This Neptune-sized world orbits backwards, hinting at a hidden giant's influence

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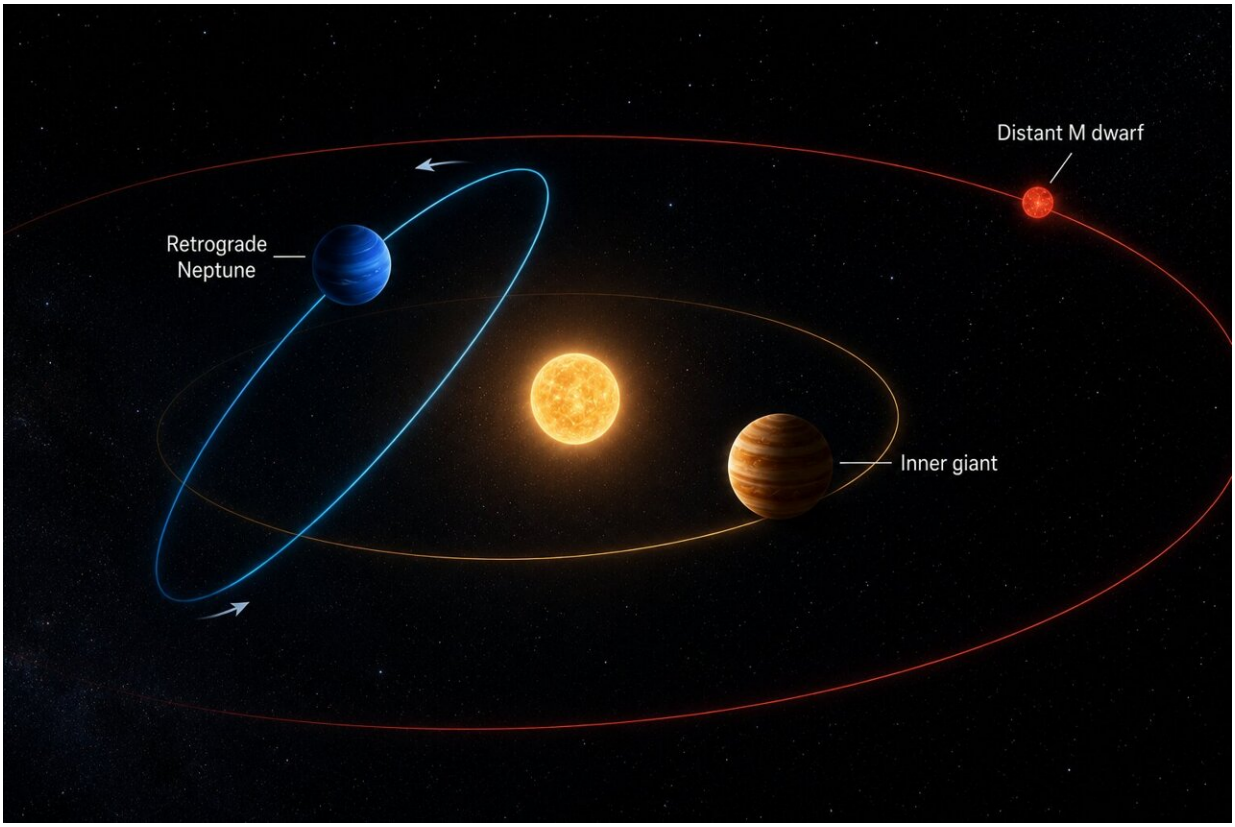


Artist's concept of the TOI-1710 system showing a retrograde warm Neptune on a tilted orbit, a closer giant planet, and a distant M-dwarf companion. The illustration highlights how these companions may interact to flip Neptune's orbit. Credit: Generated by the author using AI tools for illustrative purposes

