Survey of emission line stars in young open clusters

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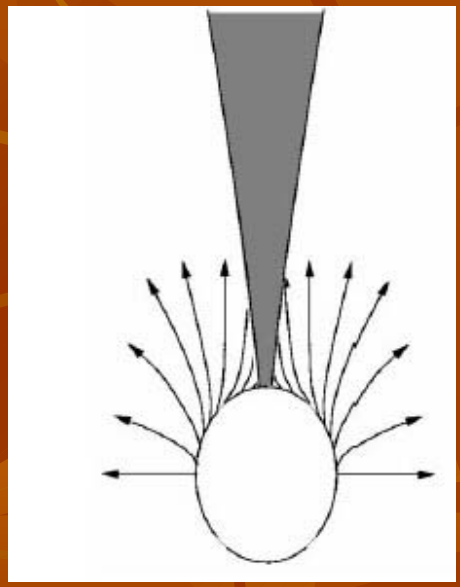
Emission line stars: what are they?

- These stars show H-alpha emission lines in their spectra – indication of circum-stellar material.
- Two classes: (1) remnant of the accretion disk – pre-Main sequence stars – Herbig Ae/Be stars (2) Classical Be stars – material thrown out of the star forming a disk.
- These stars are well studied in the field – not in clusters - uncertainty in estimating their distance, interstellar reddening, age, mass and evolutionary state.



