Search for Be stars in Massive Young Clusters

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classical Be star

- Definition:

Collins (1987)

"a non-supergiant B star whose spectrum has, or had at some time, one or more Balmer lines in emisstion"

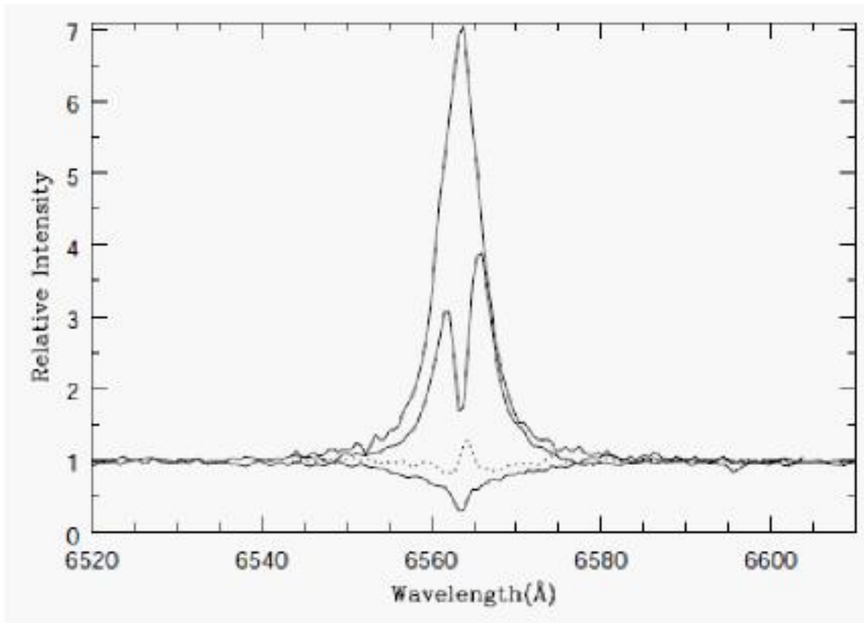


Fig. 4. The Hα profiles of stars B21 (strong emission), B31 (double peaked profile) and B16 (no emission). Indicated by the dotted line is the profile of B22 uncorrected for the surrounding HII. Note the narrow and weak emission characteristic of a HII region.

Keller et al. 1998

common emission lines: HI, HeI, FeII, SiII, MgII

■ classical Be star

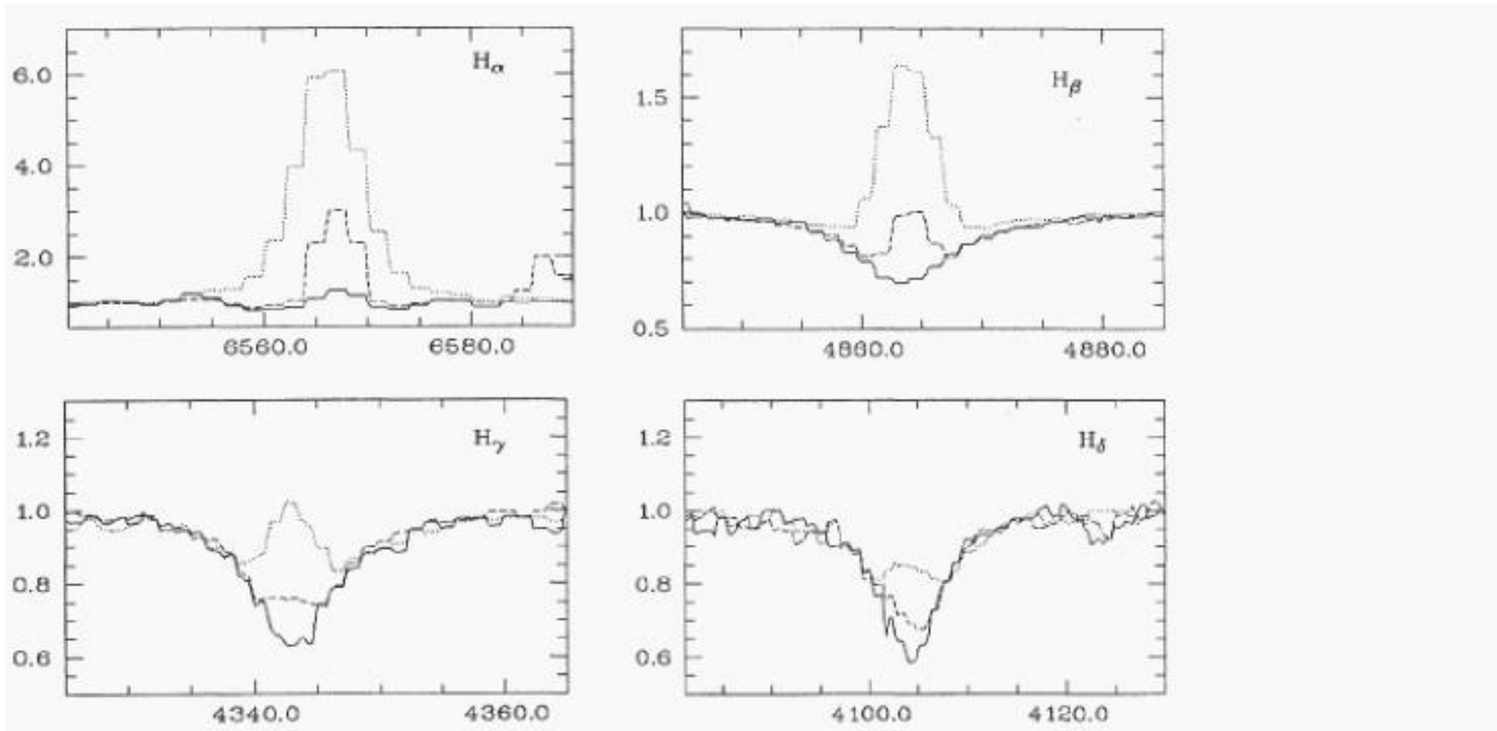


Fig. 1. Profiles of the first 4 Balmer lines for 3 representative NGC 330 Be stars: B5 (strong emission, dotted line), B18 (moderate emission, dashed line), B4 (weak Hα emission, continuous line)

