ROTATIONAL FIELD AND VELOCITY DISPERSION IN GLOBULAR CLUSTERS: ω CEN AND 47 TUC

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ABSTRACT. Thanks to numerous and accurate radial velocity measurements obtained with CORAVEL, the rotational velocity fields, the spatial velocity dispersions from the centre to the edge and the ordered to random motions ratios are deduced for two globular clusters : ω Cen and 47 Tuc. Masses through virial theorem and M/L ratios are also given. A more comprehensive study will be published in Astron. & Astrophys.

1. OBSERVATIONS

The observations of accurate radial velocities have been collected with the CORAVEL photoelectric spectrometer (Baranne et al. 1979) mounted on the 1.5 m Danish telescope at Cerro La Silla, Chile. The number of observations amounts to 390 measurements of 302 stars in ω Cen and 265 measurements of 194 stars in 47 Tuc. The kinematical description given below has been obtained through the mean radial velocities of 298 member stars in ω Cen and 192 member stars in 47 Tuc. Typical uncertainties are 0.9 km/s per measurement in ω Cen and 0.6 km/s in 47 Tuc.

These observations were obtained through collaboration with astronomers of Geneva, Marseille, Copenhagen and ESO. New measurements in the nucleus of 47 Tuc have been obtained since the publication of 47 Tuc radial velocity catalogue (Mayor et al. 1983). Radial velocities in ω Cen are in course of publication.

A preliminary discussion of the kinematics of 47 Tuc has been published, including a few results concerning stellar duplicity (Mayor et al. 1984).

2. ROTATION V(r,z)

The rotational velocity fields V(r,z) result from a least-squares fit between the observed radial velocities and the projection onto the line of sight of a parametric form of the rotation curve. These functions

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allow to estimate the main characteristics of the differential rotation in these two clusters :

- solid body rotation in the nucleus

  ω Cen : Ω_c =4.6 km $s^{-1} r_c^{-1}$ = $1.3 \cdot 10^{-6}$ y^{-1}

  47 Tuc: Ω_c =2.7 km $s^{-1} r_c^{-1}$ = $4.9 \cdot 10^{-6}$ y^{-1}

- the maximum velocity V_{max}
- the position of the maximum velocity
- the differential rotation in the outer parts
- the decrease of rotation towards the poles (non cylindrical rotation)

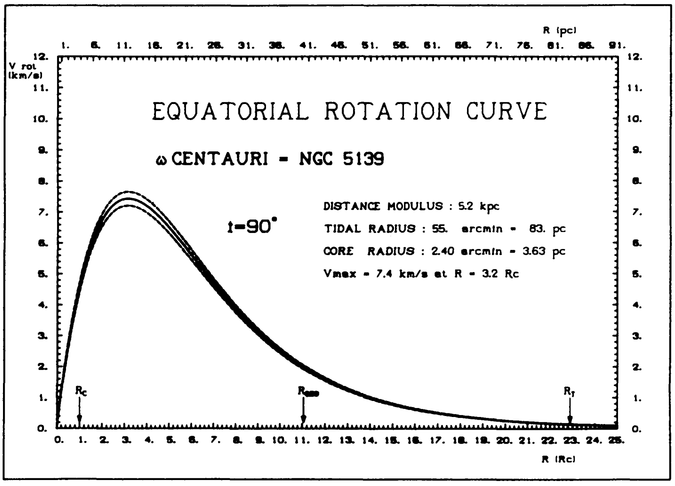


Figure 1.