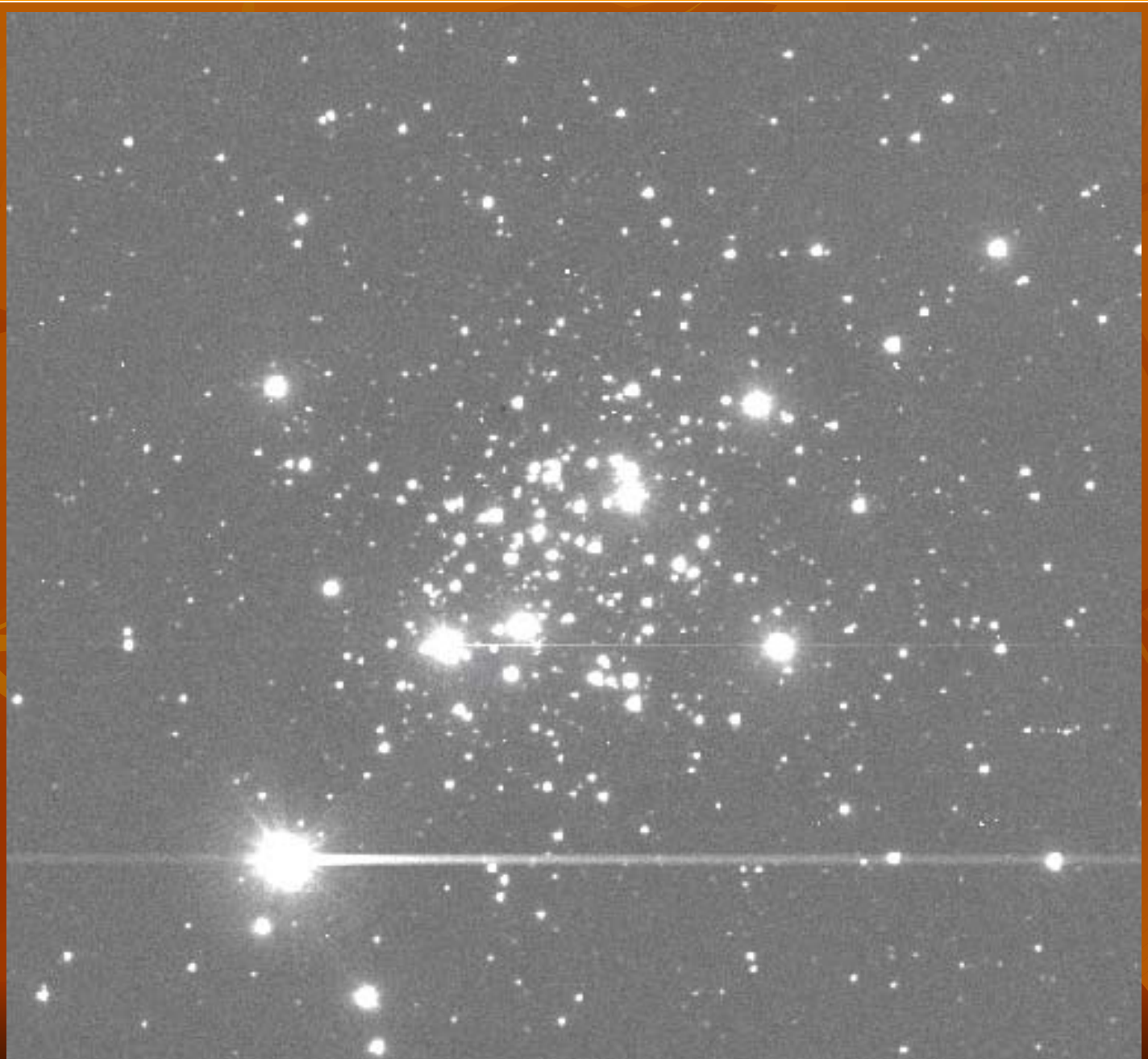
Cluster stars: advantage

- These stars located in clusters help to estimate their properties accurately – distance, reddening, mass (spectral type) and age.
- To study the emission phenomenon as a function of stellar properties – possible in the case of clusters stars.
- Properties of the circum-stellar disk can be studied as a function of mass and age.
- Large number of stars can be identified to have a large sample, will help to study and classify them into various groups.