Imagine a world the size of Neptune, but instead of following the orderly

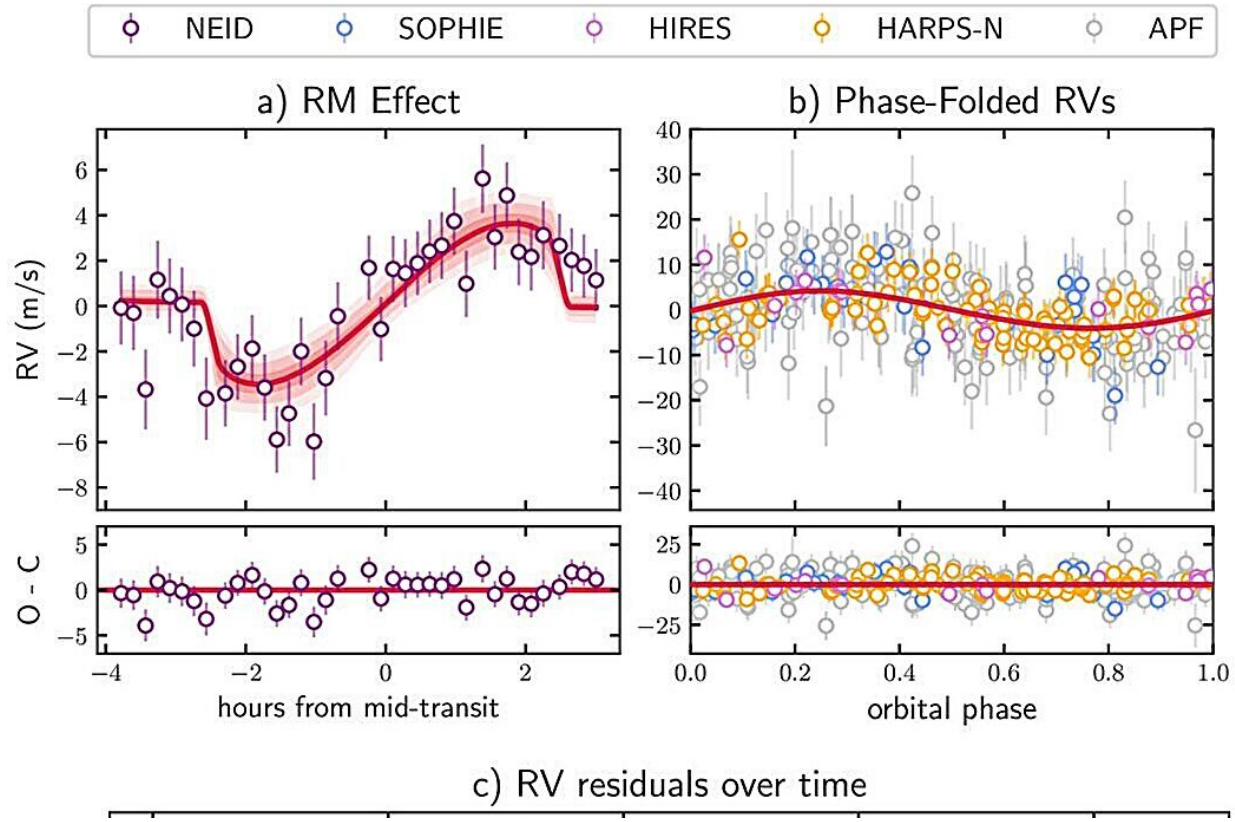
path of its neighbors, it is racing headlong against the flow of its own solar system. In the case of the exoplanet TOI-1710 b, the cosmic clockwork has gone topsy-turvy. This "warm Neptune" doesn't just have a slight tilt; it appears to be performing a backward dance around its sun—an extreme orbital misalignment that hints at a violent, tumultuous history.

A new study has now confirmed just how dramatic this reversal is. By tracking the star's motion, astronomers found that the planet's path is almost perfectly upside down relative to its star's rotation. In technical terms, the orbit is tilted by nearly 180 degrees, the equivalent of a car driving the wrong way down a one-way circular track. As the researchers note, this "retrograde" motion means the planet is essentially orbiting backward, a nearly complete flip that serves as a permanent scar from a massive gravitational upheaval in the system's past.

These new findings were published in *The Astrophysical Journal Letters*.

A Neptune in reverse?

Why would a planet go the wrong way? This is the central question that immediately arises when astronomers discover a world like TOI-1710 b. While we've found many "hot Jupiters," massive planets orbiting extremely close to their stars that exhibit misaligned or even retrograde orbits, such behavior is far less common and less understood for "warm Neptunes." These are planets like TOI-1710 b, similar in size to our own Neptune but orbiting their stars over periods of weeks, not years. Their orbits are generally expected to be much more stable and aligned with their star's rotation.