Mazzali et al. 1996

■ classical Be star

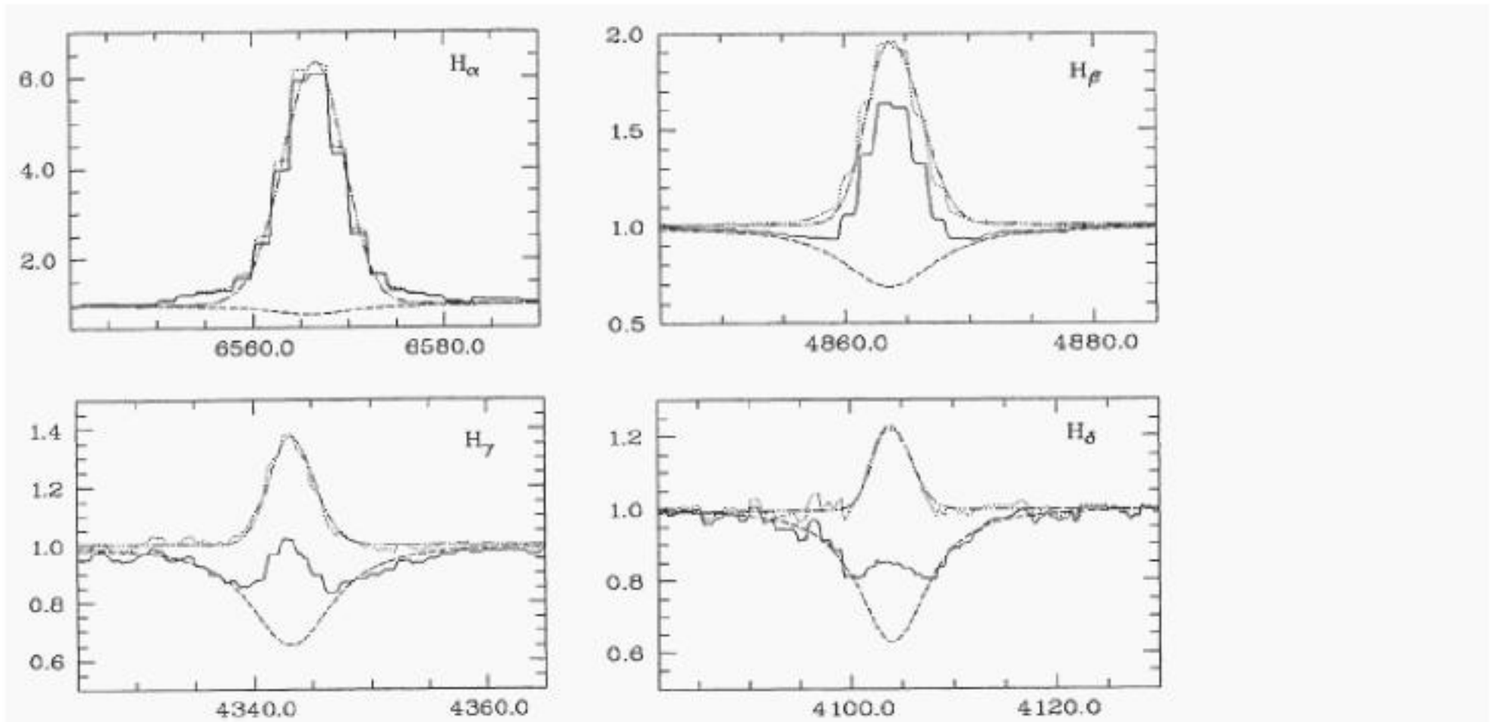


Fig. 3. Fitting procedure for one of our stars (B5): the observed profiles (continuous lines) are fitted with model profiles (dashed lines). For a Be star, the fit is obtained in the wings of Hγ and Hδ. The emission is computed as the difference between observed and model profiles (dotted line), and is then fitted with a gaussian profile (dash-dots)

Mazzali et al. 1996

■ classical Be star

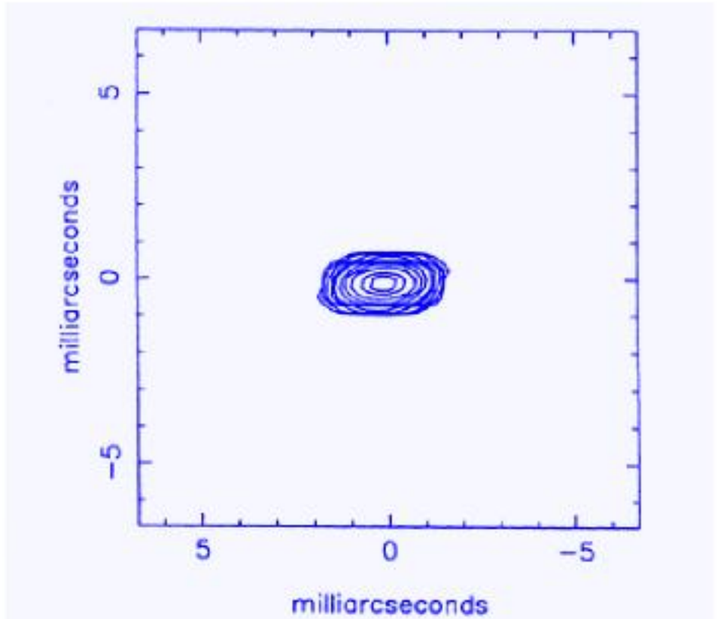


Fig. 2. Maximum-entropy reconstruction of ζ Tauri in the continuum channel centered at 550 nm. Contour levels are 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, and 80% of the peak.

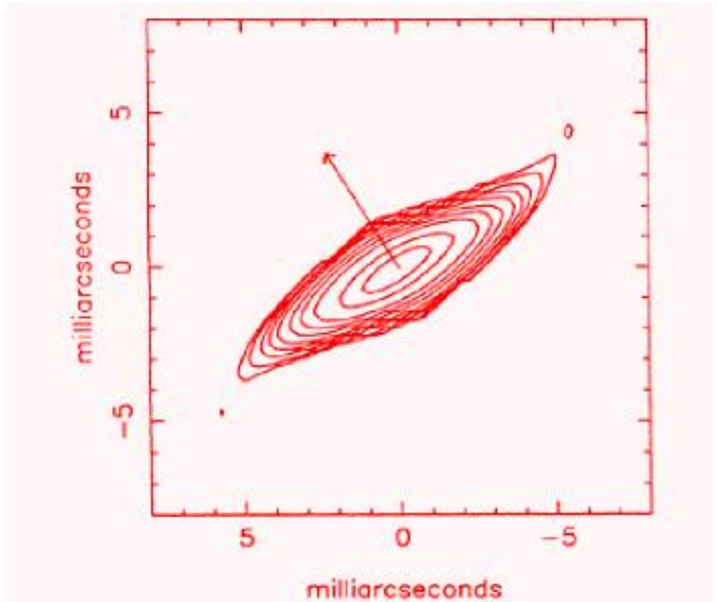


Fig. 3. Maximum-entropy reconstruction of ζ Tauri in the Hα emission line (656 nm). Contour levels are as in Fig. 2. The arrow indicates the position angle of the linear polarization.