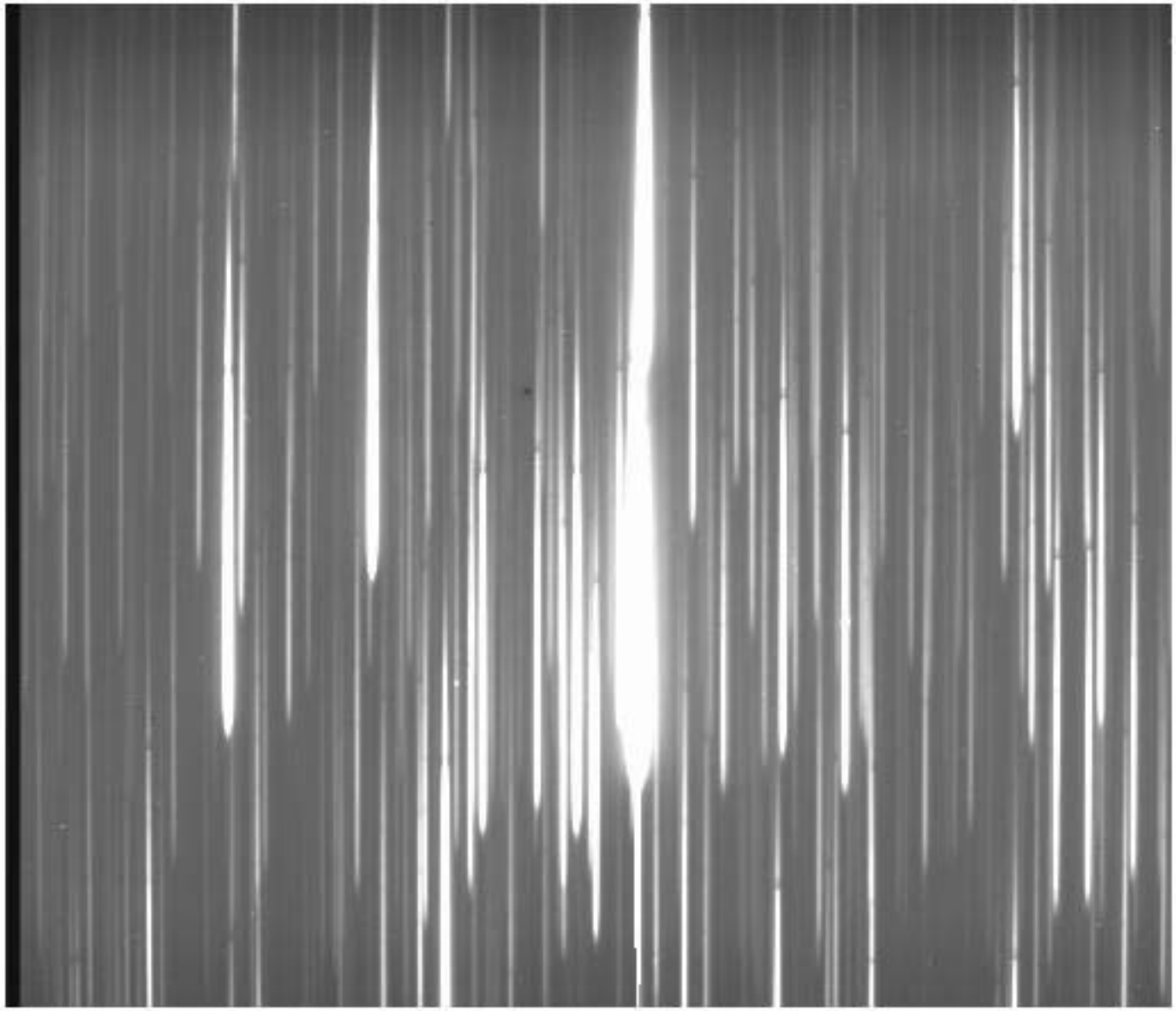
Data

- Aim: To identify stars with H-alpha emission in young clusters (younger than 100 Myr).
- Telescope used: HCT
- Method: Slit-less spectra of cluster stars
- Instrument: HFOSC – slit-less mode
- Filter and Grism: R filter and Grism 5
- Observations: October 2003 – January 2007
- Number of clusters observed: 206 clusters
- Clusters with e-stars: 44 clusters
- Total number of e-stars: 150 stars
- Clusters rich in e-stars: NGC 7419, NGC 663 , h & χ Persei, NGC 2345

R band Image (exposure time 5 sec) of the cluster NGC 7419




Slit less spectra of the cluster
NGC 7419 with an exposure of
600s using R filter and Grism5.



Slit-less spectra of the cluster NGC 2414 with an exposure of 600s using R filter and Grism5.

