Rewriting the Star-Formation History of the Nearest OB Association

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ABSTRACT

The Sco-Cen (Sco OB2) OB association is the nearest region of recent massive star formation to the Sun. Sco-Cen is important for understanding the star-formation history of GMCs, constraining circumstellar disk evolution, and providing samples of age-dated substellar objects and imaged planetary companions. Here I summarize some recent results on the classic Sco-Cen subgroups Upper Sco (US), Upper Cen-Lup (UCL), and Lower Cen-Cru (LCC): (1) isochronal analysis of the >1 Msun stars in the Upper Scorpius subgroup shows it to be twice as old as previously thought (~10 Myr vs. ~5 Myr), (2) analysis of high resolution optical spectra of FGK-type Sco-Cen members are consistent with the subgroups having solar metallicity, (3) we briefly describe a new subgroup dubbed "Lower Sco", and (5) we find that the disk census of Sco-Cen members taken together are consistent with a protoplanetary disk fraction e-folding decay timescale of ~4.5 Myr, nearly twice that inferred previously (but consistent with new results by Bell et al. 2013; arXiv:1306.3237), and perhaps with important implications for formation of gas giant planets.

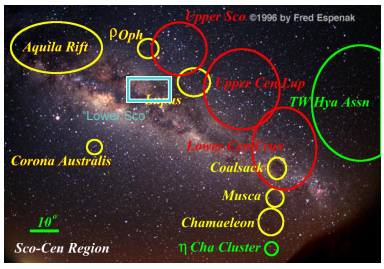
ABOUT SCO-CEN

- Nearest site of recent massive star formation (d ~ 110-150 pc; <20 Myr; ~100 pc in size)
- Known Subgroups
  - Upper Scorpius: ~11 Myr, ~145 pc
  - Upper Centaurus-Lupus: ~16 Myr, ~140 pc
  - Lower Centaurus-Crux: ~17 Myr, ~118 pc
  - Several smaller peripheral groups in Sco-Cen "complex": including Cha I, II, Eta Cha, Epsilon Cha, Lup I,II,III,IV, Oph/LDN 1688, Pipe, CrA, TW Hya, Beta Pic

Analysis of high-res optical spectra of slow-rotating Pre-MS stars in Sco-Cen taken with MIKE spectrograph on Magellan 6.5-m using MOOG and SME yields approximately solar metallicities.

We have conducted a large spectroscopic survey for new members using the SMARTS 1.5-m telescope. We've identified >300 new low-mass K/M members (Pecaut, PhD thesis; Pecaut & Mamajek, in prep.)

NEW SUBGROUP(S)?



Spectroscopic survey of ~70 X-ray-emitting stars in "Lower Scorpius" has yielded what appears to be a new concentration in Sco-Cen near μ Sco (see Nguyen poster; Nguyen et al., in prep). *d* ~ 140 pc, Age ~ 10^{+10}_{-5} Myr, [Fe/H] = +0.09+-0.09. There are also pre-MS stars in the vicinity of the early B-type "Stinger" stars κ, λ, υ Sco.

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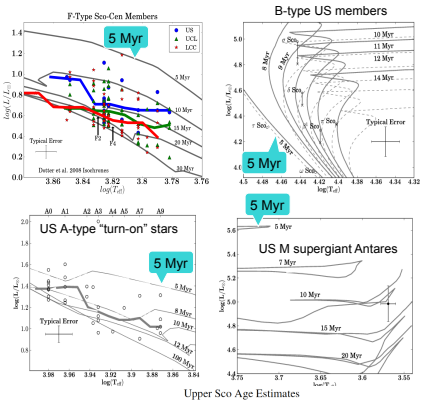
UPPER SCO AGE "CONTROVERSY"

Q: How can a well-studied group like Upper Sco (US) be twice as old (~11 Myr) as previously thought (5 Myr)?

A: All subsamples of >1 M_{sun} stars in the group are giving consistent, ind't isochronal ages. Only the low-mass stars (where the evolutionary tracks are worst – and least constrained) give consistently younger ages.



Upper Sco Age Estimates

Sample	Age (Myr)
F-Type PMS	13 ± 1
Main-sequence Turnoff	10 ± 2
Antares	12 ± 2
A-Type Turn-on	10 ± 3
G-Type PMS	9 ± 2
Adopted Age	11
Statistical uncertainty	±1
Systematic uncertainty	±2

References:

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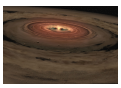
DISK LIFETIMES FOR SUN-LIKE STARS

Fraction of Sun-like (0.7-1.2 M_{sun}; actually K-type) Pre-MS stars showing evidence for accretion (Hα emission) and/or infrared excesses measured using 2MASS+WISE photometry consistent with "full" disks:

US (11 Myr): 8/89 = 9^{+4}_{-2}%
UCL (16 Myr): 8/157 = 5^{+2}_{-1}%
LCC (17 Myr): 4/118 = 3^{+3}_{-1}%



Fitting exponential curve to protoplanetary disk fraction vs. age (e.g. Mamajek 2009), one derives in Sco-Cen an e-folding time of ~4.8 Myr ($t_{1/2}$ = 3.3 Myr). This is consistent with results for other 5-20 Myr clusters using revised age scale of Bell et al. 2013 (see Ages review talk by Jeffries) but ~2x longer than previous results.

RESULTS

Upper Sco is twice as old as previously thought (~10 Myr vs. ~5 Myr). Subgroups have ~solar metallicity.

New subgroup "Lower Sco" (see poster by D. C. Nguyen) situated between Upper Sco, Lup III, and CrA.

Protoplanetary disks for Sun-like stars appear to last "longer" – perhaps ~5% @ 15 Myr. Gas giant formation epoch for some stars lasts longer than previously thought?

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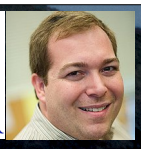

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