PHYSICAL MATH SEMINAR

The solar dynamo begins near the surface

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ABSTRACT:

The magnetic dynamo cycle of the Sun features a distinct pattern: a propagating region of sunspot emergence appears around 30° latitude and vanishes near the equator every 11 years. Moreover, longitudinal flows called torsional oscillations closely shadow sunspot migration, undoubtedly sharing a common cause. Contrary to theories suggesting deep origins of these phenomena, helioseismology pinpoints low-latitude torsional oscillations to the outer 5–10% of the Sun, the near-surface shear layer. Within this zone, inwardly increasing differential rotation coupled with a poloidal magnetic field strongly implicates the magneto-rotational instability, prominent in accretion-disk theory and observed in laboratory experiments. Together, these two facts prompt the general question: is the solar dynamo possibly a near-surface instability? Here we report strong affirmative evidence in stark contrast to traditional models focusing on the deeper tachocline. Simple analytic estimates show that the near-surface magneto-rotational instability better explains the spatiotemporal scales of the torsional oscillations and inferred subsurface magnetic field amplitudes. State-of-the-art numerical simulations corroborate these estimates and reproduce hemispherical magnetic current helicity laws. The dynamo resulting from a well-understood near-surface phenomenon improves prospects for accurate predictions of full magnetic cycles and space weather, affecting the electromagnetic infrastructure of Earth.

TUESDAY, OCTOBER 22, 2024

2:30 PM – 3:30 PM

Building 2, Room 449