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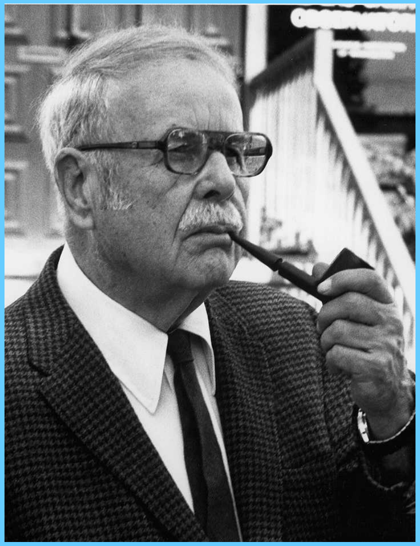
O.C. Wilson's stars: The ageing of stellar activity on the main sequence

Stockholm, 11.4. 2013

Based on: Schröder et al. 2013, A&A, in print



**Dr. Olin Wilson, 1909-1994,
long-term staff astronomer at Mt. Wilson
and faculty member of Caltech, Pasadena, CA**

The Mt. Wilson activity monitoring project:

- *monitoring the Ca II K chromospheric line emission variability, quantification relative to pseudo-continuum via the "S-index"*
- *sample: over 100 near (brighter than 7 mag) MS-stars of spectral type F-K, therefore mostly 0.7...1.5 M_sun*
- *includes „the Sun as a star" via Moon spectra*
- *duration: ca. 1962 to 1992 !! (about 3 activity cycles)*
- *some follow-up observations exist (Wright, Hall, ..., and since 2009: by the HRT = Hamburg robotic telescope, now in Guanajuato, J. Schmitt et al.)*

The Mt. Wilson project S-index of the CaII line emission is defined and normalized by:

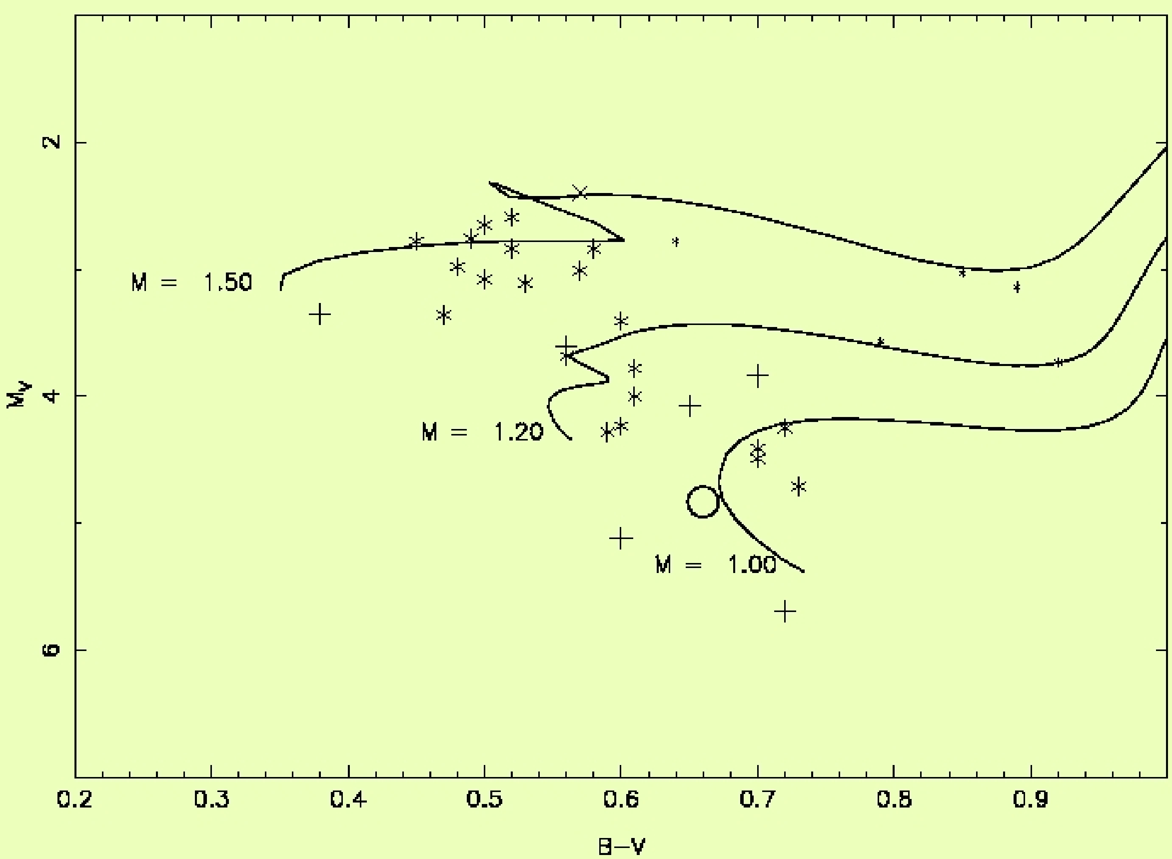
$$S = const.\ (F_H + F_K) / (F_R + F_V)$$

