, both for teaching and for EPO activities, the existing prototypes need the presence of a trained operator to manage the different configurations. A safe, unattended Terrella-device version can be conceived, but for a very limited use and not suitable for experimenting. The considered prototypes are still quite expensive, but a low-cost version is under study for a worldwide distribution in education (Lilensten et al. 2007)

³ <http://www.ts.infn.it/eventi/ComunicareFisica>

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