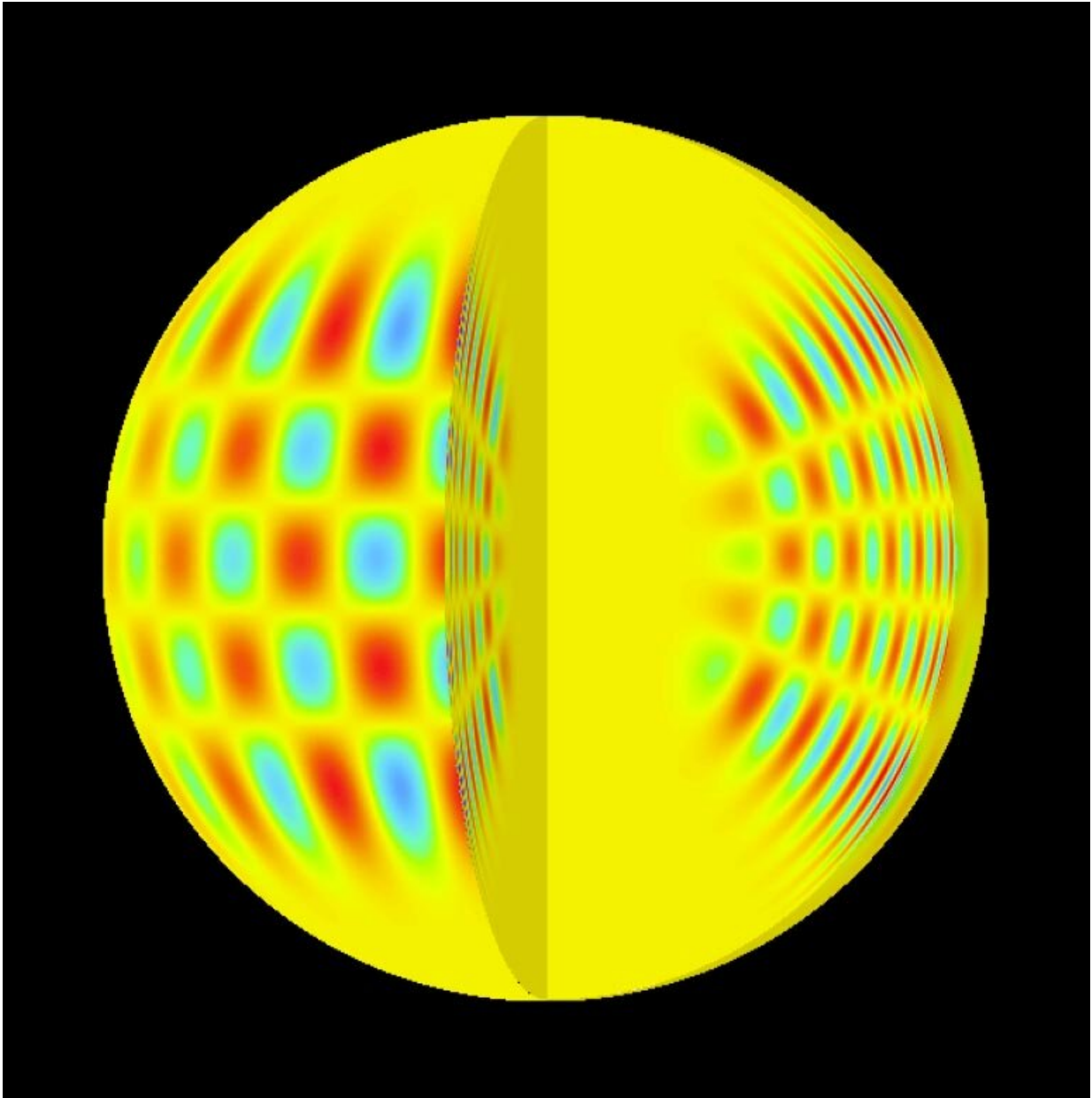


# The interiors of stars

January 13 2020

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An illustration of vibration modes in the Sun. Astronomers have used the TESS

mission to study for the first time stellar oscillations in intermediate mass stars.  
Credit: Kosovichev et al., Structure and Rotation of the Solar Interior: Initial Results from the MDI Medium-L Program

The interiors of stars are largely mysterious regions because they are so difficult to observe directly. Our lack of understanding about the physical processes there, like rotation and the mixing of hot gas, introduces considerable ambiguity about how stars shine and how they evolve. Stellar oscillations, detected through brightness fluctuations, offer one way to probe these subsurface regions. In the Sun, these vibrations are due to pressure waves generated by turbulence in its upper layers (the layers dominated by convective gas motions). Helioseismology is the name given to the study of these oscillations in the Sun, and astroseismology is the term used for other stars.

Astronomers have long detected strong brightness variations in other [stars](#), for example the class of Cepheid [variable stars](#) used to calibrate the cosmic distance scale, but the small, [solar-like oscillations](#) driven by convection near the star's surface are much harder to see. Over the past few decades, space telescopes have successfully applied astroseismology to solar-type stars spanning many stages of stellar life. CfA [astronomer](#) Dave Latham was a member of a large team of astronomers who used the new TESS (Transiting Exoplanet Survey Satellite) datasets to study the interiors of the class of intermediate mass stars known as  $\delta$  Sct and  $\gamma$  Dor stars. These stars are more massive than the Sun but not large enough to burn through their hydrogen fuel very rapidly and die as supernovae. Pulsations generally arise principally from one of two processes, those dominated by pressure (where the gas pressure restores perturbations) or by gravity (where buoyancy does). In these intermediate-mass stars both of these processes can be important, with pulsations having typical periods of roughly about six hours. The

complexity of the combined processes, among other things, results in these intermediate-mass stars coming in a veritable zoo of variability types, and this variety offers astronomers more ways to test models of stellar interiors.

The astronomers analyzed TESS data on 117 of these stars using observations taken every two minutes; accurate distances to the stars (and hence accurate luminosities) were obtained from Gaia satellite measurements. The team was able for the first time to test and successfully refine models of pulsation for these stars. They found, for example, that gas mixing in the outer envelope plays an important role. They also spotted many higher-frequency pulsators, thereby identifying promising targets for future studies. Not least, they showed that the TESS mission has unprecedented potential not just for studying exoplanets, but also for improving our understanding of intermediate mass stars.

**More information:** V Antoci et al. The first view of  $\delta$  Scuti and  $\gamma$  Doradus stars with the TESS mission, *Monthly Notices of the Royal Astronomical Society* (2019). [DOI: 10.1093/mnras/stz2787](https://doi.org/10.1093/mnras/stz2787)

Provided by Harvard-Smithsonian Center for Astrophysics

Citation: The interiors of stars (2020, January 13) retrieved 30 April 2024 from <https://phys.org/news/2020-01-interiors-stars.html>

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