Touching space: Space physics demonstrators at Aalto University

ED43C-1126

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1. Aalto Virtual Planetarium

Abstract

AU's virtual reality program, Aalto Virtual Planetarium (AVP), contains results from computer simulations made to investigate space plasma environments around planets, moons, comets and the Sun.

The freely downloadable [1] Aalto Virtual Planetarium is aimed at education and outreach, the immersive virtual reality experience showcases certain aspects of the plasma physics of the Sun, magnetospheres of inner planets, an Earth ionosphere and cometary environments. Complex structures and spatial scales of magnetospheric physics are intuitively presented.

Introduction

The immersive virtual reality technologies are especially suited for exploration of three-dimensional structures, such as plasma flows and magnetic field in space physics. The Aalto Virtual Planetarium demonstrates space research activities that involve Aalto University, including: visualizations of plasma physics simulations of the Sun and inner solar system bodies (presently: Mercury, Venus, Earth and the comet 67P/Churyumov-Gerasimenko); space probes and missions (*Rosetta, BepiColombo, Suomi100*); heliospheric structure; and the solar system to scale. The user can move and scale freely in the solar system, from towering over the ecliptic down to visiting the Philae lander in 1:1 scale on the surface of 67P. Pre-set tour points with virtual posters provide descriptions of objects and phenomena in their natural context.

Education & Outreach

Several exhibition demos have been presented, with good impact. So far, a presenter has always accompanied the demonstration (at least for equipment guidance requirements). A standalone user experience is supported, as there are virtual posters (and in a previous version, audio narration), but there is little feedback from that use case; the release of a public version is expected to provide such feedback.

For the typical guided use case, the presenter equips the user with the VR goggles and a controller. The presenter then uses a keyboard (or directs the user to interact with a virtual menu) to drive the user to specific tour points for presentation. The user controls are limited by default to translation and rotation at a fixed scale for easy accessibility. Free scaling controls may be released by the presenter for advanced manual navigation (which can be somewhat difficult).

Development

Developed initially for HTC Vive, using Unity, a C#-based game engine and development environment (Fig.2). OpenVR/SteamVR is directly supported. Some 3rd party assets were used for rapid development, including Granite SDK for high-resolution texture streaming (enabling 500m per pixel imagery of the whole Earth, for example).

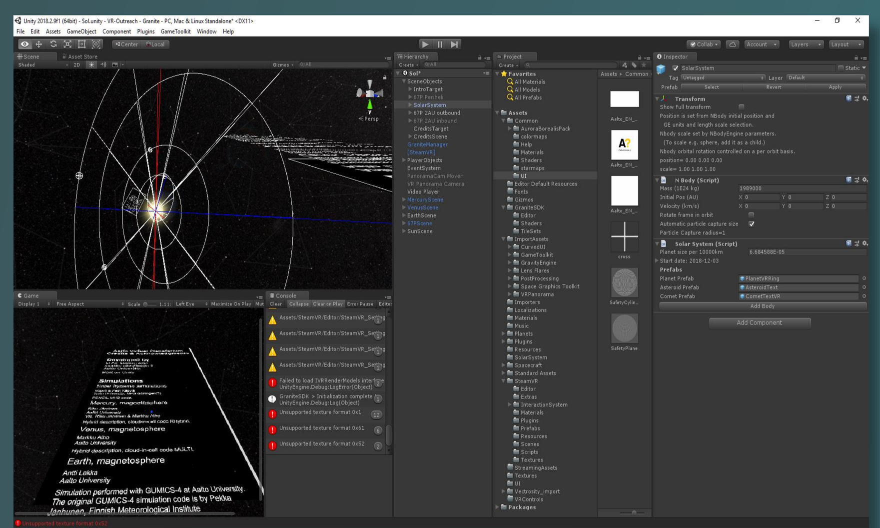

Figure 2. Unity IDE screenshot, featuring the solar system orbits and credits roll in the viewports on the left-hand side.

The main driver, 3D dataset visualization, has a few steps for data import, shown in Fig. 3. Currently supported meshed data formats are point, line (e.g. streamlines) and triangle (isocontour surface) meshes, with time-evolution support for constant-topology meshes, for more details the reader is referred to [2].

