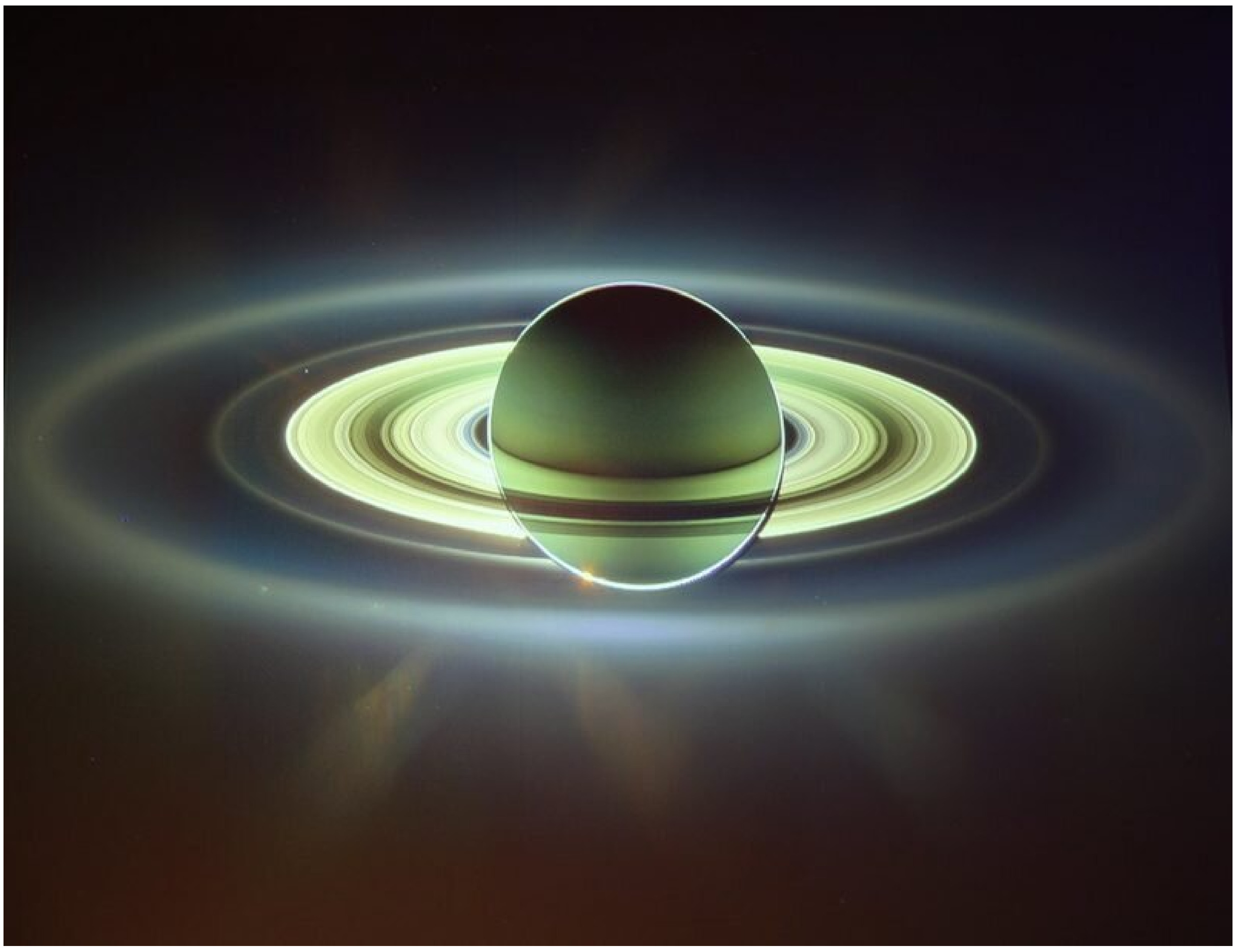
Making sense of Saturn's impossible rotation

September 6 2019, by Larry O'hanlon



Saturn eclipses the Sun, as seen by the Cassini spacecraft. Credit: NASA

Saturn may be doing a little electromagnetic shimmy and twist which has been throwing off attempts by scientists to determine how long it takes for the planet to rotate on its axis, according to a new study.

Discovering the length of a day on any planet seems like a straightforward task: Find some feature on the planet and clock it as it rotates around once. Or, if it's a gas giant like Jupiter, which has no solid surface features, scientists can listen for periodic modulations in the intensity of radio signals created within the planet's rotating magnetic field.

And then there is Saturn, which for decades has defied attempts to pin down out its exact rotation period. Now a new study in AGU's *Journal of Geophysical Research*: Space Physics may have finally unveiled the gas giant's trick for hiding its rotation, and provide the key to giving up its secret.

The new research shows how seasonal changes on Saturn may be confusing attempts by scientists to calculate its exact rotation period.

A planet's rotation period is one of the fundamental facts about a planet, along with its size, composition, orbital period and other facts that not only describe a planet but help to explain its behavior, history and even provides clues to its formation.

Coy Saturn

Saturn emits only low-frequency radio patterns that are blocked by Earth's atmosphere, make it difficult to study Saturn's rotation from the Earth's surface. In contrast, Jupiter emits radio patterns at higher frequencies that allowed radio astronomers to work out its rotation period before the space age got well under way.

