33 Stellar initial mass function from population of open clusters

Raveewat Tawantaleongrit(10th), Wat Suthiwararam School, Thailand
Montika Ruangnaparat, Kiratika Suksrithong(11th)Princess Chulabhorn's College, Thailand

INTRODUCTION

Stars in an open cluster share common origin in the same nebula, and therefore the distance from Earth to all open cluster members are approximately the same. The difference in their apparent brightness reflects the intrinsic brightness of the star, the luminosity, which can be used to estimate the mass of the star via the mass-luminosity relation. In this work, we study the population of ten open clusters photometrically to determine the stellar initial mass function (IMF), which essentially indicates the amount of stars born at each mass level.

METHODOLOGY

We obtain images of ten open clusters in the Messier Catalog using the 0.5-meter Robotic Optical Transient Search Experiment (ROTSE) telescope at McDonald Observatory, Texas, USA during 2006-2007. We perform aperture photometry for each star in every cluster using the Iris software (*http://www.astrosurf.com/buil/us/iris/iris.htm*). The software gives relative intensity measured within the 10-pixel aperture subtracted by sky background, which can be calibrated with other stars with known brightness. We determine the mass of each star using the process described by expressions below:

- $mag_1 - mag_2 = -2.5Log_{10}(F_1/F_2)$ -- convert stellar flux to apparent Magnitude by comparing to a reference star with known brightness
- $A_v = N_H / (1.8 \times 10^{21}$ atom /c.m.$^2)$ -- correct for galactic interstellar extinction in the line of sight
- $mag - Mag = 5Log_{10}(R/10)$ -- convert apparent magnitude to absolute magnitude for each cluster using distances from literatures
- $Mag - Mag_{sun} = -2.5Log_{10}(L/Lsun)$ -- convert magnitude to solar luminosity unit
- $(L/L_{sun}) = (M/M_{sun})^{3.5}$ -- apply the mass-luminosity relation to determine stellar mass

ANALYSIS AND DISCUSSION

After obtaining stellar masses, we make histogram of stellar mass in each cluster. We show a histogram in log mass in the Fig 1. The linear relation in log-log space exhibits power-law behavior, in the form of $y = ax^k$ (where a and k are constant). From the figure, we observe the low mass regime have more population than high mass interval to appear in Fig.1 characteristic to the stellar IMF.

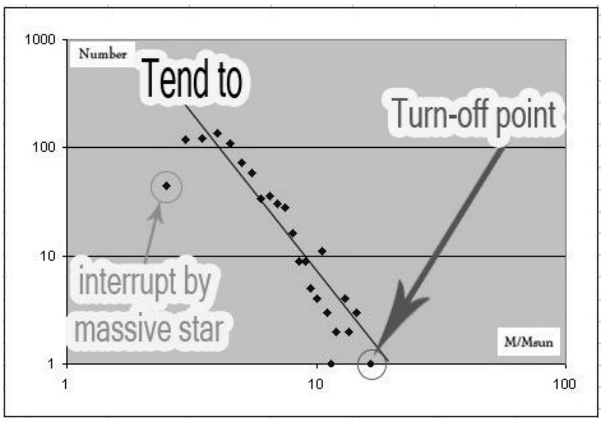

Fig.1. Example of stellar mass histogram in open cluster M38, with labels showing the highest mass observed (‘turn-off point) and low-mass end

At the high-mass end of the histogram, the most massive star on the plot reflects the age of the cluster, since the more massive stars already left main sequence and evolved into stellar remnants. On the other end, low-mass limit of our IMF is not well constrained due to completeness of our photometry (as we need to perform many more photometry in this regime and stars were barely detected). The turnover, if real, can be due to several factors, including the influence from massive stars in the cluster and intra-cluster feedback processes.

To determine the power-law index, we modeled power-law relations with various indices and compare with the observed histogram's slope (k) and the normalization (a) as shown in Fig.2.

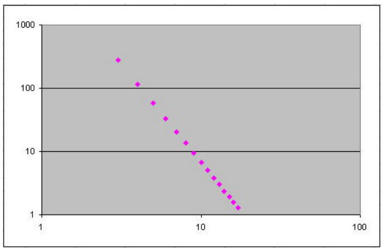

Fig. 2A. Modeled power-law

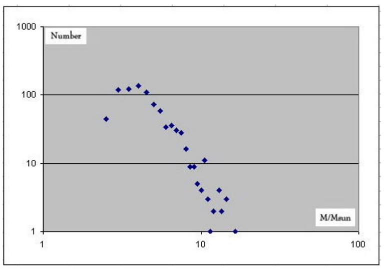

Fig. 2B. Observed power-law in M38

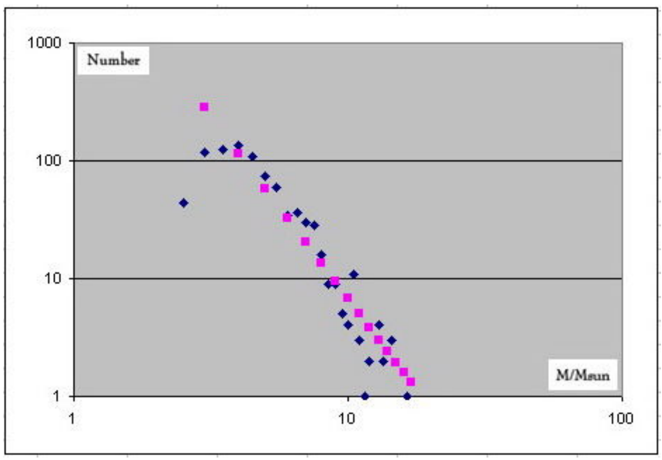

Fig. 2C. Comparison of the observed and the modeled power-law to estimate the power-law index, k, and the normalization factor, a.

We perform this analysis in ten open clusters, namely: M25, M27, M29, M34, M35, M36, M37, M38, M39 and M41, and determined the power-law indices in all of them, which is summarized in the table 1.

Our results agree in general with the accepted IMF (Salpeter 1955), which indicates the IMF index of -2.35. Uncertainties in our results can be due to several factors, including the extent of cluster we arbitrarily define, the completeness of our photometry at low-luminosity regime. Also, we have to make several assumptions in this analysis, namely: we need to assume the mass-luminosity relation for all star, we assume that all clusters are sufficiently young such that not many old stars had died to the extent of affecting our IMF shape. We assume that all stars in the cluster are at the same distance from Earth, which is approximately correct. Our results from this simple analysis are nevertheless agreed with accepted value in the order of magnitude.

SUMMARY

We photometrically analyze ten clusters, namely: M21, M25, M29, M34, M35, M36, M37, M38, M39 and M41 and, with known distances to clusters, estimate their mass via the mass-luminosity relation to determine the stellar IMF. Relationship of number of star in each mass range and mass is in the form of power-law, in which we can model and express them in the form of *number of star at mass M = a(M)* ^{k} with the following indices and normalization factors:

Open cluster	**M21**	**M25**	**M29**	**M34**	**M35**	**M36**	**M37**	**M38**	**M39**	**M41**
A	5.4E4	3.2E2	1.65E4	2.6E1	7.5E2	4.3E3	6.0E4	8.5E3	1.6E2	3.4E2
k	-3.5	-4	-3	-2.7	-2.9	-3.2	-4	-3.1	-3.6	-2.9

Table 1: Indices and normalization factors of IMF from each cluster

REFERENCE

Salpeter, E. E. 1955, ApJ, 123, 666