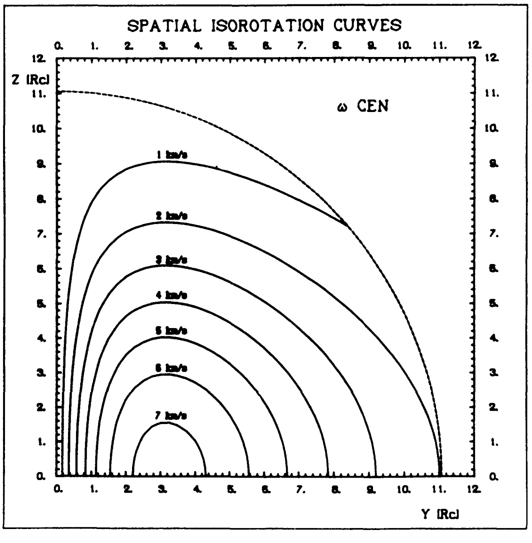


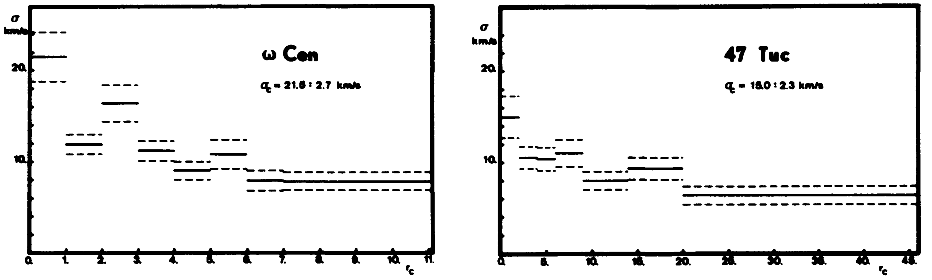
Figure 2. Spatial (non integrated) isorotation curves deduced from the rotational velocity law.

Figure 1 displays the equatorial rotation curve of ω Cen deduced from the fit. The non cylindrical rotation appears in figure 2. These results were obtained under the hypothesis of $i = 90$ degrees (equator-on).

3. VELOCITY DISPERSION

Contributions of rotation and integration along the line of sight having been eliminated, the spatial velocity dispersion component due only to random motions has been obtained in a few concentric shells : 8 for ω Cen (figure 3) and 7 for 47 Tuc (figure 4). These results show the same tendency in both clusters : slow and regular increase of the velocity dispersion from the edge of the clusters towards the centre with a strong value in the cores.

Figures 3 and 4. True velocity dispersion in the 8 and 7 concentric shells of ω Cen and 47 Tuc.



Deduction of the mean velocity of the cluster having been made, the distributions of radial velocities do not exhibit any difference from normal laws. Thus the large values of the velocity dispersions in the cores do not result from a few stars with exceptional velocities. These velocity dispersions are outstandingly larger than those obtained by Peterson & King (1975) (table 1) from the central surface brightness, integrated magnitude and models.

Table 1.

	Central dispersion from central surface brightness Peterson & King (1975)	Central dispersion from $c=\log r_t/r_c$ and integrated magnitude Peterson & King (1975)	Observed central dispersion from CORAVEL radial velocities
ω Cen	10.96 km/s	10.22 km/s	21.5 ± 2.7 km/s
47 Tuc	10.52 km/s	8.42 km/s	15.0 ± 2.3 km/s

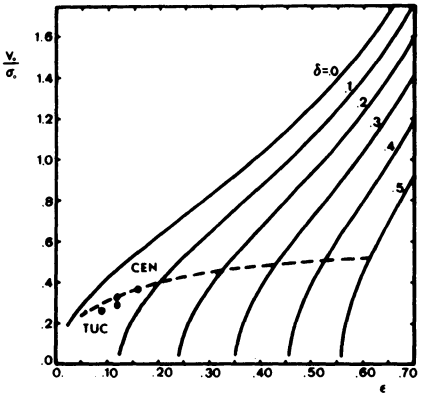
This excess of dispersion in the cores of both these clusters corresponds to the presence of some concentrated and non luminous mass.

4. ORDERED / RANDOM MOTIONS RATIOS

The relative importances of ordered and random motions are given by the ratio v_o/σ_o , where v_o^2 is the mass-weighted mean square rotation speed and σ_o^2 is the mass-weighted mean square random velocity along the line of sight.

The results visible in figure 5 show that ω Cen and 47 Tuc are in close agreement with models of oblate axisymmetric systems with small ellipticity and slight anisotropy.

Figure 5. The dashed line shows the trajectory followed by $[v_o(i)/\sigma_o, \varepsilon_a(i)]$ when i decreases from 90°, while ε_{true} and δ are held constant. For both clusters results are given for i = 90° and 60°.



i=90°	v_o/σ_o	v_{max}/σ_c
ω Cen	0.32±0.05	0.34±0.06
47 Tuc	0.26±0.05	0.31±0.06

5. MASSES AND MASS-LUMINOSITY RATIOS

Using the virial theorem, we obtain for ω Cen a mass of $3.8 \cdot 10^6$ $M_\odot$ and for 47 Tuc a mass of $0.91 \cdot 10^6$ $M_\odot$. With the absolute visual magnitude given by Harris and Racine (1979) the M/L_V ratio is equal to 3.5 ± 1.4 for ω Cen and 1.8 ± 0.8 for 47 Tuc, results in good agreement with Illingworth (1976).

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