RADIAL VELOCITIES FOR THREE DISTANT LMC GLOBULAR CLUSTERS

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ABSTRACT. In an attempt to investigate the large scale structure and dynamics of the old population of the LMC, we have obtained high precision radial velocities for three extremely outlying (10°–15° from the LMC center) globular clusters. Our results agree well with the results from Freeman *et al.* (1983) that the clusters move in a disk like system. Depending on the assumptions used we can put a lower limit to the LMC mass of about $0.5–2.5{\times}10^{10} M_\odot$

1. Data and data reduction

Radial velocities for two stars in each of the clusters NGC1841, Reticulum and ESO121SC03 have been obtained using the 2.5m DuPont telescope at Las Campanas Observatory equipped with the echelle spectrograph and 2D-Frutti photon counting detector. The stars were all very faint with V magnitudes in the range $16^m – 17^m.2$. Exposure times of the order 1 hour sufficed to give reliable velocities.

The echelle data were reduced using IRAF to perform the basic preprocessing including the extraction and wavelength calibration of the individual orders. The cross-correlation was done using the Harvard XCOR package for IRAF. For each echelle spectrogram, 10 orders were extracted covering the wavelength region from 4750-5550Å. The 10 resulting 1D-spectra were then individually cross-correlated with a sky template and a template from the star 47Tuc-C349 (a giant), each of which were observed each night. In several cases the sky template showed a bad correlation with the object spectrum probably because of a bad match between the spectral type of the star and that of the Sun. These results were rejected.

The results are summarized in the table below. The position angles (PA) and the galactocentric velocities ($V_{cl,c}$) were determined following Feitzinger and Weiss (1979) adopting their value for the effective solar apex and taking the LMC rotation center to be $(\alpha,\delta) = (5^h 21^m.1 \,;\, -69°19'.1 \,;\, 1950.0)$ (Hartwick and Cowley (1988)).

2. Discussion

In fig.1 and 2 these new points have been entered in the plots from Freeman *et al.* (1983) and it is evident that they agree well with the previous data. The curve drawn in fig.1 is solution 3 from that paper, based on the old cluster population (SWB classes V-VII, Searle *et al.* (1980)). Looking only at the oldest clusters (SWB class VII) suggests that a slightly different solution is warranted for this population. Figure 2 shows that the assumption of a flat rotation curve is good even out to these large distances.

Since the ESO cluster is very close to the line of nodes and the clusters apparently follow the general rotation pattern of the LMC, this cluster can give important information about the mass of the LMC. Assuming $(m-M)_{LMC}=18^m.5$ gives a projected distance (which is close to the real distance because this cluster is almost on the line of nodes) from the LMC center of 8.5kpc for this cluster. Correcting the galactocentric velocity for a systemic velocity of the LMC of 26km/s (solution 3) and assuming a circu-

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lar orbit then gives a lower limit for the LMC mass of $5\times10^9 M_\odot$. This number can be raised substantially if we believe that the clusters follow the general rotation of the LMC and that solution 3 from Freeman *et al.* (1983) is valid as indicated above. Correcting $V_{cl,c}$ for an inclination i=27° gives a circular velocity V_{circ} of 110km/s leading to $M_{LMC,min}=2.4\times10^{10} M_\odot$. Another approach which is based on all the available information, is to rely on the fitted model and assuming a flat rotation curve out to 15° from the center, as indicated by these observations. The angular distance of 15° converts to 15kpc. Correcting $V_{\max}$ for solution 3 (≈41km/s) for an inclination of i=27° gives a circular velocity of 90km/s leading to a mass of $\approx2.5\times10^{10} M_\odot$. The value of i is not well determined though, and adopting a more conservative value of i=45° leads to mass estimates of ≈40% of the above or about $1\times10^{10} M_\odot$.

Cluster	RA (1950.0)	DEC (1950.0)	PA degrees	d(center) degrees	Vrad km/s	Vcl,c km/s	DELTA V
Reticulum	4:35:24	-58:56:00	329.2	11.52	235.0+-1.8	28	-9
ESO121SC03	6:01:10	-60:31:31	30.4	9.74	310.8+-1.8	76	10
NGC1841	5:11:11	-84:04:54	181.0	14.77	204.3+-2.3	-1	-3

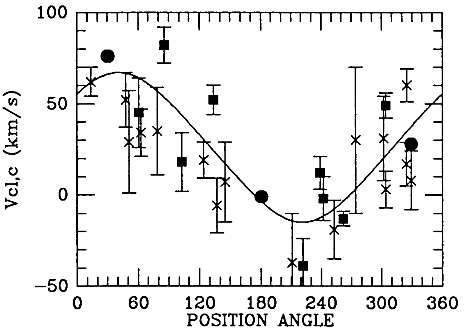

Fig.1 *Galactocentric velocities ($V_{cl,c}$) as a function of position angle. ×=SWB class V-VI, ■=SWB class VII, ●=new points*

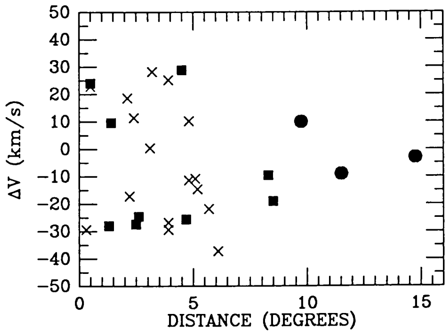

Fig.2 *Velocity difference (ΔV) between observation and model versus d, the angular distance from the LMC rotation center. ×=SWB class V-VI, ■=SWB class VII, ●=new points*

3. Conclusions

These new measurements agree well with the picture put forward by Freeman *et al.* (1983) that the old globular clusters move in a disk-like system with a flat rotation curve. A more numerous pop-II tracer is clearly needed to assess the question of the existence of a dynamical LMC halo population.

From the ESO cluster alone we can infer a minimum mass of the LMC of $5\text{x}10^9 M_\odot$, and if we believe the above conclusion that the old population moves in a disk-like system with a flat rotation curve described by solution 3, this estimate can reasonably be raised to $1\text{x}10^9 M_\odot$ if not more, depending on the value for the inclination of the disk.

4. References

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