Interactive visualization of shadow effects in the planetary system of Saturn, its rings and its moons using an OpenGL Shader in IDL

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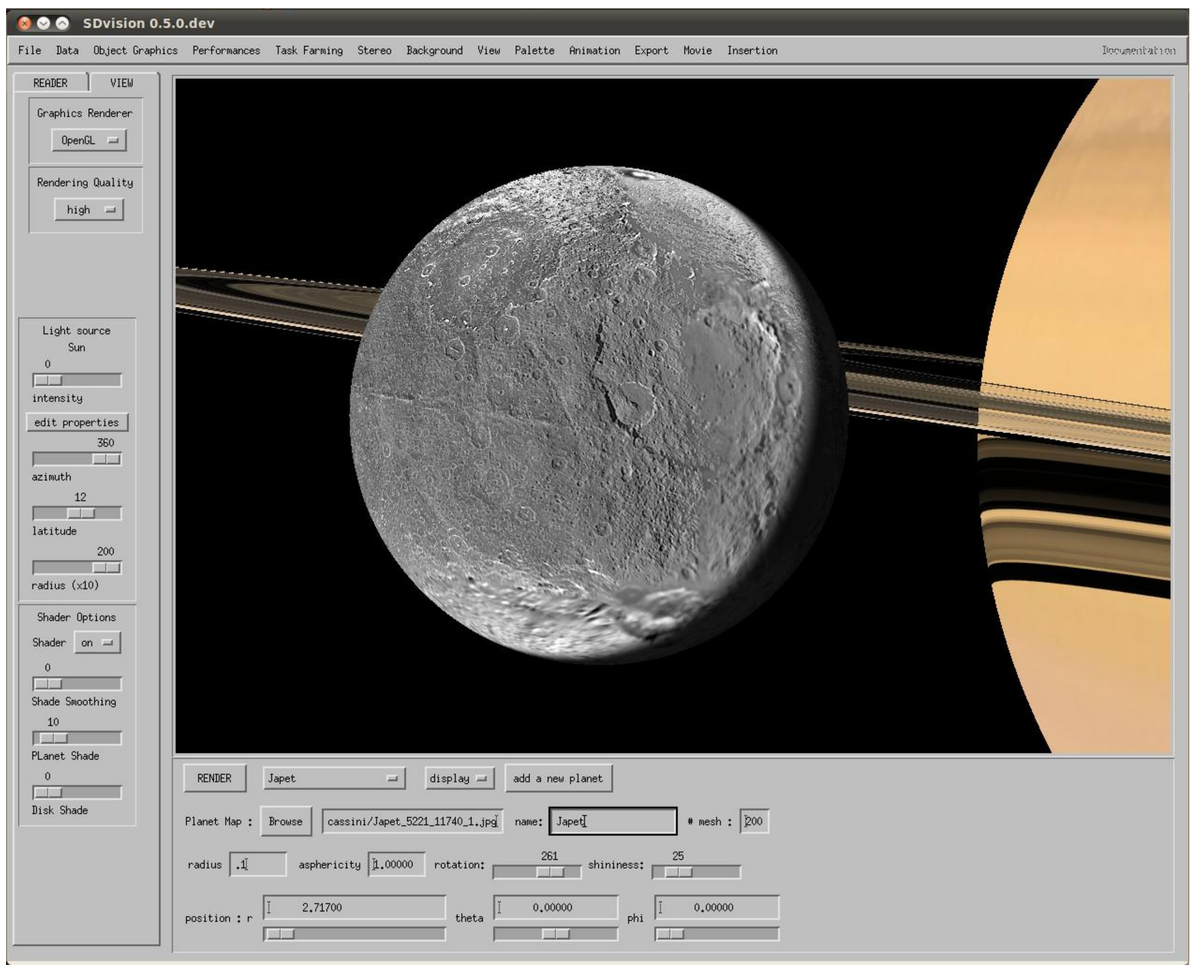
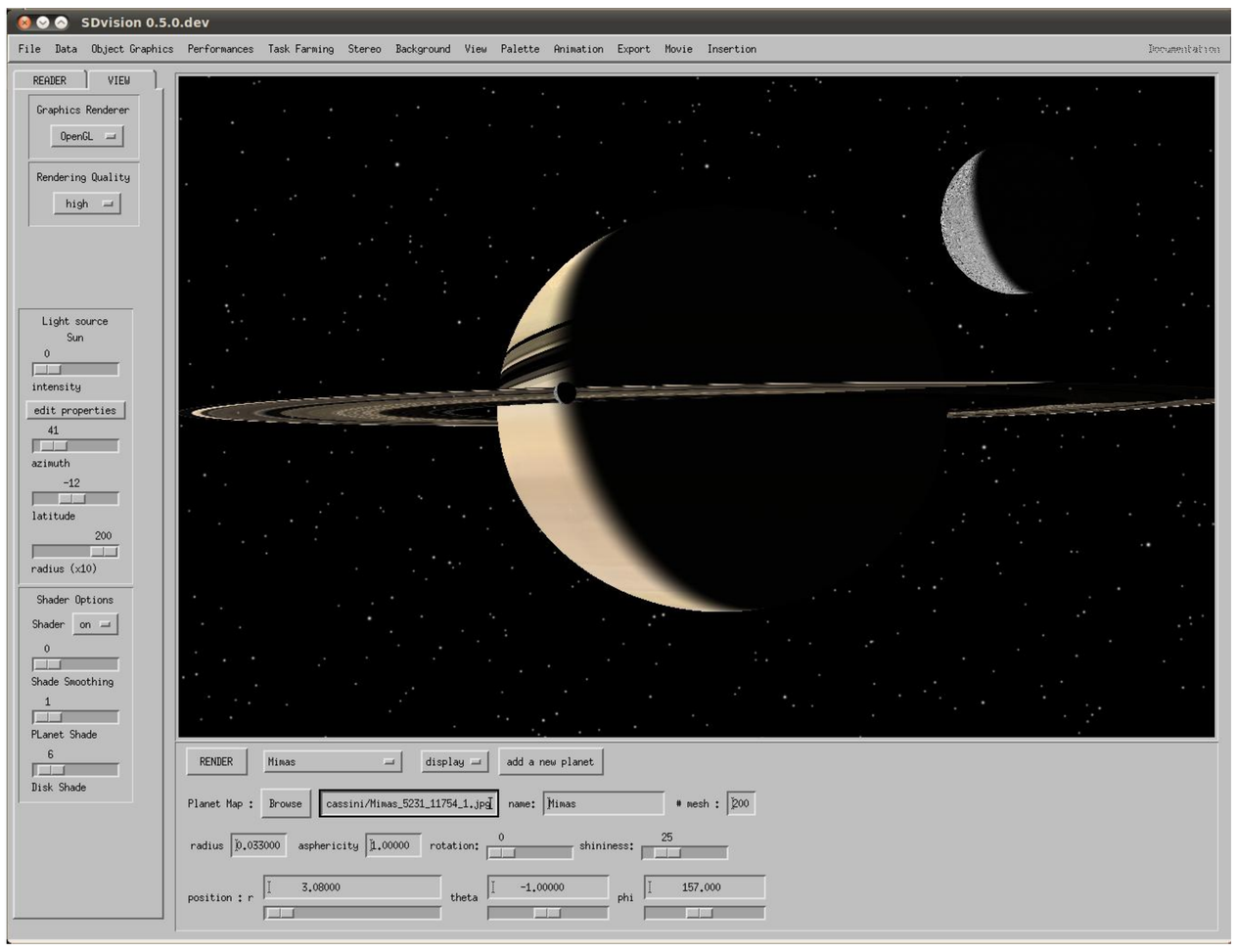
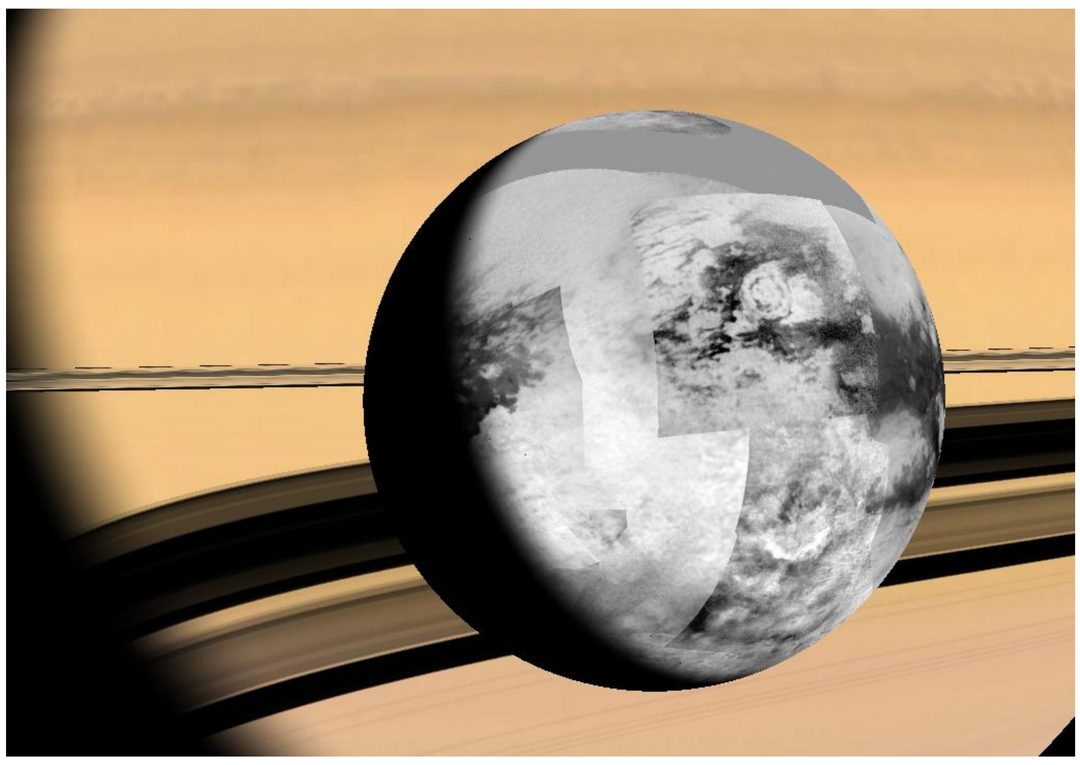
The planetary system of Saturn, its rings and its moons is a fantastic playground where physicists are confronting theories and observations. Since its insertion into orbit in 2004, the Cassini-Huygens spacecraft has returned a wealth of high-resolution images and data that calls for the development of dedicated interactive, immersive, three dimensional, multi-purpose analysis and visualization tools. Alongside with observations, numerical simulations also provide new insights into the fundamental processes at stake in the formation of this system. The SDvision graphical interface, developed in the context of IDL Object Graphics and intended primarily for the visualization of complex and massive astrophysical plasma simulations, has been extended to provide an interactive visualization of both numerical simulations and observations of Saturn, its rings, and its moons. One major missing feature of IDL Object Graphics is the ability to render shadow effects at all. We have overcome this limitation by developing a custom GLSL Shader that is invoked by IDL objects. This Shader, based on purely geometrical computations, is fast and allows for seamless exploratory visualization of the planetary system.