Quirrenbach et al. 1994

classical Be star

Census

Zorec & Briot 1997
Be/(B + Be) ~ 0.17 (mean)
~ 0.3 (B0--B4) peaking at B1-2

in young clusters

Waelkens et al. 1990
Be/(B + Be) ~ 0.5 in χ Per

Sanduleak 1979
Be/(B + Be) ~ 0.34 in NGC 663

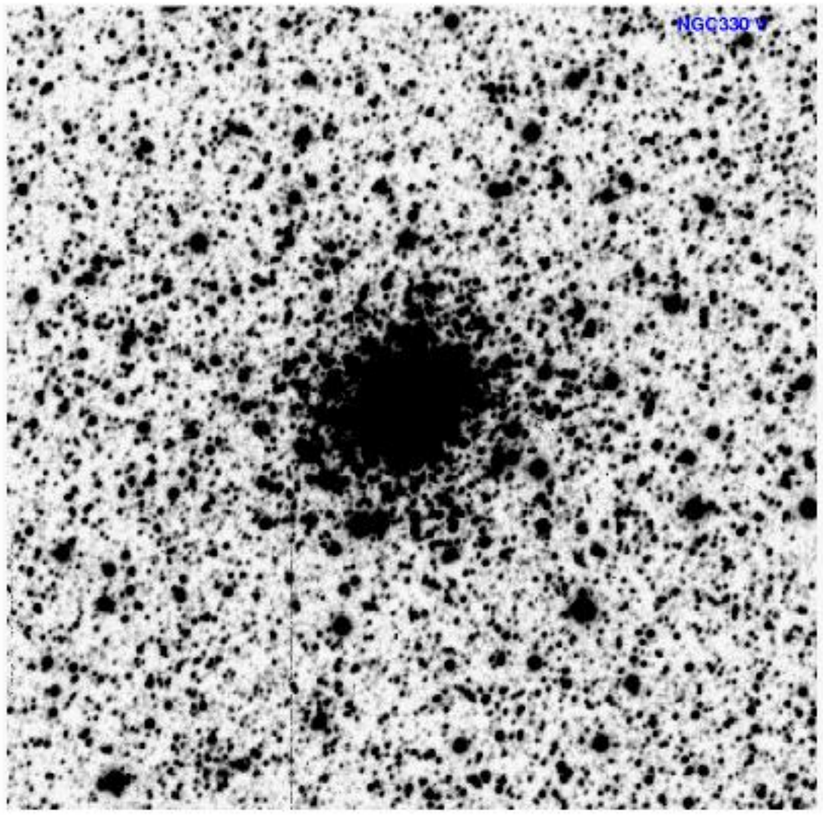
Grebel et al. 1992
Be/(B + Be) ~ 0.7 in NGC 330 (SMC cluster)

