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Orbits of 152 Globular Clusters of the Milky Way Galaxy Constructed from the Gaia DR2 data

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ABSTRACT
We present orbits and their properties for 152 globular clusters of the Milky Way galaxy obtained using average Gaia DR2 proper motions and other astrometric data from the list of Vasiliev (2019). For orbit integrating we have used the axisymmetric model of the Galactic potential based on the Navarro-Frenk-White dark halo, and modified by Bajkova&Bobylev (2016) using circular velocities of Galactic objects in wide region of Galactocentric distances (up to 200 kpc) from Bhattacharjee et al. (2014) catalog. Based on the analysis of the obtained orbits, we have modified the composition of the subsystems of globular clusters presented in Massari et al. (2019).

Key words: Globular Clusters: Galaxy (Milky Way).

1 INTRODUCTION

The appearance of accurate astrometric data from measurements from the Gaia satellite of the positions and spatial velocities of globular clusters (Helmi et al. 2018; Baumgardt et al. 2019; Vasiliev 2019) makes it possible to study their dynamics, origin and evolution (Myeong et al. 2019; Massari et al. 2019; Bajkova et al. 2020).

In this work we present orbits and their properties for the almost entire list of globular clusters compiled by Vasiliev (2019) on the basis of the most accurate measurements of their velocities and positions to date and using one of the best-fit models of the Milky Way gravitational potential. In addition, we set a goal to revise the classification of globular clusters proposed by Massari et al. (2019) on the basis of analysis of the obtained orbits. In essence, this paper is a supplement to paper of Bajkova et al. (2020), which was devoted to the division of globular clusters into subsystems of the Galaxy, namely, bulge/bar, thick disk, and halo. Recall that in paper of Bajkova et al. (2020) a new criterion of separation of globular clusters belonging to the disk and halo of the Galaxy was proposed. This criterion is based on the bimodality of the GCs distribution L_Z/ecc, where L_Z is Z component of the angular momentum, ecc is eccentricity of the orbit.

This work is structured as follows. Section 2 describes the accepted most realistic model for the axially symmetric Galactic potential. Section 3 devoted to integrating the orbits and computing parameters of the orbits. Section 4 describes data. In Section 5 we present orbits of 152 globular clusters and their properties and propose a modified classification of the GCs based on the analysis of orbits which is slightly different from the classification given by Massari et al. (2019). In Conclusions we summarize main results.

2 MODEL FOR THE AXIALLY SYMMETRIC GALACTIC POTENTIAL

The axially symmetric gravitational potential of the Galaxy is represented as the sum of three components — the central, spherical bulge $\Phi_b(r(R,Z))$, the disk $\Phi_d(r(R,Z))$, and the massive, spherical dark-matter halo $\Phi_h(r(R,Z))$:

$$\Phi(R,Z) = \Phi_b(r(R,Z)) + \Phi_d(r(R,Z)) + \Phi_h(r(R,Z)). \quad (1)$$

Here, we use a cylindrical coordinate system (R,ψ,Z) with its origin at the Galactic center. In Cartesian coordinates (X,Y,Z) with their origin at the Galactic center, the distance to a star (the spherical radius) is $r^2 = X^2+Y^2+Z^2 = R^2+Z^2$. The gravitational potential is expressed in units of 100 km^2 s^{-2}, distances in kpc, masses in units of the mass of the Galaxy, $M_{gal} = 2.325\times10^7 M_\odot$, and the gravitational constant is taken to be $G = 1$.

We express the potentials of the bulge, $\Phi_b(r(R,Z))$, and disk, $\Phi_d(r(R,Z))$, in the form suggested by Miyamoto & Nagai (1975):

$$\Phi_b(r) = -\frac{M_b}{(r^2+b_b^2)^{1/2}}, \quad (2)$$

$$\Phi_d(R,Z) = -\frac{M_d}{\left[R^2+\left(a_d+\sqrt{Z^2+b_d^2}\right)^2\right]^{1/2}}, \quad (3)$$

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Table 1. Parameters of the NFWBB Galactic potential model, $M_0 = 2.325 \times 10^7 M_\odot$

Parameter	Value
M_b $[M_0]$	443±27
M_d $[M_0]$	2798±84
M_h $[M_0]$	12474±3289
b_b [kpc]	0.2672±0.0090
a_d [kpc]	4.40±0.73
b_d [kpc]	0.3084±0.0050
a_h [kpc]	7.7±2.1
$R_\odot$ [kpc]	8.30
$V_\odot$ [km s^{-1}]	243.9
$M_{G_{(R\leqslant 200kpc)}}$ $[10^{12} M_\odot]$	0.75±0.19

where M_b, M_d are the masses of these components, and b_b, a_d, b_d are the scale parameters of the components in kpc.

For description of the halo component, we used the expression in Navarro-Frenk-White (NFW) form presented in Navarro et al. (1997):

$$\Phi_h(r) = -\frac{M_h}{r} \ln\left(1 + \frac{r}{a_h}\right), \tag{4}$$

where M_h is the mass, a_h is the scale length.

The model of the Galactic potential, considered in this work, is the NFW model modified in work of Bajkova&Bobylev (2016) by fitting of the model parameters to data on HI, maser sources and Galactic objects from Bhattacharjee et al. (2014) at distances R within $\sim$ 200 kpc. In addition the constraints (Irrgang et al. 2013) on the local dynamical matter density $\rho_\odot = 0.1 M_\odot$ pc^{-3} and the force acting perpendicularly to the Galactic plane $|K_{z=1.1}|/2\pi G = 77 M_\odot$ pc^{-2} were used.

Note that among six models of the Galactic potential summarized in Bajkova&Bobylev (2017) our model (denoted as Model III in papers Bajkova&Bobylev (2016, 2017)) ensures the best fit to the data. Here we denote the model as NFWBB for short.

Parameters of the NFWBB model are given in Table 1. Corresponding rotation curves up to $R = 200$ kpc are shown in Fig.1. When deriving the model rotation curve, we used $R_\odot = 8.3$ kpc for the Galactocentric distance of the Sun and $V_\odot = 244$ km s^{-1} for the linear velocity of the local standard of rest around the center of the Galaxy. The mass of the Galaxy according to this model is $M_{G_{(R\leqslant 200kpc)}} = 0.75 \pm 0.19 \times 10^{12} M_\odot$. This value is consistent with the recently obtained estimate of the lower mass limit for the dark spherical NFW halo $M_{200} = 0.67^{+0.30}_{-0.15} \times 10^{12} M_\odot$ Koppelman & Helmi (2020) from the escape velocity using a proper motion selected halo sample.

3 INTEGRATING THE ORBITS AND COMPUTING ORBIT PARAMETERS

The equation of motion of a test particle in an axially symmetric gravitational potential can be obtained from the Lagrangian of the system $\pounds$ (see Appendix A in Irrgang et al. (2013)):

$$\pounds(R, Z, \dot{R}, \dot{\psi}, \dot{Z}) = \\ 0.5(\dot{R}^2 + (R\dot{\psi})^2 + \dot{Z}^2) - \Phi(R, Z). \tag{5}$$

Introducing the canonical moments

$$\begin{aligned} p_R &= \partial\pounds/\partial\dot{R} = \dot{R}, \\ p_\psi &= \partial\pounds/\partial\dot{\phi} = R^2\dot{\psi}, \\ p_Z &= \partial\pounds/\partial\dot{Z} = \dot{Z}, \end{aligned} \tag{6}$$

we obtain the Lagrangian equations in the form of a system of six first-order differential equations:

$$\begin{aligned} \dot{R} &= p_R, \\ \dot{\psi} &= p_\psi/R^2, \\ \dot{Z} &= p_Z, \\ \dot{p_R} &= -\partial\Phi(R, Z)/\partial R + p_\psi^2/R^3, \\ \dot{p_\psi} &= 0, \\ \dot{p_Z} &= -\partial\Phi(R, Z)/\partial Z. \end{aligned} \tag{7}$$

We integrated Eqs. (7) using a fourth-order Runge-Kutta algorithm.

The Sun's peculiar velocity with respect to the Local Standard of Rest was taken to be $(u_\odot, v_\odot, w_\odot) = (11.1, 12.2, 7.3) \pm (0.7, 0.5, 0.4)$ km s^{-1} (Schönrich et al. 2010). Here, we use the heliocentric velocities in a moving Cartesian coordinate system with u directed towards the Galactic center, v in the direction of the Galactic rotation, and w perpendicular to the Galactic plane and directed towards the north Galactic pole.

Let the initial positions and space velocities of a test particle in the heliocentric coordinate system be $(x_o, y_o, z_o, u_o, v_o, w_o)$. The initial positions (X, Y, Z) and velocities (U, V, W) of the test particle in Galactic Cartesian coordinates are then given by the formulas:

$$\begin{aligned} &X = R_\odot - x_o, Y = y_o, Z = z_o + h_\odot, \\ &R = \sqrt{X^2 + Y^2}, \\ &U = u_o + u_\odot, \\ &V = v_o + v_\odot + V_\odot, \\ &W = w_o + w_\odot, \end{aligned} \tag{8}$$

where $R_\odot$ and $V_\odot$ are the Galactocentric distance and the linear velocity of the Local Standard of Rest around the Galactic center, $h_\odot = 16$ pc (Bobylev & Bajkova 2016) is the height of the Sun above the Galactic plane,Π and Θ are radial and tangential (rotational) velocities respectively.

Below we present the following orbital parameters of globular clusters:
(1)initial distance of the GC from the Galactic center d_{GC}:

$$d_{GC} = \sqrt{X^2 + Y^2 + Z^2}; \tag{9}$$

(2)radial velocity Π:

$$\Pi = -U\frac{X}{R} + V\frac{Y}{R}; \tag{10}$$

(3)tangential velocity Θ:

$$\Theta = U\frac{Y}{R} + V\frac{X}{R}; \tag{11}$$

(4)total 3D velocity V_{tot}:

$$V_{tot} = \sqrt{\Pi^2 + \Theta^2 + W^2}; \tag{12}$$

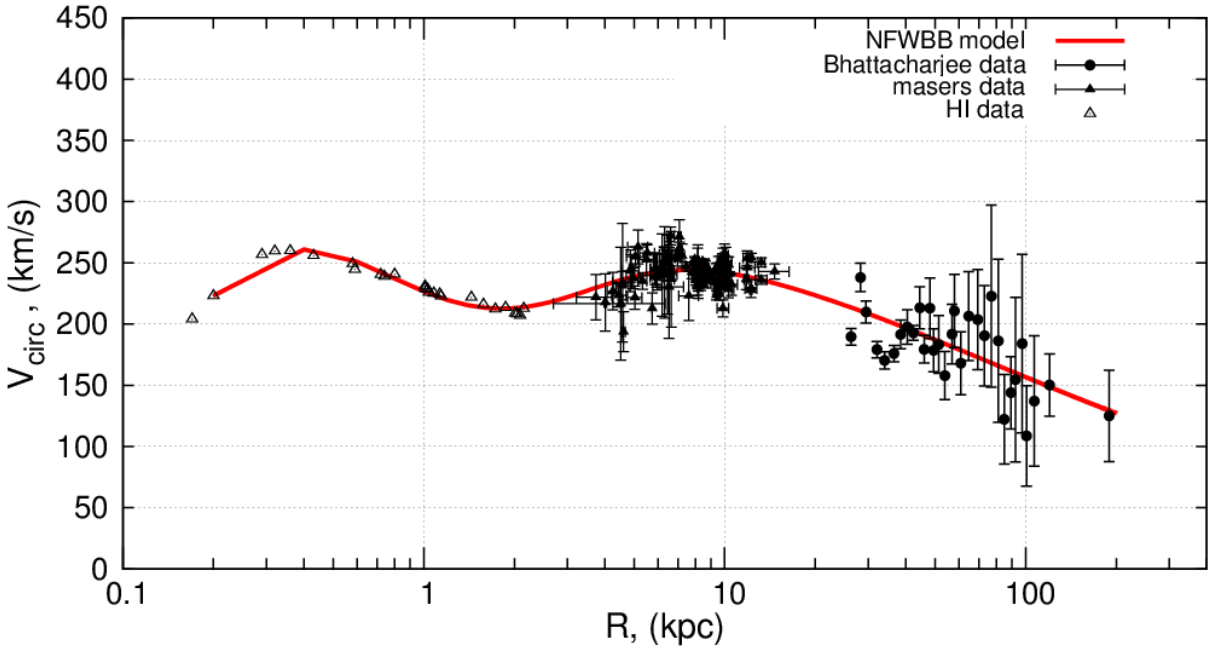

Figure 1. Rotation curve corresponding to the NFWBB model

(5)apocentric distance (apo) of the orbit;
(6)pericentric distance (peri) of the orbit;
(7)the eccentricity (ecc) of the orbit:

$$ecc = \frac{apo - peri}{apo + peri}; \tag{13}$$

(8)the components of the angular momentum:

$$L_X = Y \times W - Z \times V; \tag{14}$$

$$L_Y = Z \times U - X \times W; \tag{15}$$

$$L_Z = X \times V - Y \times U; \tag{16}$$

(9)inclination of the orbit θ:

$$\theta = \arccos(\frac{L_Z}{L}), \tag{17}$$

where $L = \sqrt{L_X^2 + L_Y^2 + L_Z^2}$;
(10)period of the orbit T_r;
(11)total energy E:

$$E = \Phi(R, Z) + \frac{V_{tot}^2}{2}. \tag{18}$$

4 DATA

In this paper, as the source of data on globular clusters the Vasiliev (2019) Catalog serves. It contains average proper motions calculated from data of the Gaia DR2 Catalog, line-of-sight velocities, (α, δ) positions and distances of 151 globular clusters. For the globular cluster FSR 1758, we took data from the work of Villanova et al. (2019).

The worklist is presented in Table 2. The initial position and velocity coordinates (the 6d phase space) $(x_o, y_o, z_o, u_o, v_o, w_o)$ calculated from these data and used for integrating the orbits are given in Table 3. Uncertainties in the initial coordinates were calculated using Monte-Carlo simulation (1000 iterations) taking into account the measurement errors. The uncertainty in the GCs heliocentric distances d was adopted as 7% from d.

5 ORBITS OF 152 GLOBULAR CLUSTERS AND THEIR PROPERTIES

The orbits of the 152 globular clusters were obtained by integrating Eg. (7) for 5 Gyr backward. The (X,Y) and (R,Z) orbit projections for each of all GCs are presented in Fig. 2. The orbit properties are presented in Table 4. To calculate the uncertainties in the orbit properties, we used the Monte Carlo method with 100 realizations, taking into account the uncertainties in the initial coordinates and velocities of GCs, as well as errors in the peculiar velocity of the Sun. For parameters T_r, L_Z and E, we give in Table 4 only nominal values to save space.

