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GALACTOCENTRIC ORBITS OF GLOBULAR CLUSTERS WITH TAKING INTO ACCOUNT THE FLATTERING OF THE DARK CORONA

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Abstract. The authors study the Milky Way assuming a three-component potential (bulge, disc and dark matter), in which the flattening of the dark-matter subsystem is varied, and calculating galactocentric orbits. As test particles a set of 38 Milky-Way globular clusters is used. After introducing of the flattening for the dark matter no significant changes in the orbits are noticed.

1. INTRODUCTION

The present paper is concentrated on two aspects: the flattening of the dark component of the Milky Way and the motion of the Milky-Way globular clusters. It is usually thought that the dark component (not only in the Milky Way) is round, but it is possible that it is (slightly) flattened (e. g. Samurović et al., 1998). As for the globular clusters, the growth of the proper-motion determinations followed by a weaker progress in the accuracy has enabled to study their galactocentric orbits (e. g. Dauphole et al., 1996). The present authors calcualte the galactocentric orbits for a set of globular clusters taking into account the possibility of the flattening for the dark subsystem.

2. PROCEDURE

We calculate galactocentric orbits in a given potential. As for the potential we assume that proposed by Miyamoto et al. (1980 - further on referred to as MSO). The main advantage of this potential is the using of the Miyamoto-Nagai formula, which is very simple and can be easily generalised towards axial symmetry. As in many other papers of this kind this potential contains three contributors - bulge, disc and dark component. For simplicity the latter one will be called corona in the rest of the present paper.

