X-ray Activity Cycles in Stellar Coronae

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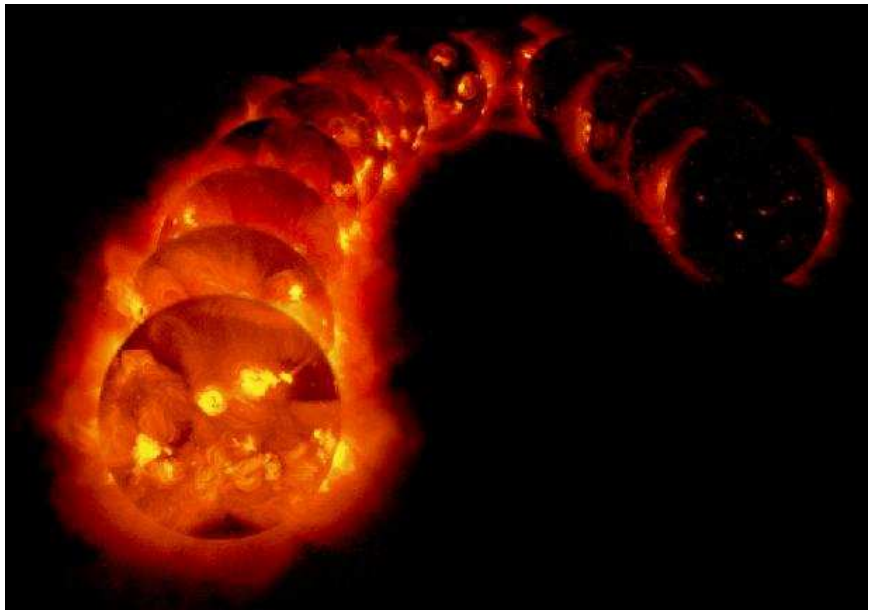
Hamburger Sternwarte

Coronae of Stars and Accretion Disks

MPIfR-Bonn, Dec. 2006

Coronal Activity Cycles



Solar coronal activity cycle (1991-1995)
(Yohkoh SXT 0.25 – 4.0 keV)

Cyclic variations of: Sunspot-number,
X-ray luminosity, Ca II emission ...

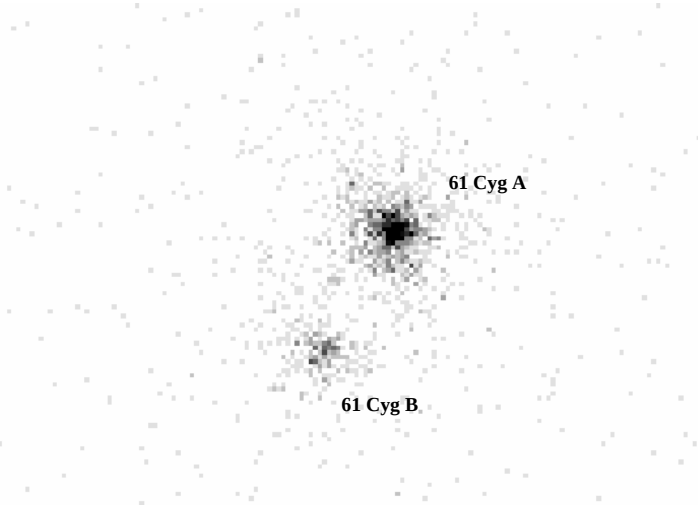
Periods of reduced/enhanced activity
$\Rightarrow$ Influence on terrestrial climate !?!

- Chromospheric stellar activity cycles well known
  from Ca II H+K (Mt. Wilson S-index) (Baliunas et al. 1995)
  - Activity + cyclic variations correlate with age/rotation (G- & K-stars)
- Coronal cycles require long-term X-ray monitoring (ROSAT: 61 Cyg)
- XMM-*Newton* program on solar-like stars (G2 – K7) with moderate levels of activity (α Cen A+B, 61 Cyg A+B, HD 81809)