Based on the analysis of orbits and their properties, a small regrouping of globular clusters by subsystems has been made. In table 3, the column designated as GS – Galactic Subsystem, gives the classification proposed by Massari et al. (2019), and the column designated as GS(m), gives a modified classification. The following designations for the Galactic subsystems are used here: D (disk), B (bulge), GE (Gaia-Enceladus jr Gaia-Sausage), H99 (Helmi Streams), Seq (Sequoia galaxy), Sgr (Sagittarius dwarf), HE (unassociated High-Energy), LE (unassociated Low-Energy), XXX (clusters with no available kinematics). In the last column, an asterisk marks those globular clusters that have changed their belonging to one or another subsystem. From the last column, it follows that the changes affected only 27 objects.

The separation of globular clusters into subsystems of the bulge/bar, thick disk, and halo was performed by us in work Bajkova et al. (2020) using a criterion based on the bimodal distribution of globular clusters over parameter

Table 2. Astrometric data for globular clusters from Vasiliev (2019)

Name	α [deg]	δ [deg]	d [kpc]	μ^*_α [mas yr^{-1}]	$\epsilon_{\mu^*_\alpha}$ [mas yr^{-1}]	μ_δ [mas yr^{-1}]	ϵ_{μ_δ} [mas yr^{-1}]	V_r [km s^{-1}]	ϵ_{V_r} [km s^{-1}]
NGC 104	6.02	-72.08	4.50	5.237	0.039	-2.524	0.039	-17.2	0.2
NGC 288	13.19	-26.58	8.90	4.267	0.054	-5.636	0.053	-44.8	0.1
NGC 362	15.81	-70.85	8.60	6.730	0.053	-2.535	0.052	223.3	0.3
Whiting 1	30.74	-3.25	30.10	-0.234	0.115	-1.782	0.094	-130.4	1.8
NGC1261	48.07	-55.22	16.30	1.632	0.057	-2.038	0.057	71.4	0.2
Pal 1	53.33	79.58	11.10	-0.171	0.074	0.070	0.081	-75.4	0.2
E1	58.76	-49.62	123.30	0.357	0.128	-0.424	0.169	118.0	14.1
Eridanus	66.19	-21.19	90.10	0.493	0.084	-0.402	0.087	-23.8	1.1
Pal 2	71.53	31.38	27.20	1.034	0.075	-1.557	0.068	-136.0	1.6
NGC 1851	78.53	-40.05	12.10	2.120	0.054	-0.589	0.054	320.3	0.3
NGC 1904	81.05	-24.52	12.90	2.467	0.057	-1.573	0.058	205.8	0.2
NGC 2298	102.25	-36.01	10.80	3.316	0.061	-2.186	0.061	146.2	0.7
NGC 2419	114.53	38.88	82.60	-0.011	0.064	-0.557	0.061	-20.7	0.3
Pyxis	136.99	-37.22	39.40	1.078	0.068	0.212	0.071	40.5	0.2
NGC 2808	138.01	-64.86	9.60	1.005	0.051	0.274	0.051	103.9	0.3
E 3	140.24	-77.28	8.10	-2.695	0.064	7.115	0.064	4.9	0.4
Pal 3	151.38	0.07	92.50	0.055	0.146	-0.085	0.171	94.0	0.8
NGC 3201	154.40	-46.41	4.90	8.324	0.044	-1.991	0.044	494.3	0.1
Pal 4	172.32	28.97	108.70	-0.135	0.106	-0.518	0.176	72.4	0.2
Crater	174.07	-10.88	145.00	0.001	0.308	-0.130	0.190	148.3	0.9
NGC 4147	182.53	18.54	19.30	-1.705	0.065	-2.114	0.063	179.5	0.3
NGC 4372	186.44	-72.66	5.80	-6.378	0.050	3.358	0.050	75.6	0.3
Rup 106	189.67	-51.15	21.20	-1.263	0.064	0.399	0.063	-38.4	0.3
NGC 4590	189.87	-26.74	10.30	-2.752	0.054	1.762	0.053	-93.0	0.2
NGC 4833	194.89	-70.88	6.60	-8.361	0.055	-0.949	0.054	202.0	0.4
NGC 5024	198.23	18.17	17.90	-0.148	0.053	-1.355	0.052	-62.9	0.3
NGC 5053	199.11	17.70	17.40	-0.366	0.058	-1.248	0.056	42.8	0.3
NGC 5139	201.70	-47.48	5.20	-3.234	0.039	-6.719	0.039	234.3	0.2
NGC 5272	205.55	28.38	10.20	-0.142	0.045	-2.647	0.043	-147.3	0.3
NGC 5286	206.61	-51.37	11.70	0.207	0.059	-0.111	0.059	62.4	0.4
NGC5466	211.36	28.53	16.00	-5.412	0.053	-0.800	0.053	106.9	0.2
NGC 5634	217.41	-5.98	25.20	-1.724	0.064	-1.507	0.064	-16.1	0.6
NGC 5694	219.90	-26.54	35.00	-0.486	0.069	-1.071	0.068	-139.6	0.5
IC 4499	225.08	-82.21	18.80	0.491	0.059	-0.485	0.059	38.4	0.3
NGC 5824	225.99	-33.07	32.10	-1.170	0.060	-2.226	0.058	-25.2	0.5
Pal 5	229.02	-0.11	23.20	-2.736	0.064	-2.646	0.064	-58.6	0.2
NGC 5897	229.35	-21.01	12.50	-5.427	0.057	-3.438	0.056	101.3	0.2
NGC 5904	229.64	2.08	7.50	4.078	0.047	-9.854	0.047	53.7	0.3
NGC 5927	232.00	-50.67	7.70	-5.049	0.055	-3.231	0.055	-104.1	0.3
NGC 5946	233.87	-50.66	10.60	-5.331	0.065	-1.614	0.064	137.4	1.4
ESO 224-8	234.78	-50.05	18.90	-4.002	0.071	-3.064	0.067	-6.0	14.0
NGC 5986	236.51	-37.79	10.40	-4.186	0.060	-4.604	0.059	101.2	0.4
FSR 1716	242.63	-53.75	9.50	-4.527	0.066	-8.639	0.064	-33.1	1.0
Pal 14	242.75	14.96	76.50	-0.504	0.081	-0.461	0.078	72.3	0.1
BH 184	242.76	-55.32	8.00	-3.844	0.064	-7.039	0.063	17.9	0.8
NGC 6093	244.26	-22.98	10.00	-2.931	0.061	-5.578	0.060	10.9	0.4
NGC 6121	245.90	-26.53	2.20	-12.490	0.044	-19.001	0.044	71.0	0.1
NGC 6101	246.45	-72.20	15.40	1.757	0.053	-0.223	0.054	366.3	0.3
NGC 6144	246.81	-26.02	8.90	-1.772	0.061	-2.626	0.060	195.7	0.7
NGC 6139	246.92	-38.85	10.10	-6.184	0.062	-2.648	0.061	24.4	1.0
Terzan 3	247.17	-35.35	8.20	-5.602	0.063	-1.690	0.062	-135.8	0.6
NGC 6171	248.13	-13.05	6.40	-1.924	0.057	-5.968	0.056	-34.7	0.2
ESO 452-11	249.86	-28.40	8.30	-1.540	0.070	-6.418	0.068	16.3	0.5
NGC 6205	250.42	36.46	7.10	-3.164	0.047	-2.588	0.047	-244.5	0.4
NGC 6229	251.75	47.53	30.50	-1.192	0.062	-0.440	0.064	-138.6	0.8
NGC 6218	251.81	-1.95	4.80	-0.141	0.052	-6.802	0.051	-41.4	0.2
FSR 1735	253.04	-47.06	10.80	-5.015	0.112	-0.141	0.103	5.0	10.0
NGC 6235	253.35	-22.18	11.50	-3.973	0.064	-7.624	0.063	126.7	0.3
NGC 6254	254.29	-4.10	4.40	-4.759	0.049	-6.554	0.048	74.0	0.3
NGC 6256	254.89	-37.12	10.30	-3.664	0.068	-1.493	0.066	-101.4	1.2
Pal 15	254.96	-0.54	45.10	-0.580	0.076	-0.861	0.070	72.3	1.7

Table 2 - continued

Name	α [deg]	δ [deg]	d [kpc]	μ^*_α [mas yr^{-1}]	$\epsilon_{\mu^*_\alpha}$ [mas yr^{-1}]	μ_δ [mas yr^{-1}]	ϵ_{μ_δ} [mas yr^{-1}]	V_r [km s^{-1}]	ϵ_{V_r} [km s^{-1}]
NGC 6266	255.30	-30.11	6.80	-5.041	0.057	-2.952	0.057	-73.5	0.7
NGC 6273	255.66	-26.27	8.80	-3.232	0.057	1.669	0.056	145.5	0.6
NGC 6284	256.12	-24.77	15.30	-3.196	0.065	-2.008	0.064	28.3	0.9
NGC 6287	256.29	-22.71	9.40	-4.977	0.063	-1.882	0.062	-294.7	1.7
NGC 6293	257.54	-26.58	9.50	0.890	0.064	-4.338	0.063	-143.7	0.4
NGC 6304	258.63	-29.46	5.90	-4.051	0.063	-1.073	0.063	-108.6	0.4
NGC 6316	259.15	-28.14	10.40	-4.945	0.066	-4.608	0.065	99.8	0.8
NGC 6341	259.28	43.14	8.30	-4.925	0.052	-0.536	0.052	-120.5	0.3
NGC 6325	259.50	-23.77	7.80	-8.426	0.068	-9.011	0.067	29.5	0.6
NGC 6333	259.80	-18.52	7.90	-2.228	0.059	-3.214	0.058	310.8	2.1
NGC 6342	260.29	-19.59	8.50	-2.932	0.064	-7.101	0.064	116.6	0.7
NGC 6356	260.90	-17.81	15.10	-3.814	0.060	-3.381	0.059	38.9	1.9
NGC 6355	260.99	-26.35	9.20	-4.657	0.066	-0.522	0.065	-194.1	0.8
NGC 6352	261.37	-48.42	5.60	-2.172	0.056	-4.398	0.056	-125.6	1.0
IC 1257	261.79	-7.09	25.00	-0.928	0.087	-1.407	0.087	-138.0	2.0
Terzan 2	261.89	-30.80	7.50	-2.237	0.081	-6.210	0.075	129.0	1.2
NGC 6366	261.93	-5.08	3.50	-0.363	0.053	-5.115	0.053	-120.7	0.2
Terzan 4	262.66	-31.60	7.20	-5.386	0.088	-3.361	0.080	-39.9	3.8
BH 229	262.77	-29.98	8.20	2.462	0.073	-10.142	0.071	40.6	1.3
FSR 1758	262.81	-39.81	11.50	-2.791	0.001	2.604	0.009	226.8	1.6
NGC 6362	262.98	-67.05	7.60	-5.510	0.051	-4.750	0.052	-14.6	0.2
Liller 1	263.35	-33.39	8.20	-5.530	0.522	-7.687	0.327	58.2	2.2
NGC 6380	263.62	-39.07	10.90	-2.142	0.067	-3.107	0.066	-6.5	1.5
Terzan 1	263.95	-30.48	6.70	-2.967	0.083	-4.811	0.080	57.5	1.6
Pismis 26	264.04	-38.55	8.20	-5.912	0.067	-0.548	0.066	-184.7	1.1
NGC 6388	264.07	-44.74	9.90	-1.331	0.057	-2.672	0.057	82.8	0.5
NGC 6402	264.40	-3.25	9.30	-3.640	0.058	-5.035	0.058	-60.7	0.5
NGC 6401	264.65	-23.91	10.60	-2.849	0.070	1.476	0.069	-99.3	3.2
NGC 6397	265.18	-53.67	2.30	3.285	0.043	-17.621	0.043	18.4	0.1
Pal 6	265.93	-26.22	5.80	-9.256	0.078	-5.330	0.076	176.3	1.5
NGC 6426	266.23	3.17	20.60	-1.862	0.064	-2.994	0.064	-210.5	0.5
Djorg 1	266.87	-33.07	9.30	-5.158	0.081	-8.323	0.076	-359.8	2.0
Terzan 5	267.02	-24.78	6.90	-1.560	0.106	-4.724	0.102	-81.4	1.4
NGC 6440	267.22	-20.36	8.50	-1.070	0.069	-3.828	0.068	-69.4	0.9
NGC 6441	267.55	-37.05	11.60	-2.568	0.059	-5.322	0.059	17.3	0.9
Terzan 6	267.69	-31.27	6.80	-5.634	0.186	-7.042	0.156	137.2	1.7
NGC 6453	267.71	-34.60	11.60	0.165	0.071	-5.895	0.070	-91.2	3.1
NGC 6496	269.76	-44.27	11.30	-3.037	0.061	-9.239	0.061	-134.7	0.3
Terzan 9	270.41	-26.84	7.10	-2.197	0.073	-7.451	0.070	29.3	3.0
Djorg 2	270.45	-27.83	6.30	0.515	0.079	-3.052	0.074	-148.1	1.4
NGC 6517	270.46	-8.96	10.60	-1.498	0.066	-4.221	0.066	-37.1	1.7
Terzan 10	270.74	-26.07	10.40	-6.912	0.085	-2.409	0.080	208.0	3.6
NGC 6522	270.89	-30.03	7.70	2.618	0.072	-6.431	0.071	-13.9	0.7
NGC 6535	270.96	-0.30	6.80	-4.249	0.064	-2.900	0.064	-214.8	0.5
NGC 6528	271.21	-30.06	7.90	-2.327	0.074	-5.527	0.071	210.3	0.8
NGC 6539	271.21	-7.59	7.80	-6.865	0.061	-3.477	0.061	35.7	0.6
NGC 6540	271.54	-27.77	5.30	-3.760	0.077	-2.799	0.076	-18.0	0.8
NGC 6544	271.84	-25.00	3.00	-2.349	0.060	-18.557	0.060	-38.1	0.8
NGC 6541	272.01	-43.72	7.50	0.349	0.056	-8.843	0.055	-164.0	0.5
ESO 280-06	272.27	-46.42	21.40	-0.552	0.082	-2.724	0.075	93.2	0.3
NGC 6553	272.32	-25.91	6.00	0.246	0.063	-0.409	0.063	0.7	0.4
NGC 6558	272.57	-31.76	7.40	-1.810	0.067	-4.133	0.066	-195.7	0.7
Pal 7	272.68	-7.21	5.40	-2.577	0.059	-4.374	0.059	155.1	0.7
Terzan 12	273.07	-22.74	4.80	-6.151	0.069	-2.679	0.068	94.8	1.0
NGC 6569	273.41	-31.83	10.90	-4.109	0.062	-7.267	0.062	-49.8	0.5
ESO 456-78	273.53	-28.64	6.50	3.590	0.077	-3.573	0.076	-29.4	0.6
NGC 6584	274.66	-52.22	13.50	-0.053	0.061	-7.185	0.061	260.6	1.6
NGC 6624	275.92	-30.36	7.90	0.099	0.065	-6.904	0.064	54.3	0.5
NGC 6626	276.14	-24.87	5.50	-0.301	0.061	-8.913	0.061	11.1	0.6
NGC 6638	277.73	-25.50	9.40	-2.550	0.066	-4.075	0.065	8.6	2.0
NGC 6637	277.85	-32.35	8.80	-5.113	0.063	-5.813	0.063	46.6	1.5
NGC 6642	277.98	-23.48	8.10	-0.189	0.065	-3.898	0.065	-33.2	1.1
NGC 6652	278.94	-32.99	10.00	-5.506	0.064	-4.204	0.063	-99.0	0.5

