BINARY RESEARCH

# THE THIRD MOTION

## How a 500-Year-Old Assumption Shaped Modern Astronomy's Understanding of Precession

By Walter Cruttenden

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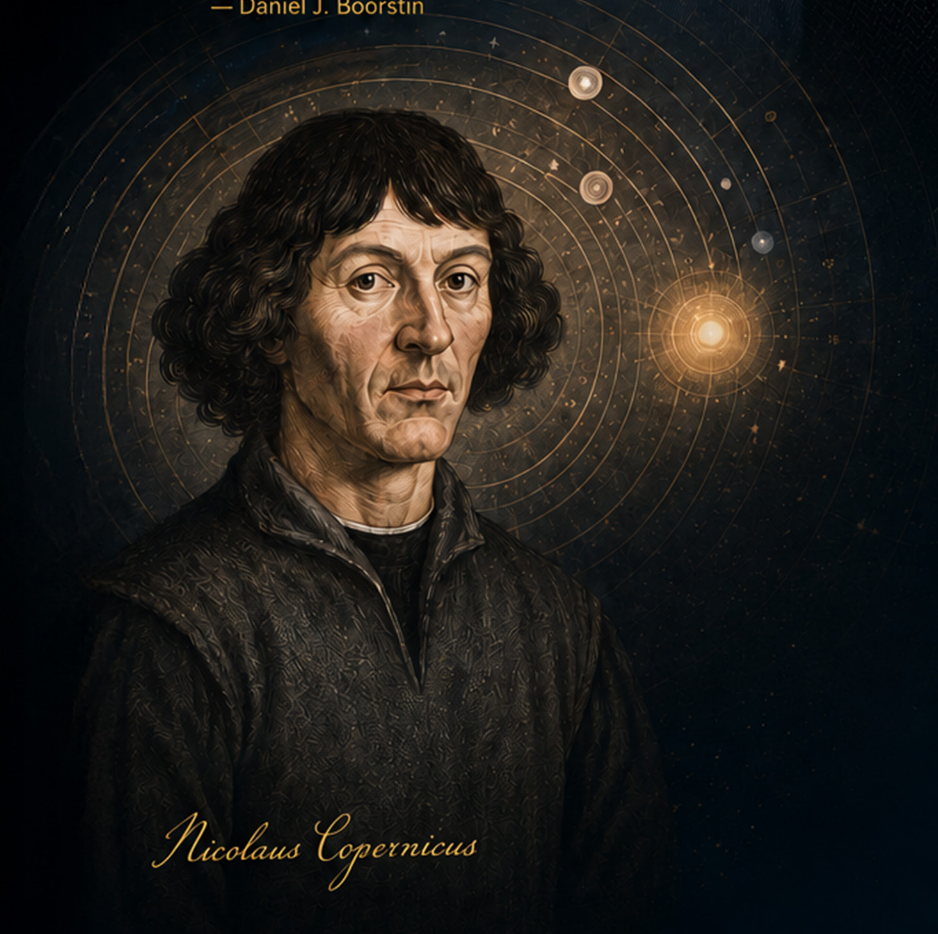
>
> — Daniel J. Boorstin




### A QUESTION THAT OUTLIVED THE CENTURIES

Copernicus correctly identified Earth's rotation and revolution. But by assuming the Sun was fixed, he introduced a third motion—what we now call axial precession.

Modern astronomy explains the Sun's backward drift through the zodiac as the Earth's axis wobbling.

But what if the Sun—and the entire Solar System—is actually moving?

*For the observable came first. The explanation came later.*

***And science advances whenever explanations remain open to examination.***

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## The Revolution That Changed Everything

Few individuals have changed humanity's view of the cosmos more profoundly than Nicolaus Copernicus.

Before Copernicus, the Earth was widely believed to occupy the center of creation. The Sun, Moon, planets, and stars were thought to revolve around us. In 1543, with the publication of *De Revolutionibus Orbium Coelestium*, Copernicus proposed a radically different vision: the Earth itself moved.

Initially ridiculed, history has largely vindicated his work.

The Earth rotates on its axis once each day. This rotation explains why the Sun, Moon, planets, and stars appear to rise in the east and set in the west.

The Earth also revolves around the Sun once each year. This motion explains why the Sun appears against a different constellation of the zodiac as the months progress.

These two insights transformed science.

Yet Copernicus made a third assumption that is rarely discussed.

He assumed the Sun itself was immovable.

To a sixteenth-century scholar this was perfectly reasonable. No one knew that stars moved through space. Binary star systems were unknown. The Milky Way had not yet been recognized as a galaxy. Astronomers had no concept of stellar populations, galactic rotation, or the vast motions now known to occur throughout the universe.