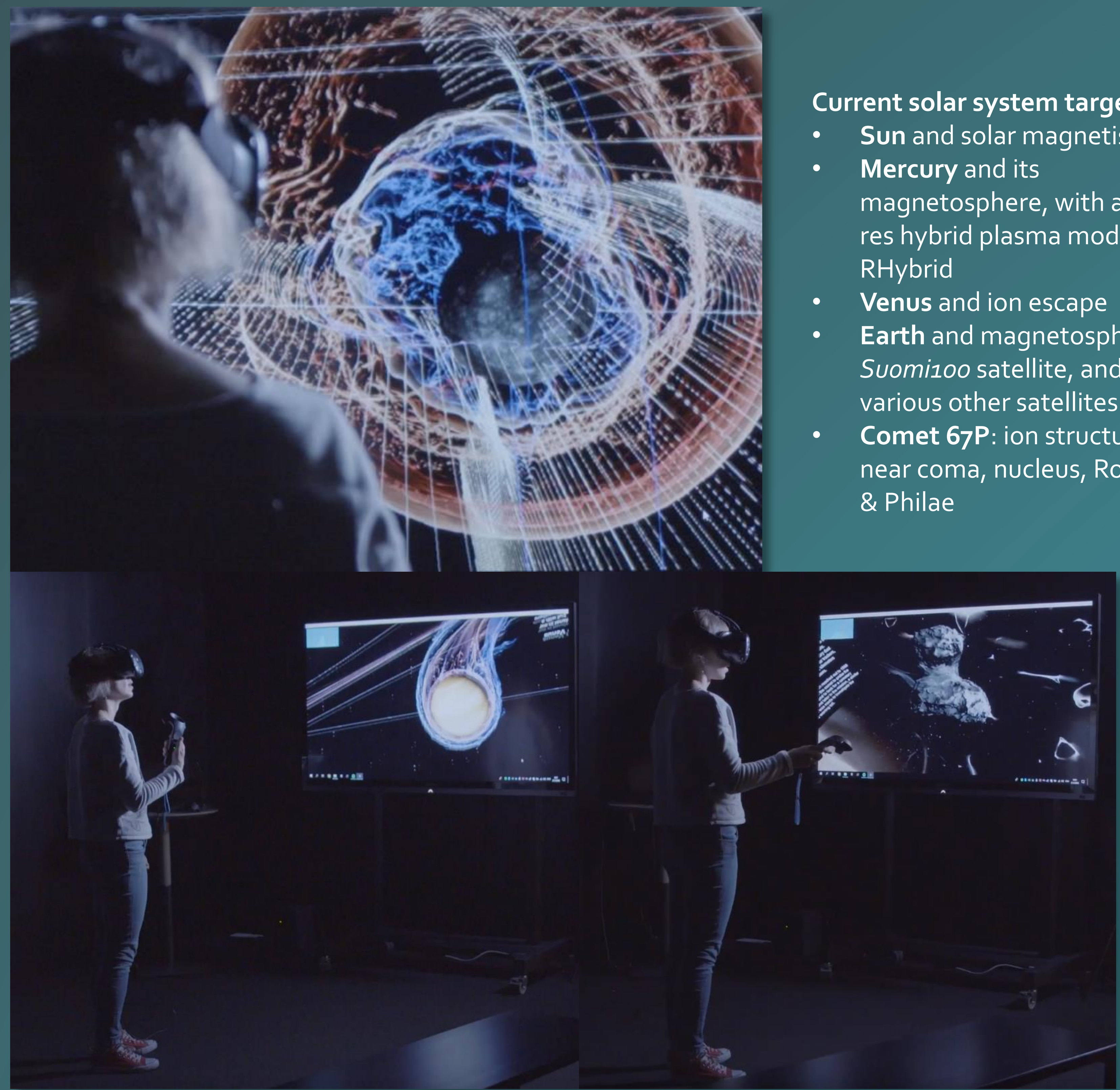

Figure 1. User view visible on screen. Top: Mercury and its magnetosphere; Bottom left: Ion escape from Venus; Bottom right: Nucleus of 67P/Churyumov-Gerasimenko [3].

Current solar system targets

- **Sun** and solar magnetism
- **Mercury** and its magnetosphere, with a hi-res hybrid plasma model RHybrid
- **Venus** and ion escape
- **Earth** and magnetosphere, *Suomi100* satellite, and various other satellites
- **Comet 67P**: ion structures in near coma, nucleus, Rosetta & Philae

Pros and Cons - summary of experiences:

\+ Intensive experience for user
  Especially with enough time per user
\+ Excellent user feedback
  e.g. presenting and contextualizing the geospace system
\+ No/few VR sickness effects => successful interface design
\- Suboptimal scaling properties
  Several minutes per user recommended for effect
  -> constrained throughput
  Structured presentations for groups still successfully done with a rotating user for each presentation target; 30-45 min sessions to go through current material
\- Labor-intensive, as of yet
  Besides narration, laypersons need guidance with gear. MPS event with three dedicated persons: Narrator, gear assistant, queue manager(!)

