Stellar Evidence of a Solar Dynamo in Transition

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Skumanich relation

Skumanich (1972)
Rotational evolution

Bouvier (2008)
Gyrochronology

van Saders et al. (2016, Nature); Meibom et al. (2011, 2015); Barnes et al. (2016)

slide from Jen van Saders
Gyrochronology

ZAMS Teff $\sim$6200-5100 K

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)
Gyrochronology

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)

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Gyrochronology

ZAMS Teff ~6200-5900 K

Age (Gyr)

Period (days)

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)
Gyrochronology

ZAMS Teff ~5900-5600 K

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)
Gyrochronology

ZAMS Teff ~5400-5100 K

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)
Gyrochronology revised

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)
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Gyrochronology revised

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Gyrochronology revised

van Saders et al. (2016, Nature); Creevey et al. (2016, submitted)
Stellar rotation with Kepler

Garcia et al. (2014)
Asteroseismology with Kepler

Metcalfe et al. (2012)
Rotation-activity relation

Metcalfe et al. (2016)
Rotation-activity relation

Metcalfe et al. (2016)
Differential rotation

Gastine et al. (2014)
Rapid magnetic evolution

Pace et al. (2009)
Rapid magnetic evolution

Metcalfe et al. (2016)
Spots and faculae

Lockwood et al. (2007)
Breaking magnetic braking

Metcalfe et al. (2016)
Breaking magnetic braking

Metcalfe et al. (2016)
Breaking magnetic braking

Metcalfe et al. (2016)
Solar analogs

Metcalfe et al. (2016)
Spindown and magnetic topology

Reville et al. (2015); see also Garraffo et al. (2015)
Zeeman Doppler imaging

Petit et al. (2008)
Zeeman Doppler imaging

• Young solar analog is dominated by a dipole (80% of poloidal field)

• Dipole (35%) is already disappearing in 18 Sco, with 55% in quadrupole

• Old solar analog has no Zeeman signatures, weak average line-of-sight field

Petit et al. (2008, + priv. comm.)
Stellar activity cycles

Metcalfe et al. (2016)
TESS: all-sky asteroseismology

ecliptic pole

ecliptic latitude 6°
Summary

- A change in differential rotation at $Ro \sim 1$ pushes stars across the V-P gap, rapidly decreases spot area, then disrupts magnetic braking at $Ro \sim 2$

- The Sun is in a transitional evolutionary phase, and its 11-year activity cycle may represent a special case of stellar dynamo theory

- Future ZDI measurements, more constraints on differential rotation, and asteroseismology of the Mount Wilson sample will help test this scenario