Table 2 - continued

Name	α [deg]	δ [deg]	d [kpc]	μ^*_α [mas yr^{-1}]	$\epsilon_{\mu^*_\alpha}$ [mas yr^{-1}]	μ_δ [mas yr^{-1}]	ϵ_{μ_δ} [mas yr^{-1}]	V_r [km s^{-1}]	ϵ_{V_r} [km s^{-1}]
NGC 6656	279.10	-23.91	3.20	9.833	0.047	-5.557	0.047	-147.8	0.3
Pal 8	280.38	-19.83	12.80	-2.031	0.063	-5.634	0.063	-41.1	1.8
NGC 6681	280.80	-32.29	9.00	1.458	0.060	-4.688	0.060	216.6	0.8
NGC 6712	283.27	-8.71	6.90	3.341	0.062	-4.384	0.061	-107.5	0.3
NGC 6715	283.76	-30.48	26.50	-2.711	0.058	-1.355	0.058	143.1	0.6
NGC 6717	283.77	-22.70	7.10	-3.106	0.065	-4.951	0.064	32.5	1.4
NGC 6723	284.89	-36.63	8.70	1.033	0.057	-2.445	0.057	-94.2	0.3
NGC 6749	286.31	1.90	7.90	-2.865	0.061	-5.987	0.061	-58.4	1.0
NGC 6752	287.72	-59.98	4.00	-3.170	0.042	-4.043	0.042	-26.3	0.2
NGC 6760	287.80	1.03	7.40	-1.129	0.060	-3.561	0.059	-0.4	1.6
NGC 6779	289.15	30.18	9.40	-2.020	0.059	1.644	0.059	-137.0	0.5
Terzan 7	289.43	-34.66	22.80	-2.999	0.068	-1.586	0.000	159.4	0.1
Pal 10	289.51	18.57	5.90	-4.250	0.064	-6.924	0.064	-31.7	0.2
Arp 2	292.18	-30.36	28.60	-2.381	0.067	-1.510	0.066	123.0	0.3
NGC 6809	295.00	-30.97	5.40	-3.420	0.050	-9.269	0.050	174.4	0.2
Terzan 8	295.44	-34.00	26.30	-2.472	0.062	-1.556	0.060	148.5	0.2
Pal 11	296.31	-8.01	13.40	-1.821	0.066	-4.934	0.064	-67.6	0.8
NGC 6838	298.44	18.78	4.00	-3.415	0.054	-2.614	0.054	-22.3	0.2
NGC 6864	301.52	-21.92	20.90	-0.559	0.062	-2.798	0.061	-189.1	1.1
NGC 6934	308.55	7.40	15.60	-2.636	0.060	-4.667	0.060	-406.2	0.7
NGC 6981	313.37	-12.54	17.00	-1.233	0.062	-3.290	0.061	-331.4	1.5
NGC 7006	315.37	16.19	41.20	-0.102	0.067	-0.569	0.068	-383.5	0.7
NGC 7078	322.49	12.17	10.40	-0.643	0.051	-3.763	0.051	-106.8	0.3
NGC 7089	323.36	-0.82	11.50	3.518	0.054	-2.145	0.054	-3.7	0.3
NGC 7099	325.09	-23.18	8.10	-0.694	0.055	-7.271	0.054	-185.2	0.2
Pal 12	326.66	-21.25	19.00	-3.249	0.067	-3.303	0.067	27.9	0.3
Pal 13	346.69	12.77	26.00	1.615	0.101	0.142	0.089	25.9	0.3
NGC 7492	347.11	-15.61	26.30	0.799	0.065	-2.273	0.064	-176.7	0.3

L_Z/ecc. The composition of the bulge/bar and thick disk reflects these results. In the redistribution of the remaining globular clusters between the halo subsystems (GE, Seq, Sgr, H99), we took into account the parameters of the orbits. For example, globular clusters with strong radially elongated orbits were assigned to GE. The rest of the rearrangement also took into account the proximity of the orbital shapes.

In Fig. 3 the "L_Z– Energy", "L_Z/ecc– Energy" and "Radial velocity – Rotational velocity" diagrams are presented. These diagrams are given both for classification of GCs by Massari et al. (2019) and for the modified one for comparison. As you can see from Fig. 2, the modified classification looks like a more correct one from the point of view of a greater similarity of the orbits of globular clusters included in their subsystem. From a comparison of the diagrams "L_Z – Energy", "L_Z/ecc – Energy" and "Radial velocity – Rotational velocity", it can also be concluded that the modified classification is more organic.

CONCLUSIONS

For the first time since the emergence of the Gaia Data Release 2, a catalog of orbits for 152 galactic globular clusters, which form an almost complete known population, is presented.

The main orbital parameters of globular clusters are determined. The astrometric data catalog compiled by Vasiliev (2019) was used as data for calculating the initial 6d phase space (heliocentric positions and velocities of globular clusters) needed for orbit construction. The orbits were integrated for 5 Gyr backward.

For integrating the orbits, we used a recently obtained by Bajkova&Bobylev (2016) the best-fit model of an axisymmetric Galactic potential with a dark halo in the form of NFW (Navarro et al. 1997) using data on circular velocities of Galactic objects in a wide range of galactocentric distances (data on HI region, masers, and catalog of Bhattacharjee et al. (2014)).

Based on the analysis of the obtained orbits and their properties, we have formed a modified composition of the subsystems of globular clusters, slightly different from the composition presented in Massari et al. (2019). This modification affected 27 GCs. The modified classification looks like a more correct one from the point of view of a greater similarity of the orbits of globular clusters included in their subsystem.

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Table 3. Globular clusters positions and velocities from the Sun, not corrected for the solar motion or the LSR

Name	x_o [kpc]	y_o [kpc]	z_o [kpc]	u_o [km s^{-1}]	v_o [km s^{-1}]	w_o [km s^{-1}]	GS	GS(m)	
NGC 104	1.87±0.13	-2.58±0.18	-3.18±0.22	-88.0± 5.5	-80.5± 6.2	38.0± 1.9	D	D	
NGC 288	-0.08±0.01	0.05±0.00	-8.90±0.61	-20.6± 2.7	-297.7±20.4	43.5± 0.2	GE	GE	
NGC 362	3.11±0.21	-5.07±0.35	-6.21±0.42	-100.9±12.4	-345.9±14.7	-77.4± 5.9	GE	GE	
Whiting 1	-14.01±0.96	4.65±0.32	-26.23±1.80	214.8±18.0	-191.4±18.5	1.0±10.8	Sgr	Sgr	
NGC 1261	0.09±0.01	-10.01±0.69	-12.87±0.89	64.2± 6.2	-194.7±11.1	61.5± 8.7	GE	GE	
Pal 1	-6.75±0.47	8.03±0.56	3.62±0.25	52.5± 3.3	-47.9± 2.8	-27.0± 3.9	D	D	
E 1	-16.49±1.19	-80.07±5.79	-92.30±6.68	123.5±95.7	-309.4±63.0	88.7±51.0	HE	HE	
Eridanus	-53.24±3.56	-41.75±2.79	-59.51±3.98	78.8±28.0	-228.7±34.4	126.0±27.2	HE	HE	
Pal 2	-26.49±1.85	4.42±0.31	-4.29±0.30	97.0± 3.6	-259.1±18.5	-3.7± 9.3	GE	GE	
NGC 1851	-4.26±0.29	-8.94±0.61	-6.95±0.48	-96.1± 3.0	-318.4± 6.0	-89.1± 7.1	GE	GE	
NGC 1904	-7.63±0.52	-8.25±0.56	-6.32±0.43	-57.0± 5.2	-266.7± 9.6	-2.9± 7.4	GE	GE	
NGC 2298	-4.28±0.29	-9.46±0.65	-2.98±0.20	81.8±10.1	-226.1± 7.0	70.1± 8.3	GE	GE	
NGC 2419	-74.71±5.25	-0.48±0.03	35.22±2.47	-6.6±10.9	-209.1±28.0	-65.3±23.2	Sgr	Sgr	
Pyxis	-5.90±0.40	-38.66±2.60	4.80±0.32	101.5±14.5	-34.4± 2.6	179.6±17.3	HE	HE	
NGC 2808	1.99±0.14	-9.20±0.64	-1.87±0.13	44.2± 2.7	-103.1± 0.7	21.2± 3.7	GE	GE	
E 3	2.90±0.20	-7.09±0.48	-2.64±0.18	-238.1±16.5	-139.1± 9.3	96.6± 6.9	H99	D	*
Pal 3	-34.30±2.37	-59.74±4.13	61.73±4.27	2.3±61.4	-84.9±56.6	60.0±51.3	HE	HE	
NGC 3201	0.61±0.04	-4.81±0.33	0.74±0.05	244.8±12.6	-451.0± 2.3	143.4± 4.9	Seq	Seq	
Pal 4	-31.41±2.18	-12.89±0.90	103.26±7.17	23.3±56.9	-280.1±86.8	48.3±16.4	HE	HE	
Crater	8.15±0.56	-96.97±6.70	107.50±7.43	52.0±198.2	-155.4±114.0	55.9±96.4	HE	HE	
NGC 4147	-1.26±0.09	-4.09±0.28	18.82±1.29	-53.0± 6.5	-276.9±17.6	120.4± 4.1	GE	GE	
NGC 4372	2.94±0.20	-4.90±0.34	-1.00±0.07	-112.7±10.5	-169.4± 7.4	60.1± 5.2	D	D	
Rup 106	10.66±0.77	-17.82±1.28	4.29±0.31	-133.3±10.0	-28.0± 5.6	25.2± 6.8	H99	H99	
NGC 4590	4.12±0.28	-7.24±0.50	6.06±0.42	-180.8±10.2	36.6± 2.7	8.5± 4.8	H99	H99	
NGC 4833	3.62±0.25	-5.44±0.38	-0.92±0.06	-109.5±15.2	-309.3± 9.9	-49.3± 2.2	GE	GE	
NGC 5024	2.83±0.20	-1.45±0.10	17.61±1.27	44.4± 6.0	-95.6± 8.7	-78.9± 1.5	H99	H99	
NGC 5053	3.04±0.21	-1.37±0.10	17.08±1.19	41.1± 5.3	-104.3± 8.2	27.9± 1.3	H99	H99	
NGC 5139	3.17±0.22	-3.90±0.27	1.34±0.09	88.2± 3.8	-270.8± 6.6	-87.0±10.2	Seq	Seq	
NGC 5272	1.48±0.10	1.34±0.09	10.00±0.70	53.8± 5.5	-123.2± 7.6	-141.6± 0.6	H99	H99	
NGC 5286	7.64±0.51	-8.60±0.58	2.15±0.14	49.1± 2.5	-40.4± 2.3	3.1± 3.2	GE	GE	
NGC 5466	3.35±0.23	3.03±0.21	15.35±1.07	-231.7±18.3	-286.6±21.8	218.7± 8.2	Seq	GE	*
NGC 5634	15.66±1.11	-5.03±0.36	19.09±1.36	-70.1± 7.3	-262.8±20.3	-32.9± 5.0	H99	GE	*
NGC 5694	26.43±1.82	-14.62±1.00	17.69±1.22	-127.5± 7.7	-106.1±15.2	-173.3±12.1	HE	GE	*
IC 4499	10.69±0.76	-14.00±1.00	-6.58±0.47	21.8± 4.3	-2.5± 4.0	-69.1± 6.4	Seq	Seq	
NGC 5824	26.40±1.76	-13.71±0.91	12.06±0.80	-107.6± 7.3	-315.2±22.9	-190.1±14.8	Sgr	H99	*
Pal 5	16.16±1.13	0.24±0.02	16.65±1.16	-60.3± 5.1	-418.0±30.1	-17.1± 5.1	H99	H99	
NGC 5897	10.32±0.70	-3.17±0.21	6.31±0.42	-45.0± 8.8	-382.6±24.2	82.3± 3.4	GE	GE	
NGC 5904	5.12±0.35	0.35±0.02	5.47±0.37	290.9±17.2	-162.5±11.3	-188.7±15.4	H99	GE	*
NGC 5927	6.41±0.43	-4.22±0.28	0.65±0.04	-207.4± 8.1	-125.2±12.2	-2.3± 2.0	D	D	
NGC 5946	8.92±0.60	-5.67±0.38	0.78±0.05	-31.8±10.2	-293.3±15.4	100.9± 6.9	LE	LE	
ES 224-8	16.05±1.14	-9.87±0.70	1.43±0.10	-241.2±20.4	-381.8±28.9	-7.0± 6.2	D	D	
NGC 5986	9.32±0.66	-3.95±0.28	2.39±0.17	-18.1± 7.8	-321.8±20.2	-21.3± 4.3	LE	LE	
FSR 1716	8.21±0.56	-4.78±0.32	-0.26±0.02	-240.5±14.3	-339.0±24.1	-145.8±10.3	D	D	
Pal 14	49.69±3.54	27.26±1.94	51.38±3.66	95.5±21.0	-205.1±30.6	124.1±21.6	HE	GE	*
BH 184	6.83±0.47	-4.14±0.28	-0.39±0.03	-138.4±10.6	-253.6±16.8	-96.7± 7.0	D	D	
NGC 6093	9.35±0.64	-1.20±0.08	3.33±0.23	-1.5± 1.3	-291.1±19.9	-68.0± 5.6	LE	LE	
NGC 6121	2.09±0.14	-0.33±0.02	0.61±0.04	40.8± 1.9	-243.7±16.1	-16.0± 2.5	LE	LE	
NGC 6101	10.97±0.72	-9.96±0.66	-4.20±0.28	288.8± 3.3	-163.1± 5.8	-202.2± 7.9	Seq	Seq	
NGC 6144	8.48±0.59	-1.20±0.08	2.41±0.17	172.7± 1.5	-158.3± 9.5	35.9± 2.7	LE	Seq	*
NGC 6139	9.55±0.66	-3.04±0.21	1.22±0.08	-81.2± 7.3	-284.5±19.4	129.7± 9.1	LE	LE	
Terzan 3	7.82±0.56	-2.08±0.15	1.31±0.09	-197.8± 5.0	-150.6±13.5	91.6± 8.4	D	D	
NGC 6171	5.88±0.41	0.35±0.02	2.50±0.17	3.5± 2.6	-179.4±12.4	-72.0± 4.4	B	B	
E 452-11	8.04±0.55	-1.14±0.08	1.74±0.12	7.4± 1.0	-235.3±15.9	-110.9± 8.3	B	B	
NGC 6205	2.76±0.19	4.60±0.32	4.65±0.33	-43.4± 3.9	-263.0± 7.4	-87.4± 5.2	GE	GE	
NGC 6229	6.55±0.45	22.32±1.54	19.73±1.36	-7.4± 8.9	-225.9±10.4	43.6±11.2	GE	GE	
NGC 6218	4.14±0.28	1.17±0.08	2.13±0.14	34.0± 4.8	-129.0± 8.2	-88.8± 4.9	D	D	
FSR 1735	10.09±0.72	-3.84±0.27	-0.35±0.02	-49.4±10.2	-161.6±13.2	193.5±14.8	LE	LE	
NGC 6235	11.18±0.81	-0.21±0.02	2.69±0.19	132.8± 1.1	-464.6±33.9	-46.9± 6.4	GE	D	*
NGC 6254	3.91±0.27	1.06±0.07	1.73±0.12	105.1± 2.8	-146.1±11.5	40.3± 1.2	LE	D	*
NGC 6256	10.05±0.69	-2.17±0.15	0.59±0.04	-139.8± 3.2	-141.3±11.7	89.9± 7.2	LE	LE	
Pal 15	38.89±2.60	13.28±0.89	18.59±1.24	128.4± 9.2	-190.2±20.7	42.7±14.8	GE	GE	