1 Angstr. wide line cores H&K / 20 Angstr. wide quasi-continua

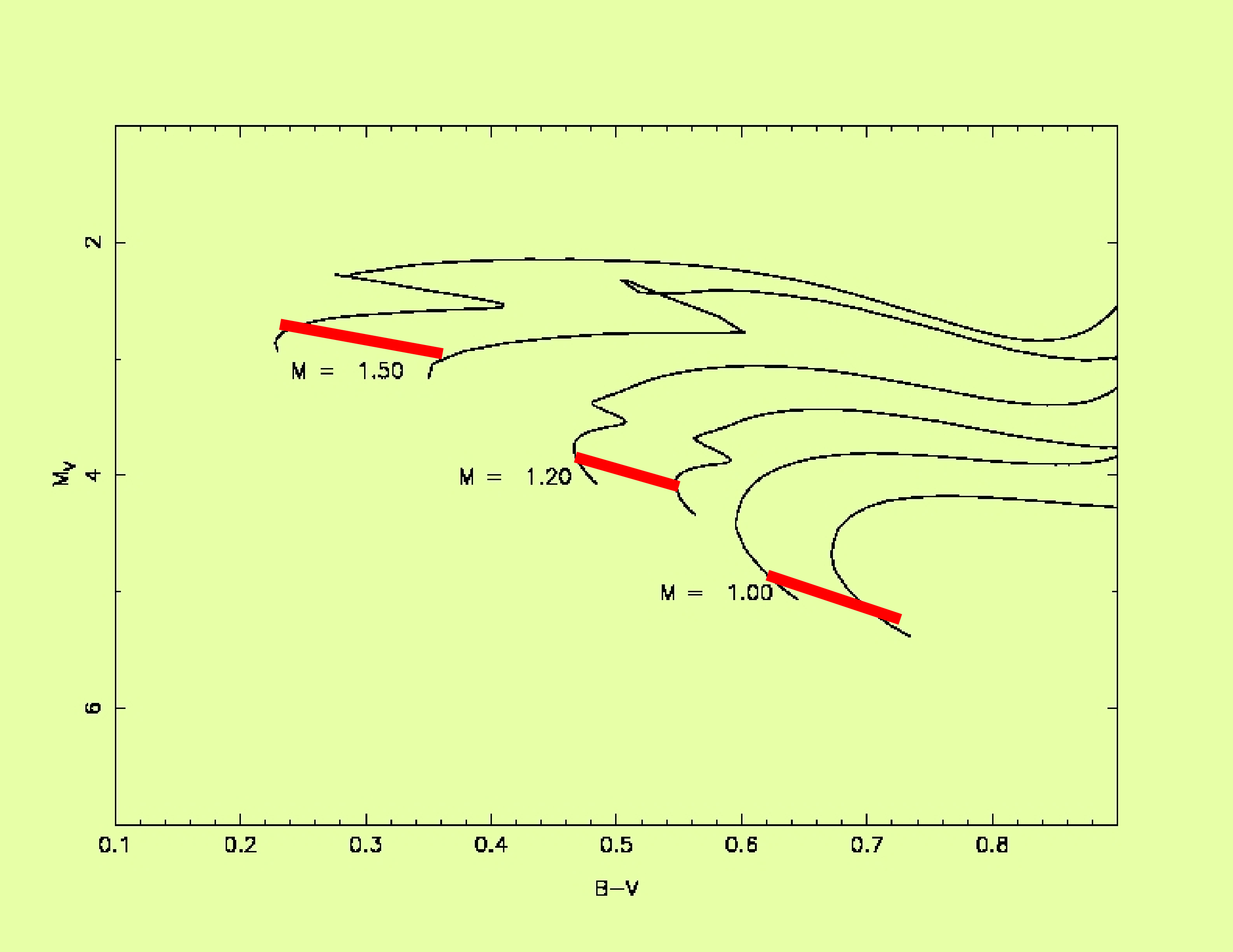
Hence, S is of the order of the line core intensity over cont. intensity
Modern spectra: const. ca. 19, star-calibrations needed.