■ Detection of Paα from Be stars

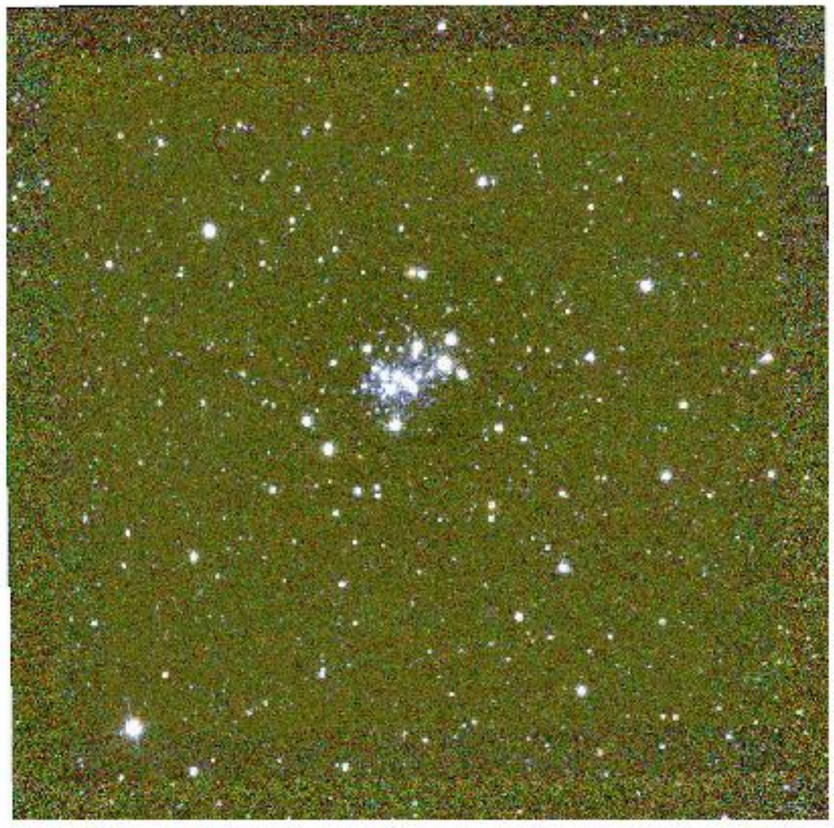
■ NGC 330

R.A. = 00:56:18.0
DEC = -72:27:50.0

age = 10-30 Myr
[M/H] ~ -1.2 Z~0.004
m-M = 18.9



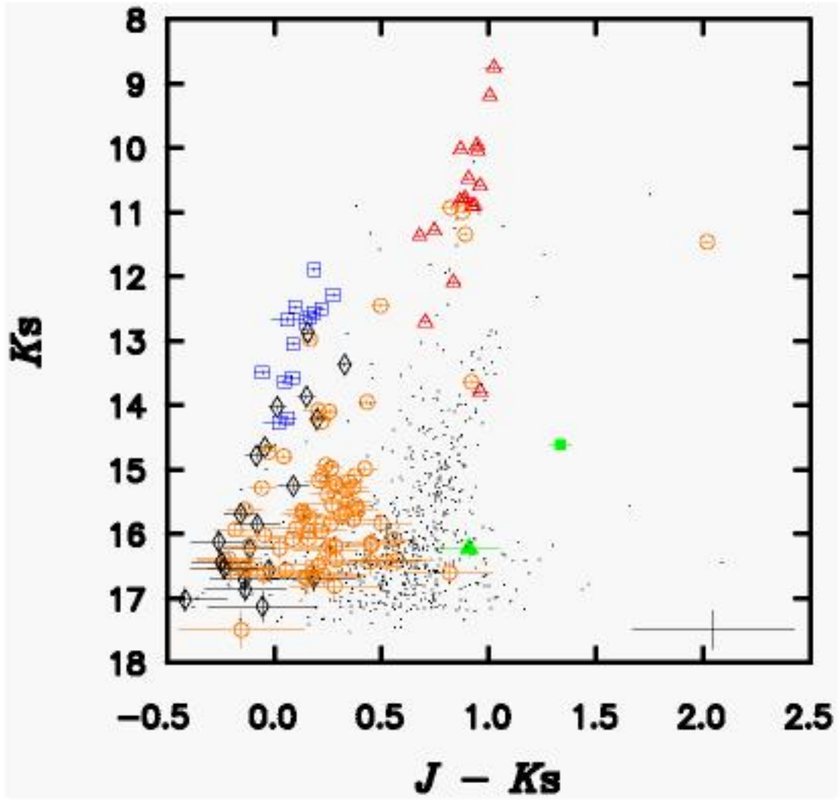
NGC330 V-band image



JHK image

■ Detection of Paα from Be stars

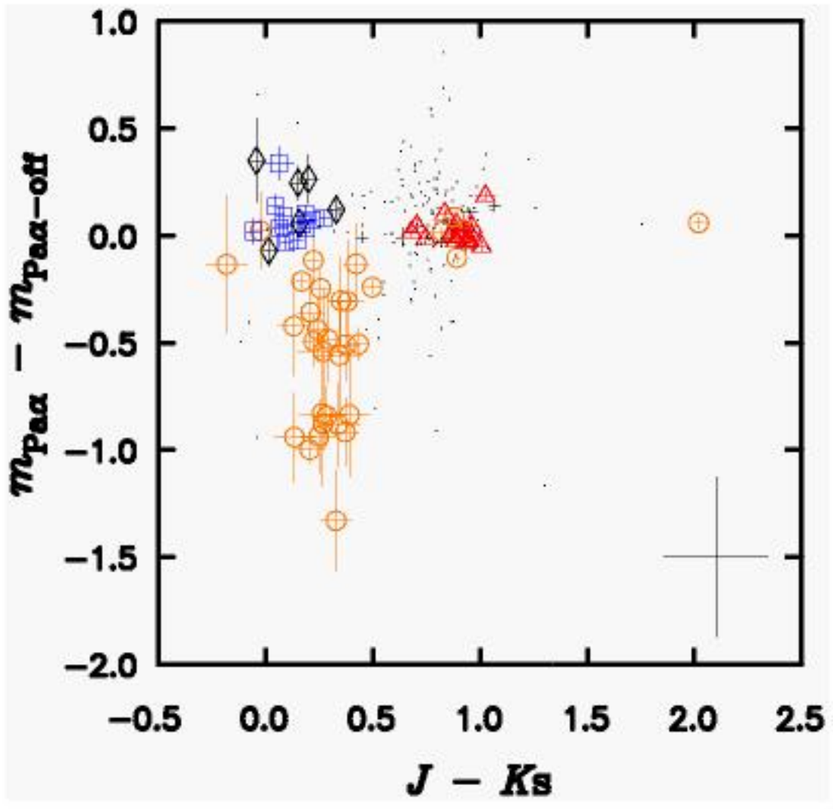
■ NGC330: Color-Magnitude diagram

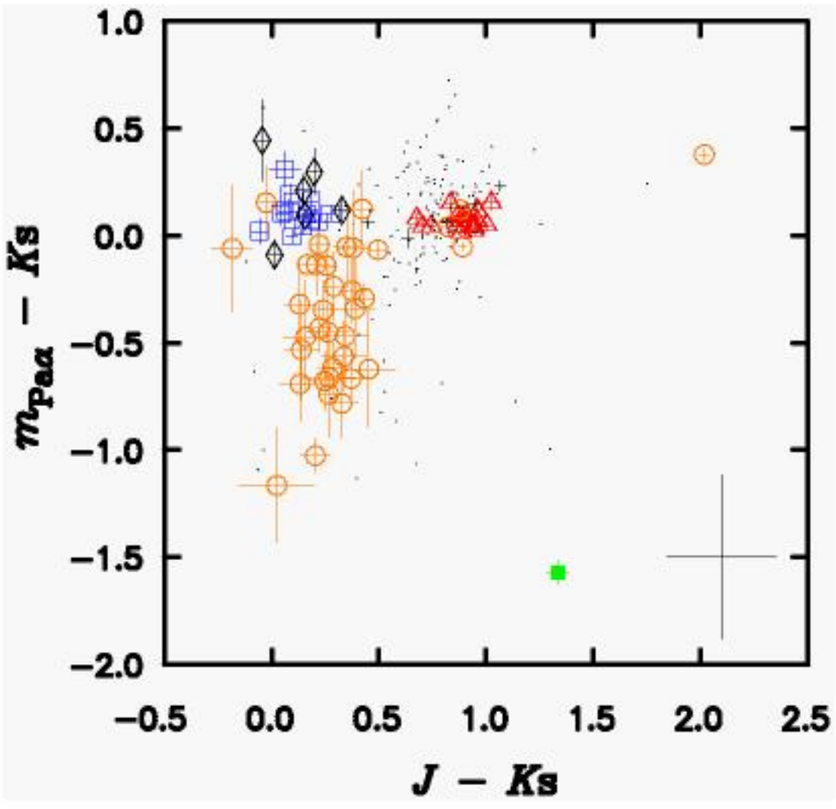


△ : M supergiant
□ : OBA star Lum class I
: OBA star Lum class II-V
○: (O)B(A) known emission star
▲ :L305 (PN)
■: PPN or Herbig Ae/Be ?
・ : No Spectral information