By fixing the Sun in place, however, Copernicus created an important constraint:

Any apparent motion of the Sun relative to the stars had to be explained entirely as a motion of the Earth.

It is this assumption that ultimately led to one of astronomy's most enduring ideas: the theory of axial precession.

## Forgotten Origins: Copernicus and the Greeks

Nicolaus Copernicus is often credited with inventing the heliocentric system, but the idea that the Earth moved around the Sun long predated him.

Nearly eighteen centuries earlier, Aristarchus of Samos (c. 310–230 BC) proposed that the Earth revolved around the Sun and rotated on its axis. Although only fragments of his work survive, later writers recorded that Aristarchus placed the Sun at the center and treated the Earth as a moving planet.

Copernicus was aware of Aristarchus. In an early draft of *De Revolutionibus*, he even mentioned Aristarchus by name as someone who had previously proposed a moving Earth. The reference was later removed from the published version, but surviving manuscripts reveal that Copernicus knew he was reviving an ancient idea rather than creating an entirely new one.

The history of astronomy reminds us that even great breakthroughs often begin with the recovery of forgotten ideas.

# The Observable Came First

Long before Copernicus, astronomers had noticed a curious phenomenon. As the Sun moved forward through the twelve constellations during the year (Capricorn, Aquarius, Pisces, etc.), the Sun moved backwards year after year (Pisces, Aquarius, Capricorn, etc).

Viewed another way, the equinoctial points—the locations where the celestial equator intersects the ecliptic—do not remain fixed relative to the stars at every equinox. Instead, they drift slowly backward through the zodiac at approximately fifty arc seconds per year.

Today this phenomenon is known as the precession of the equinoxes.

Importantly, the observable existed before any accepted explanation.

Ancient observers knew the Sun or equinoxes moved. What they did not know was why.

This distinction is critical.

Science often progresses by observing a phenomenon first and identifying its cause later. The danger comes when an explanation becomes so familiar that it is mistaken for the observation itself.

The observable is simple:

The Sun's position at the equinoxes shifts slowly westward relative to the background stars.

The explanation is another matter entirely.

# Copernicus's Third Motion

Because Copernicus assumed the Sun could not move, he concluded that the Earth itself must possess a third motion.

In addition to daily rotation and annual revolution, the Earth in his mind would have to maintain a changing orientation relative to the stars.

He referred to this motion as libration, an early precursor to what would later be known as axial precession

The idea solved a practical problem within the heliocentric framework. If the Earth moved around the Sun while maintaining the seasons, but changed its relationship to the sky on the equinox (not aligning with the same stars in the heavens), that could be explained if the axis itself changed position. The crucial point is that Copernicus did not begin with evidence that the Earth's axis physically wobbled.

Rather, he began with a moving Earth and a stationary Sun.

With these constraints the only possibility was a third motion of the earth.

Whether that motion represented the true cause of the Sun's retrograde motion, a.k.a. the precession observable, remained an unasked and unanswered question.

# Newton Solves the Wrong Problem?

More than a century later, Isaac Newton provided what would become the foundation of modern precession theory.

Like most astronomers of his era, Newton accepted the Copernican framework. Indeed, he may have seen it as a chance to put his newly discovered laws of physics to work, reasoning that if the Earth's axis wobbled, it must be due to the gravitational forces from the nearby Sun and Moon exerting torques on the earth's equatorial bulge.

It was an elegant explanation, but proved difficult to model.

Over the next three centuries, Euler, d'Alembert, Lagrange, Laplace, and countless others added inputs and refined the mathematics, to make the result better match the observable. Simon Newcomb even added a constant to help the equation match the slowly increasing precession rate. Modern precession theory was considered one of the most sophisticated achievements in celestial mechanics.

Yet every refinement shared a common starting point inherited from Copernicus:

The observed retrograde motion of the equinoxes was assumed to arise from motion of the Earth's axis. No one thought to ask if the solar system itself might move.

The question became:

Why does the axis move?

Had Copernicus and Newton not been such great authorities, a different question might

have been explored:
Why does the Sun move backward through the stars at approximately fifty arc seconds per year?

One question assumes the cause.

The other investigates it.

# A Different View

Copernicus relocated the center of motion from the Earth to the Sun, but he never considered whether the Sun itself might participate in larger celestial motions.

In 1894, an Indian astronomer and philosopher named Sri Yukteswar published a small book entitled The Holy Science.

The work is best known in spiritual circles, yet it contains an unusual astronomical observation.