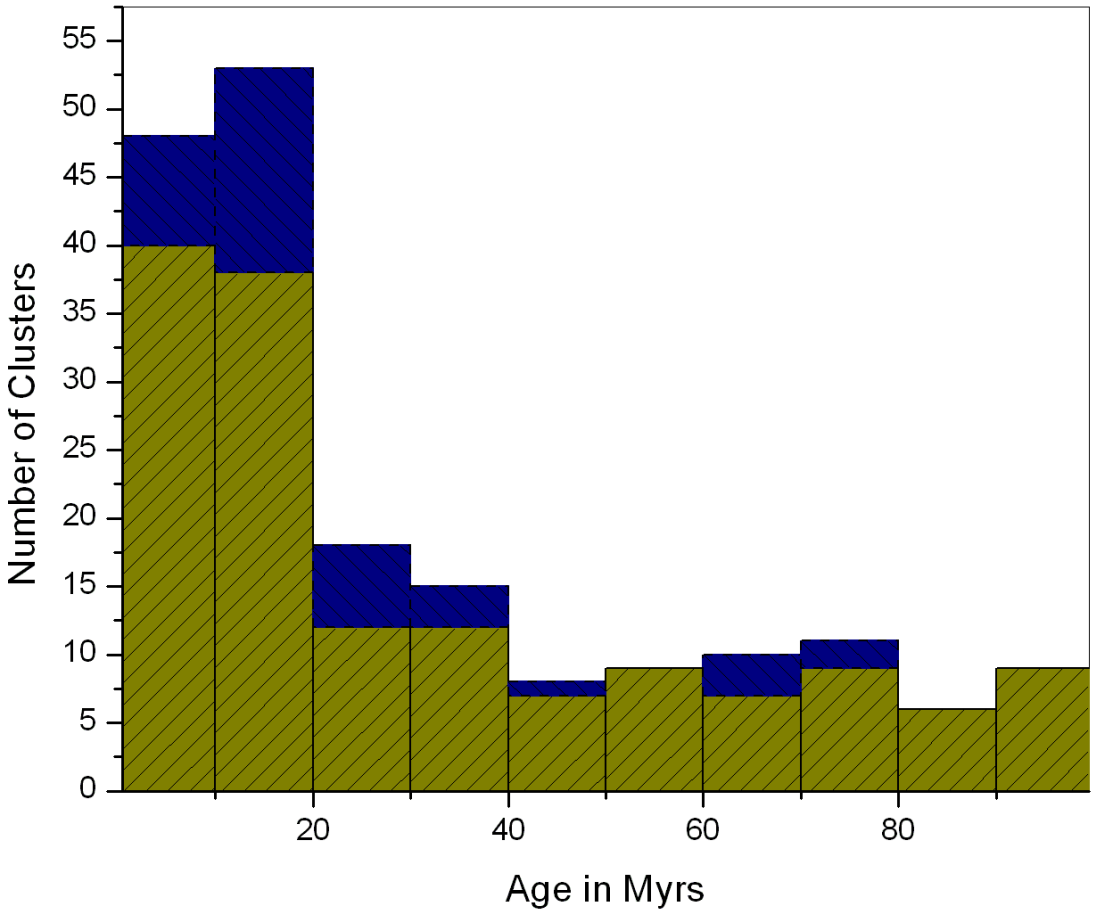
Advantages of HCT

- This method of identifying e-stars can be done only with HFOSC instrument.
- A very efficient method to identify e-stars – saves a lot of telescope time.
- Requires good seeing to identify emission in faints stars – limit being V = 16.0 mag (a few stars at V= 18.0 mag).
- This project exploits the better seeing in Hanle and the slit-less mode of the HFOSC instrument.
- The spectra can be wavelength calibrated using the slit spectra of one e-star and using the atmospheric lines.
- The e-stars can be identified by superposing or blinking with an R band image.