Table 3 - continued

Name	x_o [kpc]	y_o [kpc]	z_o [kpc]	u_o [km s^{-1}]	v_o [km s^{-1}]	w_o [km s^{-1}]	GS	GS(m)	
NGC 6266	6.70±0.46	-0.76±0.05	0.87±0.06	-101.0± 2.1	-163.9±11.9	61.7± 5.2	B	B	
NGC 6273	8.67±0.59	-0.47±0.03	1.44±0.10	117.7± 1.9	-31.1± 2.9	171.5±10.5	LE	LE	
NGC 6284	15.06±1.01	-0.44±0.03	2.64±0.18	3.1± 2.1	-254.6±17.6	104.4± 8.4	GE	GE	
NGC 6287	9.23±0.63	0.02±0.00	1.80±0.12	-313.9± 2.4	-198.5±13.8	72.0± 9.1	LE	LE	
NGC 6293	9.40±0.65	-0.39±0.03	1.29±0.09	-127.9± 1.1	-130.1± 9.8	-164.8±10.6	B	B	
NGC 6304	5.86±0.39	-0.43±0.03	0.55±0.04	-121.4± 1.0	-81.5± 6.2	64.5± 5.4	B	D	*
NGC 6316	10.34±0.72	-0.51±0.04	1.04±0.07	76.2± 1.9	-330.1±22.9	79.0± 5.9	B	B	
NGC 6341	2.51±0.17	6.33±0.43	4.74±0.32	-37.6± 2.0	-208.5± 8.1	87.3±10.7	GE	GE	
NGC 6325	7.72±0.52	0.13±0.01	1.09±0.07	27.3± 0.7	-450.5±30.7	72.2± 5.2	B	B	
NGC 6333	7.73±0.56	0.75±0.05	1.47±0.11	317.5± 2.3	-116.3±10.7	60.7± 2.2	LE	LE	
NGC 6342	8.35±0.57	0.72±0.05	1.44±0.10	150.4± 2.6	-292.0±20.8	-38.9± 4.8	B	B	
NGC 6356	14.76±1.04	1.74±0.12	2.68±0.19	62.1± 2.6	-346.8±25.3	102.5± 8.0	D	D	
NGC 6355	9.16±0.63	-0.07±0.00	0.87±0.06	-208.9± 1.4	-130.8± 9.3	136.7±11.0	B	B	
NGC 6352	5.27±0.36	-1.77±0.12	-0.70±0.05	-161.2± 3.2	-82.1± 8.5	-0.4± 1.8	D	D	
IC 1257	23.14±1.58	6.87±0.47	6.53±0.45	-73.3± 5.6	-229.9±16.3	-26.8± 9.6	GE	GE	
Terzan 2	7.48±0.52	-0.48±0.03	0.30±0.02	116.2± 1.5	-235.7±16.2	-51.2± 4.8	B	B	
NGC 6366	3.19±0.22	1.06±0.07	0.97±0.07	-76.1± 2.4	-105.9± 4.9	-69.3± 2.7	D	D	
Terzan 4	7.18±0.49	-0.50±0.03	0.16±0.01	-55.5± 3.9	-193.5±13.7	89.6± 6.8	B	B	
BH 229	8.19±0.55	-0.37±0.02	0.30±0.02	39.0± 1.3	-279.3±18.7	-294.4±20.2	B	B	
FSR 1758	11.28±0.78	-2.15±0.15	-0.66±0.05	240.7± 2.0	-9.5± 2.3	191.6±14.2	Seq	Seq	
NGC 6362	5.97±0.41	-4.10±0.28	-2.29±0.16	-127.2± 8.0	-210.2±15.0	92.4± 6.2	D	D	
Liller 1	8.17±0.57	-0.74±0.05	-0.02±0.00	24.9± 3.5	-371.4±29.0	17.5±17.6	XXX	B	*
NGC 6380	10.72±0.71	-1.86±0.12	-0.65±0.04	-39.3± 2.7	-191.0±13.1	6.9± 3.6	B	B	
Terzan 1	6.69±0.46	-0.29±0.02	0.12±0.01	49.9± 1.7	-181.8±12.5	-2.1± 2.5	B	B	
Pismis 26	8.08±0.53	-1.31±0.09	-0.49±0.03	-193.9± 1.4	-111.7± 9.6	193.2±12.2	LE	LE	
NGC 6388	9.52±0.62	-2.45±0.16	-1.16±0.08	43.4± 2.5	-155.2± 9.1	-23.0± 2.8	B	Seq	*
NGC 6402	8.38±0.59	3.27±0.23	2.38±0.17	36.6± 6.5	-277.7±18.1	15.4± 3.2	LE	LE	
NGC 6401	10.55±0.72	0.64±0.04	0.74±0.05	-109.2± 3.3	-19.7± 3.6	153.4±11.3	LE	Seq	*
NGC 6397	2.09±0.15	-0.84±0.06	-0.48±0.03	-63.0± 5.6	-134.9± 9.1	-127.9± 8.8	D	D	
Pal 6	5.79±0.38	0.21±0.01	0.18±0.01	181.2± 1.5	-251.7±17.0	145.4± 9.3	LE	LE	
NGC 6426	17.45±1.24	9.31±0.66	5.76±0.41	-23.4±11.4	-401.5±22.2	-32.8± 6.2	HE	H99	*
Djorg 1	9.28±0.62	-0.54±0.04	-0.40±0.03	-383.7± 2.5	-410.1±29.2	20.8± 3.5	GE	GE	
Terzan 5	6.88±0.45	0.46±0.03	0.20±0.01	-69.5± 1.6	-163.7±10.9	-38.4± 4.1	B	B	
NGC 6440	8.40±0.57	1.14±0.08	0.56±0.04	-45.1± 1.9	-162.1±10.8	-46.5± 4.0	B	B	
NGC 6441	11.48±0.83	-1.30±0.09	-1.01±0.07	-21.7± 3.0	-323.4±23.4	-28.2± 3.7	LE	LE	
Terzan 6	6.79±0.49	-0.17±0.01	-0.26±0.02	131.3± 1.7	-291.3±21.4	34.9± 6.6	B	B	
NGC 6453	11.54±0.79	-0.86±0.06	-0.78±0.05	-122.8± 3.8	-266.1±19.1	-166.1±12.4	LE	LE	
NGC 6496	10.89±0.75	-2.31±0.16	-1.97±0.14	-251.8± 8.5	-470.9±34.5	-66.8± 6.9	D	D	
Terzan 9	7.08±0.50	0.45±0.03	-0.25±0.02	43.2± 3.1	-252.4±18.0	-60.5± 4.7	B	B	
Djorg 2	6.29±0.44	0.30±0.02	-0.28±0.02	-146.8± 1.3	-78.9± 5.5	-51.8± 4.5	B	B	
NGC 6517	9.94±0.68	3.47±0.24	1.25±0.09	42.4± 5.6	-220.4±14.8	-40.8± 4.1	LE	LE	
Terzan 10	10.36±0.70	0.80±0.05	-0.34±0.02	235.9± 4.2	-253.6±18.6	231.4±16.7	GE	GE	
NGC 6522	7.68±0.53	0.14±0.01	-0.53±0.04	-24.6± 1.0	-158.7±11.3	-196.6±13.8	B	B	
NGC 6535	5.95±0.40	3.05±0.21	1.23±0.08	-133.6± 3.8	-233.2± 9.4	37.6± 5.5	Seq	Seq	
NGC 6528	7.88±0.54	0.16±0.01	-0.58±0.04	212.4± 0.8	-219.1±15.6	-39.7± 3.2	B	B	
NGC 6539	7.24±0.49	2.75±0.19	0.92±0.06	98.6± 4.6	-213.4±15.6	164.3±11.1	B	D	*
NGC 6540	5.28±0.38	0.30±0.02	-0.31±0.02	-9.0± 1.1	-108.0± 7.9	49.4± 3.9	B	D	*
NGC 6544	2.98±0.21	0.31±0.02	-0.12±0.01	-16.6± 1.7	-249.9±17.1	-97.4± 7.0	LE	GE	*
NGC 6541	7.23±0.51	-1.37±0.10	-1.46±0.10	-238.4± 5.7	-234.3±18.7	-119.0±10.9	LE	LE	
E 280-06	20.34±1.39	-4.73±0.32	-4.66±0.32	11.5± 5.8	-282.5±19.6	-90.9± 9.4	GE	GE	
NGC 6553	5.97±0.42	0.55±0.04	-0.32±0.02	0.7± 0.4	-6.8± 1.8	-11.8± 2.0	B	D	*
NGC 6558	7.36±0.53	0.03±0.00	-0.78±0.06	-195.4± 0.8	-158.4±11.4	7.8± 2.5	B	B	
Pal 7	4.99±0.34	2.00±0.14	0.53±0.04	191.1± 3.4	-63.3± 8.4	20.2± 1.5	D	D	
Terzan 12	4.75±0.33	0.70±0.05	-0.18±0.01	114.6± 1.7	-105.0± 8.4	90.1± 6.6	D	D	
NGC 6569	10.83±0.74	0.09±0.01	-1.27±0.09	-44.5± 0.7	-431.6±29.4	17.8± 3.2	B	D	*
E 456-78	6.46±0.46	0.38±0.03	-0.60±0.04	-40.3± 1.0	-47.4± 3.9	-146.1±10.9	B	D	*
NGC 6584	12.33±0.83	-3.97±0.27	-3.82±0.26	60.0±12.2	-464.4±26.4	-245.3±12.2	HE	GE	*
NGC 6624	7.82±0.55	0.38±0.03	-1.09±0.08	48.3± 0.7	-226.9±16.2	-126.5± 8.6	B	B	
NGC 6626	5.42±0.37	0.74±0.05	-0.54±0.04	29.8± 1.5	-207.9±14.2	-100.5± 6.9	B	B	
NGC 6638	9.24±0.64	1.28±0.09	-1.17±0.08	40.2± 3.0	-209.7±14.8	18.7± 3.2	B	B	
NGC 6637	8.65±0.60	0.26±0.02	-1.57±0.11	70.7± 2.3	-309.0±21.6	77.3± 6.5	B	B	
NGC 6642	7.93±0.56	1.37±0.10	-0.91±0.06	-16.0± 1.7	-141.6±10.0	-57.0± 4.9	B	B	
NGC 6652	9.80±0.71	0.26±0.02	-1.97±0.14	-59.3± 2.8	-292.8±21.3	168.5±11.1	B	B	

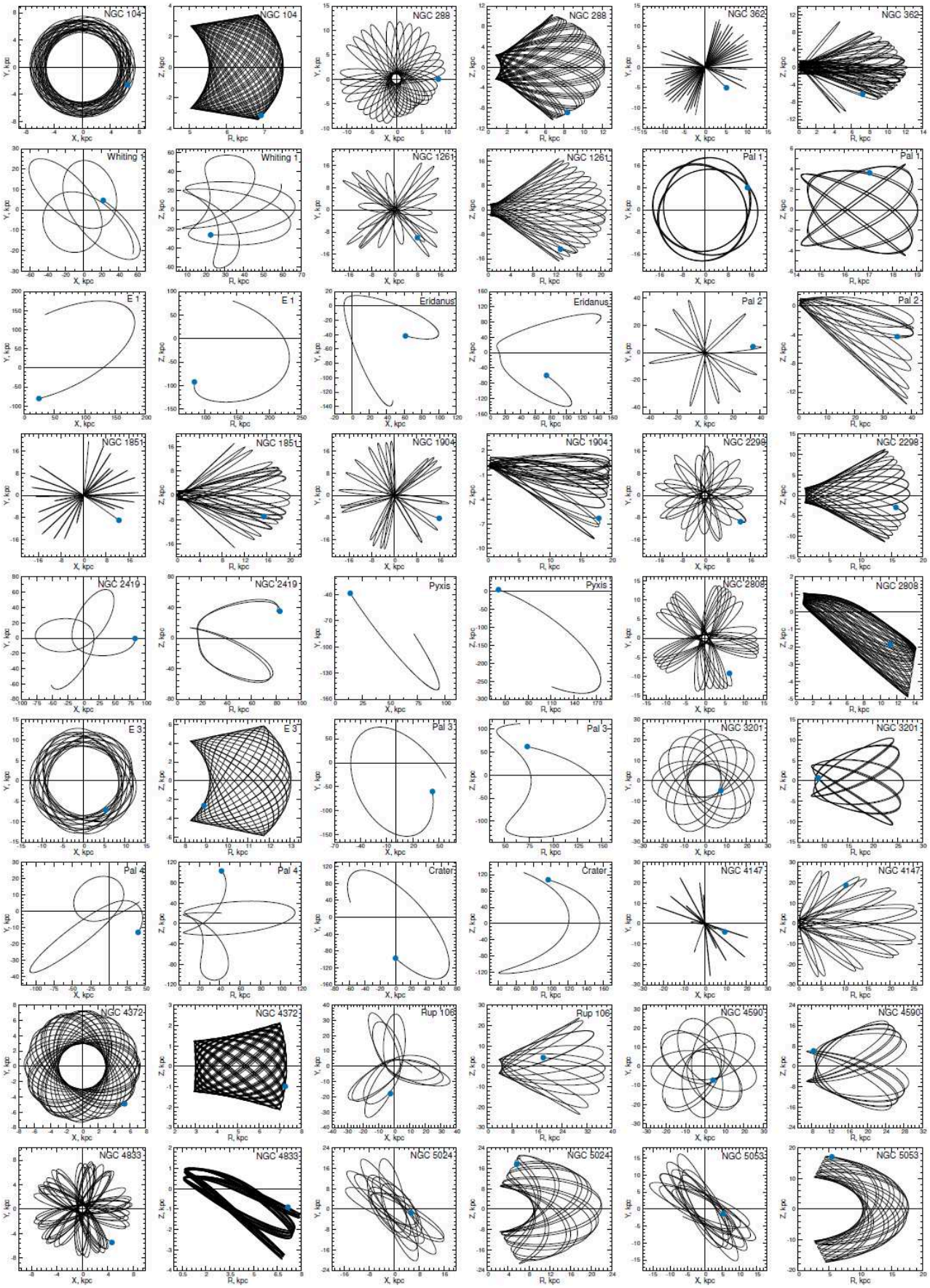

Figure 2. Orbits of the GCs obtained by integrating for 5 Gyr backward. (X,Y) and (R,Z) projections are given. The blue dot indicates the beginning of the orbit.