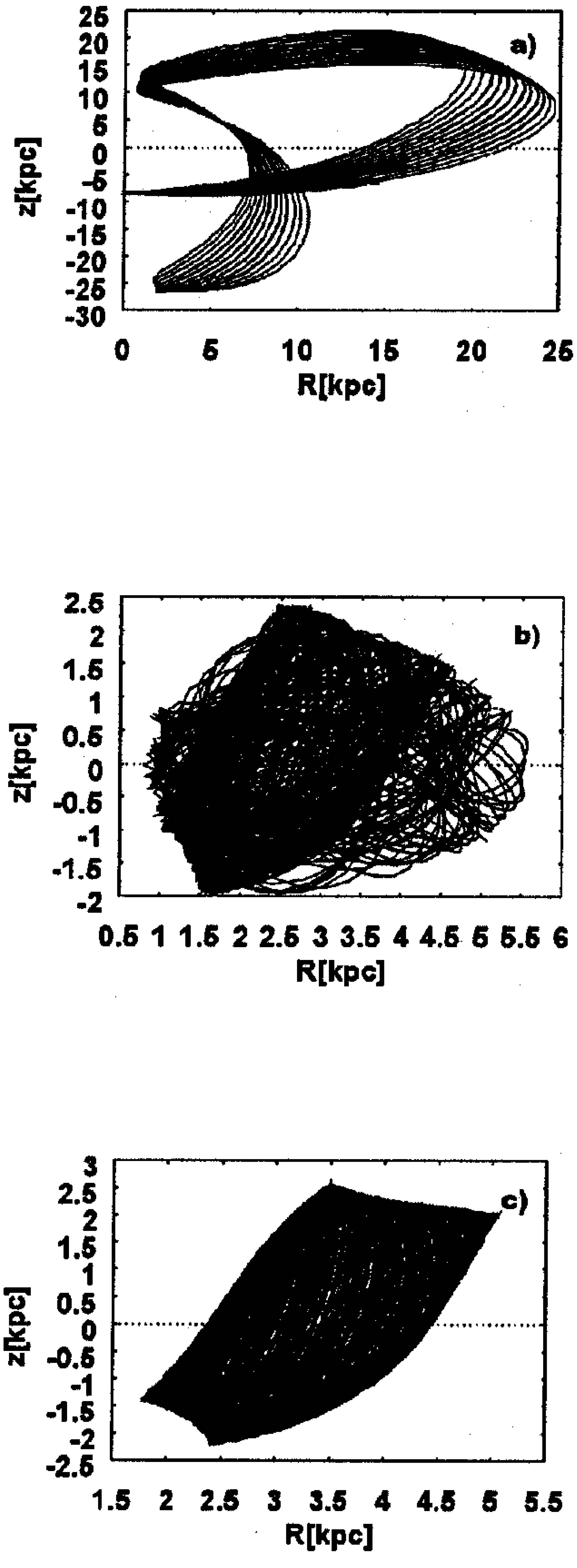

Fig.1: Orbits of globular clusters for a=0
a)NGC1851
b)NGC6171
c)NGC6254

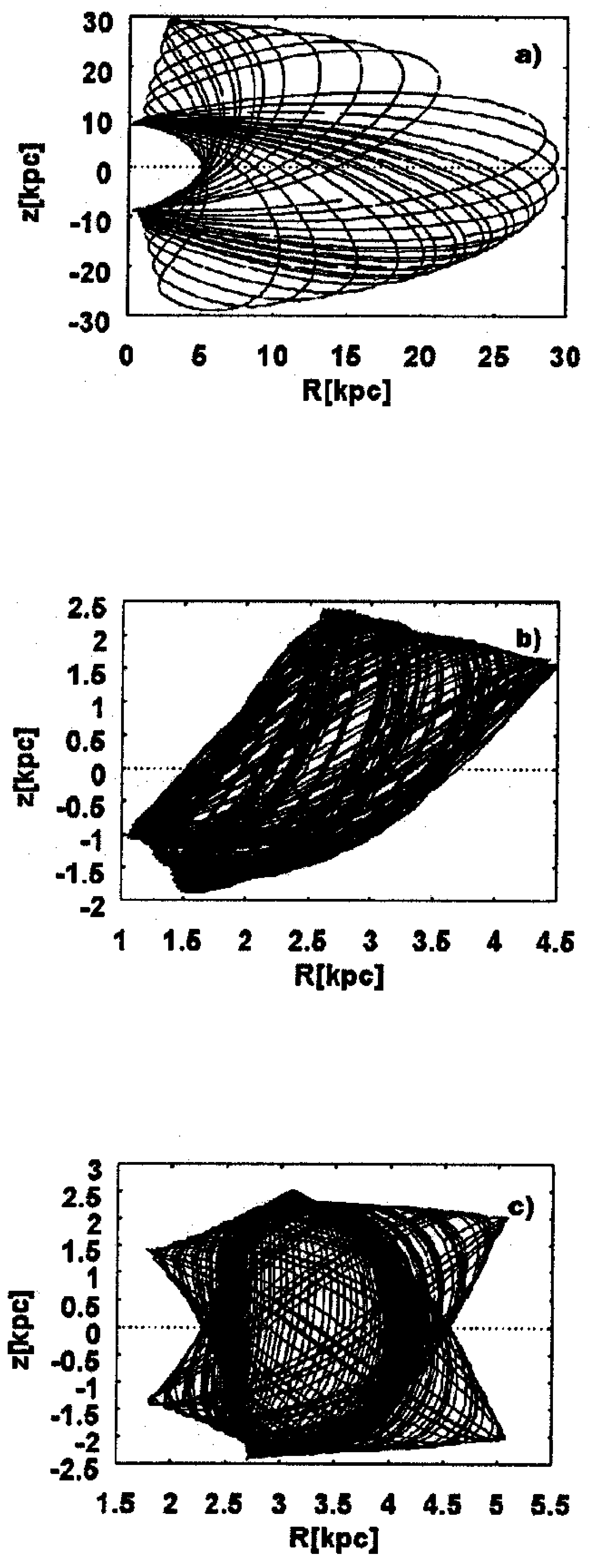

Fig.2: Orbits of globular clusters for a=6.24
a)NGC1851
b)NGC6171
c)NGC6254

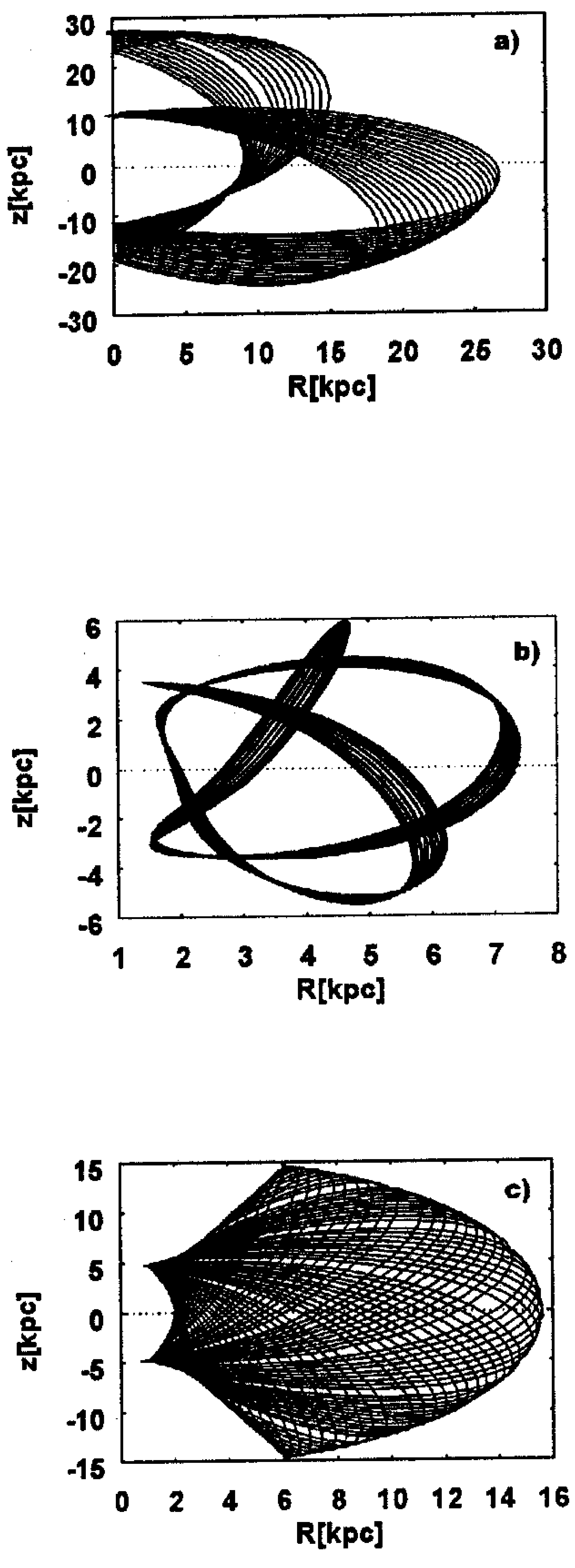

Fig.3: Orbits of globular clusters for a=0
a)NGC7089
b)NGC7099
c)Pal 0005

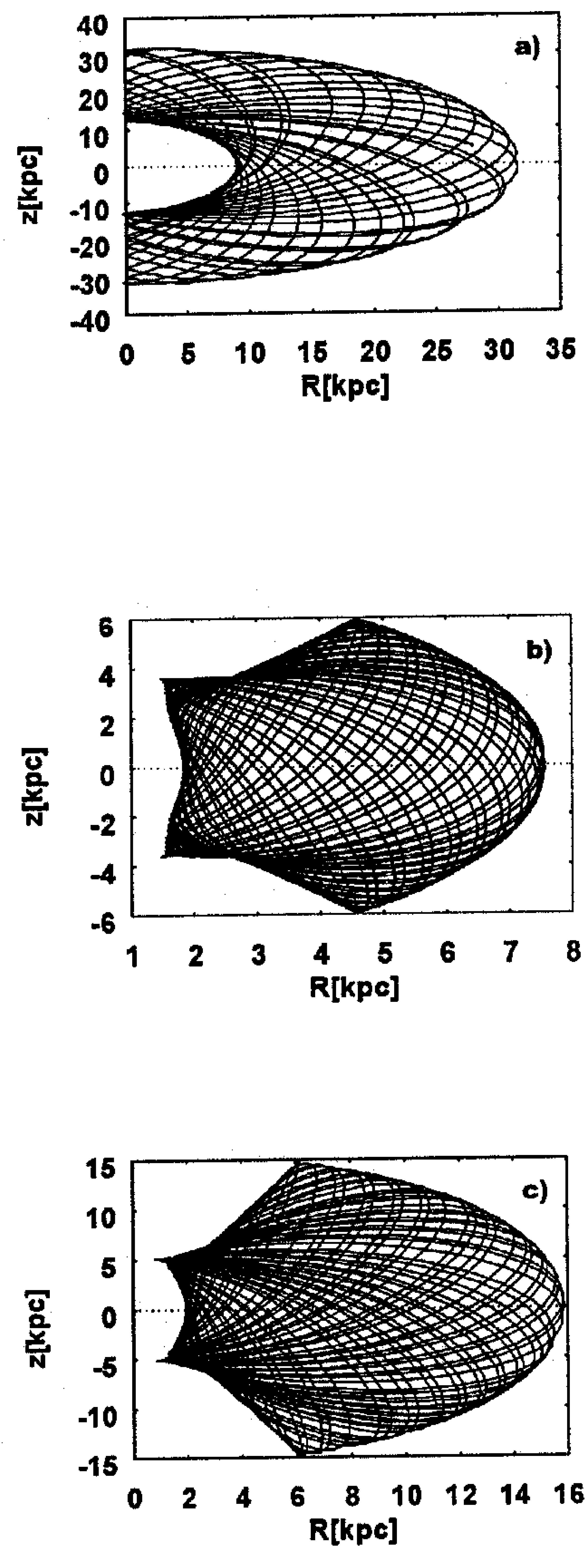

Fig.4: Orbits of globular clusters for a=6.24
a)NGC7089
b)NGC7099
c)Pal 0005

In MSO the bulge and corona are both spherical, whereas in our paper the corona parameter a (see MSO) is subjected to varying, i. e. we take into account the possibility of its flattening. In the concrete calculations we use two values for this parameter: $a = 0$ (spherical corona) and ($a = 6.24 kpc$ (a slightly flattened corona). With both variants we calculate the galactocentric orbits utilising a programme based on Runge-Kutta 4 which we possess thanks to the courtesy of our St-Petersburg colleagues. The possibilities of the programme, including the accuracy verified through the energy integral, are well known (e. g. Ninković et al., 1999). Thus having good initial conditions one can obtain galactocentric position of a test particle covering a time interval of 1×10^{10} years.