Advantage: S is independent of sky quality and calibration lamps
Disadvantage: S does not directly compare with modern line fluxes!

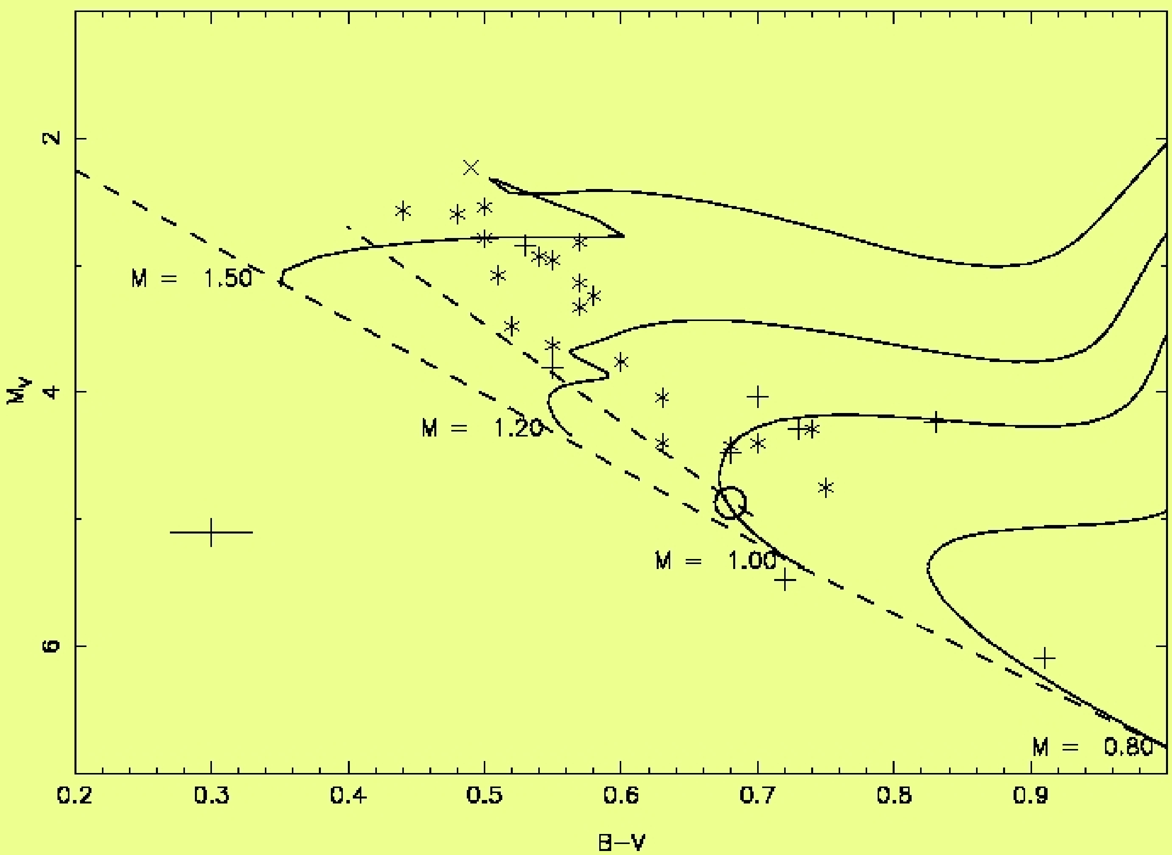
Inactive Mt.Wilson MS-stars (S < 0.17) over Z=0.02 evolution tracks: more evolved than the Sun (circle)! (as noticed already by Write 2004)