Detection of Paα from Be stars

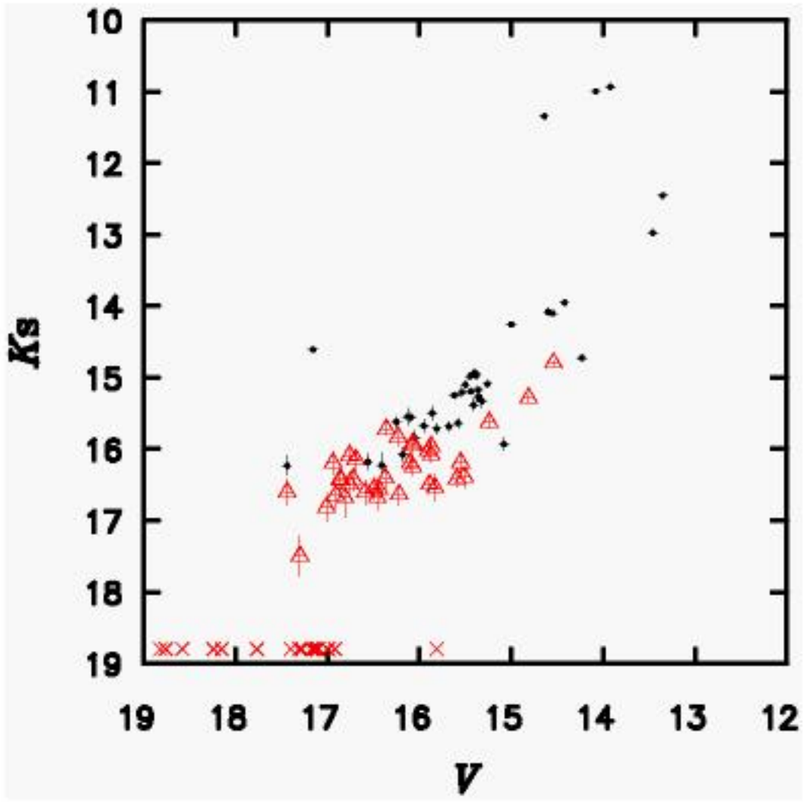
- NGC330: Paα index





■ Detection of Paα from Be stars

■ NGC330: detection limit



Be star K vs. V

・ : Pa α detected

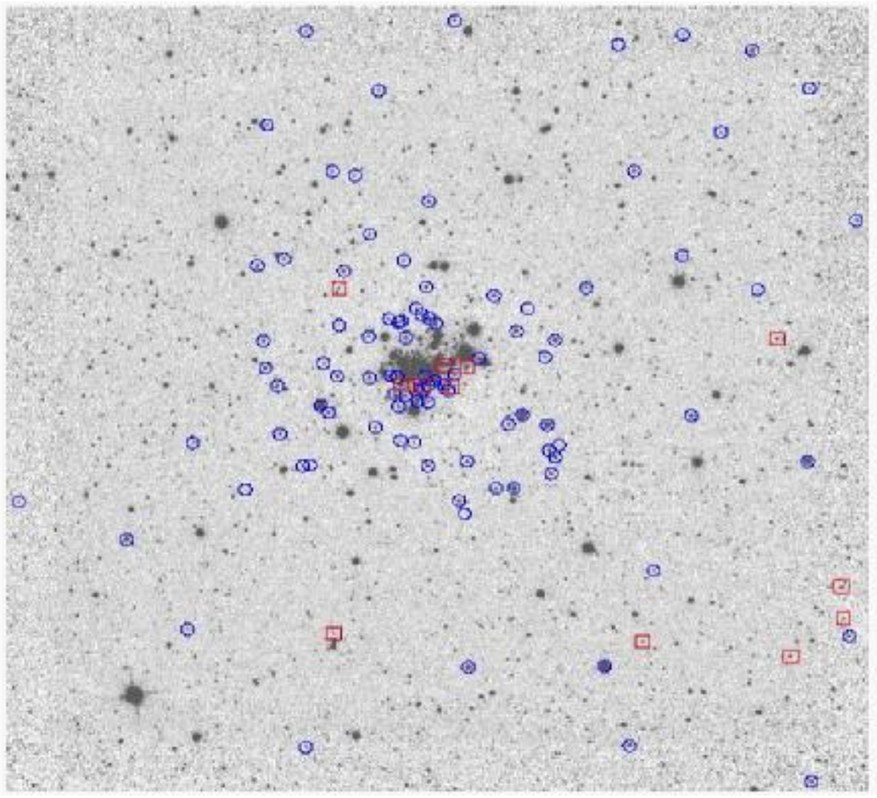
△ : Pa α too weak for miniTAO/ANIR

× : less luminous Be stars cannot be detected even at K band

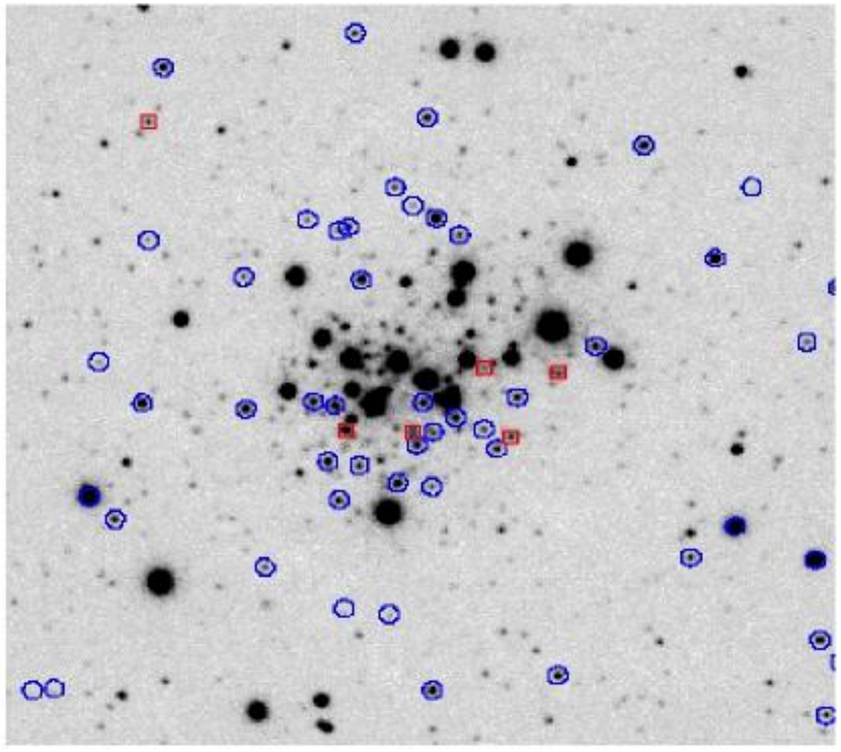
明るい Be型星からは全て Pa α が受かった

■ Detection of Paα from Be stars

■ NGC330: New Be star candidate



NGC330 J



blue: known Be stars
red: New Be star candidates

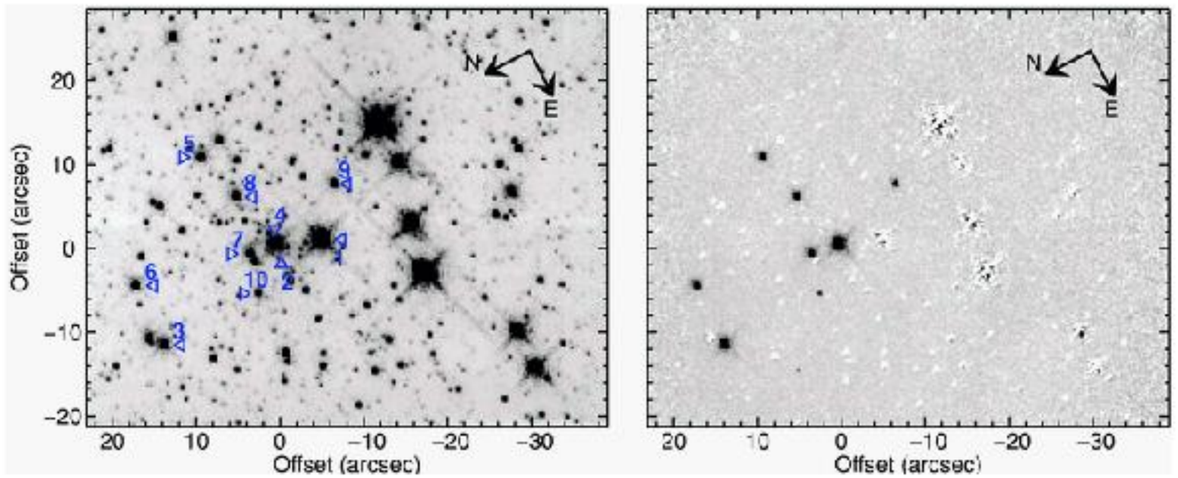
■ Young massive clusters

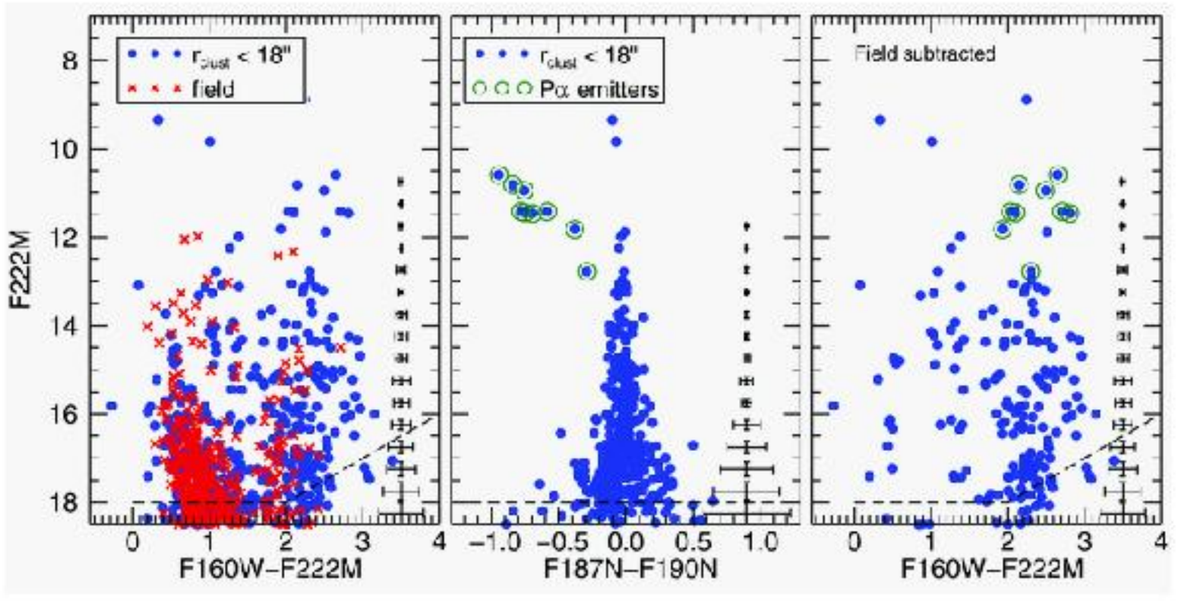
■ Mercer 81 (Mc81, GLIMPSE81)