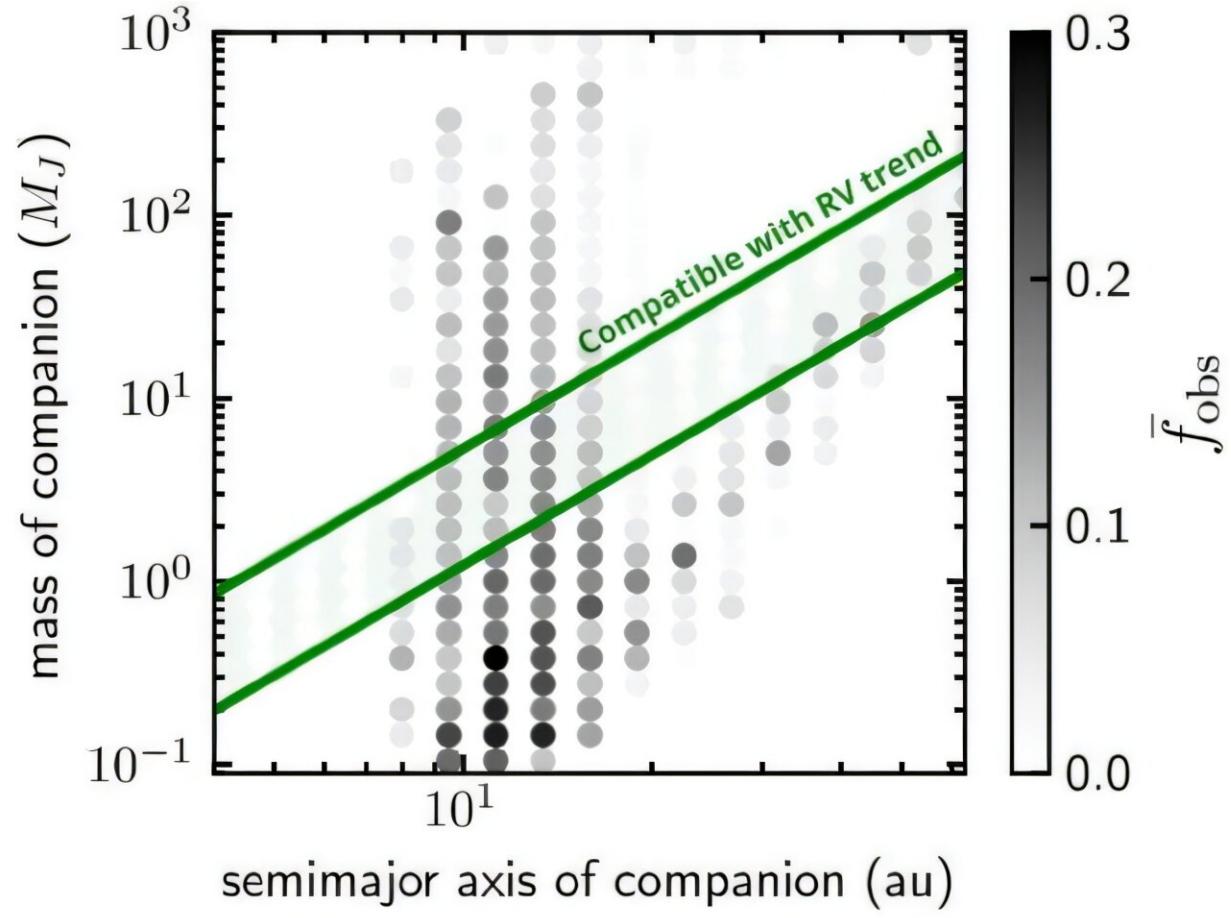


Tracking the TOI-1710 system. Astronomers combined observations from the NEID instrument, TESS, and other telescopes to study the planet's orbit. The data revealed the planet's tilted path, confirmed its transit signal, and showed a long-term change in the star's motion—a clue that another hidden companion may be influencing the system. Credit : Juan I. Espinoza-Retamal et al, POSEIDON. II. The Antialigned Orbit of the Warm Neptune TOI-1710 A b, *The Astrophysical Journal Letters* (2026). DOI: 10.3847/2041-8213/ae7711

The mere fact that TOI-1710 b is taking the cosmic equivalent of a U-turn is significant, but it matters in more ways than one. Such a dramatic misalignment does not happen by chance; rather, it is akin to the fossilized imprint of what transpired in the evolutionary history of this system.