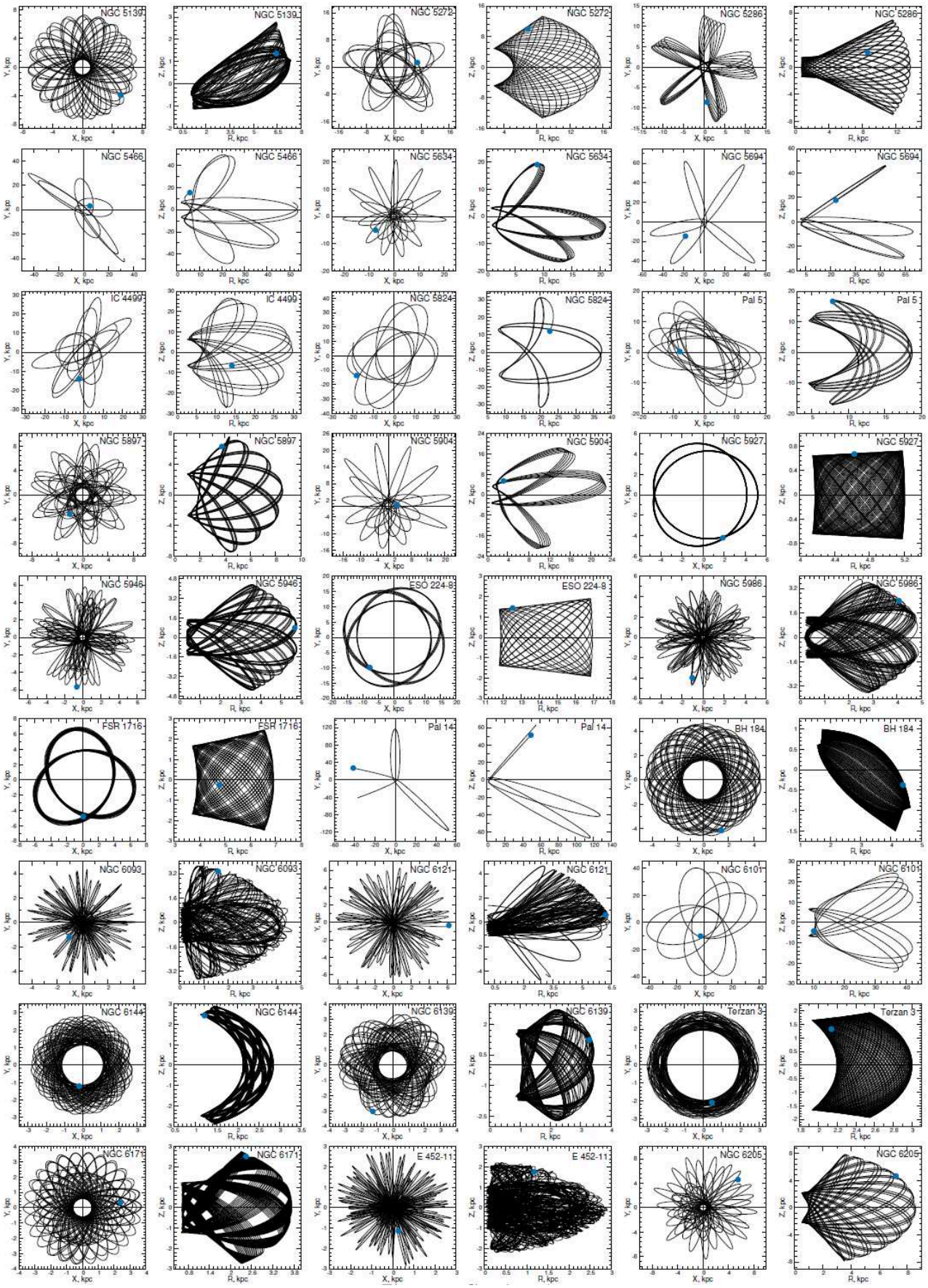

Figure 2 - continued

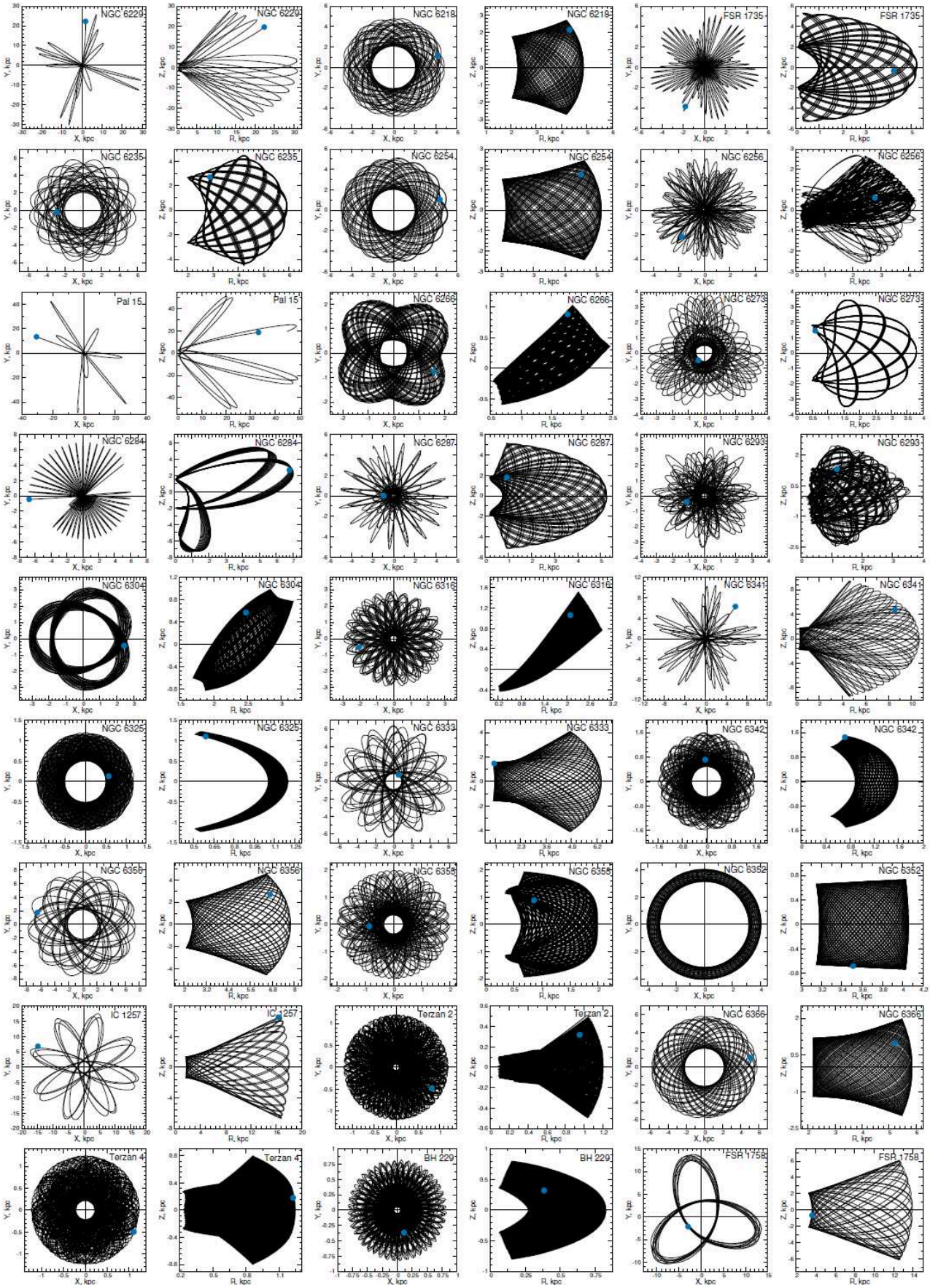

Figure 2 - continued

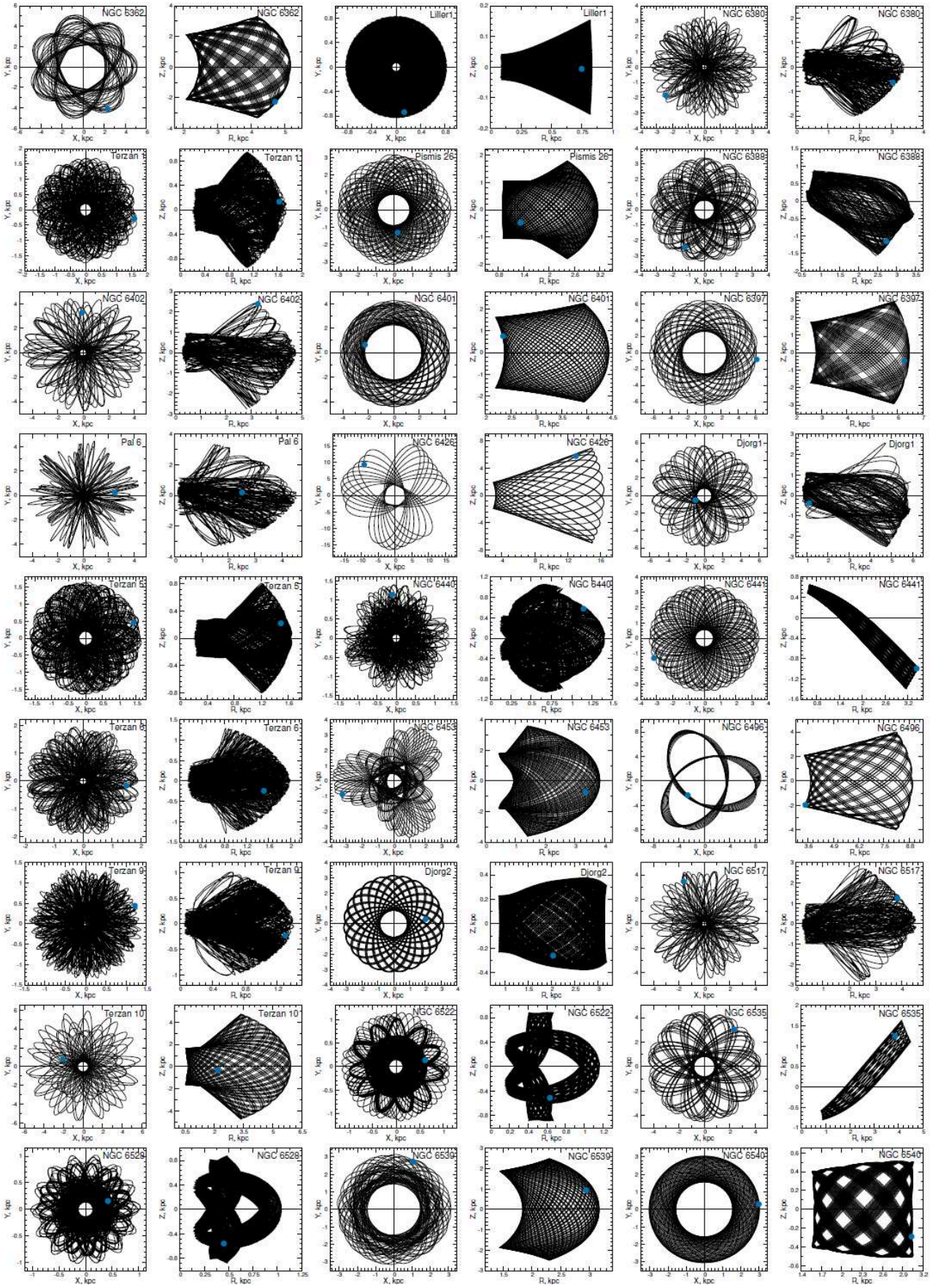

Figure 2 - continued

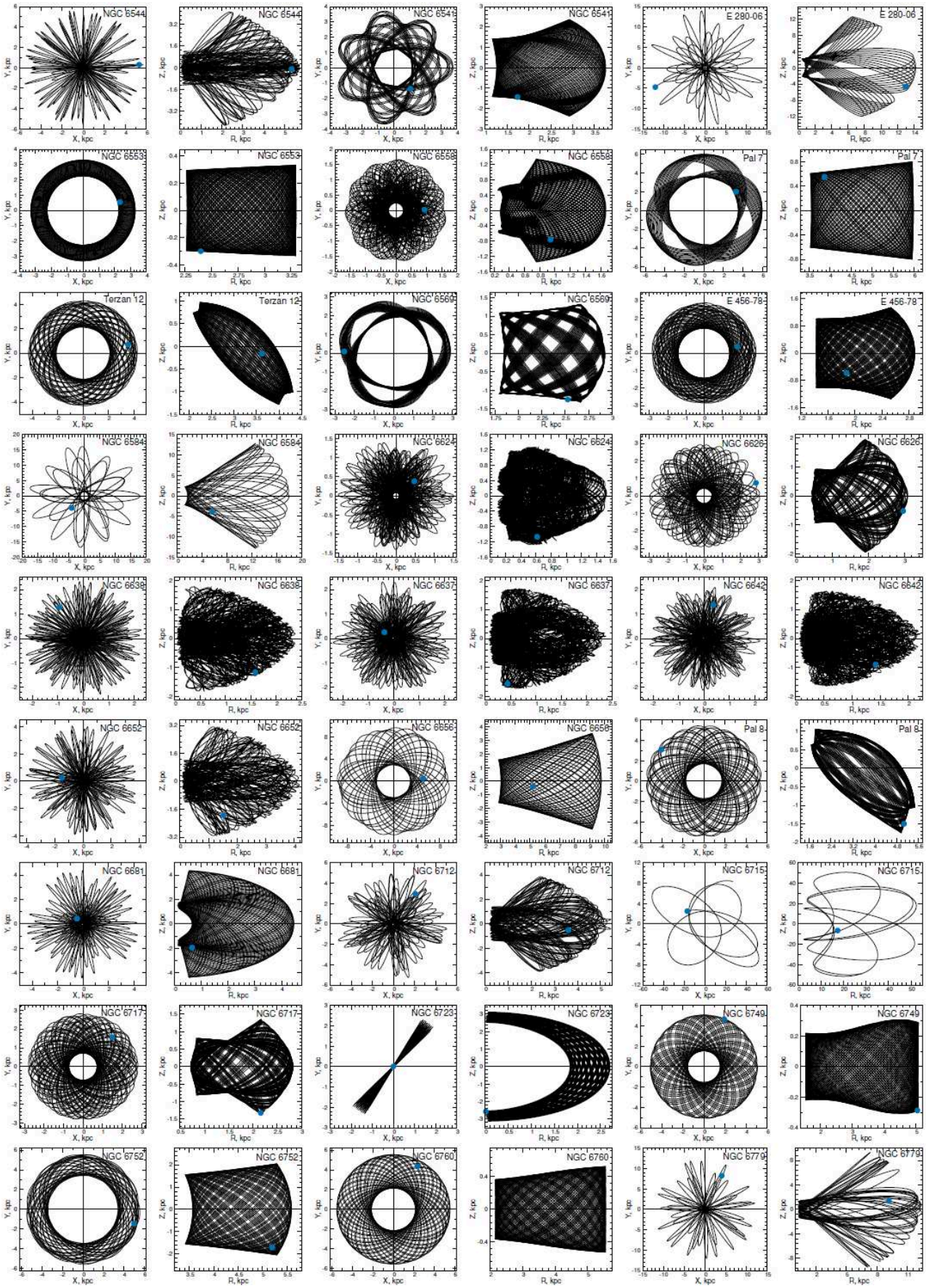

Figure 2 - continued

Table 3 - continued

Name	x_o [kpc]	y_o [kpc]	z_o [kpc]	u_o [km s^{-1}]	v_o [km s^{-1}]	w_o [km s^{-1}]	GS	GS(m)	
NGC 6656	3.13±0.22	0.55±0.04	-0.42±0.03	-164.9± 1.5	-38.1± 1.2	-150.2±12.0	D	D	
Pal 8	12.33±0.86	3.10±0.22	-1.52±0.11	43.5± 6.1	-361.3±24.8	-36.7± 4.6	D	D	
NGC 6681	8.78±0.60	0.44±0.03	-1.95±0.13	188.9± 1.8	-147.4±11.1	-182.8± 9.6	LE	LE	
NGC 6712	6.22±0.44	2.95±0.21	-0.52±0.04	-74.2± 1.9	-122.2± 5.7	-153.7±11.6	LE	GE	*
NGC 6715	25.58±1.82	2.51±0.18	-6.45±0.46	225.9± 6.6	-270.9±21.5	202.6±18.5	Sgr	Sgr	
NGC 6717	6.80±0.46	1.55±0.11	-1.34±0.09	79.0± 3.6	-182.2±12.9	17.7± 2.7	B	B	
NGC 6723	8.31±0.56	0.01±0.00	-2.59±0.17	-112.5± 1.7	-78.6± 5.7	-44.9± 5.3	B	B	
NGC 6749	6.37±0.45	4.66±0.33	-0.30±0.02	99.4±10.5	-235.1±14.3	-5.0± 2.3	D	D	
NGC 6752	3.31±0.23	-1.44±0.10	-1.73±0.12	-38.2± 1.2	-77.5± 6.2	52.2± 3.0	D	D	
NGC 6760	5.97±0.41	4.35±0.30	-0.51±0.03	74.6± 5.5	-105.5± 7.5	-22.0± 2.5	D	D	
NGC 6779	4.27±0.30	8.26±0.58	1.36±0.10	-92.2± 3.0	-123.4± 1.3	92.2± 8.1	GE	GE	
Terzan 7	21.38±1.46	1.26±0.09	-7.82±0.53	250.2± 7.3	-256.5±18.2	177.5±17.0	Sgr	Sgr	
Pal 10	3.59±0.25	4.67±0.32	0.28±0.02	160.0±12.5	-163.9± 9.7	13.5± 2.1	D	D	
Arp 2	26.44±1.83	3.97±0.28	-10.15±0.70	240.5± 9.5	-270.3±21.4	174.2±17.5	Sgr	Sgr	
NGC 6809	4.90±0.34	0.76±0.05	-2.13±0.15	199.6± 2.9	-224.9±17.3	-62.7± 1.3	LE	LE	
Terzan 8	23.80±1.66	2.40±0.17	-10.93±0.76	260.1± 9.1	-251.8±20.2	153.7±16.0	Sgr	Sgr	
Pal 11	10.97±0.77	6.80±0.48	-3.60±0.25	112.1±12.1	-321.6±20.5	-14.2± 4.6	D	D	
NGC 6838	2.19±0.16	3.33±0.24	-0.32±0.02	52.4± 4.7	-58.0± 2.9	32.1± 2.4	D	D	
NGC 6864	17.66±1.19	6.53±0.44	-9.08±0.61	-81.5± 6.1	-327.6±18.8	41.0± 6.4	GE	GE	
NGC 6934	9.07±0.62	11.65±0.80	-5.05±0.35	72.8±21.4	-551.1±17.2	114.7± 4.5	HE	GE	*
NGC 6981	11.70±0.84	8.24±0.59	-9.18±0.66	-73.6±11.8	-397.4±17.5	163.1± 4.4	H99	GE	*
NGC 7006	17.18±1.13	34.86±2.30	-13.69±0.90	-77.3±13.0	-384.2± 7.9	78.9±12.3	Seq	GE	*
NGC 7078	3.90±0.27	8.38±0.59	-4.77±0.33	89.8± 9.5	-193.9± 7.7	-34.2± 6.2	D	D	
NGC 7089	5.57±0.38	7.49±0.52	-6.72±0.46	-86.7± 6.3	-102.8± 7.4	-180.0±12.8	GE	GE	
NGC 7099	4.93±0.35	2.53±0.18	-5.91±0.42	-18.6± 6.9	-319.9±18.6	101.3± 2.7	GE	GE	
Pal 12	11.02±0.76	6.49±0.45	-14.05±0.97	325.9±22.1	-239.2±18.2	107.3± 9.8	Sgr	Sgr	
Pal 13	0.97±0.07	19.08±1.38	-17.63±1.27	-179.6±18.7	-34.0± 8.4	-84.8± 9.6	Seq	GE	*
NGC 7492	7.00±0.48	9.43±0.65	-23.53±1.62	-11.8± 8.1	-343.7±20.4	56.3± 7.7	GE	GE	

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Table 4. Orbital properties of the GCs. For each GC we quote values derived from orbits integrated for 5 Gyr backward