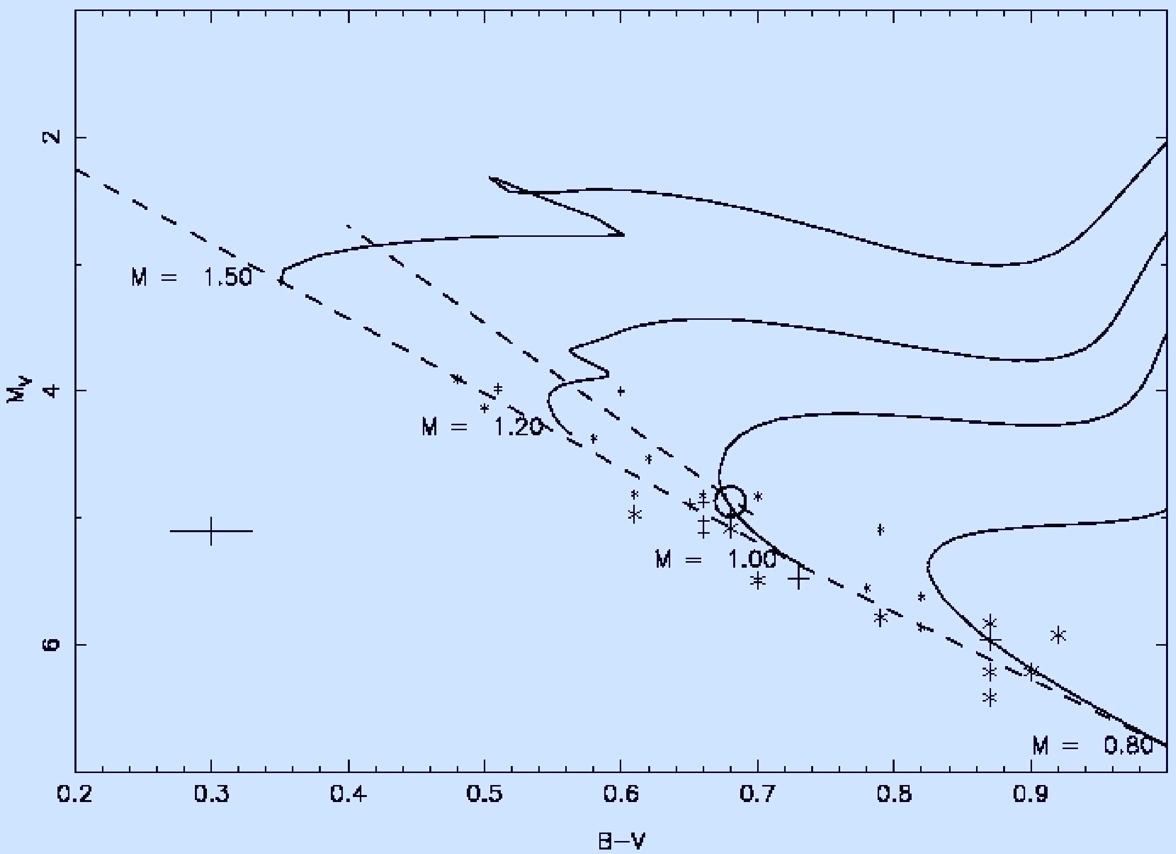
Evolution tracks for Z=0.02 (left set) and Z=0.01 (right):
Metallicity does matter for HRD position on the MS !
Holmberg et al. 2009 & Geneva-Copenhagen ubvy photom.:
Mt. Wilson stars occupy a range of Z ~ 0.005 ... 0.04 !