Davies, B. et al. 2012
HST/NICMOS observations
Mc81
R.A. = 16:40:30
DEC = -46:23:29

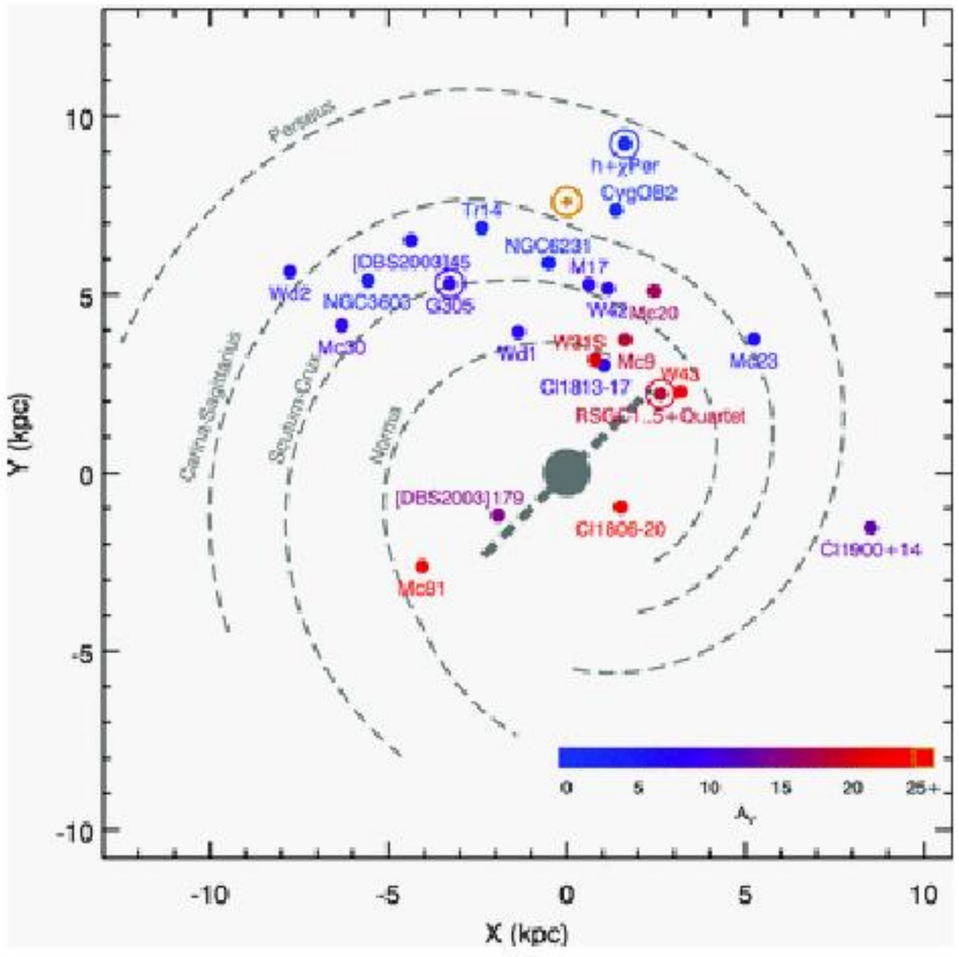
距離: 11 ± 2 kpc
Av: 45 ± 15
age = 3.7 Myr

Emission line detected at 1.875 μ m
from WR stars





Young massive clusters



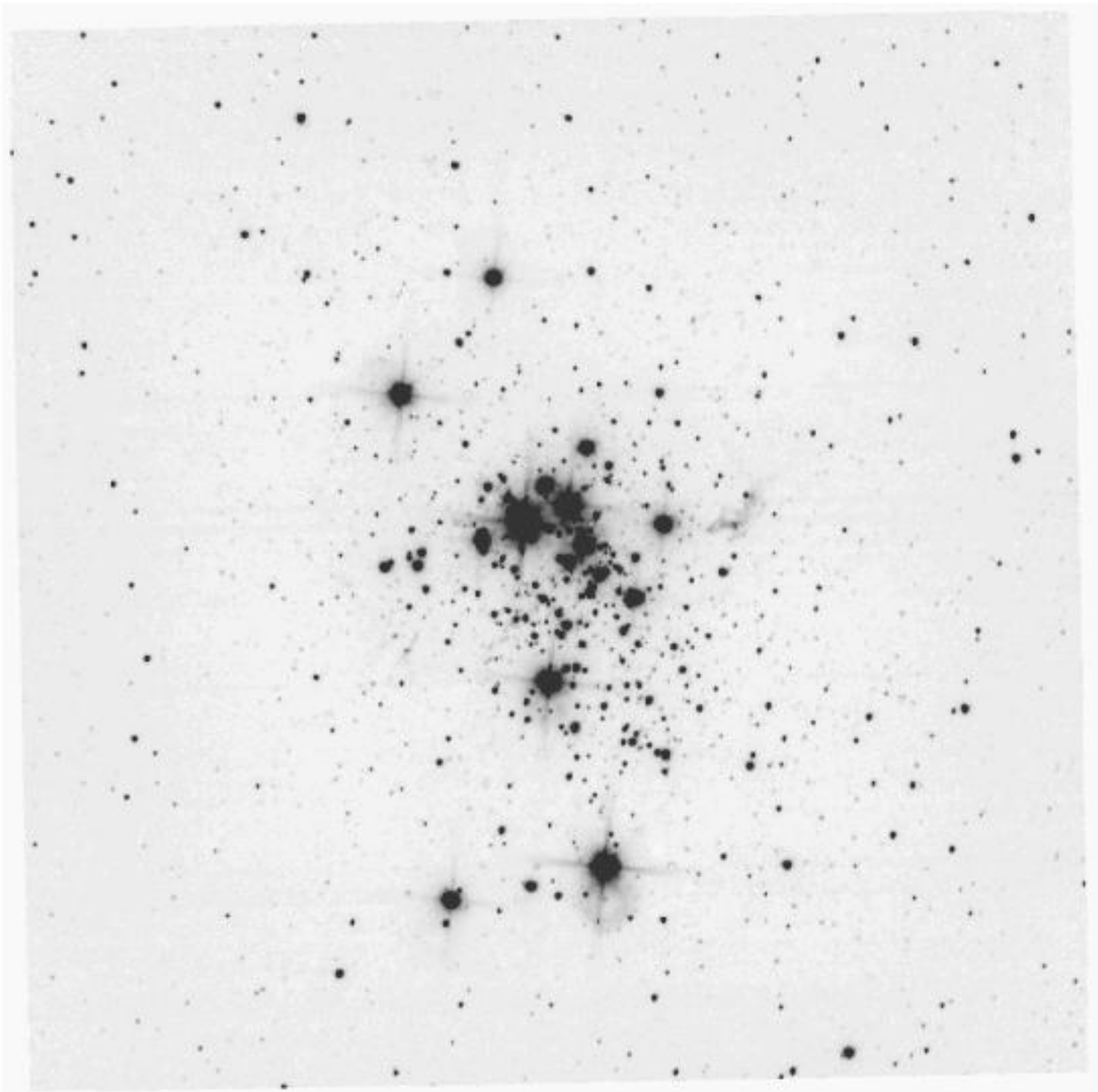
	l	D (kpc)	Av
Cl 1806-20	10.0	8.7	30.3
W31S	10.1	4.5	20.9
Cl 1813-17	12.7	4.7	9.5
M17	15.0	2.4	9.5
Mc9	22.8	4.2	19.0
W42	25.4	2.7	9.5
RSGC1-5, Quartet	26.0	6.0	19.0
W43	30.8	6.2	39.8
Cl 1900+14	43.0	12.5	13.3
Mc20	44.2	3.5	17.1
Mc23	53.7	6.5	6.6
Cyg OB2	80.2	1.4	6.0
h+χPer	135.0	2.3	1.9
[DBS2003]45	283.9	4.5	7.6
Westerlund 2	284.2	8.0	7.6
Trumpler 14	287.0	2.5	2.5
NGC 3603	291.6	6.0	4.7
Mc30	298.8	7.2	10.5
Danks 1 and 2	305.0	4.0	9.5
Mc81	338.4	11.0	41.7
Westerlund 1	339.5	3.9	9.5
NGC 6231	343.5	1.8	3.8
[DBS2003]179	347.6	9.0	15.2

