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Young open clusters and star formation

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The initial mass function (IMF) is a distribution of stars with mass m at their birth. The IMF, which plays important role for understanding of star formation, is not clearly understood yet. In spite of considerable efforts of numerous workers during last five decades only general understanding of the IMF behavior at the domain of moderate and high mass stars ($m > 2$ or $3m_{\odot}$), where it can roughly be approximated with a power law distribution, is achieved. At lower masses no unique view on the IMF behavior is established so far.

Young open clusters play important role in the IMF study. In contrast to the general stellar field they provide observations of stars being formed at approximately same time and just at the same site. In spite of general agreement between IMFs derived from open cluster and general field data, observers find that stellar mass spectra of some young open clusters display non monotonic behavior, demonstrating lack of stars in some mass range, specific to the cluster (see Piskunov and Belikov, 1996 for references). This might have important consequences with respect to the IMF universality and other related issues.

It should be noted, that since stellar mass can be directly measured in very rare and specific cases, the IMF is not observed directly, but is converted from the observed distribution of stars over their absolute magnitudes M, called as luminosity function (LF), which is related to the IMF via mass luminosity relation m(M) (MLR) and (what is more important) via MLR derivative

$$\phi(M) = \frac{dN}{dM} = \frac{dN}{d\lg m} \times \left| \frac{d\lg m}{dM} \right| = f(m[M]) \times \left| \frac{d\lg m}{dM} \right|$$

Here $\phi(M)$ and $f(m)$ are the LF and the IMF.

Since cluster stars reside not in the Main Sequence (MS) only, but evolve off or approach to it, the cluster MLR should also evolve with time, being different at every moment from the standard one (usually adopted to be the MLR of the Main Sequence stars). The "instant" MLR has a definite fine structure due to evolution of arriving to or leaving the MS stars. The structure itself is not too prominent to influence the luminosity function, but it produces bumps in the MLR derivative. This detail can be easily seen in the LF as a peak accompanied by a depression in the LF. We called this detail as H-feature (Piskunov and Belikov 1996), since it appears at a moment when hydrogen burning starts in the cores of arriving to the MS stars. The H-feature formation is shown in Fig. 1 for a moderately young open cluster of age of 50 Myr. As it is seen neither color magnitude diagram (CMD) nor MLR predict the H-feature appearing in the LF if no MLR derivative behavior is taken into account. The immediate conclusion, which could be drawn from this fact is, that existence of any gaps in the LF or near the turn on point of young clusters should not be regarded as an evidence of non monotonous behaviour of the IMF.

