What’s So Peculiar about the Cycle 23/24 Solar Minimum?

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What’s so peculiar about the present sunspot minimum?

Cycle 23 has ended and cycle 24 has started.

Let’s look at the sunspot numbers ...
Returning to the Deep Minima of Pre-Sputnik Sunspot Cycles

\[ \log_e(\text{SS#}) \]

\[ \text{SS#} \]

Time (years)
Eras of Deep and Shallow Sunspot Minima During the Past 250 Years

\( \log_e (SS\#) \)

SS#
What’s so peculiar about the present sunspot minimum?

1. Low sunspot numbers

What about the duration of the minimum? ...
MWO Ca II K images, showing intensity variations during the sunspot cycle

Jan. 15, 1958

Jun. 21, 1954

Jan. 30, 1958

Jun. 5, 1966

ACTIVE NORTH

INACTIVE SOUTH
MWO Doppler Residuals, Ulrich & Boyden (2005), Symmetrized by R. Howe

What’s so peculiar about the present sunspot minimum?

1. Low sunspot numbers
2. Delayed new-cycle activity

What about the polar fields? …
Ni I 6767Å photospheric magnetograms (SOHO/MDI) 1997-2009, …

... displayed with 26.9 days per map (equatorial rotations)
6767 Å continuum images during Feb. 7-21 of each year 1997-2005, showing long-term variations in the number of south polar faculae.
Comparing MWO polar faculae & WSO polar fields during 1976-2006

**North Polar Field vs. North Polar Faculae**

- Number of polar faculae vs. WSO line-of-sight field (gauss)
- $m = 11.2$
- $b = -1.75$
- $r = 0.962$

**South Polar Field vs. South Polar Faculae**

- Number of polar faculae vs. WSO line-of-sight field (gauss)
- $m = 10.2$
- $b = 0.99$
- $r = 0.944$
What’s so peculiar about the present sunspot minimum?

1. Low sunspot numbers
2. Delayed new-cycle activity
3. Weak polar magnetic fields

What about coronal holes and open flux? …
Slightly smaller polar holes ...

... with much less magnetic flux.
This sunspot minimum has less open flux than any cycle in the past 40 years.
\[ B = B_{\text{obs}} \ (12/29/07 - 01/25/08) \]

CARRINGTON ROTATION 2065 (NSO)

\[ B = B_{\text{obs}} - 6 \ \text{(Gauss)} \ \cos^7 \theta \]

CARRINGTON ROTATION 2065 (NSO)
\[ B = B_{\text{obs}} \ (08/30/08-09/26/08) \]

CARRINGTON ROTATION 2074 (NSO)

\[ B = B_{\text{obs}} - 6 \text{ (Gauss)} \cos^7 \theta \]

CARRINGTON ROTATION 2074 (NSO)
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3. Weak polar magnetic fields

4. Smaller polar holes with less open flux

Perhaps meridional flow provides some clues...
MWO (CR1516-2084) (4/-4 G)

17.5 m/s
6.4 m/s
10.8 m/s

NSO (CR1645-2084) (4/-4 G)
The low-latitude battle determines the amount of unbalanced trailing-polarity flux... available in each hemisphere for reversing the polar fields.
The high-latitude battle determines the shape of the polar topknot of flux...

... \( v = \frac{\kappa \text{ grad } B}{B} \)  

\( B \sim \cos^{N\theta} \) with \( N = \frac{vR}{\kappa} \)
Meridional flow regulates the polar field reversal.
Meridional Flow Speed – A link the the dynamo

1. Variations from cycle to cycle  →  polar field reversals.

2. A slightly faster low-latitude flow  →  a much weaker polar field.

3. A slightly faster high-latitude flow  →  a smaller polar cap.

4. A smaller cap of weaker field  →  a smaller polar coronal hole with less open flux.

5. A slower subsurface return flow  →  delayed onset of the next cycle.
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… all linked to the Sun’s meridional flow?

This is not your father’s solar minimum …

It’s your grandfather’s solar minimum!
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