# Four-Dimensional Digital Universe Project

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The Four-Dimensional Digital Universe Project (4D2U Project) is a project led by the National Astronomical Observatory of Japan. The project's goal is to visualize astronomical data in a way that helps watchers feel as if they are witnessing the unfolding of the universe. The project provides astronomical movies and application software, and web based flash contents. In this article, we report current state of space viewer Mitaka and movies of astronomical simulations provided by the project.

## 1. Introduction

The Four-Dimensional Digital Universe Project (4D2U Project) is a project led by the National Astronomical Observatory of Japan [1]. The project's goal is to visualize astronomical data in a way that helps watchers feel as if they are witnessing the unfolding of the universe. "Four dimensions" refer to the three dimensions of space and the one dimension of time embedded in their data. "Digital" refers to computer graphics visualizations of digital data. The resulting acronym is "4D2U", and it is also astronomy's way of saying "4D to you."

In the following, we report the current state of space viewer Mitaka and movies of astronomical simulations provided by the project.

## 2. Using the 4D2U Contents

In this section, we explain the conditions for use of the 4D2U contents. For personal or non-commercial educational purposes, anyone can use the 4D2U contents without needing apply for permission. Explicit credit shall be given to the 4D2U Project, such as "Courtesy of the 4D2U Project, NAOJ." No redistribution or modification of material are allowed.

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http://4d2u.nao.ac.jp/english/index.html#notice

## 3. Mitaka : A Four-Dimensional Universe Viewer

Mitaka is software for visualizing the known Universe with up-to-date observational data and theoretical models. Mitaka users can seamlessly navigate through space, from the Earth to the edges of the known Universe (Fig. 2). The software is freeware and available from our web site.

 

**Fig. 1** The 4D2U Dome Theater with 10m diameter dome. The theater was renewed at spring 2015. For stereoscopic projection, liquid-crystal shutter is used.

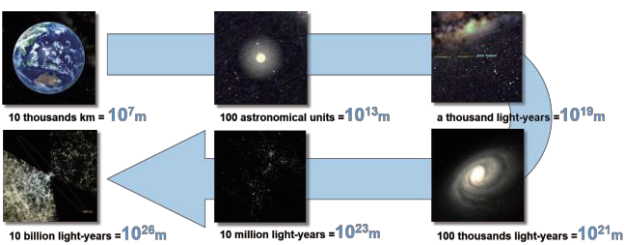


**Fig. 2** Hierarchical structure of the Universe that can be seen with Mitaka: Earth, Solar System, Stars, Milky Way, Clusters of galaxies, and the Large-scale structure of the Universe.

**Fig. 3** Pluto with a new surface texture obtained by the New Horizons spacecraft.

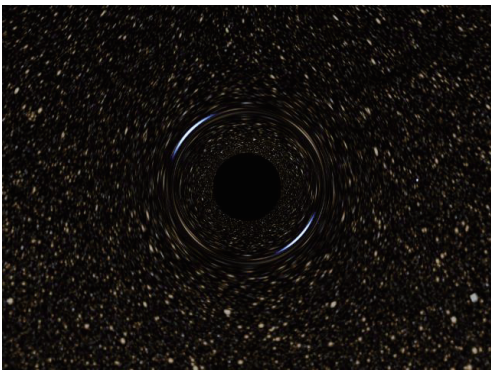

**Fig. 4** Gravitational lens effect around the super-massive black hole at the center of Milky Way.

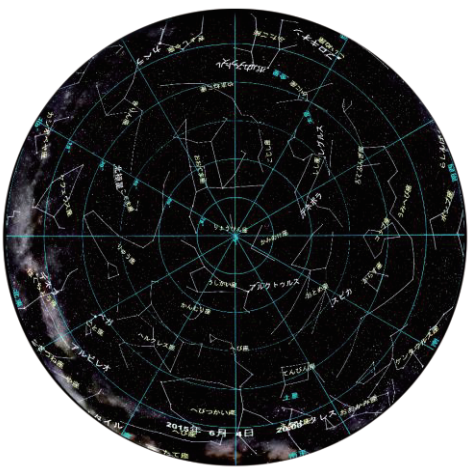

**Fig. 5** Fisheye rendering mode for projection on dome screens.

Recently (version 1.2.5), some new features were added: for instance, new surface texture of Pluto obtained by the New Horizons spacecraft (Fig. 3), 3D model of New Horizons, and the super-massive black hole at the center of Milky Way together with stars orbiting it. Especially, gravitational lens effect around the black hole is implemented (Fig. 4). Also, several new display modes (fish-eye mode (Fig. 5) and virtual reality mode for Oculus Rift DK2) are added. At the latest version (1.3.0), Mitaka has been multilingualized and French is supported for displaying text. In addition, the anti-aliasing for character rendering is implemented, so that readability is greatly improved. Three-dimensional models of two spacecraft (Akatsuki and Hayabusa 2) as well as their trajectories are also added. Many other new features are added in the latest version. See the following web site for details.