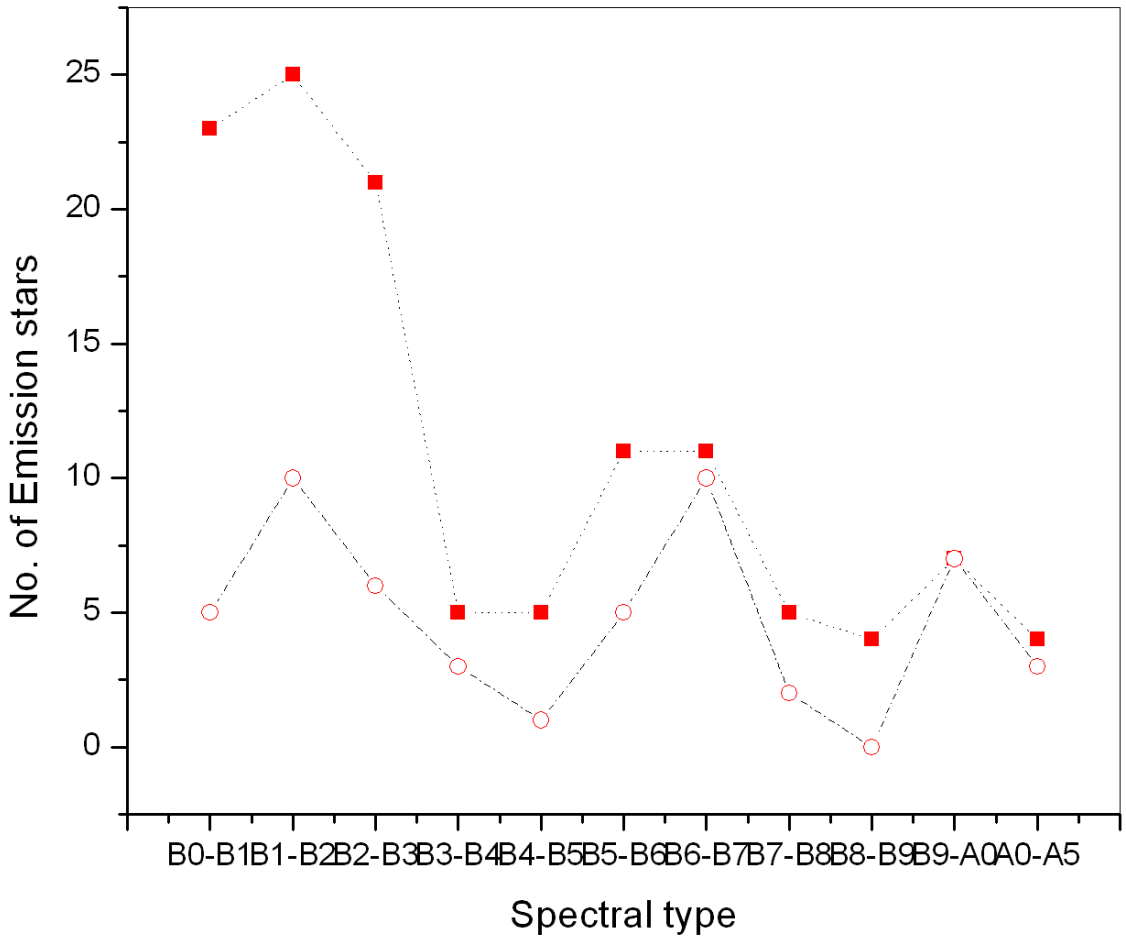
Results

Cluster Names and No.of e-stars

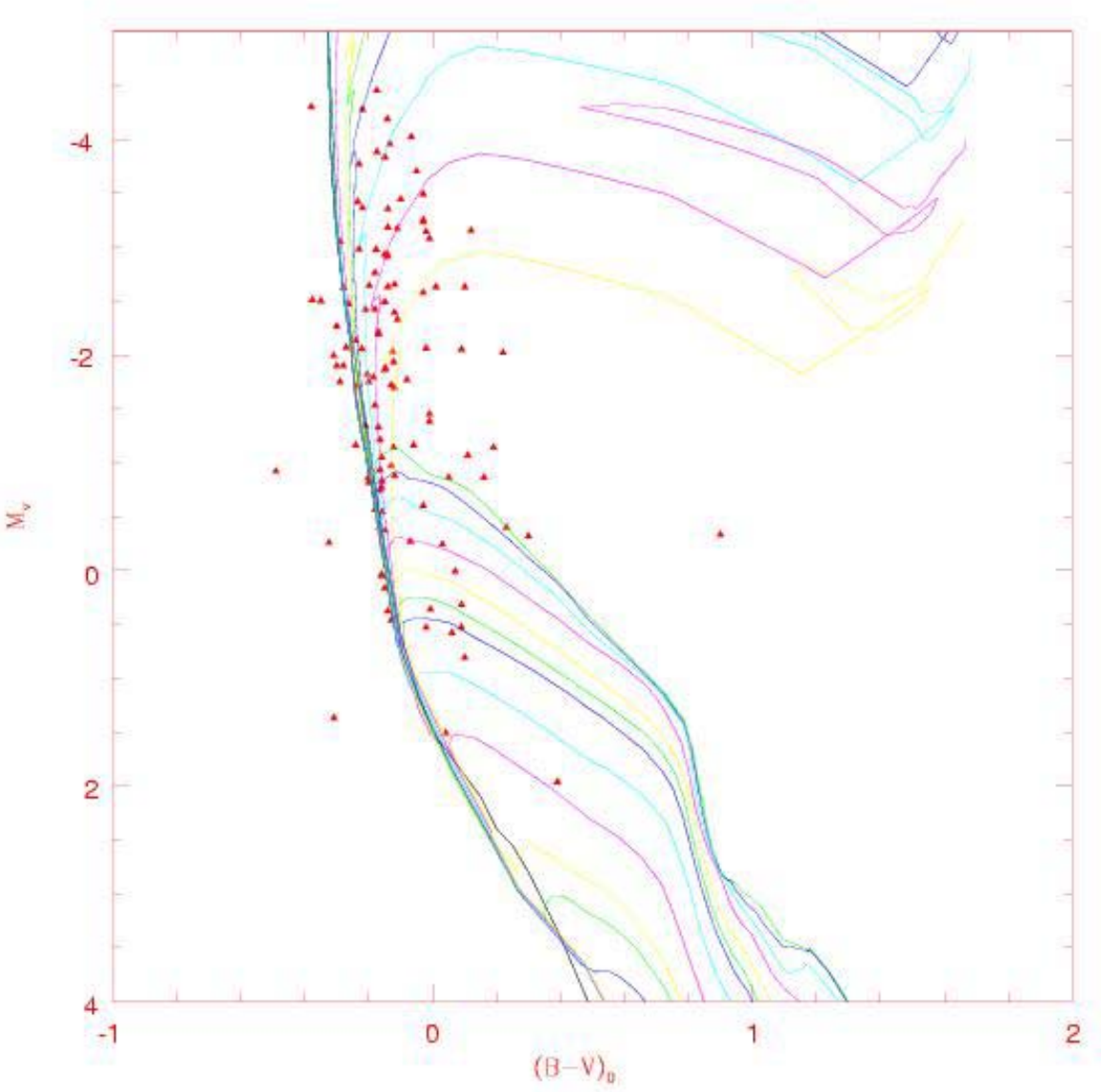
Berkeley 62	1	Berkeley 63	1	Berkeley 86	2	Berkeley 87	4
Berkeley 90	1	Bochum 2	1	Bochum 6	1	Collinder 96	2
IC 1590	3	IC 4996	1	King 10	4	King 21	3
NGC 146	2	NGC 457	2	NGC 581	4	NGC 637	1
NGC 654	1	NGC 659	3	NGC 663	22	NGC 869	6
NGC 884	6	NGC 957	2	NGC 1220	1	NGC 1624	1
NGC 1893	1	NGC 2345	10	NGC 2414	2	NGC 2421	4
NGC 6604	1	NGC 6613	1	NGC 6649	6	NGC 6756	2
NGC 6823	1	NGC 6834	4	NGC 6871	2	NGC 6910	2
NGC 7039	1	NGC 7128	3	NGC 7235	1	NGC 7261	3
NGC 7380	4	NGC 7419	25	NGC 7510	3	Roslund 4	2