■ Young massive clusters

■ Westerlund1

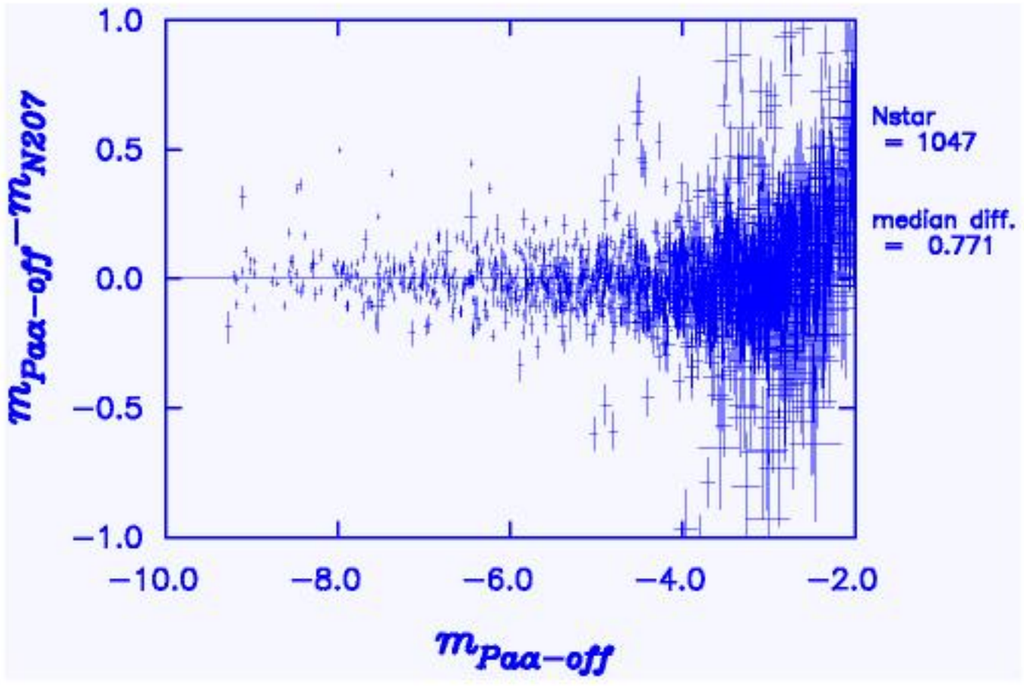
R.A. = 16:47:03
DEC = -45:50:37

距離: 3.55 ± 0.17 kpc
Aks: 1.13 ± 0.03
age = 3-5 Myr



Search for emission line object

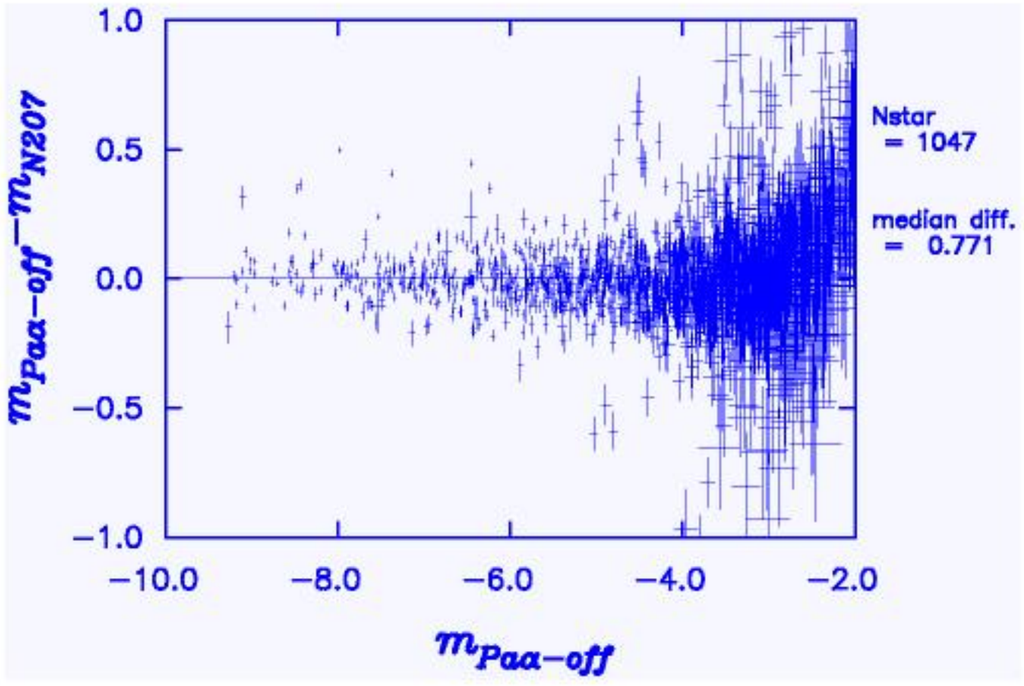
- Comparison of Paα-off filter with N207 filter



