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THE HIGH MASS END OF THE INITIAL MASS FUNCTION

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RESUMEN

En esta charla se presentó un resumen de las principales dificultades para derivar la función inicial de masa (IMF) a partir de las observaciones y se hizo un resumen de los datos observacionales que pueden ser utilizados para constreñir la IMF. Tambien se mostró cuan bien la IMF propuesta, así como otras IMFs en la literatura, satisfacen estas restricciones. En esta corta contribución nos concentraremos en cuantificar el conjunto de efectos que deben ser tomados en cuenta para reconstruir la IMF a altas masas a partir de la función de masa estelar actual (PDMF).

ABSTRACT

In this talk we present a review of the observational difficulties for the determination of the Initial Mass Function (IMF) and make a summary of the observational data that can be used to constrain the IMF. We also show how well the proposed effective IMF and other popular IMFs fit some of these constraints. In this short contribution we point out a series of effects that must be taken into account to recover the high mass IMF from the observed Present Day Mass Function (PDMF).

Key Words: stars: luminosity function, mass function

There are very few IMFs derived for clusters to establish if there is a general trend between the mass distribution of the objects and the cluster density, or if instead the observed differences are the result of the statistical variations in particular realizations of the star forming process. To estimate the galactic time-averaged IMF, the IMFs from clusters must be averaged in order to obtain the IMF of all the stars ever formed in all clusters. If there is any general trend of the IMF with the cluster size, the sample must have adequate representation of the various association sizes. From radio observations, McKee & Williams (1997) derived a size distribution of associations in which the associations formed in each logarithmic interval of size produce equal number of stars (the size of an association is defined by the number of stars it forms). In this distribution half of the stars are formed in associations that ultimately form $\gtrsim 75$ high-mass stars ($m > 8\ M_\odot$), the minimum-size association forms about one high-mass star, and the maximum-size association forms 5900 high-mass stars (see Parravano, Hollenbach, & McKee 2003). McKee & Williams (1997) also point out that an association is typically made up of roughly 5 generations or clusters whose births are separated by 3–4 Myr. Consequently, the typical cluster forms 75/5 ~ 15 hot stars, a size comparable with the Trapezium cluster. The Taurus star forming region, on the other hand, is representative of the low end of the cluster distribution that produces only a small fraction of the stars in the Galaxy; if there is any trend of the IMF with size, it is unlikely that the IMF of Taurus follows the average IMF.

On the other hand, the current rate of star formation in the Galaxy, which may differ from the time-averaged rate, can be determined from observations of massive star formation in the Galaxy. Determining the formation rate of massive stars from optical surveys tends to underestimate the rate because these short-lived stars spend an appreciable fraction of their lives obscured by their parent molecular cloud (see point (ii) below). In addition, the local value of the current SFR may differ from the current SFR averaged over the solar circle since there can be large fluctuations in the SFR due to the low space density of large associations, which contain a significant fraction of massive stars (see point (i) below). We circumvent both of these problems by utilizing radio and far-infrared (N II λ 122 μm) observations of the rate of hydrogen ionizing photons produced in the Galaxy (McKee & Williams 1997). This rate is proportional to the high-mass SFR averaged over large volumes of the Galaxy, and, in addition, the radio and far IR observations are not affected by extinction. Therefore, these observations do not suffer the two limitations discussed above. McKee & Williams (1997) inferred the radial gradient of the

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current SFR and the average value at the solar-circle. We can then compare the current SFR at the solar circle with that averaged over the age of the galactic disk (see point (iii) below). The ratio of these two quantities is just the parameter b_0 defined by Scalo (1986).

Therefore, in the determination of the high mass IMF from optical surveys it must be considered that:

(i) The observed PDMF at a given mass m is expected to reflect the typical (median) star formation rate $sfr_{\rm typical}$ in the volume of observation during the time $t_{\rm ms}(m)$. The number of massive stars formed in a given area A of the disk and over a given time interval Δt will depend on the size and number of associations formed. For small areas (e.g., ~ 1 kpc^2) large fluctuations are expected even if Δt is tens of millions of years. As a result, the typical rate of massive star formation can be significantly less than the average rate in the Galaxy for small values of $A\Delta t$ (Parravano, Hollenbach, & McKee 2003). Therefore, to obtain the IMF the observed PDMF must be boosted by the ratio of the mean to typical (median) sfr.

(ii) The observed PDMF does not include the stars obscured by their mother clouds. In particular, short-lived stars spend an appreciable fraction of their lives obscured. As a result, the PDMF at a given mass m must be boosted by the factor $1/F_{\rm obs} = 1 - t_{\rm obs}/t_{\rm ms}(m)$, where, $t_{\rm ms}$ is the main sequence life time and $t_{\rm obs}$ is the average time that stars are obscured by their mother clouds (Parravano, Hollenbach, & McKee 2003).

(iii) The time variations in the star formation rate (sfr) are reflected in the PDMF. At a given mass m the PDMF is proportional to the mean star formation over the lifetime of these stars. To correct for a time dependent star formation rate the PDMF(m) must be boosted by the factor $\overline{\rm sfr}(t_{\rm ms}(m))/\overline{\rm sfr}(t_{\rm disk})$, where $\overline{\rm sfr}(t)$ is the mean star formation over the last t years, and $t_{\rm disk}$ is the age of the galactic disk. For high mass stars (life times less than ~ 20 Myr) this factor is just the Scalo's parameter b_0 ($= 0.55$ in our model).

To show the importance of each of these corrections we consider the high mass IMF derived by Scalo (1986). Figure 1 shows Scalo (1986) PDMF for massive stars (triangles), Scalo data corrected by the typical to mean sfr factor (circles) and Scalo data corrected by both, obscuration and typical to mean sfr (squares). Additionally, Figure 1 shows the average PDMF derived by assuming a constant sfr that produces the observed surface density of M dwarf during the age of the disk ($t_{\rm disk} = 11$ Gyr; continuous curve) and the average PDMF corrected by a factor $b_0 = 0.55$ (dashed curve).

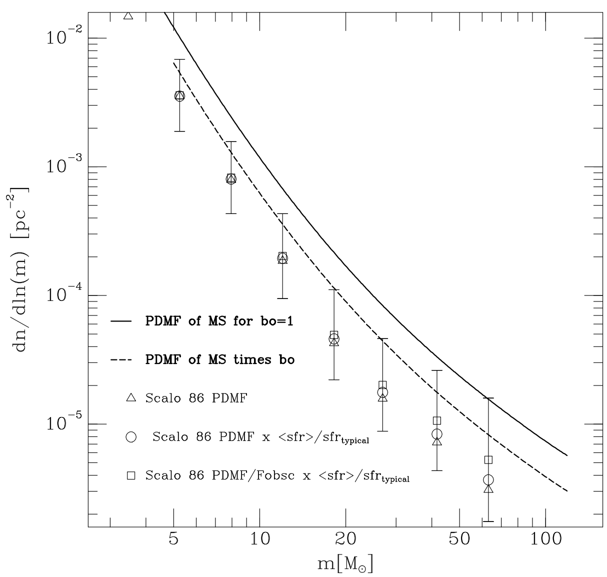

Fig. 1. Corrections to Scalo (1986) PDMF; see text.

Note that a fit to Scalo (1986) IMF gives a high-mass IMF slope of $1.5 < \Gamma < 1.7$, whereas, $1.3 < \Gamma < 1.5$ when Scalo (1986) PDMF is corrected by obscuration and the typical to mean sfr effect.

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