61 Cygni

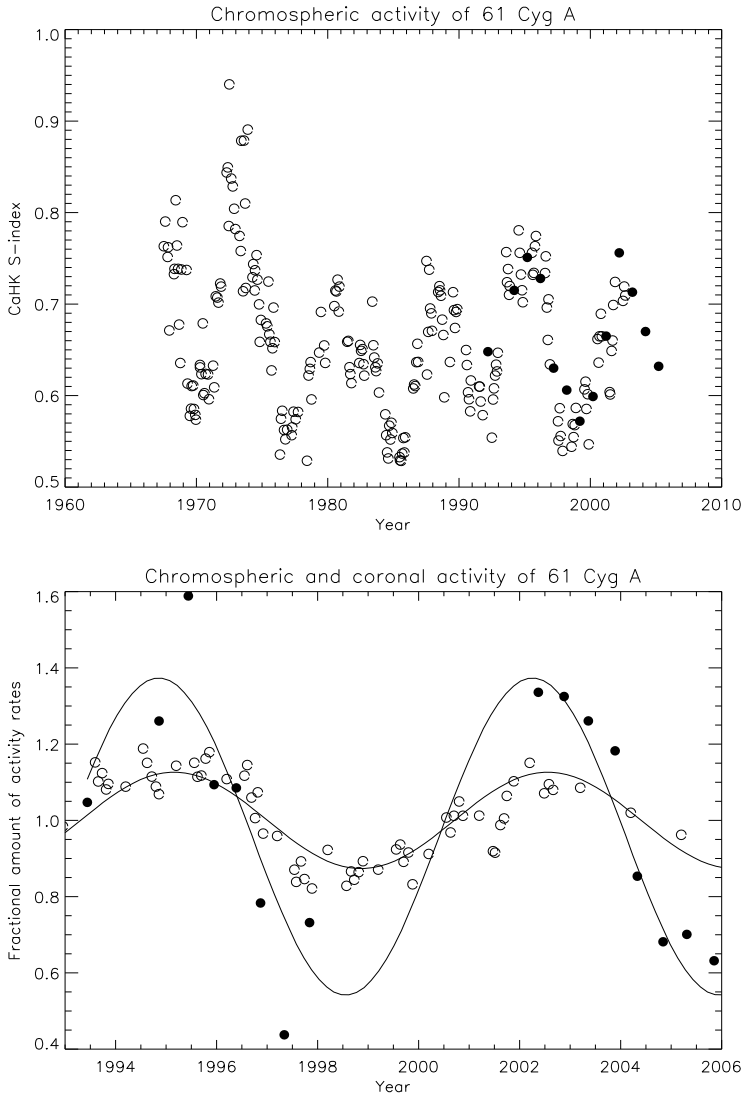
- 61 Cyg A (K5V) and B (K7V) at 3.5 pc, both slow rotators
- Chromospheric activity cycles from Mt. Wilson (+ Lowell Obs.)
  - 61 Cyg A: Smooth and regular cycle (7.3 yr)
  - 61 Cyg B: Longer and more irregular cycle (11.7 yr)
- Monitored with ROSAT (9 Obs. from 1993 – 1997)
  - L_X corr. with chromospheric activity (Hempelmann et al. 2003)

$\Longrightarrow$ 10 XMM-*Newton* observations (2002 – 2006)



MOS1 - Nov. 2002

61 Cyg A



Ca II S-Index, chrom. vs. coronal activity

- First persistent coronal cycle detected
  - In phase with Ca II and ROSAT
- Comparable flux-level and cycle amplitude (2.5 – 3.0) during both cycles
- Cyclic behaviour comparable to the Sun
  - Hot component (8 MK) during max. – decays over cycle
  - Cooler components (1 – 4 MK): moderate cooling / decline in EM

α Centauri

- α Cen A (G2V), α Cen B (K1V) at 1.3 pc, P_{rot} (29/42 d)
- Both inactive stars, dominated by cool plasma (1 – 3 MK)
- Already spatially resolved with *Einstein*, ROSAT, *Chandra*
- All prev. observations: comparable luminosities, B/A ratio of $\sim$ 2 – 3

$\Longrightarrow$ 8 XMM-*Newton* Observations (March 2003 – Aug. 2006)