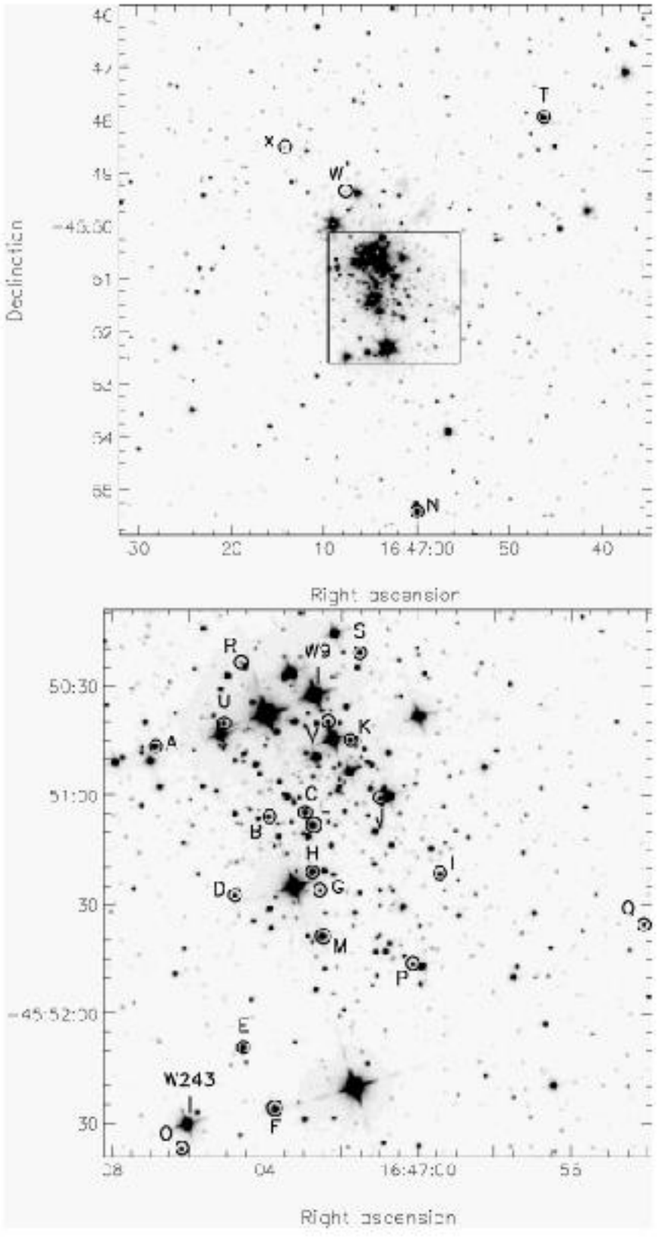
N207 filter can be used in place of Paα-off filter
for non-WC stars

Search for emission line object

- Comparison of Paα-off filter with N207 filter



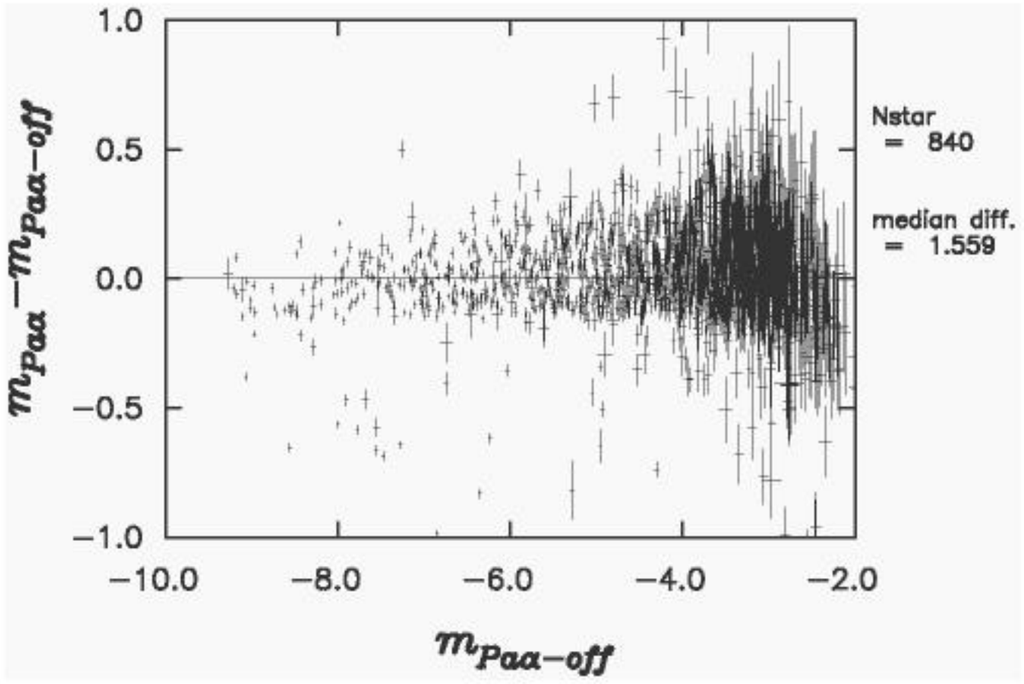
WC stars are seen in emission at N207 in this figure

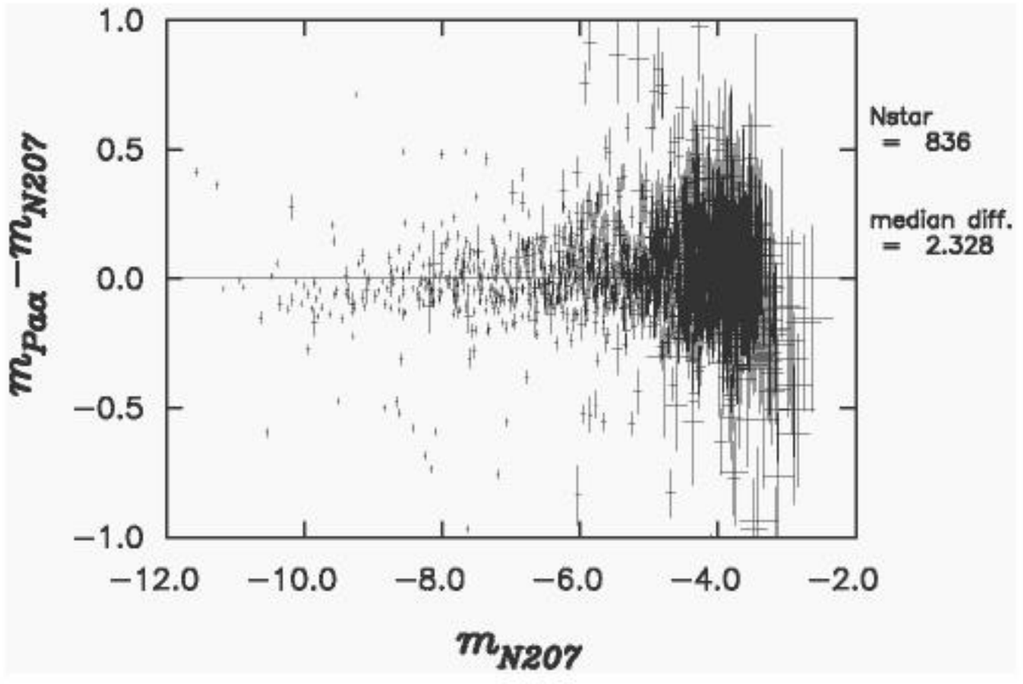


WR stars in Westerlund 1

Search for emission line object

- Westerlund1: Paα index





Several stars are seen in emission at 1.875 μm

Imaging observations of young massive clusters
at (J,) H, Ks, Paα, (Paα-off,) N207
to search for emission line object at 1.875 μm