Space System Modeling: Saturnian Moons

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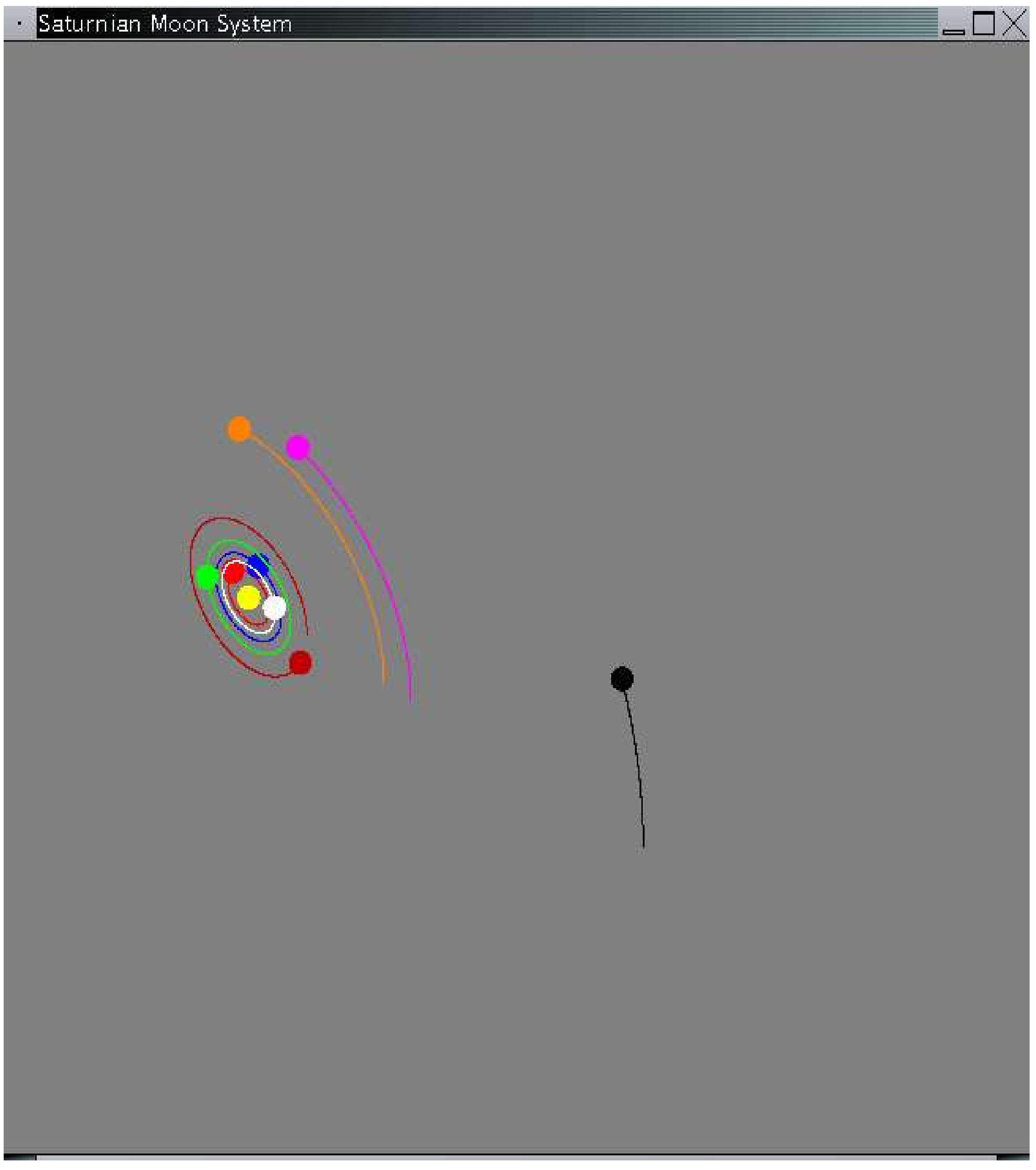

Abstract

The Saturnian moon system is home to many fascinating and unusual astronomical phenomena. For example, Epimetheus and Janus share orbits and exchange momentum every four years. Hyperion has chaotic rotation. Our understanding of these phenomena, however, is unfortunately limited. This project hopes to add to our understanding of space systems by providing a comprehensive simulation of the Saturnian moon system. By doing this, this project attempts to expose what phenomena can't be explained with modern models and perhaps suggest theories to explain the unexplained.

Background

The Saturnian moon system is a hotbed of interesting phenomena. There are moons that have odd orbital inclinations, there are moons that are unusually colored, and some moons may contribute to the regulation of Saturn's rings. One moon is effected by the forces within the system to such a degree that it's rotation is chaotic. There are two moons that share an orbit, with the appearance that one will overtake the other and the two will collide. This does not occur, however, as every four years they exchange momentum, making the slower moon faster than the originally faster moon. Nowhere else in the solar system do phenomenas such these occur in such abundance. This makes the Saturnian moon system a natural choice for simulating.

Numerous solar system simulators exist today. A simple example, named Orrery, can be found at http://orrery.unstable.cjb.net/. Other simulations have been made concerning the N-Body problem, which attempt to find subsequent motions of bodies based on initial parameters. One of these simulations, which uses NetLogo, is found at http://ccl.northwestern.edu/netlogo/models/N-Bodies. This project will build upon these past models by applying some of their techniques to the Saturnian moon system.

One major technique used to model space systems is Newton's Law of Universal Gravitation. This is a basic law used in innumerable simulations. Newton's Law of Universal Gravitation is as follows:

$$F = (G * m_1 * m_2) / (r^2)$$

Where F is the force (newtons) exerted on a massive body through gravity, G is the gravitational constant (approximately 6.67×10^{-11} N m^2 kg^{-2}), m_1 is the mass (kilograms) of the body upon which the gravitational force is being exerted, m_2 is the mass (kilograms) of the body that is exerting the gravitational force, and and r is the distance (meters) between the two bodies. To incorporate this law into a 3-D model, 3 force vectors are calculated to account for movements in the x, y, and z directions.

Please note that, while very important, Newton's Law of Universal Gravitation is not the *only* important factor. For example, an attempt to simulate the effects of Saturn's magnetosphere on the may be revealing, but would have an immensely different focus. Time is still a limiting factor in this project, after all, and the processes that would need to be simulated for this to be an adequate portrayal would be numerous and complex. As such, this project will generally avoid such factors and focus on the movement of objects within the system unless enough time can be put aside to add these factors in.

By simulating the Saturnian moon system, one hopes to better understand the extent of our understanding. By basing this simulation upon commonly used models, we can gage how accurate and effective these models are. Furthermore, we can determine which phenomena we know how to explain which we don't, making it clearly which events are worth further research.