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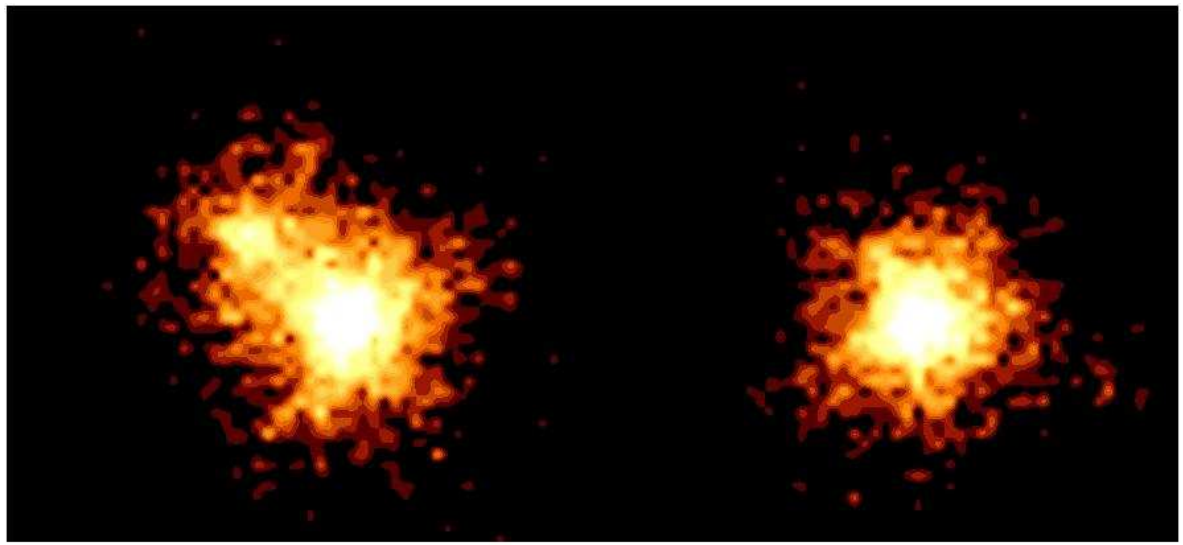
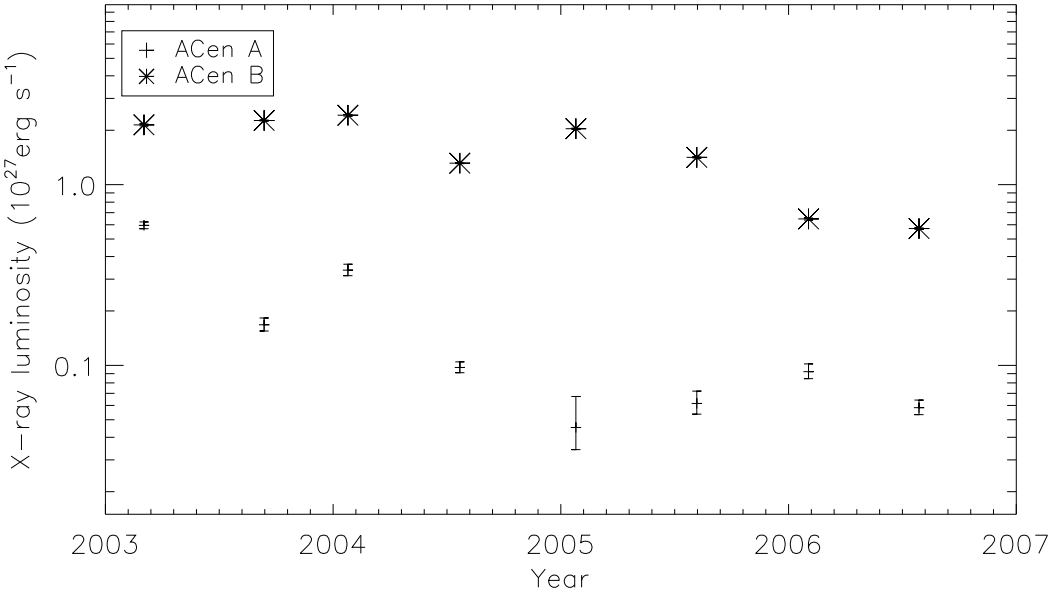


$\Longrightarrow$ **Darkening of the solar twin α Cen A** (03/2003 – 02/2005)

α Centauri A + B



- α Cen A : strong decline (order of magnitude) & moderate re-rising
- α Cen B : irr. variations, decline since 2005

- X-ray darkening of α Cen A observed for the first time in over 25 years
- No chromospheric data available
  - Singular event or
  - Coronal activity cycle – period ?
- Spectral changes resemble solar cycle
- Further data/observations: FUSE, *Chandra*

Summary

- Coronal activity cycles do exist in mod. active solar-like stars
- Spectral changes resemble solar behaviour
- Diversity of cycle parameters present
- Many open questions $\Rightarrow$ Obs. program ongoing

Star	Chr. Cycle/ mean S	L_X (0.2-2.0 keV)	log $L_X/Lbol$	X-ray Ampl.
α Cen A (G2)	?	25.5-26.7	- 7.0	$\gtrsim 10$
α Cen B (K1)	?	26.8-27.3	- 6.0	irr.(?)
61 Cyg A (K5)	7.3 yr (excl) 0.66	27.0-27.4/26.9-27.3	- 5.5	2-3/2-3
61 Cyg B (K7)	11.7 yr (good) 0.99	26.6-27.0/26.8-26.9	- 5.5	2-3/irr.
HD 81809 (G2)	8.2 yr (excl) 0.17	28.3-29.3	-6.0	~ 10

Collaborators & Publications:

HD 81809: F. Favata, G. Micela, S.L. Baliunas, et al. 2004, A&A, 418, L13

α Cen: J. Robrade, J.H.M.M. Schmitt, F. Favata 2005, A&A, 442, 315

61 Cyg: A. Hempelmann, J. Robrade, J.H.M.M. Schmitt, et al. 2006, A&A, 460, 261