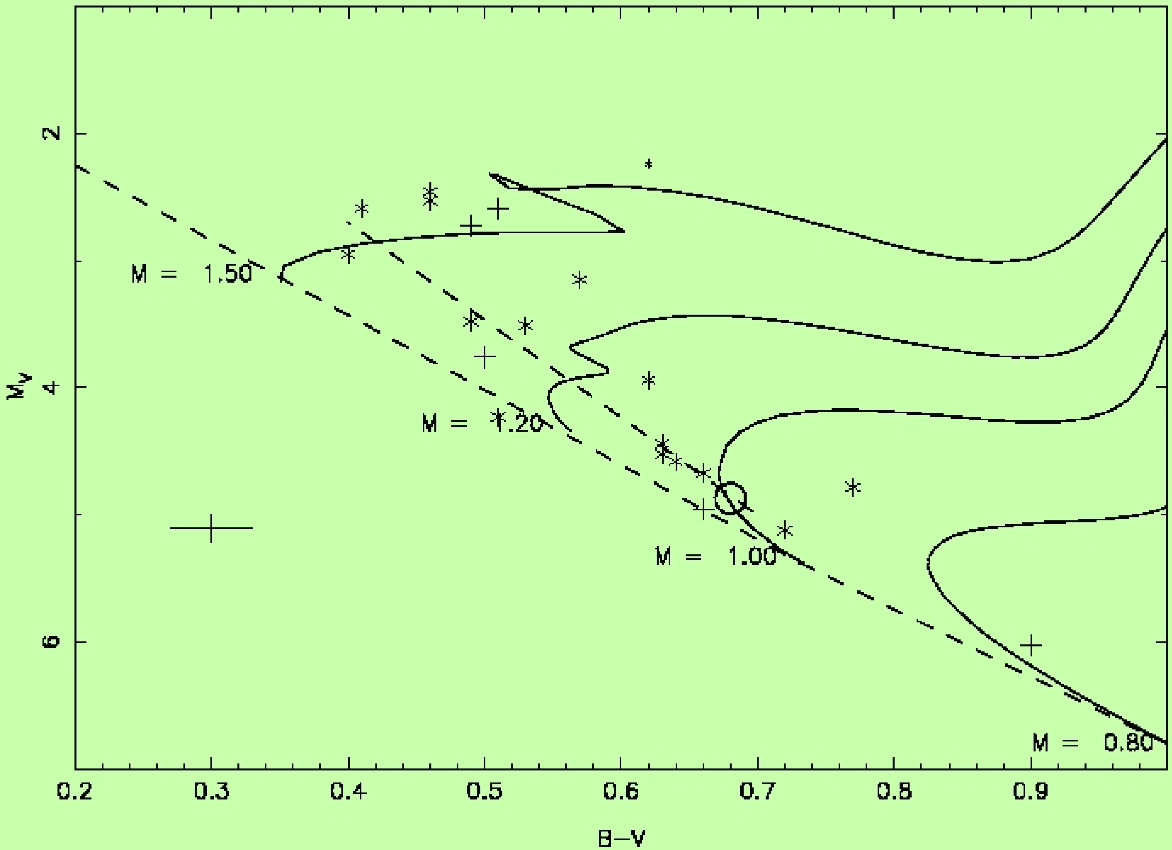
Inactive Mt.Wilson MS-stars (S < 0.17, near basal) over Z=0.02 evolution tracks, now adjusted for metallicity-differences: All these stars are over 50% MS-lifetime (- -), most over 75%! Note: NO evolved/inactive stars < 1 M_sun, age-limited.....