http://4d2u.nao.ac.jp/html/program/mitaka/index_E.html

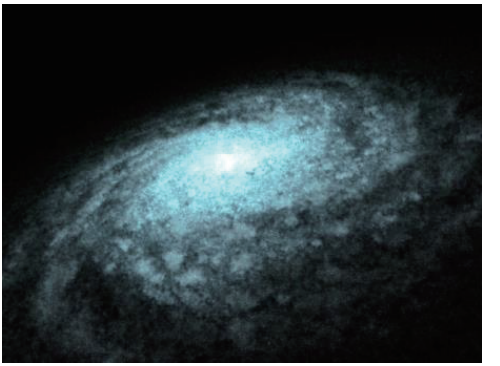

**Fig. 6** A snapshot of a movie "Dynamics of a spiral galaxy."

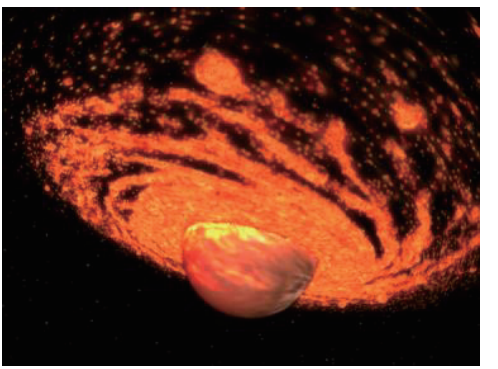

**Fig. 7** A snapshot of a movie "Formation of the Moon."

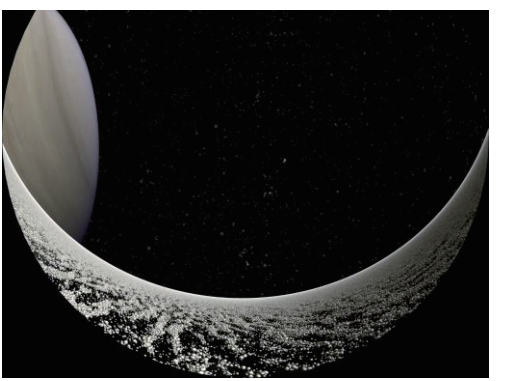

**Fig. 8** A snapshot of a movie about propeller structure on Saturn' s ring.

## 4. Astronomical Simulation Movies

### *4.1. Simulation Movies*

We have made stereoscopic visualization movies since the project was started based on astronomical simulations or observed data (Fig. 6 and 7 for examples).

Recent movies are made for both flat screen and dome screen (fisheye). These movies are available through a free download from our web site.

### *4.2. Zindaiji3*

Most of our movies based on N-body particle simulations are rendered by a house made visualization tool Zindaiji3. Zindaiji3 is specialized for rendering large number of particles, up to near a billion. Once, it could render only featureless halo particles or textured polygon-spheres. It is now greatly improved. The following are examples of recently added features: rendering normal-mapped and textured billboard polygon, importing the wavefront .obj files to use them as particle instances, duplicating simulation box, scripting with expressions. Combining these features, we have made a movie about the Saturn's ring dynamics with a billion of particle instances (Fig. 8). The software is available through a free download from the web site below.

http://qcganime.web.fc2.com/ZINDAIJI3/Zindaiji3Top_E.html

## 5. Summary

The 4D2U Project provides astronomical movies and application software, and web based flash contents. This article reported about current state of the contents. Please see the 4D2U web site below for details.

http://4d2u.nao.ac.jp/

## References

[1] Kokubo E., Hayashi M., Kato T., Takeda T., Kaifu N., Miyama S., Miura H., and Takahei T., 2005,"4-Dimensional Digital Universe Project", Journal of the Korean Astronomical Society, 38, pp. 153–155