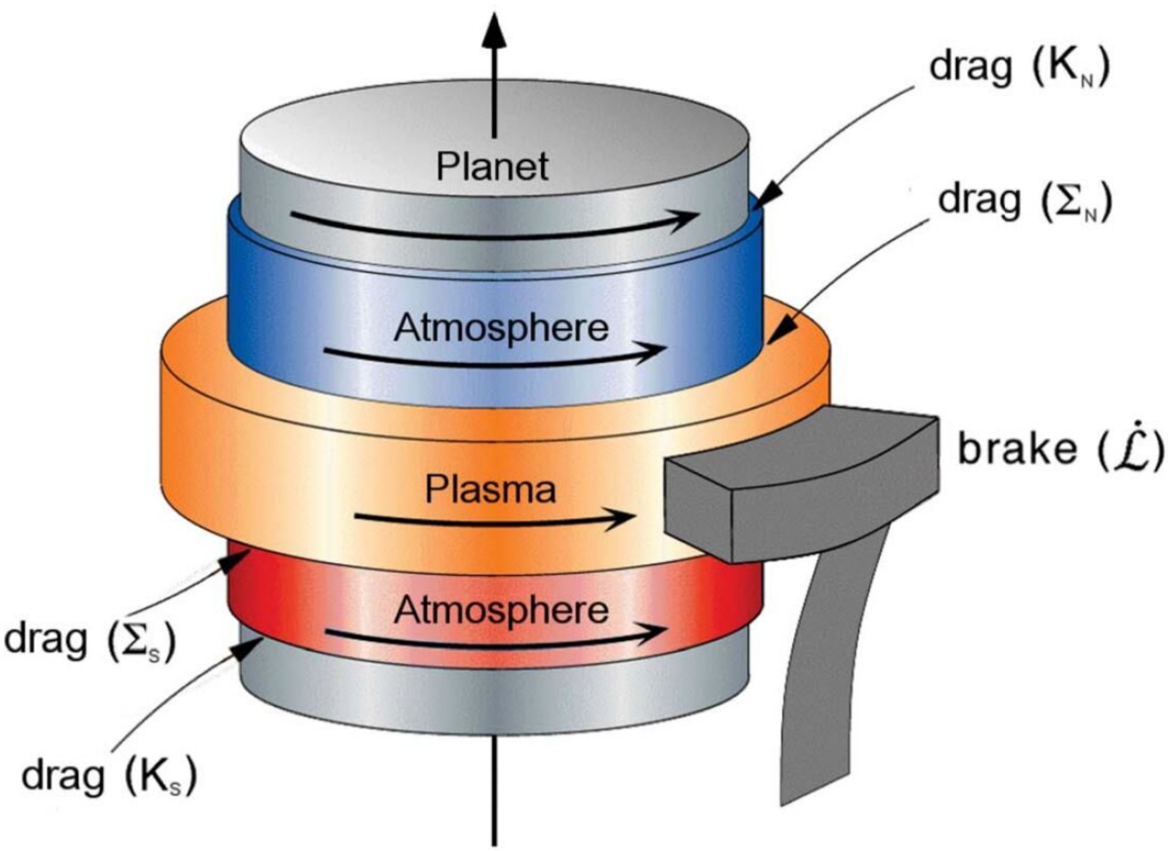
It wasn't until spacecraft were sent to Saturn that scientists were able to collect data about its rotation. Voyagers 1 and 2 sent home the first hints of Saturn's rotation in 1980 and 1981. They detected a modulation of radio intensity that suggested the planet rotated once every 10 hours and

40 minutes.

"So that was what was called the rotation period," said Duane Pontius of Birmingham-Southern College in Alabama and a co-author of the new study.

When the Cassini spacecraft arrived at Saturn 23 years later to study the planet for 13 years, it found something astonishing.

"In about 2004 we saw the period had changed by 6 minutes, about 1 percent," Pontius said.



A mechanical analog model of what might be happening with the northern and southern hemispheres of Saturn’s atmosphere and magnetospheric plasma to create misleading signals of how fast the planet is rotating. The “brake” is the slowing of plasma as it flies further from the planet, in the same way a spinning dancer’s arms move slower when they are outstretched than when they are held close to the body. Credit: E. L. Brooks, et al, 2019, *JGR: Space Physics*

But how does an entire planet change the speed of its rotation in 20 years? That's the sort of change that takes hundreds of millions of years. Even more mysterious was Cassini's detection of electromagnetic patterns that suggested the planet's rotation is different in the northern and southern hemispheres.

"For a long time, I assumed there was something wrong with the data interpretation," Pontius recalled. "It's just not possible."

Seasons of Saturn

To find out what was really going on, Pontius and his co-authors started by looking at how Saturn is different from its closest sibling, Jupiter.

"What does Saturn have that Jupiter lacks, beside the obvious rings?" Pontius asked. The answer: seasons. Saturn's axis is tilted about 27 degrees, similar to Earth's 23-degree tilt. Jupiter has barely any tilt at all—just 3 degrees.

The tilt means the northern and southern hemispheres of Saturn receive different amounts of radiation from the Sun depending on the season. The different doses of ultraviolet light affect the stripped-down atoms—called plasma—at the edge of Saturn's atmosphere.

According to the model being proposed by Pontius and his colleagues, the variations in UV from summer to winter in the different hemispheres affects the plasma so that it creates more or less drag at the altitudes where it encounters the planet's gaseous atmosphere.

That difference in drag makes the atmosphere slow down, which is what sets the period seen in the radio signals.

Change the plasma seasonally, and you change the period of the radio emissions, which is what is seen on Saturn.

The new model provides a solution to the puzzle of Saturn's impossible changing rotation periods. It also shows that the observed periods are not the rotation period of Saturn's core, which remains unmeasured.

Pontius presented the model earlier this year at a meeting of Saturn scientists and said it was well received. Now he hopes that other researchers will take the next step to refine the model by exploring how well it fits with 13 years of Saturn data collected by Cassini.

More information: E.L. Brooks et al. Saturn's multiple, variable periodicities: A dual-flywheel model of thermosphere-ionosphere-magnetosphere coupling, *Journal of Geophysical Research: Space Physics* (2019). DOI: 10.1029/2019JA026870