MINIMUM OF THE ECCENTRICITY OF THE GALACTIC GLOBULAR CLUSTER ORBITS

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ABSTRACT. We determine if the orbits of the galactic globular clusters can be circular, using a spherical logarithmic potential. If they are not, we calculate their perigalactic distances and we deduce a pseudo-eccentricity. Using a numerical and geometrical method, we obtain the minimum of all the possible pseudo-eccentricities for each cluster. The corresponding perigalactic distances are compared with the values given by Innanen et al. (1983) with a different method.

In this paper we consider that the galactic potential can be represented by a logarithmic function. This is consistent with the observed flat rotation curve, and the existence of a massive halo. In such a model, the visible disk will not, to first order, modify the orbital characteristics of the globular clusters.

Using this potential and the radial velocity V_R given by Harris and Racine (1979), we consider all the orbits compatible with the model and we select those which have the minimum pseudo-eccentricity.

Thus, we obtain a sample of globular clusters whose orbits are not circular and we compare the corresponding perigalactic distances with those given by Innanen et al. (1983).

If V_{Rot} is the constant rotational velocity corresponding to the flat rotation curve, V_T, the unknown tangential velocity and V_S the unknown spatial velocity, the orbit is circular if:

$$V_S = V_{Rot}$$

This is possible only if $V_{Rot} > (V_R / \sin B)$ where B is the angle under which is seen the distance Sun-Galactic center.

If $V_{Rot} < (V_R / \sin B)$, the orbit cannot be circular, thus there exists a perigalactic and an apogalactic distance r_p and r_a, and we define a pseudo-eccentricity:

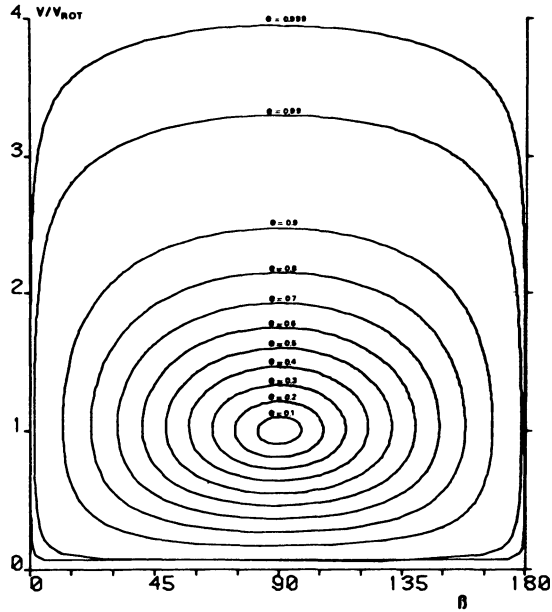$$e = (r_a - r_p) / (r_a + r_p)$$

Figure 1 - Eccentricity of an orbit in a logarithmic potential as a function of the velocity vector define by the modulus V/V_{Rot} and the direction β. This diagram is independant of the distance to the galactic center.
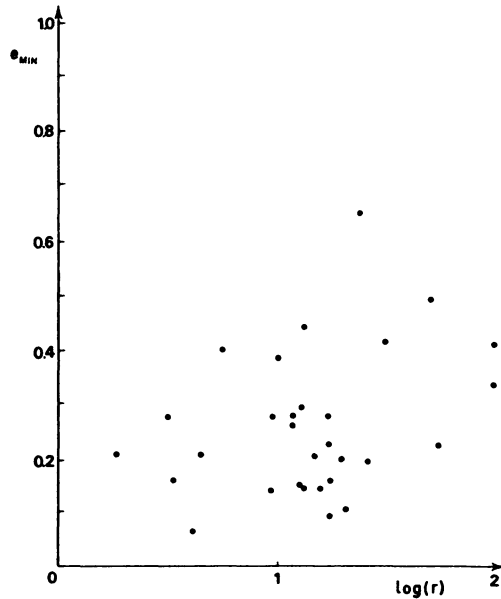

Figure 2 - Minimum of the eccentricity for 30 globular clusters as a function of the distance r. For the other clusters, the minimum is zero.

By varying V_T we explore all the possible orbits and the corresponding
pseudo- eccentricities. For that, we use two methods, a geometrical and
a numerical one.

NUMERICAL METHOD

For each cluster we compute a sample of possible orbit by varying V_T.
We represent the variation of e relative to V_T and we obtain a minimum
for the eccentricity.

GEOMETRICAL METHOD

In a logarithmic potential it is possible to determine the eccentricity
of the orbit of a test particle, when its velocity vector is known
(Colin and Puel, unpublished).

On Figure 1 we show the relation between the components of the velocity
vector (modulus V and direction ß) and the ellipticity of the orbits.
This diagram must be compared to the Bottlinger diagram but here the
distance to the galactic center is ignored. With this diagram the
radial velocity and the position of the cluster it is possible to
determine the minimum of the pseudo-eccentrictry of a globular cluster.
But we don't obtain r_a and r_p with this method.

We obtain 30 globular clusters for which the pseudo-eccentricity is
different from zero. We also obtain the ratio (R_p/R) of the pericenter
distance to the present distance of the clusters. These values may be
compared with those of Innanen et al. (1982) but the significance is
not exactly the same. For Innanen et al. the values are deduced from
the observations and must correspond to the true orbits. In our case
the given values correspond to the maximum possible value, but not
necessarily to the real one. Thus, the values of Innanen et al. (1982)
must not be greater than ours.

DISCUSSION

From a geometrical and a mechanical point of vue, 60% of the globular
clusters may have a circular orbit, if the galaxy is represented by a
spherical logarithmic potential. If we exclude the $R_p/R > 1$, most of
the values of R_p/R given by Innanen et al. (1982) agree with ours, they
don't exceed our values that normally are maximum values.

It also seems that the minimum eccentricity grows with distance. Figure
2 shows this peculiarity already pointed out by Rastorguev and Surdin
(1980) for a different parameter ($e_{min} = (R - R_p) / (R + R_p)$.

REFERENCES

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