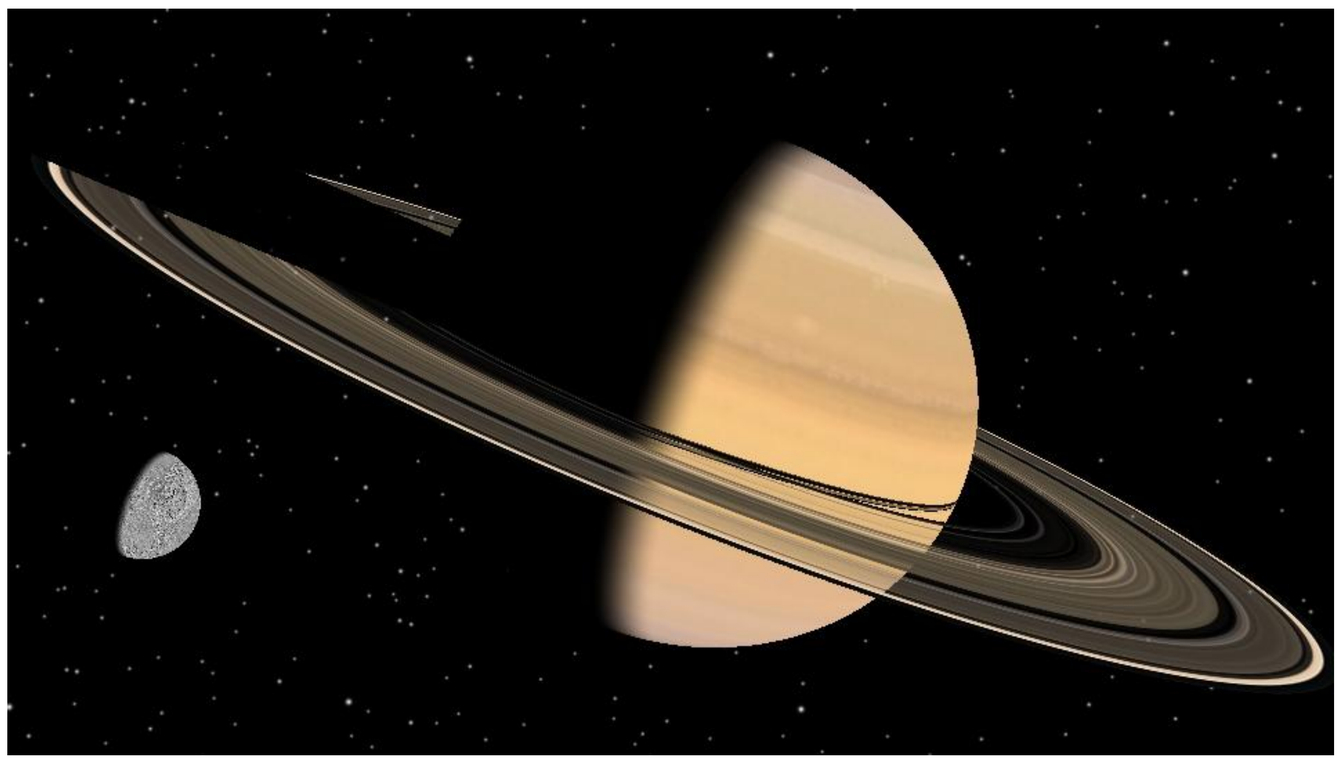
The SDvision interface used to visualize the Iapetus Moon. The equatorial ridge discovered by the Cassini Mission is clearly visible. In this dramatic view, the moon is voluntarily magnified and approached to Saturn. A number of controls are available to play with the light sources, add other moons, and act on their orbit parameters.



