Why is the Sun less active than (some) other solar-like stars?

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Sample selection

369 “solar-like” stars
- Rotation: 20-30 days
- 13% of composite sample

2529 “pseudo-solar” stars
- Rotation: not detected
- 87% of composite sample

Reinhold+ (2020)
Range of variability

A. $R_{\text{var, max}} = 0.18\%$

B. $R_{\text{var}} = 0.18\%$

D. $R_{\text{var}} = 0.84\%$

Reinhold+ (2020)
Variability distribution

- Composite sample (corrected)
- Periodic sample (corrected)
- Noisy Sun

Reinholt+ (2020)
Activity distribution

![Graph showing activity distribution with labels for non-periodic sample, 20 < $P_{\text{rot}}$ < 30 days, and 10 < $P_{\text{rot}}$ < 20 days.](Zhang+ (2020))
Multivariate linear regression

- Account for wide range of stellar properties with linear regression model
- Correct variability range to the value it would have if star had Sun's properties
- Dependencies on Teff, [Fe/H] and rotation period approximately removed
Periodic stars typically cooler and slightly more metal-rich than average.

Non-periodic stars often hotter and metal-poor compared to the Sun.

Opposite biases in depth of convective envelope, important for activity!
Rotation and activity decouple

Metcalfe+ (2016)
Spin-down stalls near solar age

van Saders+ (2016)
Large-scale dynamo shuts down

Metcalfe & van Saders (2017)
Slow rotators missing or undetected

McQuillan+ (2014); van Saders+ (2019)
Dipole magnetic field disappears

88 Leo: non-axisym. \( \langle B \rangle_{ZDI} \sim 2.5 \) G

\( \rho \) CrB: \( \langle B \rangle_d < 20\% \) \( \langle B \rangle_q < 53\% \)

- Less evolved than Sun
- Activity cycle from MWO
- Field mostly dipole

- More evolved than Sun
- Flat activity from MWO
- Field mostly smaller-scale
Sample bias: Rossby number

- Bins with detected rotation and observed periods are biased toward lower Ro

- Scatter from large errors on both Teff (150-200 K) and [Fe/H] (0.15-0.30 dex)

- Alternative interpretation would not be expected to show dependence on Ro
Sample bias: evolutionary phase

The image shows a hexagonal binning graph with the effective temperature ($T_{\text{eff}}$) on the x-axis and the magnitude (G) on the y-axis. The colors represent different values, with higher values indicated by darker shades of purple and lower values by lighter shades. The color bar on the right shows the range of values from 0.0 to >0.6.
Interpretation: magnetic evolution

- Ro > critical
- Ro ~ critical
- Ro < critical

Composite sample (corrected)
Periodic sample (corrected)
Noisy Sun

Reinhold+ (2020)