BOSTON UNIVERSITY

Boston University College of Arts & Sciences Center for Space Physics

2023—2024 SPACE PHYSICS SEMINAR SERIES

Oscillating relic magnetic field in the Sun: A new paradigm for space climate allowing multi-cycle forecasting

We use a novel method to show that solar radio fluxes and sunspot numbers depict a similar systematic 22-year variation in hemispheric dominance during the last 75 years. Cycle maximum radio fluxes and sunspot numbers in all odd solar cycles (19, 21, 23) are larger in the north than in the south, but smaller in all even cycles (18, 20, 22 24). This indicates a new type of Hale-cycle related alternation of hemispheric activity and magnetic flux emergence.

Such an alternating hemispheric asymmetry gives strong evidence for the existence of a northward directed relic magnetic field, which was shifted northward during the 20th century. During a positive polarity minimum, poloidal fields are more enhanced in the northern than in the southern hemisphere, leading to a more active north during the subsequent odd cycle. Similarly, during a negative polarity minimum, poloidal fields are depleted more in the north than in the south, leading to a more active south during the subsequent even cycle. This creates the observed Hale-cycle related alternation of hemispheric dominance.

We also find that the maximum hemispheric asymmetry and the height of cycles are roughly correlated. This can be understood so that the relic field (distribution) shifts away from the solar equator (to the north) and back during one Gleissberg cycle. Asymmetry maximizes when the shift is large (as in cycle 19) and minimizes with no shift (in cycle 24). This also gives a new interpretation for Gleissberg cyclicity. However, a full relic shift oscillation consists of one century-long excursion to the north and one to the south. This gives a new interpretation for the 210-year Suess/deVries cycle as the relic shift cycle, and connects the Gleissberg cyclicity and the Suess/deVries cyclicity under the same new paradigm of an oscillating relic magnetic field.

A relic magnetic field (without shift) has earlier been used to explain the long-held variation of cycle heights, so called Gnevyshev -Ohl (G-O) rule, with a lower even cycle preceding a higher odd cycle. However, the G-O rule broke during cycle 23, which remained lower than cycle 22. In the shifted relic field model, the G-O rule remains valid when the relic shift and solar activity remain fairly constant, not when they change significantly, which happened in cycle 23. Accordingly, the oscillating relic field also explains why the G-O rule broke during cycle 23. The centennial alternation of hemispheric asymmetry has already earlier been evidenced in geomagnetic activity, suggesting that the heliospheric streamer belt follows the relic shift location and that the relic shift indeed changed its direction in the 19th century.

The oscillating relic field allows to make long-term forecasting for several cycles into the future, contrary to the one-cycle limit of current dynamo theories. Cycle 25 will become slightly, but not much larger than cycle 24, and cycle 26 will still remain rather small. However, cycle 27 will be much higher, with maximum annual sunspot number reaching 200. Finally, cycle 29 will be a century-high cycle, in analogy with cycle 19 being the highest cycle of the 20th century. However, cycle 29, as all odd cycles of the 21st century will be south-dominated while even cycles will be north-dominated, contrary to the hemispheric dominance of the 20th century.

Thursday, November 16th

4:00-5:00 p.m.

725 Commonwealth Ave | Room 502

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