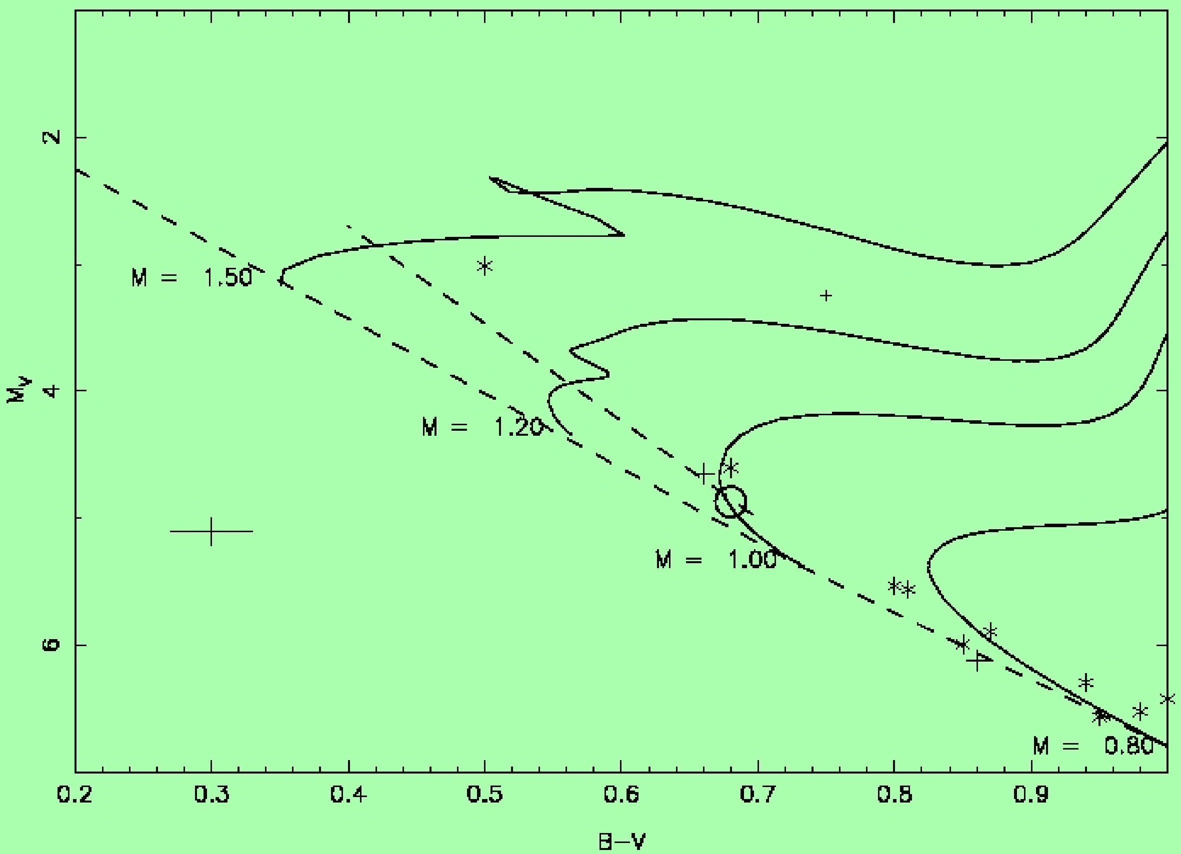
Higly active Mt.Wilson MS-stars (S > 0.25 ... 0.5), Z-adjusted, over Z=0.02 evolution tracks on MS: Very young, scattered around the ZAMS (no surprise)



Moderate, irregular Mt.Wilson MS-stars (0.17<S < 0.25), Z-adjusted, over Z=0.02 evolution tracks on MS: Evolved between 50% and 75% of their MS-lifetime



Moderate, cyclic Mt.Wilson MS-stars (0.17<S < 0.25), Z-adjusted, over Z=0.02 evolution tracks on MS: Surprise: mostly less massive than the Sun!! (~50% MS-lifetime)



Summary of emprical results:

3) MS-Activity decays with relative MS-lifetime (tau ~ $M^{-2.8}$), NOT with absolute age!!

2) Neither very high, nor very low activity permits stable activity cycles – most active stars do NOT show cycles!

- *The Sun: at 50% of its MS-lifetime and has low S (average: 0.19). Indeed it approaches its age-limit AND is near an empirical upper mass-limit for activity cycles on MS !*

=> two reasons for the Sun to show an instable dynamo (Maunder Minima = M.M.) ?!

15) The true solar M.M. analogues are NOT the entirely inactive stars (too evolved), but the ones near the Sun in the HRD, which show residual activity, non-cyclic and long-term changes (Wilson: „long“) - like the Sun in M.M.

P.S.: comparison with theory:

Reiners & Mohanty (2012, ApJ 746) find a relative intrinsic braking efficiency for the angular momentum of MS-stars of

$$dJ/J \sim R^{16/3} M^{-2/3}$$

Since on the MS (solar-type stars) we find $R \sim M^{0.7}$, and the decay-time tau ~ $(dJ/J)^{-1}$, this yields

$$tau \sim M^{-3}$$

......in very good agreement with the MS-lifetime, i.e. the decay of stellar activity should indeed go along with the relative age on the MS, not with absolute age!