3. RESULTS

The test particles in this paper are Milky-Way globular clusters. Of course, with regard to our purpose only those globulars with determined proper motions can be of interest. Recently a group of authors (Dinescu et al., private communication) studied the galactocentric orbits of globular clusters. We use here their list of globular clusters since it contains those globulars for which the proper motion is relatively reliable. The number of such clusters is 38. However, the potential used by them is different from that used by us, i. e. it does not offer the possibility of corona flattening unlike our case. Due to the space limitation we shall present here the results of the orbit calculation only noting that these results have a rather preliminary character. They can be seen in the tables and figures.

4. CONCLUSION

As can be seen from the figures, the orbits obtained here are mutually rather different taking into account the shapes of their projections to the meridional plane. However, the differences existing for the same cluster when its orbit is calculated for one of the two variants are not significant. There are a few exceptions only (see figures). Among the reasons why the orbits corresponding to the two variants in the potential are so similar may be the fact that here we introduce a slight flattening of the corona only bearing in mind the results cited in the literature.

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Table1. Orbital elements for the 38 globular clusters:

R_m mean distance to the galactic rotation axis;
e eccentricity;
h relative mean distance to the galactic plane.

	$a=0$			$a=6.24\ kpc$		
name	$R_m[kpc]$	e	h	$R_m[kpc]$	e	h
NGC0104	5.34	0.49	0.19	5.38	0.49	0.47
NGC0288	6.98	0.92	0.11	7.12	0.93	0.03
NGC0362	5.34	0.66	0.34	5.38	0.65	0.44
NGC1851	12.59	0.96	0.82	14.92	0.97	0.56
NGC1904	10.95	0.94	0.64	11.56	0.95	0.26
NGC2298	8.08	0.99	0.46	8.08	0.99	0.31
NGC4147	10.35	0.91	0.08	10.54	0.90	1.03
NGC4590	13.13	0.60	0.18	14.72	0.63	0.07
NGC5024	15.39	0.69	0.40	17.81	0.72	0.27
NGC5139	3.83	0.85	0.34	3.84	0.85	0.30
NGC5272	7.42	0.72	1.23	7.63	0.71	1.21
NGC5466	19.66	0.94	1.42	24.37	0.95	1.48
NGC5897	4.40	0.63	1.20	4.43	0.63	0.35
NGC5904	12.81	0.96	1.32	15.24	0.96	0.81
NGC6093	2.79	0.95	0.46	2.76	0.95	0.38
NGC6121	3.41	0.96	0.51	3.37	0.96	0.06
NGC6144	1.65	0.80	0.93	1.65	0.79	0.71
NGC6171	3.18	0.75	0.11	2.76	0.62	0.50
NGC6205	11.39	0.82	0.24	12.62	0.83	0.38
NGC6218	3.93	0.55	0.28	3.93	0.54	0.54
NGC6254	3.41	0.48	0.22	3.43	0.48	0.47
NGC6341	5.30	0.78	0.57	5.26	0.77	0.03
NGC6362	3.61	0.71	0.22	3.40	0.65	0.76
NGC6397	4.23	0.50	0.06	4.31	0.53	0.22
NGC6584	6.35	0.55	0.46	6.56	0.56	0.44
NGC6626	2.33	0.34	0.16	2.33	0.34	0.04
NGC6656	5.27	0.48	0.10	5.36	0.49	0.24
NGC6712	3.34	0.36	0.32	3.36	0.36	0.32

NGC6752	4.54	0.21	0.06	4.57	0.21	0.22
NGC6779	6.92	0.55	0.13	7.02	0.55	0.06
NGC6809	3.38	0.99	0.21	3.13	0.99	0.51
NGC6838	5.04	0.41	0.02	5.07	0.40	0.01
NGC6934	19.98	0.49	0.23	23.48	0.56	0.49
NGC7078	6.79	0.96	0.15	6.95	0.97	0.42
NGC7089	13.40	1.00	0.61	15.77	1.00	0.82
NGC7099	4.45	0.66	0.73	4.54	0.66	0.11
Pal0003	860.21	0.92	0.42	922.37	0.93	0.43
Pal0005	8.28	0.88	1.10	8.44	0.88	0.47

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