

# PHYSICS UPDATE

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## JUPITER'S DYNAMO IS UNLIKE ANY OTHER

Before NASA's *Juno* mission, the best available data suggested that the spatial structure of Jupiter's magnetic field looked similar to Earth's. But when Kimberly Moore and Jeremy Bloxham from Harvard University, John Connerney from NASA's Goddard Space Flight Center, and their colleagues mapped Jupiter's magnetic field with a new analysis of *Juno* observations, they found that the planet's magnetic

field differed "from all other known planetary magnetic fields."

Jupiter's magnetic field, like Earth's, comprises a dipolar field (analogous to a bar magnet) and a nondipolar component. But Jupiter's nondipolar field, unlike Earth's, resides mostly in the northern hemisphere, whose turbulent atmosphere is shown here.

The researchers suggest that the complex structure in Jupiter's metallic hydrogen region may explain the hemispheric asymmetry. Planetary formation models hypothesize that Jupiter should have a rocky core. At high temperatures and pressures, the rock dissolves



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nonuniformly into the surrounding metallic hydrogen and could separate the hydrogen region into layers of different density. If the inner layer is stable, then the dynamo action would depend on the convectively unstable thin outer layer—a feature that would produce hemispheric asymmetry and reduce the magnetic flux at high latitude. Such a pattern would be unlikely if the inner layer was also convectively unstable. The stability of the inner layer may be determined soon: The second half of *Juno*'s mission brings the instrument to the northern hemisphere for finer resolution magnetic flux measurements. (K. M. Moore et al., *Nature* **561**, 76, 2018). —AL

## STIFFNESS GRADIENTS IN SPIDER WEBS

The familiar spoke-and-spiral pattern of spiders' orb webs incorporates a remarkable degree of engineering. For starters, the spiders produce different silks for each part: Radial threads are strong and stiff, while glue-coated spiral threads are soft and stretchable. The two sets of threads work synergistically to absorb the impact of a flying insect that gets trapped. Yang Guo and colleagues at Tsinghua University and Brown University now report that whereas the intrinsic mechanical properties of the radial threads in a web are roughly uniform, those of the spiral threads vary with distance from the center. Through systematic

measurements of multiple webs spun by *Araeneus ventricosus* spiders, the researchers found that although the diameters of the spiral silks are fairly constant, spiral silks at the periphery have up to 10 times the Young's modulus—a measure of intrinsic stiffness—and 6 times the tensile strength of spiral silks near the center. To understand the implications of the stiffness and strength gradients, the team turned to a model web with 10 radial and 10 spiral threads; the im-



pect of a flying insect was represented as a force concentrated at the midpoint of a given spiral segment. The spiral threads' stiffness was either uniform or varied linearly with distance from the center. The researchers found that the stiffness gradient enhanced the web's structural integrity and ability to efficiently absorb the impact energy regardless of how far out the impact occurred. (Y. Guo et al., *Appl. Phys. Lett.* **113**, 103701, 2018). —RJF

## DETECTING DIFFERENTIAL ROTATION OF SUN-LIKE STARS

At its equator, our sun rotates with a period of 25 days, which is about 11% faster than at its midlatitudes (45°). What generates the differential rotation isn't clear, but it's thought to sustain the Sun's magnetic field through a dynamo mechanism. To appreciate the relative magnitude of the Sun's differential rotation, scientists want to compare it with that of other stars with Sun-like masses. Most rotation studies monitor starspots at different latitudes or use Doppler imaging to track the migration in latitude of magnetic features on the surface. But most stars, especially their surface features, are too distant to be clearly resolved in images.

An international collaboration led by Othman Benomar of New York University's Abu Dhabi Center for Space Science adopted a more sensitive and precise method—asteroseismology, which probes features temporally rather than spatially. (See the article by Conny Aerts, *PHYSICS TODAY*, May 2015, page 36.) The technique

measures the various resonant frequencies of acoustic waves and oscillations that are driven by motions in a star's outer layers. Benomar and colleagues used NASA's *Kepler* spacecraft to study the outer convection zones of some 40 stars for up to four years. Splitting the observed modes of oscillation into separate frequency components distinguishable by angular degree and azimuthal order provided data about the rotation rate and the shape of the stars. That information puts constraints on such physical processes as flows, tidal forces, and magnetic fields acting in the star. The decomposition has been used extensively in helioseismology but not previously in the analysis of other stars.

The *Kepler* measurements revealed that the equators of 13 of the stars in the sample rotated approximately twice as fast as their midlatitudes. That was a surprise. The latitudinal shear inferred from that rate is much larger than predictions from numerical simulations. (O. Benomar et al., *Science* **361**, 1231, 2018). —RMW [PT](#)