Name	d_{GC} [kpc]	Π [km s^{-1}]	Θ [km s^{-1}]	V_{tot} [km s^{-1}]	apo [kpc]	peri [kpc]	ecc	incl. θ [deg]	T_r [Myr]	L_Z [kpc km s^{-1}]	E [km^2 s^{-2}]
NGC 104	7.6	$5.9^{+12.0}_{-4.7}$	$191.7^{+9.7}_{-4.1}$	$197.0^{+9.9}_{-3.6}$	$7.66^{+0.19}_{-0.06}$	$5.54^{+0.53}_{-0.14}$	$0.16^{+0.02}_{-0.04}$	$27.5^{+1.6}_{-2.3}$	116	1328	−126288
NGC 288	12.2	$9.3^{+3.9}_{-2.2}$	$-41.6^{+10.2}_{-14.9}$	$66.3^{+10.9}_{-6.4}$	$12.33^{+0.25}_{-0.44}$	$1.40^{+0.52}_{-0.33}$	$0.80^{+0.04}_{-0.07}$	$119.1^{+4.1}_{-4.1}$	142	−349	−116280
NGC 362	9.5	$127.0^{+20.9}_{-7.4}$	$-1.4^{+11.7}_{-21.2}$	$145.1^{+19.7}_{-5.0}$	$12.29^{+0.00}_{-0.78}$	$0.08^{+0.44}_{-0.00}$	$0.99^{+0.00}_{-0.07}$	$92.1^{+22.6}_{-15.7}$	126	−10	−121290
Whiting 1	34.7	$-207.9^{+11.9}_{-16.2}$	$109.5^{+12.8}_{-10.4}$	$235.1^{+17.2}_{-11.6}$	$67.00^{+16.59}_{-8.86}$	$20.31^{+3.08}_{-1.29}$	$0.53^{+0.04}_{-0.03}$	$67.4^{+2.7}_{-1.3}$	1162	2494	−42265
NGC 1261	18.2	$-95.3^{+6.9}_{-10.6}$	$-19.3^{+9.3}_{-8.5}$	$119.0^{+9.3}_{-5.3}$	$21.09^{+1.14}_{-0.46}$	$0.68^{+0.48}_{-0.24}$	$0.94^{+0.02}_{-0.04}$	$120.9^{+1.4}_{-16.5}$	244	−249	−91385
Pal 1	17.4	$41.9^{+4.8}_{-9.7}$	$213.7^{+2.8}_{-2.3}$	$218.7^{+2.4}_{-2.5}$	$19.08^{+0.41}_{-0.87}$	$14.59^{+0.92}_{-0.78}$	$0.13^{+0.02}_{-0.03}$	$14.1^{+0.8}_{-0.4}$	350	3646	−78086
E 1	124.7	$11.1^{+28.1}_{-88.4}$	$-144.4^{+91.3}_{-54.6}$	$173.7^{+62.3}_{-63.0}$	$237.88^{+45.21}_{-42.86}$	$124.73^{+3.19}_{-78.75}$	$0.31^{+0.44}_{-0.00}$	$126.9^{+11.0}_{-34.0}$	5594	−12100	−15914
Eridanus	95.2	$-89.8^{+39.9}_{-20.9}$	$-27.8^{+42.5}_{-22.9}$	$163.1^{+33.6}_{-10.1}$	$174.54^{+83.64}_{-24.28}$	$12.04^{+40.97}_{-11.86}$	$0.87^{+0.06}_{-0.22}$	$113.0^{+7.1}_{-38.6}$	3220	−2064	−23988
Pal 2	35.3	$-107.6^{+5.7}_{-5.4}$	$10.7^{+13.3}_{-15.2}$	$108.2^{+5.9}_{-3.6}$	$40.98^{+3.65}_{-1.46}$	$0.61^{+1.00}_{-0.20}$	$0.97^{+0.01}_{-0.05}$	$42.3^{+84.5}_{-41.9}$	506	373	−63896
NGC 1851	16.9	$105.3^{+5.8}_{-4.0}$	$-1.4^{+7.3}_{-4.1}$	$133.4^{+4.9}_{-3.8}$	$20.14^{+0.47}_{-0.00}$	$0.05^{+0.24}_{-0.00}$	$0.99^{+0.00}_{-0.02}$	$92.3^{+8.0}_{-11.0}$	232	−22	−94063
NGC 1904	19.0	$45.6^{+7.0}_{-6.5}$	$11.8^{+8.2}_{-3.7}$	$47.3^{+8.8}_{-4.0}$	$19.74^{+0.69}_{-0.34}$	$0.33^{+0.47}_{-0.00}$	$0.97^{+0.00}_{-0.05}$	$60.5^{+13.7}_{-25.9}$	218	211	−96192
NGC 2298	16.0	$-92.3^{+7.0}_{-9.2}$	$-31.8^{+7.6}_{-12.1}$	$124.6^{+7.8}_{-5.5}$	$18.01^{+0.56}_{-0.51}$	$1.24^{+0.47}_{-0.25}$	$0.87^{+0.03}_{-0.04}$	$117.8^{+12.0}_{-7.3}$	208	−500	−98716
NGC 2419	90.2	$-4.8^{+9.5}_{-14.4}$	$47.1^{+28.4}_{-32.9}$	$74.9^{+34.7}_{-12.3}$	$91.78^{+7.62}_{-3.91}$	$17.29^{+16.08}_{-5.61}$	$0.68^{+0.09}_{-0.20}$	$51.7^{+27.5}_{-15.0}$	1562	3907	−35896
Pyxis	41.5	$-246.9^{+6.7}_{-5.7}$	$-29.3^{+22.0}_{-1.6}$	$311.0^{+18.2}_{-14.3}$	$324.17^{+95.80}_{-90.88}$	$41.69^{+0.00}_{-21.20}$	$0.77^{+0.09}_{-0.00}$	$97.7^{+2.6}_{-5.8}$	7100	−1205	−15098
NGC 2808	11.3	$-157.4^{+1.9}_{-1.1}$	$40.9^{+6.1}_{-3.8}$	$165.2^{+1.8}_{-1.1}$	$14.39^{+0.44}_{-0.70}$	$1.00^{+0.94}_{-0.07}$	$0.87^{+0.01}_{-0.02}$	$9.9^{+4.1}_{-0.3}$	158	457	−111797
E 3	9.3	$44.4^{+22.0}_{-2.1}$	$251.5^{+18.0}_{-4.7}$	$275.7^{+19.6}_{-2.3}$	$13.12^{+2.72}_{-0.32}$	$9.18^{+0.35}_{-0.53}$	$0.18^{+0.09}_{-0.00}$	$28.8^{+2.0}_{-1.3}$	224	2240	−97684
Pal 3	95.9	$-147.2^{+70.7}_{-45.1}$	$88.5^{+34.2}_{-62.8}$	$184.5^{+42.1}_{-40.2}$	$173.39^{+77.44}_{-73.94}$	$76.26^{+23.33}_{-20.70}$	$0.39^{+0.26}_{-0.13}$	$66.7^{+16.2}_{-11.2}$	4524	6495	−20091
NGC 3201	9.1	$-113.7^{+16.8}_{-15.0}$	$-300.9^{+10.5}_{-7.5}$	$355.2^{+11.3}_{-11.4}$	$26.27^{+3.22}_{-3.23}$	$8.38^{+0.26}_{-0.31}$	$0.52^{+0.04}_{-0.05}$	$151.7^{+0.3}_{-1.5}$	372	−2728	−75483
Pal 4	111.4	$-25.3^{+45.6}_{-86.2}$	$-33.4^{+137.5}_{-74.5}$	$69.6^{+112.1}_{-0.0}$	$116.51^{+62.26}_{-42.57}$	$16.30^{+82.18}_{-0.00}$	$0.75^{+0.00}_{-0.50}$	$103.0^{+3.1}_{-30.2}$	2032	−1394	−31065
Crater	144.8	$-100.8^{+76.6}_{-98.6}$	$-63.0^{+201.8}_{-117.4}$	$134.6^{+198.3}_{-13.3}$	$156.10^{+97.55}_{-90.00}$	$117.38^{+42.18}_{-47.66}$	$0.14^{+0.69}_{-0.00}$	$108.5^{+17.9}_{-31.0}$	5082	−6104	−18859
NGC 4147	21.5	$46.7^{+4.6}_{-8.0}$	$-2.6^{+21.2}_{-10.7}$	$135.9^{+5.3}_{-2.3}$	$26.44^{+1.39}_{-2.38}$	$0.44^{+0.93}_{-0.04}$	$0.97^{+0.00}_{-0.07}$	$93.4^{+10.1}_{-16.6}$	314	−27	−81117
NGC 4372	7.3	$16.4^{+10.1}_{-8.4}$	$132.6^{+12.4}_{-3.0}$	$149.6^{+12.3}_{-4.8}$	$7.33^{+0.31}_{-0.32}$	$3.00^{+0.36}_{-0.13}$	$0.42^{+0.02}_{-0.05}$	$28.4^{+0.6}_{-3.2}$	98	962	−139570
Rup 106	18.5	$-242.2^{+2.1}_{-8.5}$	$91.3^{+12.1}_{-20.3}$	$260.9^{+8.4}_{-4.1}$	$37.94^{+4.37}_{-1.87}$	$4.67^{+0.63}_{-0.81}$	$0.78^{+0.04}_{-0.02}$	$45.6^{+7.8}_{-4.7}$	498	1640	−64986
NGC 4590	10.3	$-168.5^{+15.6}_{-12.8}$	$293.4^{+9.3}_{-13.1}$	$338.7^{+2.6}_{-6.6}$	$29.88^{+0.53}_{-3.44}$	$8.88^{+0.05}_{-0.63}$	$0.54^{+0.01}_{-0.02}$	$40.9^{+1.8}_{-2.7}$	428	2453	−70495
NGC 4833	7.2	$104.5^{+8.0}_{-15.0}$	$39.9^{+15.2}_{-11.8}$	$119.5^{+10.9}_{-14.6}$	$8.04^{+0.45}_{-0.35}$	$0.74^{+0.28}_{-0.25}$	$0.83^{+0.05}_{-0.05}$	$36.3^{+12.0}_{-10.0}$	86	286	−144428
NGC 5024	18.5	$-94.7^{+8.8}_{-3.5}$	$141.0^{+9.7}_{-5.4}$	$184.3^{+7.9}_{-6.0}$	$22.28^{+0.03}_{-2.27}$	$8.92^{+0.22}_{-1.26}$	$0.43^{+0.02}_{-0.02}$	$74.0^{+0.0}_{-2.5}$	332	797	−80241
NGC 5053	17.9	$-88.9^{+9.2}_{-3.4}$	$133.8^{+9.1}_{-10.3}$	$164.4^{+7.2}_{-11.1}$	$17.96^{+0.40}_{-1.16}$	$10.41^{+0.65}_{-1.48}$	$0.27^{+0.05}_{-0.04}$	$75.7^{+0.3}_{-1.2}$	300	727	−85221
NGC 5139	6.6	$-70.2^{+1.9}_{-5.9}$	$-71.7^{+5.5}_{-4.6}$	$128.2^{+6.8}_{-9.1}$	$7.43^{+0.00}_{-0.39}$	$1.14^{+0.15}_{-0.04}$	$0.73^{+0.01}_{-0.04}$	$137.1^{+7.6}_{-3.2}$	80	−462	−147850
NGC 5272	12.2	$-38.0^{+3.0}_{-5.9}$	$143.0^{+7.5}_{-7.2}$	$199.9^{+5.9}_{-4.9}$	$15.92^{+1.28}_{-1.06}$	$5.19^{+0.41}_{-0.40}$	$0.51^{+0.02}_{-0.02}$	$57.1^{+1.9}_{-2.1}$	212	994	−98226
NGC 5286	8.9	$-219.7^{+4.0}_{-2.2}$	$-43.5^{+12.9}_{-10.1}$	$224.2^{+1.0}_{-2.6}$	$13.70^{+0.44}_{-0.90}$	$0.81^{+0.17}_{-0.17}$	$0.89^{+0.02}_{-0.03}$	$123.3^{+5.5}_{-8.9}$	154	−375	−113332