Yukteswar described a hierarchy of celestial motions. Moons revolve around their planets. Planets with their moons orbit stars, and stars, with their planets and moons, participate in larger orbital systems.

He also said, the Sun and its family of planets, revolve around a companion star in a cycle of approximately 24,000 years. He mentioned that the last perihelion was around 11,500BC and last aphelion about 500AD.

Important to our subject, he explicitly linked this motion to the precession observable, writing that the Sun's revolution around its "dual" star caused the "backward movement of the equinoctial points around the zodiac."

In other words, Yukteswar was not merely proposing a companion star.

He was deducing the precession observable, a moving equinox, to be an artifact of a larger motion, a moving solar system.

# Predictions East vs. West

Applying Kepler's laws to Yukteswar's orbit, we can estimate that the observable precession rate should not remain constant but would gradually increase as the Solar System moved away from aphelion toward perihelion. Assuming modest eccentricity his model implies a secular increase of approximately **0.000349 arc seconds per year**, in the current era.

Around the year 1900, Newcomb, apparently unaware of Yukteswar's explanation, introduced a correction to the prevailing lunisolar theory of precession. Based on his analysis of historical observations, Newcomb concluded that the precession rate was also increasing, but at a slower rate of approximately **0.000222 arc seconds per year.** While Newcomb's constant had no known dynamical foundation, it did allow the precession equation to better match the observable.

It has now been over hundred years since Yukteswar and Newcomb published their work. Recent measurements indicate an increase of approximately **0.000346 arc seconds per year**, remarkably close to the value implied by Yukteswar's model.

Whether this agreement is coincidental or physically significant remains open to debate. Yet the comparison raises an intriguing possibility. Even if precession ultimately has multiple contributing causes, the Keplarian motion of the Sun in a larger orbit appears capable of accounting for most of the observed secular increase and, potentially, a substantial portion of the approximately **50.3 arc seconds per year** precession observable itself. If so, Solar System motion may play a far greater role in precession than is generally recognized.

## What Does VLBI Actually Measure?

Modern astronomy measures Earth's orientation using Very Long Baseline Interferometry (VLBI).

VLBI compares signals from distant quasars to determine how the Earth is oriented in space.

The technique is extraordinarily precise.

Yet an important philosophical question remains.

VLBI measures orientation relative to distant objects.

It does not directly reveal the cause of an orientation change.

If an observer's frame changes orientation relative to distant quasars, the measurement itself cannot immediately determine whether that change arose from:

- motion of the Earth,
- motion of the Solar System,
- or some combination of both.

The interpretation depends upon the model used to explain the measurement.

For supporters of the conventional framework, this distinction changes nothing.

For advocates of alternative interpretations, it remains central.

## The Search for the Missing Mass

If precession is primarily a manifestation of Solar System motion, an obvious question follows:

What causes that motion?

Over the past decade astronomers have become increasingly interested in the possibility of unseen masses in the outer Solar System.

The proposed Planet Nine hypothesis seeks to explain several anomalous solar system features, including the inclined and elongated orbits of trans-Neptunian objects.

While a Planet Nine has not yet been found, some have suggested more exotic possibilities, including distant brown dwarfs or stellar companions.

No consensus has emerged.

Yet the search itself reflects a broader reality:

Modern astronomy already accepts that significant unseen masses may influence the architecture of the Solar System.

The debate concerns their nature, location, and effects.

# The Question That Remains

The purpose of revisiting Copernicus is not to diminish his achievements.

Without his insights, modern astronomy may not exist.

Rather, it is to recognize that great scientific advances often contain assumptions that later generations inherit without question.

Copernicus correctly identified Earth's rotation.

He correctly identified Earth's revolution.

He also assumed that the Sun was fixed.

Five centuries later, the observable that motivated his third motion remains with us.

The Sun still moves backward through the zodiac at approximately fifty arc seconds per year.

Modern astronomy explains this motion through changes in the orientation of the Earth's axis. Although the Earth participates in larger motions, such as solar system motion through the galaxy, this contributes less than one ten-thousands of an arc second to the precession observable. In other words, modern astronomy attributes virtually all of the observed retrograde motion of the Sun to changes in Earth's orientation rather than actual motion of the Solar System.

Alternative interpretations suggest that some portion of the observable may instead arise from larger motions of the Solar System itself.

The debate remains unresolved.

But perhaps the most important lesson is historical.

Copernicus challenged the assumption that the Earth was fixed.

The next great advance—if one remains to be made—may begin by asking whether another assumption deserves the same scrutiny.

For the observable came first.

The explanation came later.

**And science advances whenever explanations remain open to examination.**