Visualization of Saturn, its rings and two crescent moons : Dione in the foreground and Mimas above the terminator on Saturn's surface. The Saturn Shader is used to compute the various shadowing effects seen in this view : self-shadowing of the planets and shadows cast by the rings on Saturn, taking into account their radial-dependent transparency.

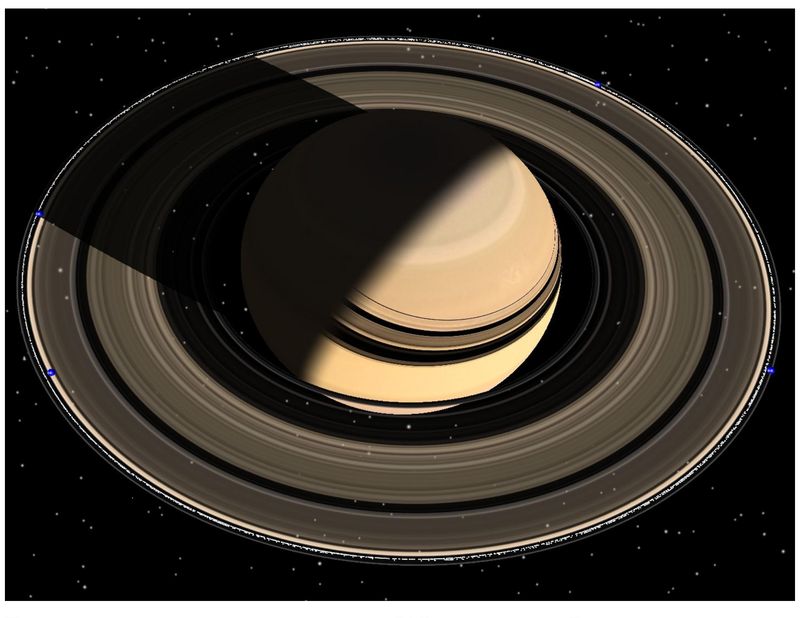


Three-dimensional visualization of Titan. This composite, uncomplete mosaic image of the moon, provided by the Cassini Mission, is mapped onto a spheroid, showing some fine details of its surface. A smooth terminator is implemented in the Shader to mimick atmospheric absorption.

