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STELLAR DYNAMICS IN 30 DORADUS

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RESUMEN

Con espectroscopía multiranura de 180 estrellas en el cúmulo ionizante de 30 Doradus, hemos obtenido velocidades radiales confiables para 58 estrellas. Con ellas, calculamos la dispersión de velocidades, la cual es de 35 km s^{-1}. Si el cúmulo está relajado dinámicamente, la masa virial estimada es de $\sim 1 \times 10^7\ M_\odot$.

ABSTRACT

From multislit spectroscopy of 180 stars in the ionising cluster of 30 Doradus, we have obtained reliable stellar radial velocities for 58 stars. With these we calculated the stellar radial velocity dispersion and found it to be 35 km s^{-1}. If the cluster is dinamically relaxed the virial mass is $\sim 1 \times 10^7\ M_\odot$.

Key Words: **GALAXIES: MAGELLANIC CLOUDS — STARS: KINEMATICS — STARS: EARLY-TYPE**

1. INTRODUCTION

In spite of the large number of studies performed on the 30 Doradus stellar cluster (NGC 2070) and its nebular surroundings, there is no conclusive estimate of the total mass of the region. Adding the determinations of masses from stars and gas in its several phases, there is up to $10^6 M_\odot$. But still all these determinations are of *photometric* masses. Or masses from stellar models, in the case of ionizing stars. They both share the need of guessing a distribution of the 'unseen' stars, as they are too faint to be detected. Still, their *dynamical* effect on the whole stellar population can be observed on the kinematics of the bright stars. In this case, the 'visible' stars act only as probes of the potential field produced by all the stars. By means of the virial theorem, we can estimate the total mass of the cluster, within a specified radius.

2. DATA & ANALYSIS

The observations were obtained with the NTT telescope, using the Multislit option of EMMI's RILD mode. In this mode, grism # 5 was used, which in combination with a .8 arcsec wide slit yields a resolution of 1.3 Å / pixel. A total of seven masks were produced within the instrument, each of them including an average of 35 slitlets. The total number of spectra which could have their radial velocity measured with at least 3 lines is 97, with a few stars with more than one observation. The limiting factors were either low S/N, for the weakest stars within each mask, or nebular contamination, in the case of stars whose only absorption features matched the strong emission lines from the gas. We finally used stars with internal dispersion of their average radial velocities smaller than 25 km s^{-1}. This comprises 52 stars, distributed in the 30 Doradus field.

3. STELLAR KINEMATICS

If we consider the possibility of a single gaussian distribution, we have a good chance of estimating the total gravitational mass that is governing the observed stellar motions. To achieve this, we checked for the influence of 'hidden' spectroscopic binaries as they are very difficult to detect in a single observation. As we are interested in the effect these stars can produce on the measured velocity dispersion, we have used the Montecarlo experiments with an artificial binary population described in Bosch & Meza (2001). The velocity dispersion of a population of stars in which all of them are binaries is found to be $\sigma \sim 35$ km s^{-1}.

The next question is if the stellar cluster is evolved enough as to consider it dynamically relaxed. If not, we could be observing a system that is expanding, or collapsing. We have detected evidence of mass segregation, already discussed in Selman et al. (1999) and Bosch et al. (1999). If this segregation is originated dinamically, it indicates the cluster might be relaxed. Furthermore, if the mass segregation observed has a dynamical origin, it should be reflected in the stellar kinematics. The condition of energy equipartition described by Spitzer (1969) for a spherical stellar system composed of stars of two masses m_1 and m_2 requires that $m_1\langle {v_1}^2\rangle = m_2\langle {v_2}^2\rangle$.

If we split our observed stars into two groups, namely stars more massive than 25 $M_\odot$ and less massive than 20 $M_\odot$, they do fulfill the condition of energy equipartition. Although not conclusive, we consider all this evidence to support a dynamical relaxation of the cluster.

4. RESULTS

With the above considerations in mind, we can then calculate the stellar velocity dispersion in our sample. To account for the binary effect we calculate the stellar velocity dispersion with and without including the stars we have detected as binaries, $\sigma^\star_{obs}$. In order to obtain the true stellar radial velocity dispersion $\sigma^\star$, we need to correct for the average internal dispersion, being $\sigma^\star = \sqrt{{\sigma^\star_{obs}}^2 - \langle\sigma_{int}\rangle^2}$.

This correction yields $\sigma^\star = 35.21$ km s^{-1} for the sample without binaries, and $\sigma^\star = 47.29$ km s^{-1} when including them. The difference, quadratically is 31.6 km s^{-1}, which gives an observed estimate of the influence of the presence of binaries on the final value, which is quite close to the value that we estimate from our simulation.

We calculated a dynamical mass for 30 Dor in the range $0.8 - 2 \times 10^7$ $M_\odot$. This mass is almost one order of magnitude larger than the one found from photometric studies. This discrepancy can be due to several reasons: (i) there is a change in the IMF slope of 30 Dor for low-mass stars, which makes the extrapolation useless; (ii) 30 Dor has a dark matter halo; (iii) there are other factors than enhance our measured value of $\sigma^\star$, such as sub-clustering.

We have already started a programme to obtain higher resolution spectroscopy in the 30 Dor field, to reduce the internal dispersion of our radial velocity determinations and check for the presence of radial velocity variable stars.

5. SUMMARY

We have performed the first analysis of the kinematics of stars in 30 Dor. With it, we found evidence supporting dynamical mass segregation, we checked for the effects of hidden binary population. We also calculated the virial mass of the cluster and found it to be $\sim 10^7$ $\mathrm{M}_\odot$, one order of magnitude larger than the mass estimated from photometric studies.

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