NGC 5466	16.4	$172.2^{+9.3}_{-30.8}$	$-141.2^{+7.1}_{-19.3}$	$317.2^{+11.1}_{-17.4}$	$53.69^{+10.46}_{-9.15}$	$5.93^{+1.03}_{-0.50}$	$0.80^{+0.01}_{-0.03}$	$107.8^{+2.2}_{-1.5}$	750	−820	−52693
NGC 5634	21.1	$-45.0^{+12.9}_{-12.9}$	$38.8^{+16.1}_{-14.1}$	$64.7^{+5.2}_{-5.8}$	$21.57^{+1.68}_{-1.88}$	$2.14^{+0.94}_{-0.47}$	$0.82^{+0.03}_{-0.07}$	$70.5^{+6.0}_{-3.4}$	256	346	−89143
NGC 5694	29.3	$-184.8^{+18.3}_{-13.1}$	$-43.8^{+7.3}_{-14.4}$	$252.3^{+13.5}_{-16.9}$	$70.43^{+9.25}_{-9.74}$	$2.58^{+1.04}_{-0.59}$	$0.93^{+0.02}_{-0.03}$	$136.2^{+5.3}_{-6.2}$	992	−1019	−45290
IC 4499	15.6	$-244.5^{+4.2}_{-5.1}$	$-75.1^{+20.0}_{-10.5}$	$263.2^{+1.8}_{-3.1}$	$29.98^{+0.68}_{-3.96}$	$6.46^{+0.20}_{-0.70}$	$0.65^{+0.02}_{-0.05}$	$112.8^{+2.8}_{-6.5}$	406	−1066	−72235
NGC 5824	25.7	$-41.2^{+3.0}_{-24.1}$	$105.4^{+5.7}_{-27.6}$	$215.0^{+14.0}_{-10.9}$	$37.42^{+5.68}_{-2.44}$	$14.04^{+1.44}_{-3.50}$	$0.45^{+0.11}_{-0.00}$	$58.3^{+6.4}_{-1.7}$	598	2393	−59779
Pal 5	18.4	$-54.1^{+1.4}_{-5.3}$	$160.3^{+35.7}_{-21.3}$	$169.5^{+34.5}_{-18.7}$	$18.91^{+1.40}_{-0.07}$	$10.78^{+4.49}_{-1.99}$	$0.27^{+0.10}_{-0.14}$	$65.7^{+3.8}_{-4.6}$	308	1260	−83194
NGC 5897	7.3	$88.4^{+19.4}_{-3.7}$	$96.5^{+5.8}_{-30.6}$	$158.6^{+14.1}_{-16.5}$	$8.74^{+0.56}_{-0.37}$	$1.93^{+0.22}_{-0.62}$	$0.64^{+0.09}_{-0.02}$	$60.9^{+7.7}_{-0.3}$	106	362	−131771
NGC 5904	6.3	$-290.2^{+11.7}_{-11.6}$	$125.7^{+15.8}_{-12.6}$	$364.6^{+14.9}_{-8.2}$	$23.33^{+5.11}_{-1.75}$	$2.27^{+0.63}_{-0.20}$	$0.82^{+0.02}_{-0.02}$	$71.8^{+3.5}_{-2.7}$	286	402	−85576
NGC 5927	4.7	$-39.1^{+33.0}_{-14.9}$	$232.7^{+3.3}_{-8.2}$	$236.0^{+1.7}_{-6.7}$	$5.23^{+0.25}_{-0.47}$	$4.17^{+0.58}_{-0.42}$	$0.11^{+0.05}_{-0.08}$	$8.6^{+0.9}_{-1.0}$	82	1077	−148662
NGC 5946	5.8	$34.7^{+25.8}_{-19.2}$	$24.6^{+11.3}_{-11.8}$	$116.2^{+13.7}_{-4.2}$	$5.90^{+0.51}_{-0.11}$	$0.36^{+0.20}_{-0.15}$	$0.89^{+0.04}_{-0.06}$	$76.6^{+6.4}_{-5.7}$	66	141	−158006
ESO 224-8	12.6	$-43.3^{+31.6}_{-20.9}$	$258.5^{+40.7}_{-27.8}$	$262.1^{+38.6}_{-24.1}$	$16.98^{+6.77}_{-1.83}$	$11.89^{+0.13}_{-1.71}$	$0.18^{+0.14}_{-0.01}$	$6.7^{+1.7}_{-0.6}$	292	3245	−85205
NGC 5986	4.7	$61.9^{+8.0}_{-28.2}$	$23.1^{+10.1}_{-7.4}$	$67.5^{+9.9}_{-25.6}$	$5.00^{+0.63}_{-0.00}$	$0.20^{+0.15}_{-0.08}$	$0.92^{+0.04}_{-0.04}$	$66.1^{+2.4}_{-11.5}$	56	94	−168505
FSR 1716	4.8	$87.3^{+34.8}_{-21.4}$	$227.8^{+15.6}_{-11.1}$	$280.5^{+15.4}_{-0.3}$	$7.00^{+0.83}_{-0.00}$	$3.90^{+0.55}_{-0.53}$	$0.28^{+0.10}_{-0.04}$	$30.6^{+2.4}_{-1.4}$	106	1089	−137191
Pal 14	71.4	$117.1^{+20.9}_{-17.1}$	$16.0^{+36.4}_{-12.3}$	$176.7^{+27.5}_{-20.3}$	$133.87^{+31.29}_{-22.52}$	$2.18^{+7.12}_{-1.10}$	$0.97^{+0.02}_{-0.10}$	$50.3^{+36.1}_{-6.4}$	2202	794	−29458
BH 184	4.4	$40.1^{+16.0}_{-15.1}$	$120.8^{+11.7}_{-9.8}$	$155.6^{+11.9}_{-7.6}$	$4.72^{+0.52}_{-0.24}$	$1.69^{+0.24}_{-0.19}$	$0.47^{+0.06}_{-0.04}$	$35.6^{+3.1}_{-3.2}$	58	531	−168579
NGC 6093	3.7	$32.6^{+20.3}_{-13.3}$	$15.8^{+6.9}_{-20.0}$	$70.8^{+14.4}_{-9.4}$	$4.65^{+0.00}_{-0.89}$	$0.10^{+0.43}_{-0.08}$	$0.96^{+0.03}_{-0.20}$	$83.3^{+8.3}_{-1.1}$	44	25	−176933
NGC 6121	6.3	$-52.5^{+2.9}_{-1.4}$	$9.7^{+3.3}_{-29.0}$	$54.1^{+3.5}_{-1.7}$	$6.43^{+0.20}_{-0.09}$	$0.14^{+0.11}_{-0.07}$	$0.96^{+0.02}_{-0.03}$	$20.7^{+11.2}_{-1.9}$	68	60	−159021
NGC 6101	11.1	$-12.3^{+25.2}_{-10.4}$	$-313.8^{+7.4}_{-2.1}$	$369.6^{+0.9}_{-10.6}$	$44.18^{+0.23}_{-7.84}$	$10.86^{+0.19}_{-0.87}$	$0.61^{+0.00}_{-0.05}$	$142.9^{+1.9}_{-0.8}$	658	−3236	−56722
NGC 6144	2.7	$-69.1^{+109.0}_{-34.0}$	$-196.4^{+20.5}_{-16.3}$	$212.7^{+4.8}_{-4.4}$	$3.25^{+0.48}_{-0.07}$	$2.13^{+0.09}_{-0.13}$	$0.21^{+0.08}_{-0.02}$	$114.5^{+11.4}_{-3.8}$	40	−239	−172662
NGC 6139	3.5	$-0.6^{+5.9}_{-36.6}$	$75.6^{+3.6}_{-14.6}$	$156.4^{+14.7}_{-7.2}$	$3.64^{+0.59}_{-0.16}$	$1.07^{+0.32}_{-0.12}$	$0.54^{+0.06}_{-0.07}$	$61.6^{+6.7}_{-0.4}$	52	248	−176480
Terzan 3	2.5	$-61.2^{+68.4}_{-59.0}$	$205.6^{+11.8}_{-22.9}$	$236.1^{+13.3}_{-9.4}$	$3.19^{+0.74}_{-0.17}$	$2.20^{+0.24}_{-0.40}$	$0.18^{+0.17}_{-0.04}$	$42.3^{+7.0}_{-7.4}$	44	440	−175324
NGC 6171	3.5	$-3.5^{+6.0}_{-2.6}$	$78.0^{+17.6}_{-6.2}$	$101.5^{+13.8}_{-3.7}$	$3.77^{+0.37}_{-0.36}$	$0.62^{+0.24}_{-0.10}$	$0.72^{+0.05}_{-0.11}$	$52.3^{+3.6}_{-2.1}$	44	191	−178959
E 452-11	2.1	$-24.5^{+19.6}_{-18.1}$	$-13.3^{+21.2}_{-13.7}$	$107.3^{+10.9}_{-0.0}$	$2.92^{+0.42}_{-0.09}$	$0.07^{+0.03}_{-0.04}$	$0.96^{+0.02}_{-0.02}$	$100.8^{+5.2}_{-16.9}$	26	−16	−202684
NGC 6205	8.6	$20.4^{+5.8}_{-4.0}$	$-25.9^{+7.5}_{-4.7}$	$86.6^{+4.3}_{-6.9}$	$8.64^{+0.36}_{-0.16}$	$1.00^{+0.14}_{-0.17}$	$0.79^{+0.04}_{-0.02}$	$105.3^{+2.5}_{-3.9}$	100	−187	−134416
NGC 6229	29.9	$29.9^{+10.8}_{-7.2}$	$6.0^{+2.7}_{-11.8}$	$59.3^{+12.8}_{-9.1}$	$31.02^{+1.49}_{-1.64}$	$0.46^{+0.44}_{-0.24}$	$0.97^{+0.02}_{-0.03}$	$76.5^{+26.4}_{-10.5}$	376	135	−74434
NGC 6218	4.8	$-9.1^{+4.8}_{-7.0}$	$134.6^{+5.1}_{-7.5}$	$157.7^{+3.6}_{-8.6}$	$4.98^{+0.31}_{-0.29}$	$2.27^{+0.12}_{-0.21}$	$0.37^{+0.05}_{-0.02}$	$37.2^{+1.1}_{-2.3}$	64	581	−158135
FSR 1735	4.3	$-101.9^{+9.8}_{-9.9}$	$-5.3^{+13.4}_{-23.8}$	$225.2^{+11.9}_{-7.8}$	$5.33^{+0.86}_{-0.19}$	$0.97^{+0.49}_{-0.11}$	$0.69^{+0.04}_{-0.09}$	$91.6^{+7.3}_{-4.1}$	68	−22	−157538
NGC 6235	4.0	$158.8^{+2.0}_{-4.9}$	$197.4^{+27.3}_{-26.0}$	$256.4^{+22.5}_{-22.6}$	$6.17^{+1.19}_{-0.37}$	$2.72^{+0.43}_{-0.26}$	$0.39^{+0.04}_{-0.01}$	$53.2^{+1.2}_{-7.1}$	84	570	−145439
NGC 6254	4.8	$-87.3^{+4.1}_{-6.1}$	$134.2^{+9.1}_{-15.4}$	$166.9^{+6.4}_{-10.1}$	$5.21^{+0.38}_{-0.30}$	$2.15^{+0.19}_{-0.30}$	$0.42^{+0.06}_{-0.04}$	$35.6^{+3.1}_{-2.1}$	78	606	−157472
NGC 6256	2.9	$-170.1^{+17.4}_{-10.2}$	$28.3^{+35.4}_{-37.5}$	$197.9^{+7.6}_{-8.9}$	$4.27^{+0.91}_{-0.77}$	$0.16^{+0.23}_{-0.13}$	$0.93^{+0.06}_{-0.13}$	$78.1^{+15.7}_{-13.6}$	46	79	−181873
Pal 15	38.2	$154.2^{+11.5}_{-14.6}$	$-4.9^{+11.9}_{-21.1}$	$162.1^{+12.1}_{-14.2}$	$54.64^{+4.96}_{-4.06}$	$1.16^{+2.06}_{-0.48}$	$0.96^{+0.01}_{-0.06}$	$97.8^{+20.8}_{-19.9}$	726	−165	−53233