Clusters which contain emission line stars (blue) is shown with respect to the total clusters surveyed.



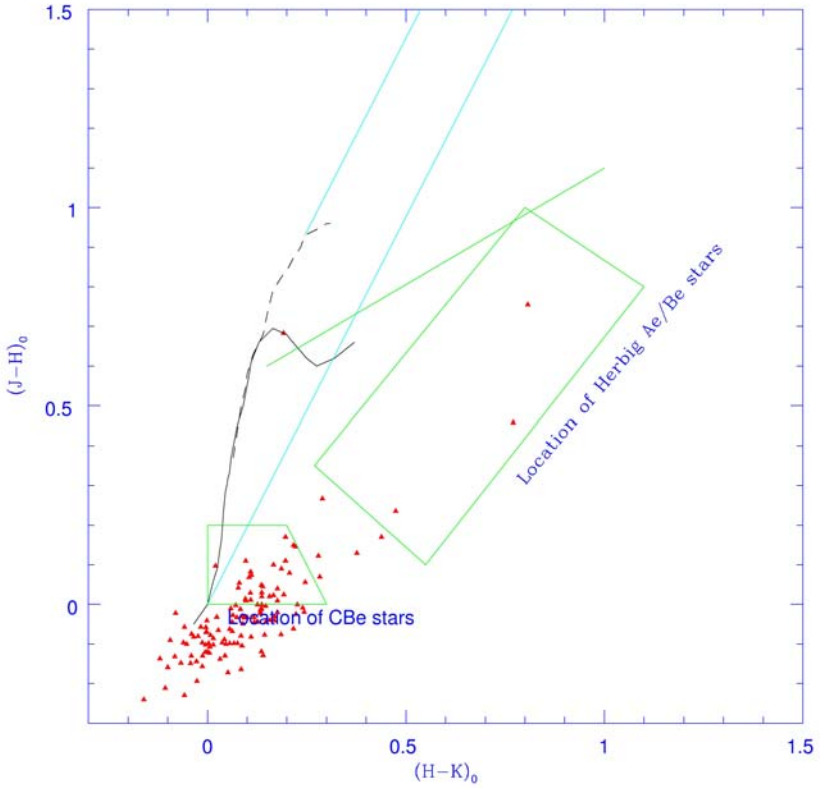
Spectral type distribution of all emission stars are shown as solid squares while that in minor clusters are shown as open circles.



Optical CMD of the emission stars surveyed is shown with absolute magnitude along Y axis and reddening corrected colour along X axis. PMS Isochrones from 0.1-100Myrs are fitted.

Conclusions

- We have identified around 150 emission line stars in 44 young open clusters, 44 new e-stars identified in 20 clusters.
- Emission stars are found mostly in 10 – 20 Myr clusters. Surprisingly, 60 – 80 Myr clusters also have these stars. This might be due to multiple star formation events in the cluster vicinity.
- The emission-line stars in rich clusters show a bias towards early B spectral type while no such preference is there for other clusters. In general, they are found to peak at B1-B2 and B6-B7 spectral types.
- From the Optical CMD and the NIR CCD, it can be seen that most of the emission stars belong to Classical Be type, some could be Herbig Ae/Be type.
- The identified emission stars are studied in detail to understand their physical properties.



(J-H)_0 vs. (H-K)_0 CCD with the emission stars shown as red triangles, black solid line as main sequence, dotted black line as giant sequence, solid cyan lines as reddening vectors, solid green line as T-Tauri location along with the green boxes of Herbig Ae/Be stars and Classical Be stars.