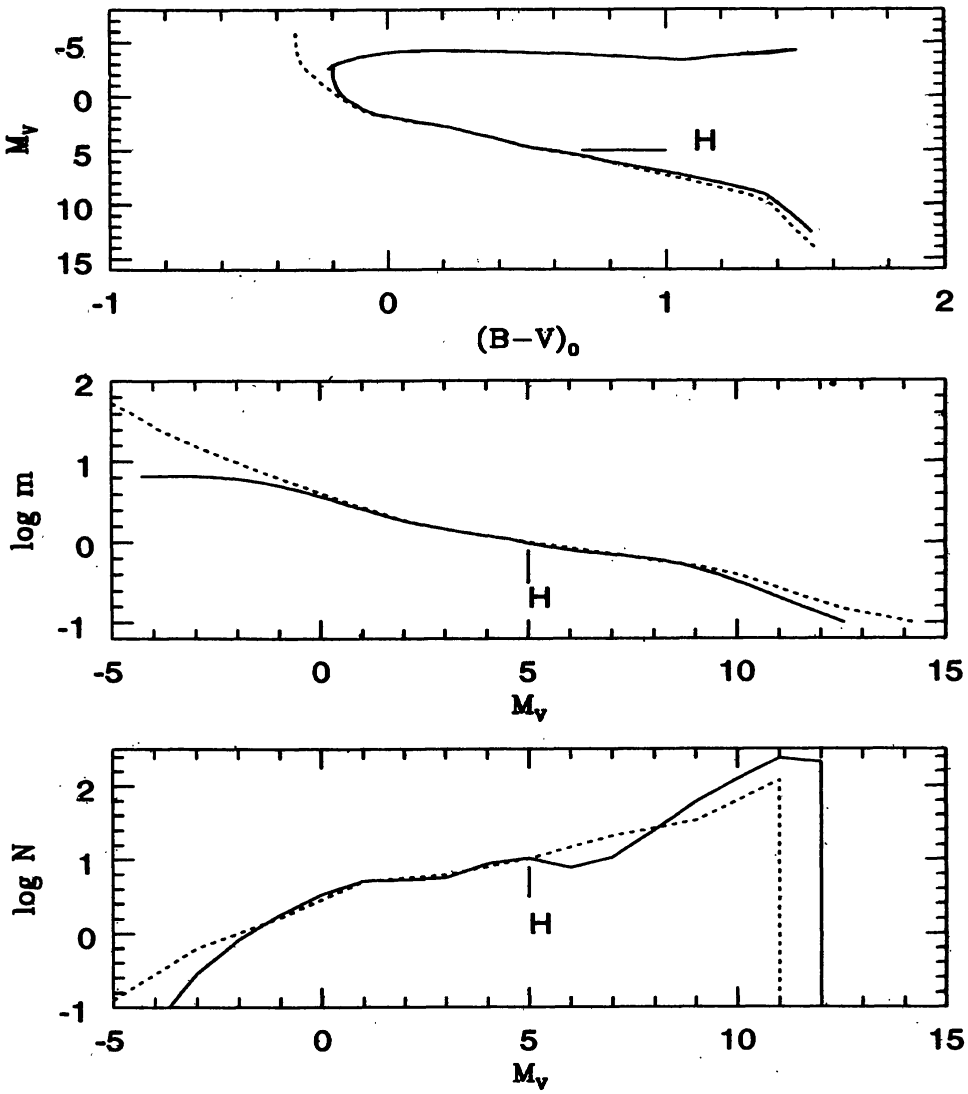

Figure 1. Illustration of an effect of the MLR derivative on the LF H-peak formation for a moderately young cluster of age lg t = 7.7. The position of the peak is indicated with letter H. The corresponding isochrone (solid curve) along with the ZAMS (dotted curve) are shown in the upper panel. The isochrone' and ZAMS' MLRs are shown in the middle panel. The luminosity functions, counted along the ZAMS, and along the isochrone are shown in the bottom panel. The difference between both LFs is due to evolution of brightest stars off the ZAMS, and due to settling of the fainter stars onto the ZAMS (H-feature).