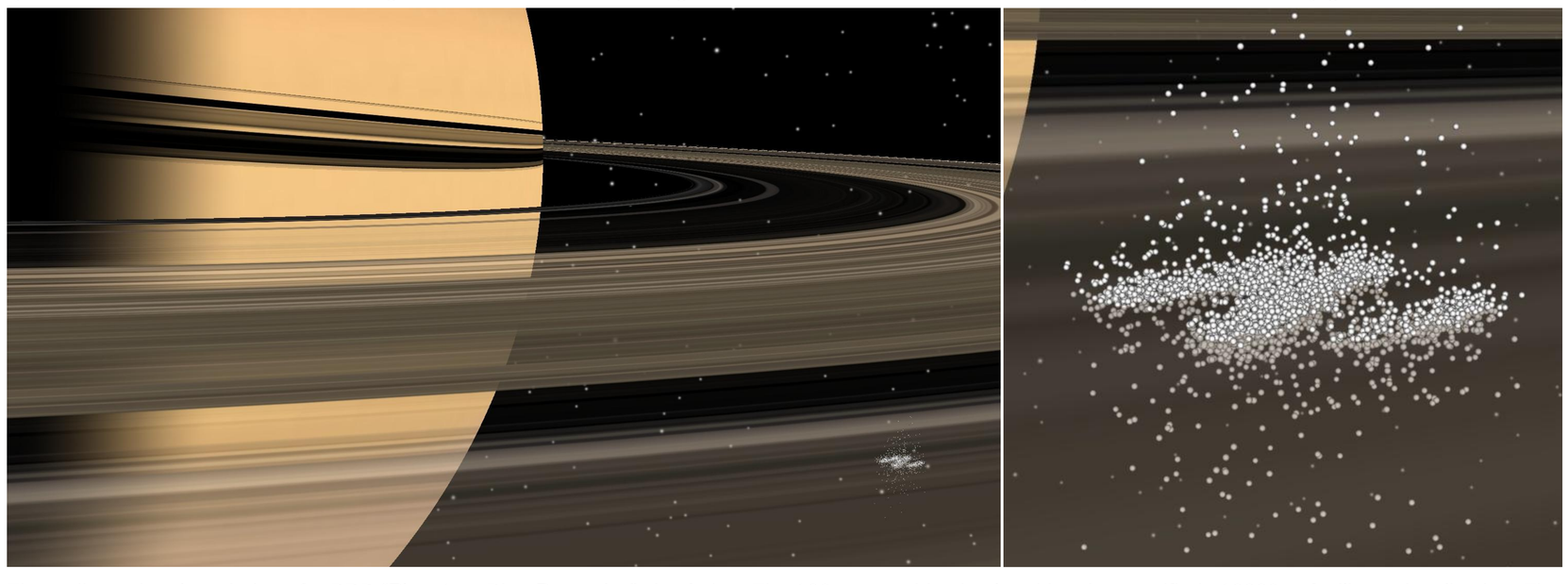


Self-shadowing applied to Saturn and its moon Thetys, and shadow cast by Saturn onto its rings. All the high-resolution images of the rings and the moons presented here are obtained from CICLOPS, the Cassini Imaging Central Laboratory for Operations. The Shader was tested on several nVidia video cards, including a Quadro Fermi 6000 on a powerful HP graphics cluster and a Quadro FX 880M on a laptop. Typical frame rates of 0.01 fps are obtained, allowing for seamless interactive visualization.

Visualization of numerical simulations of planetary ring dynamics benefits from being contextualized using the observations obtained by the Cassini-Huygens Mission



Three-dimensional visualization of a BUL simulation. Four massive bodies are displayed in the outer regions of the rings as blue spheres, while 7546 test particles are shown as smaller white spheres.



Three-dimensional rendering of a PRD "Planetary Ring Dynamics" simulation. The 100 meter-wide simulated box is magnified x10000 to facilitate visualization. The particles used in this sheared-box simulation are displayed as Gouraud-shaded orbs subject to lighting from various sources. The implementation of the Saturn Shader allows to improve the realism achieved in the rendering of both observational and simulation data. It thus contributes in the production of appealing snapshots or movies targeted at public communication, including media for stereoscopic display systems, with the intend to illustrate what are the benefits of numerical simulations to further our understanding of planetary rings dynamics.

References:

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