RevMexAA (Serie de Conferencias), **38**, 96–97 (2010)

BE PHENOMENON IN OPEN CLUSTERS: RESULTS FROM A SURVEY OF EMISSION-LINE STARS IN YOUNG OPEN CLUSTERS

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RESUMEN

Las estrellas con líneas de emisión en cúmulos abiertos jóvenes son identificadas para estudiar sus características, en función de su edad, tipo espectral y estado evolutivo. Se observan 207 cúmulos abiertos de estrellas usando método "slitless" espectroscópico y 157 estrellas con líneas de emisión fueron identificadas en 42 cúmulos. Hemos encontrado 54 nuevas estrellas con líneas de emisión en 24 cúmulos abiertos; se encontro que, por primera vez, 19 de estos cúmulos contienen estrellas con emisión. Nuestros resultados indican que podría haber dos mecanismos responsables de fenómeno Be clásico. Algunas nacen como Be clásicas (rotores rápidos), según lo indica su presencia en cúmulos más jovenes que 10 Maños. Algunas estrellas se desarrollan a Be clásica, en el transcurso de su vida en la secuencia principal, según lo indicado por el aumento en la fracción de cúmulos con estrellas Be clásico en el rango de 20 a 30 Maños de edad del cúmulo.

ABSTRACT

Emission-line stars in young open clusters are identified to study their properties, as a function of age, spectral type and evolutionary state. 207 open star clusters were observed using slitless spectroscopy method and 157 emission stars were identified in 42 clusters. We have found 54 new emission-line stars in 24 open clusters, out of which 19 clusters are found to house emission stars for the first time. Our results indicate there could be two mechanisms responsible for the Classical Be phenomenon. Some are born Classical Be stars (fast rotators), as indicated by their presence in clusters younger than 10 Myr. Some stars evolve to Classical Be stars, witin the MS lifetime, as indicated by the enhancement in the fraction of clusters with Classical Be stars in the 20–30 Myr age bin.

Key Words: open clusters — stars: emission-line, Be — stars: pre-main sequence

1. INTRODUCTION

Open clusters are dynamically associated system of stars which are found to be formed from giant molecular clouds through bursts of star formation. Apart from the coeval nature of the stars, they are assumed to be at the same distance and have the same chemical composition. Hence it is a perfect place to study emission stars since we do not have a hold on these parameters in the field. Young open clusters are found to contain emission stars since the emission stars are found to undergo evolution over a time scale of less then 100 Myr.

Early type emission stars are broadly classified as Classical Be (CBe) stars and Herbig Be (HBe) stars. The production of disk in CBe stars is still a mystery and majority of the studies point towards an optically thin equatorial disk formed by channeling of matter from the star through wind, rotation and magnetic field (Porter & Rivinius 2003, and references therein).

2. OBSERVATION AND DATA ANALYSIS

The spectroscopic and the R band (7100 Å, BW=2200 Å) imaging observations of the clusters have been obtained using the HFOSC instrument, available with the 2.0 m Himalayan Chandra Telescope (HCT), located at HANLE and operated by the Indian Institute of Astrophysics. Details of the telescope and the instrument are available at the institute's homepage (`http://www.iiap.res.in/`). The cluster region was observed in the slit-less spectral mode with grism (Grism 5, 5200–10300 Å, low resolution) as the dispersing element using the HFOSC in order to identify stars which show H_α in emission. The Near-Infrared photometric magnitudes in J, H, K_s bands for all the candidate stars are taken from 2MASS (`http://vizier.u-strasbg.fr/cgi-bin/VizieR?-source=II/246`) database.

In this study, we have performed a systematic survey of 207 open clusters in the northern sky, in order to increase the sample of emission stars in

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clusters and to study their properties. In order to study the identified emission stars as well as the hosting cluster in detail, we have taken the photometric data from the references listed in WEBDA (`http://www.univie.ac.at/webda/navigation.html`). After cross-correlating the emission stars from our R band image with the location given in the reference, the photometric parameters were taken.

