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Seismic Echoes of Magnetism: Sunspots and Starspots

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Sunspots, together with their stellar counterparts—starspots—serve as powerful tracers of magnetic activity on solar and stellar surfaces. Although visually dark, these regions are acoustically rich, as their intricate magnetic structures strongly influence the propagation of pressure waves. In this work, I present a comparative helioseismic investigation of sunspots on the Sun and extend the insights gained to the study of starspots on other stars, with the goal of decoding subsurface magnetic geometries through acoustic diagnostics. Using high-resolution Dopplergrams and intensity observations from the Solar Dynamics Observatory, we apply advanced helioseismic methods to examine the acoustic signatures of sunspots of varying size, age, complexity, and evolutionary stage. Measurements of wave absorption, phase shifts, and scattering properties provide new constraints on sunspot morphology and the underlying magnetic topology. These solar diagnostics form a benchmark for stellar applications, enabling us to better interpret magnetic activity and rotation in other stars—and ultimately advancing our understanding of stellar/solar evolution through the physics of magnetism and sound.

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