References

[1] http://space.aalto.fi/software – Virtual Planetarium homepage, includes the software binary for Windows/SteamVR.
[2] Virtual Reality for Space Science Outreach and Research, special assignment, 2017, Aalto. Available at http://space.aalto.fi/research_suomi100.html .
[3] Virtual reality trip to space, Aalto in Space exposition promotion material, 2018, Aalto. https://www.youtube.com/watch?v=ONPXA65qrbs .

2. MULTI cloud service

Abstract

MULTI [4] is a cloud service which gives students a simple access to space plasma simulations, which are analyzed in Aalto University's Space Physics course and also shown in the AVP. A student needs only a web browser to analyze pre-existing space physics simulations without the need to install programs to a physical computer or to download data files. The MULTI space physics simulation platform also contains BigBlueButton [5] for online learning.

The cloud service enables exploration of the MULTI space plasma physic simulation model [6], its results as well as doubling as a teaching platform.

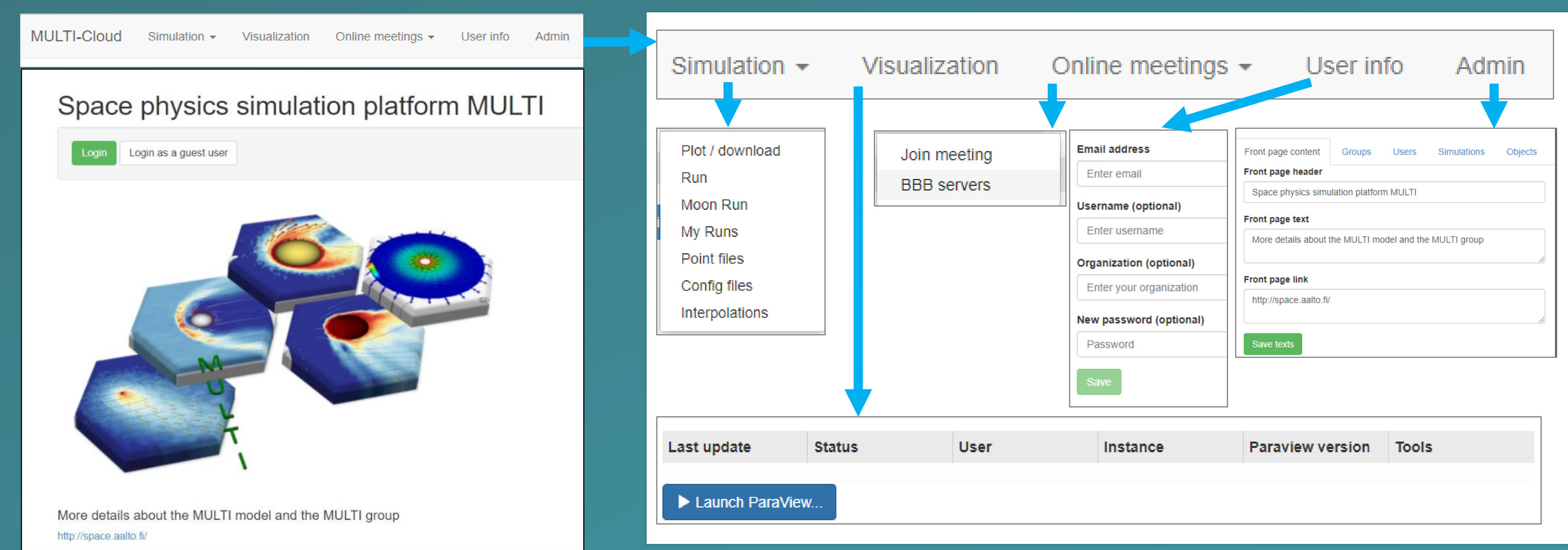

Figure 3. (left) A guest user login page to the MULTI cloud service. (right) Options in the administration login page [4].

References [4] http://52.19.37.188/# [5] https://bigbluebutton.org/ [6] https://space.aalto.fi/research_hyb.html

3. Terrella Cubica

Abstract

Aalto University has built a Terrella plasma discharge vacuum chamber, to simulate polar auroras and associated space plasma physics phenomena. The device, called Terrella Cubica [7] (Fig. 4), is a single-structure glass-aluminium vacuum chamber of cubic shape, based on a modern iteration of Kristian Birkeland's lab experiments (Fig. 5), as part of the Planeterrella network [8]. The aim of the device is to support the teaching of space physics at Aalto University by demonstrating plasma phenomena (auroral ovals, ring currents, Birkeland currents, etc.).