3. RESULTS AND DISCUSSION

From the slitless spectra of 207 clusters, we identified 42 clusters to have emission stars. On the whole, we identified 157 emission stars. We estimated their distance, age and spectral type from the optical Colour-Magnitude Diagram (CMD) of open clusters to which they are associated. We also identified their evolutionary phase by finding their location in the cluster MS. We looked for nebulosity around the emission stars in addition to the location in optical CMD and NIR (J−H) versus (H−K)Colour-Colour Diagram, to separate possible HBe stars from CBe stars. In general, most of the identified emission stars are CBe candidates (145 stars, 92.3%), whereas some are HBe candidates (9 stars, 5.7%). A very few (3, 1.9%) HAe candidates are also present.

3.1. *Distribution of emission stars versus Cluster Age*

We have surveyed 207 open clusters, out of which 140 were younger than 100 Myr, 39 clusters were older than 100 Myrs while the ages of 28 clusters are unknown. Out of the total number of clusters surveyed 20.28% has been found to have emission stars. The fraction of clusters which have emission stars with respect to total surveyed clusters as a function of age is shown as histograms in Figure 1. We find that the maximum fraction of clusters which house CBe stars fall in the age bin 0−10 Myr and 20−30 Myr ($\sim$ 40%). There seems to be a dip in the fraction of CBe clusters in the 10−20 Myr age bin. For older clusters, the estimated fraction ranges between 10−25%. The reduction in the fraction from 0−10 Myr age bin to 10−20 Myr age bin could be due to evolutionary effects and also due to the MS evolution of the probable HBe stars. Also the fraction in the 10−20 Myr age bin is similar to the value found for older clusters. There seems to be an enhancement in the cluster fraction with Be stars in the 20−30 Myr age bin.

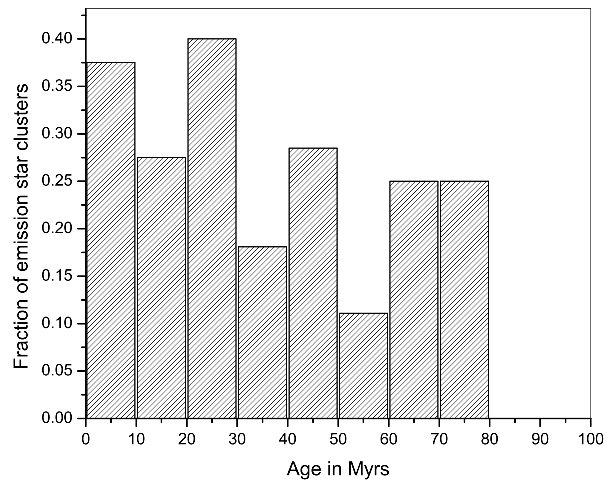

Fig. 1. Fraction of clusters which have emission-line stars with respect to the age is shown.

We find that the fraction of clusters with CBe stars significantly increases in the age range 20−30 Myr, similar to the result found by Wisniewski & Bjorkman (2006) (10−25 Myr) and McSwain & Gies (2005) (10−20 Myr).This indicate that there is an enhancement in the 10−30 Myr age range. These suggest that stars in these clusters evolve to become CBe stars. Thus, there could be two mechanisms responsible for the Be phenomenon. First mechanism is where the stars start off as CBe stars early in their lifetime, as indicated by CBe stars in very young clusters. These probably are born fast-rotators. These type of stars are found in all age groups of clusters. These types of stars are likely to be later than B1, as indicated by the paucity of very early type CBe stars in young clusters. The second mechanism is responsible for the enhanced appearance of Be stars in the 10−30 Myr age group clusters. This is likely to be an evolutionary effect. This component is probably due to the structural or rotational changes in the early B-type stars, in their second half of the MS life time Fabregat & Torrejon (2000).

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