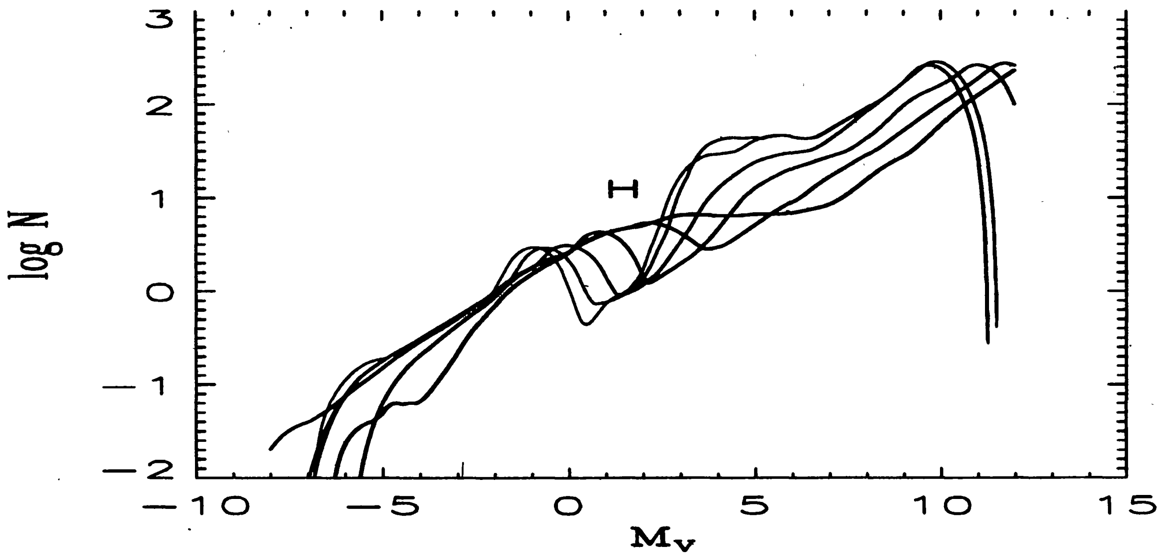

Figure 2. Evolution of the LF with time for lg t = 5.5, 6.0, 6.5, 7.0, 7.5, 8.0. indicated by curves of different width. The lightest curve corresponds to the youngest age, the heaviest one to the oldest age.

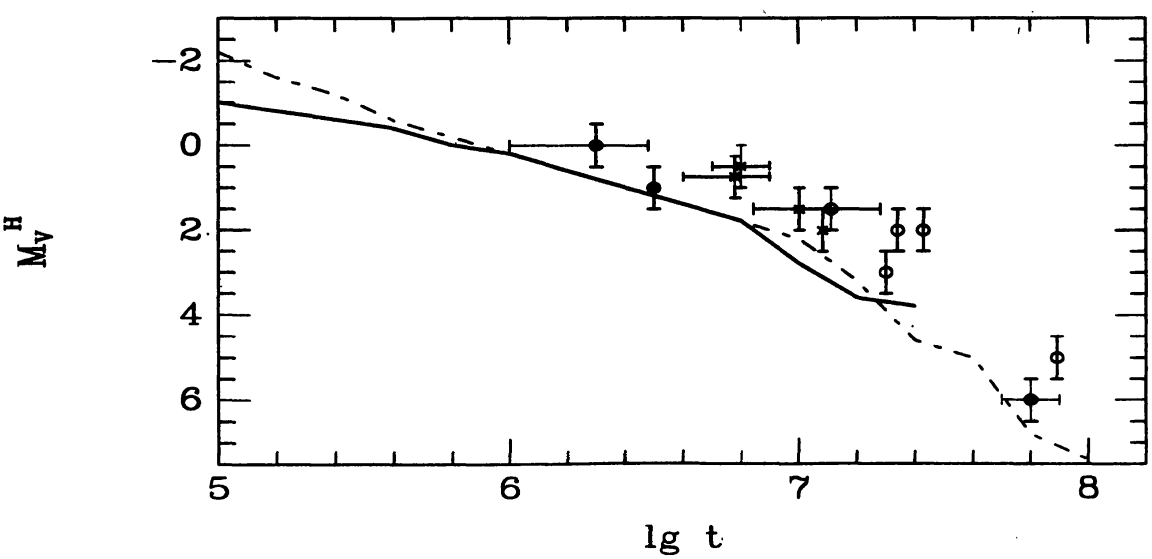

Figure 3. The H-calibration of the luminosity function. The curves are theoretical relations, constructed with help of different Pre-MS model grids (P includes the birthline, while I does not). The dots are observed data on H-feature positions in LFs of 25 selected young open clusters. Open dots: Post-MS ages, filled dots: Pre-MS ages. Bars indicate uncertainty both in age and in H-peak position.

Since the position of a cluster turn on point evolves with time, the H-feature should move faintward with cluster age also, as it is shown in Fig. 2, which illustrates evolution of a young cluster LF with time. In principle this makes the LF of young clusters to be a suitable tool for cluster age determination (H-calibration of the LF). The feature not only moves to fainter magnitudes, but also degrades with time. As calculations show it disappears completely for lg $t \geq 8.2$. This puts a limit on the H-calibration applicability. Theoretical curves calculated from different Pre-MS track grids is shown in Fig. 3 together with observed data, on cluster LFs where this detail was detected (Belikov and Piskunov, 1997).

References

Piskunov A.E., Belikov A.N., 1996, Astr. Lett, 22, 466

Belikov A.N., Piskunov A.E., 1997, Astr. Rep., 41, 28