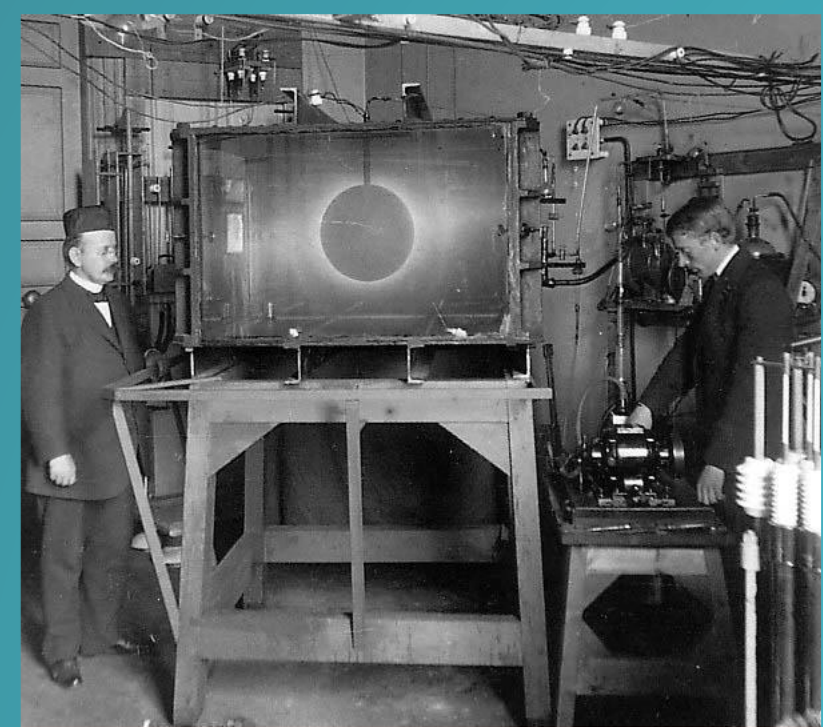

Figure 5. Birkeland (left) in his laboratory. (*Nasjonalbiblioteket, Billedsamlingen, Oslo*)

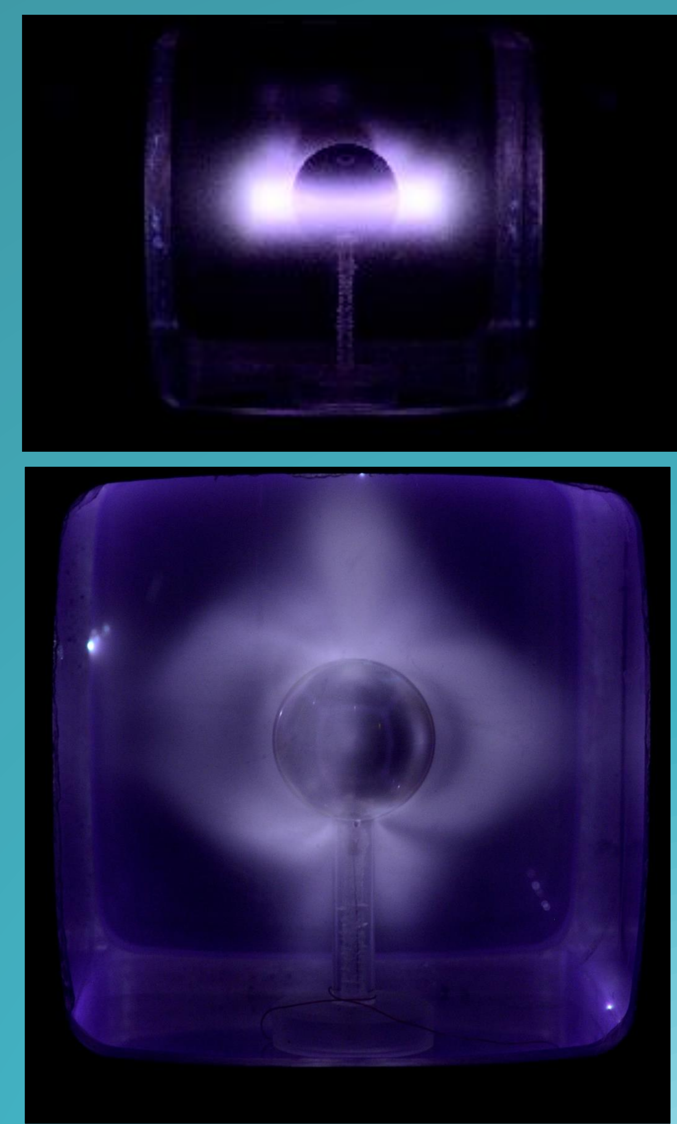

Figure 4. Terrella Cubica in it's

- (top) Ring current mode; cathode: the aluminum ball with a magnet
- (bottom) Aurora mode; cathode : the aluminium frame

Acknowledgments: Dr. Jean Lilensten, Institute of Planetology and Astrophysics, Grenoble

References [7] http://space.aalto.fi/outreach_terella.html [8] http://planeterrella.osug.fr/?lang=en