TOI-1710 b's backward orbit strongly suggests that some significant gravitational event "kicked" it into this unusual configuration. Initially, astronomers might look to obvious culprits. Indeed, the host star of TOI-1710 b isn't alone; it has a known companion—a distant M-dwarf star orbiting at an immense distance of about 3,600 astronomical units (AU). But this distant stellar companion is too far away to exert the kind of strong gravitational influence required to fully flip the orbit of an inner planet. Its gravity would be far too weak to account for such an extreme tilt.

Instead, the evidence suggests a more complicated, and perhaps hidden, gravitational dance. Some other massive, unseen player—or a complex web of gravitational interactions—may be pulling the strings behind this planet's odd, retrograde journey. But if the distant star isn't the direct cause, what else might set off such a cosmic upheaval?



Mass–semimajor axis diagram for the hypothetical intermediate companion. The points are colored according to the probability of observing TOI-1710 A b in its current configuration, as computed from our secular integrations. Each point represents an average over a range of initial mutual inclinations between the intermediate companion and the M dwarf companion. The green region indicates the 5σ constraints imposed by the observed RV trend. Credit : Juan I. Espinoza-Retamal et al, POSEIDON. II. The Antialigned Orbit of the Warm Neptune TOI-1710 A b, *The Astrophysical Journal Letters* (2026). DOI: 10.3847/2041-8213/ae7711

Cosmic dominoes: The hidden planet

The star's motion offers a clue: Its long-term radial velocity shows a steady trend, indicating an unseen companion. The team proposes a gas giant of roughly 5 Jupiter masses orbiting at about 15 AU. In simulations, this intermediate planet acts as a gravitational bridge: it is tugged by the faraway star and, in turn, yanks on the inner Neptune. The models even keep Neptune's orbit nearly circular, matching its observed low eccentricity. As the authors explain, such a companion can "dynamically couple the warm Neptune to the distant M dwarf, enabling the transfer of inclination from the wide binary orbit to the planetary orbit."

In their simulations, the researchers explored different companion orbits. They found that only when the proposed companion was at approximately 15–16 AU did Neptune's tilt regularly enter the observed retrograde range. In that specific scenario, the inner planet's orbit also remained nearly circular, consistent with observations. As the researchers note, "Assuming this scenario is correct, we predict the intermediate companion is a ~5 M_J planet on a ~15 au orbit that is nearly aligned with the transiting planet's orbit."

Looking ahead

If this picture is correct, future observations should confirm the hidden giant. In particular, Gaia's high-precision astrometry could detect the planet's tiny wobble in the sky. Continued monitoring with NEID and other spectrographs, or even more precise transit-timing measurements, could also nail down its orbit. Finding a ~5-Jupiter-mass world at ~15 AU would validate this "inclination cascade" scenario.

This isn't the first time astronomers have found a gravitational "domino effect." For example, in the HAT-P-7 system, a distant star and giant planet sequentially flipped a close-in world into a backward orbit. TOI-1710 A b may be an even more dramatic case: a smaller planet

flipped by a remote star, with a hidden giant linking them.

Beyond the data, the result tells a compelling story. A Neptune-sized planet going the wrong way is an intuitive hook that captures the imagination. It implies that invisible forces—other planets and stars—sculpt the system. As one researcher puts it, the observations "reveal that [TOI-1710 A b] orbits in the direction opposite to the stellar spin," a striking result that illuminates the complex origin of planetary systems. For now, TOI-1710 A b's backward dance is a striking oddity; future surveys of Neptune-sized worlds will reveal whether this pattern recurs in other planetary systems.

More information: Juan I. Espinoza-Retamal et al, POSEIDON. II. The Antialigned Orbit of the Warm Neptune TOI-1710 A b, *The Astrophysical Journal Letters* (2026). DOI: 10.3847/2041-8213/ae7711