Table 4 - continued

Name	d_{GC} [kpc]	Π [km s^{-1}]	Θ [km s^{-1}]	V_{tot} [km s^{-1}]	apo [kpc]	peri [kpc]	ecc	incl. θ [deg]	T_r [Myr]	L_Z [kpc km s^{-1}]	E [km^2 s^{-2}]
NGC 6266	2.0	$41.9^{+7.0}_{-21.8}$	$121.8^{+12.1}_{-12.3}$	$146.1^{+8.1}_{-10.2}$	$2.48^{+0.15}_{-0.65}$	$0.59^{+0.15}_{-0.17}$	$0.62^{+0.05}_{-0.10}$	$32.5^{+7.0}_{-1.6}$	32	215	−205537
NGC 6273	1.6	$-98.5^{+20.8}_{-158.2}$	$-239.8^{+230.1}_{-10.6}$	$314.9^{+6.5}_{-6.0}$	$3.85^{+0.57}_{-0.32}$	$1.00^{+0.16}_{-0.13}$	$0.59^{+0.03}_{-0.02}$	$108.6^{+5.3}_{-20.3}$	48	−144	−172941
NGC 6284	7.3	$14.0^{+1.6}_{-1.8}$	$-2.4^{+17.2}_{-19.9}$	$112.5^{+10.8}_{-2.3}$	$7.51^{+0.26}_{-0.86}$	$0.70^{+0.22}_{-0.09}$	$0.83^{+0.01}_{-0.05}$	$91.3^{+10.8}_{-9.0}$	90	−16	−142332
NGC 6287	2.0	$-301.4^{+242.0}_{-121.4}$	$-64.5^{+46.9}_{-19.8}$	$318.2^{+1.6}_{-2.4}$	$5.30^{+1.13}_{-0.42}$	$0.76^{+0.06}_{-0.11}$	$0.75^{+0.05}_{-0.02}$	$95.4^{+2.4}_{-4.0}$	66	−60	−159009
NGC 6293	1.8	$-152.2^{+10.6}_{-15.4}$	$-79.8^{+32.2}_{-13.3}$	$233.1^{+6.5}_{-12.4}$	$3.58^{+0.41}_{-0.59}$	$0.21^{+0.08}_{-0.11}$	$0.89^{+0.05}_{-0.03}$	$131.4^{+5.4}_{-23.0}$	38	−93	−191358
NGC 6304	2.5	$78.5^{+5.0}_{-6.3}$	$191.1^{+2.2}_{-7.5}$	$218.7^{+2.6}_{-6.4}$	$3.27^{+0.26}_{-0.44}$	$1.80^{+0.12}_{-0.35}$	$0.29^{+0.04}_{-0.00}$	$19.9^{+1.7}_{-0.1}$	52	474	−183132
NGC 6316	2.4	$102.6^{+6.5}_{-4.2}$	$50.5^{+15.2}_{-24.7}$	$143.3^{+9.3}_{-6.3}$	$3.02^{+0.46}_{-0.55}$	$0.40^{+0.11}_{-0.27}$	$0.77^{+0.13}_{-0.04}$	$40.3^{+19.6}_{-8.8}$	36	106	−197316
NGC 6341	9.8	$53.0^{+2.2}_{-4.3}$	$12.6^{+4.9}_{-5.8}$	$109.1^{+13.5}_{-6.1}$	$10.70^{+0.29}_{-0.35}$	$0.34^{+0.24}_{-0.09}$	$0.94^{+0.02}_{-0.05}$	$79.1^{+5.4}_{-3.6}$	124	108	−125312
NGC 6325	1.3	$-80.5^{+16.4}_{-61.3}$	$-181.1^{+211.8}_{-74.0}$	$213.5^{+38.4}_{-14.4}$	$1.35^{+0.76}_{-0.16}$	$1.06^{+0.06}_{-0.31}$	$0.12^{+0.24}_{-0.00}$	$113.9^{+9.2}_{-20.9}$	18	−107	−212097
NGC 6333	1.8	$-88.7^{+38.9}_{-125.6}$	$345.9^{+0.0}_{-48.6}$	$363.5^{+4.7}_{-2.8}$	$6.44^{+0.89}_{-0.35}$	$0.97^{+0.24}_{-0.10}$	$0.74^{+0.01}_{-0.03}$	$59.3^{+1.0}_{-5.7}$	74	327	−151409
NGC 6342	1.6	$-25.2^{+73.4}_{-99.8}$	$163.5^{+5.7}_{-67.7}$	$168.4^{+5.5}_{-3.0}$	$1.68^{+0.79}_{-0.15}$	$0.89^{+0.21}_{-0.37}$	$0.31^{+0.30}_{-0.09}$	$63.8^{+6.7}_{-2.0}$	24	117	−207010
NGC 6356	7.2	$47.1^{+7.2}_{-6.1}$	$106.6^{+14.4}_{-25.9}$	$160.1^{+10.8}_{-14.2}$	$7.92^{+0.99}_{-0.92}$	$2.47^{+0.45}_{-0.70}$	$0.52^{+0.12}_{-0.07}$	$43.3^{+8.3}_{-3.3}$	104	713	−136303
NGC 6355	1.2	$-206.9^{+149.6}_{-71.7}$	$-109.9^{+110.0}_{-48.4}$	$274.9^{+0.1}_{-9.5}$	$2.24^{+1.38}_{-0.15}$	$0.64^{+0.17}_{-0.21}$	$0.56^{+0.20}_{-0.05}$	$106.3^{+10.9}_{-11.5}$	28	−95	−199192
NGC 6352	3.6	$42.0^{+19.9}_{-18.9}$	$226.0^{+5.0}_{-5.3}$	$229.9^{+5.1}_{-3.6}$	$4.09^{+0.79}_{-0.43}$	$3.18^{+0.29}_{-0.17}$	$0.13^{+0.05}_{-0.04}$	$11.6^{+0.6}_{-1.9}$	68	794	−163864
IC 1257	17.6	$-45.4^{+4.2}_{-6.6}$	$-50.0^{+15.2}_{-6.7}$	$70.3^{+6.7}_{-8.1}$	$18.07^{+1.66}_{-1.28}$	$1.82^{+0.31}_{-0.62}$	$0.82^{+0.06}_{-0.03}$	$158.1^{+0.1}_{-4.3}$	208	−817	−98556
Terzan 2	1.0	$-120.2^{+30.7}_{-14.0}$	$-46.8^{+37.3}_{-41.6}$	$136.2^{+5.7}_{-2.7}$	$1.21^{+0.82}_{-0.45}$	$0.09^{+0.05}_{-0.02}$	$0.86^{+0.08}_{-0.15}$	$161.0^{+12.4}_{-54.4}$	14	−44	−242360
NGC 6366	5.3	$94.2^{+3.6}_{-4.6}$	$133.9^{+5.4}_{-2.7}$	$175.1^{+3.9}_{-2.1}$	$5.85^{+0.28}_{-0.20}$	$2.20^{+0.21}_{-0.12}$	$0.45^{+0.02}_{-0.02}$	$32.0^{+0.9}_{-1.4}$	74	699	−153378
Terzan 4	1.2	$15.1^{+18.1}_{-21.5}$	$75.3^{+12.3}_{-13.2}$	$123.6^{+10.2}_{-5.1}$	$1.26^{+0.85}_{-0.21}$	$0.24^{+0.11}_{-0.04}$	$0.68^{+0.08}_{-0.07}$	$51.7^{+5.9}_{-3.7}$	14	92	−234494
BH 229	0.5	$7.3^{+22.4}_{-41.4}$	$-54.7^{+30.4}_{-7.8}$	$292.4^{+13.6}_{-2.1}$	$0.83^{+1.11}_{-0.03}$	$0.29^{+0.11}_{-0.15}$	$0.49^{+0.33}_{-0.06}$	$100.5^{+1.7}_{-5.7}$	10	−21	−249808
FSR 1758	3.7	$59.9^{+15.4}_{-63.3}$	$-347.4^{+2.2}_{-5.8}$	$404.7^{+9.0}_{-0.9}$	$14.29^{+0.94}_{-1.95}$	$3.67^{+0.12}_{-0.69}$	$0.59^{+0.03}_{-0.00}$	$147.9^{+1.4}_{-2.1}$	178	−1275	−106508
NGC 6362	5.2	$17.3^{+21.3}_{-25.4}$	$123.7^{+11.9}_{-5.7}$	$159.8^{+10.4}_{-4.9}$	$5.35^{+0.65}_{-0.02}$	$2.46^{+0.40}_{-0.11}$	$0.37^{+0.04}_{-0.04}$	$45.0^{+1.2}_{-4.3}$	70	583	−153468
Liller 1	0.8	$107.0^{+15.2}_{-50.5}$	$-56.0^{+65.6}_{-22.3}$	$123.3^{+13.8}_{-41.2}$	$0.83^{+0.18}_{-0.07}$	$0.09^{+0.07}_{-0.08}$	$0.81^{+0.15}_{-0.08}$	$155.4^{+22.7}_{-61.4}$	8	−42	−261395
NGC 6380	3.1	$-62.0^{+14.2}_{-13.9}$	$-34.6^{+14.1}_{-11.1}$	$72.4^{+16.3}_{-17.3}$	$3.40^{+0.40}_{-0.24}$	$0.21^{+0.14}_{-0.05}$	$0.88^{+0.03}_{-0.06}$	$168.1^{+2.7}_{-14.1}$	40	−105	−194646
Terzan 1	1.6	$-73.0^{+0.4}_{-10.3}$	$62.6^{+19.5}_{-9.8}$	$96.3^{+16.4}_{-0.9}$	$1.75^{+0.19}_{-0.55}$	$0.21^{+0.08}_{-0.08}$	$0.79^{+0.03}_{-0.07}$	$11.1^{+10.5}_{-5.2}$	22	102	−224803
Pismis 26	1.4	$-112.2^{+66.2}_{-27.0}$	$204.2^{+17.9}_{-10.9}$	$307.3^{+7.1}_{-10.7}$	$3.16^{+0.32}_{-0.28}$	$0.90^{+0.48}_{-0.20}$	$0.56^{+0.06}_{-0.15}$	$40.8^{+1.6}_{-1.6}$	44	271	−186876
NGC 6388	3.0	$-66.1^{+4.6}_{-29.6}$	$-93.8^{+24.4}_{-7.7}$	$115.8^{+7.8}_{-0.4}$	$3.49^{+0.15}_{-0.31}$	$0.65^{+0.14}_{-0.23}$	$0.69^{+0.09}_{-0.06}$	$148.1^{+3.2}_{-13.5}$	46	−257	−190150
NGC 6402	4.0	$-20.5^{+20.6}_{-7.6}$	$48.2^{+10.5}_{-5.6}$	$57.1^{+9.8}_{-5.8}$	$4.77^{+0.37}_{-0.12}$	$0.29^{+0.17}_{-0.02}$	$0.88^{+0.02}_{-0.06}$	$46.9^{+2.7}_{-6.8}$	52	158	−176457
NGC 6401	2.5	$-30.2^{+29.7}_{-20.7}$	$-254.1^{+1.6}_{-3.1}$	$302.2^{+3.9}_{-5.4}$	$4.54^{+0.73}_{-0.80}$	$2.37^{+0.48}_{-0.56}$	$0.31^{+0.04}_{-0.02}$	$143.4^{+1.7}_{-1.0}$	62	−595	−161761
NGC 6397	6.3	$35.2^{+8.2}_{-2.3}$	$127.1^{+3.5}_{-6.5}$	$178.8^{+3.1}_{-5.1}$	$6.55^{+0.23}_{-0.12}$	$2.78^{+0.06}_{-0.17}$	$0.40^{+0.03}_{-0.00}$	$43.0^{+2.5}_{-2.4}$	86	796	−144538
Pal 6	2.5	$-191.2^{+1.3}_{-2.8}$	$20.6^{+5.8}_{-23.2}$	$245.5^{+8.5}_{-2.3}$	$4.55^{+0.91}_{-0.15}$	$0.13^{+0.00}_{-0.08}$	$0.94^{+0.04}_{-0.00}$	$83.0^{+8.0}_{-1.8}$	44	52	−179351
NGC 6426	14.3	$-112.3^{+38.1}_{-13.8}$	$93.1^{+3.9}_{-17.4}$	$148.1^{+8.2}_{-32.6}$	$16.56^{+1.31}_{-1.30}$	$3.22^{+0.35}_{-0.64}$	$0.67^{+0.06}_{-0.02}$	$27.2^{+8.1}_{-7.0}$	202	1216	−100666
Djorg 1	1.2	$-251.7^{+32.1}_{-45.6}$	$314.9^{+30.0}_{-53.9}$	$404.1^{+11.1}_{-13.2}$	$5.95^{+1.86}_{-0.91}$	$0.83^{+0.14}_{-0.11}$	$0.76^{+0.03}_{-0.02}$	$21.5^{+3.8}_{-5.7}$	66	351	−161437
Terzan 5	1.5	$84.2^{+10.5}_{-8.3}$	$69.8^{+15.6}_{-3.6}$	$113.7^{+16.4}_{-7.1}$	$1.66^{+0.44}_{-0.19}$	$0.22^{+0.10}_{-0.02}$	$0.77^{+0.02}_{-0.07}$	$32.7^{+1.5}_{-6.0}$	20	104	−226313
NGC 6440	1.3	$90.6^{+7.7}_{-33.2}$	$-42.4^{+34.6}_{-41.3}$	$107.4^{+5.1}_{-6.2}$	$1.41^{+0.38}_{-0.00}$	$0.17^{+0.14}_{-0.11}$	$0.78^{+0.14}_{-0.09}$	$115.8^{+25.1}_{-21.3}$	14	−49	−231796
NGC 6441	3.6	$15.7^{+17.5}_{-6.6}$	$66.3^{+25.0}_{-11.7}$	$71.3^{+27.3}_{-11.1}$	$3.61^{+0.99}_{-0.67}$	$0.75^{+0.33}_{-0.18}$	$0.66^{+0.05}_{-0.08}$	$20.9^{+3.4}_{-2.9}$	42	228	−186312
Terzan 6	1.5	$-137.6^{+4.5}_{-1.0}$	$-50.8^{+5.1}_{-22.2}$	$152.7^{+7.0}_{-2.6}$	$1.99^{+0.36}_{-0.66}$	$0.14^{+0.13}_{-0.04}$	$0.87^{+0.00}_{-0.10}$	$156.6^{+7.4}_{-2.3}$	22	−77	−220185
NGC 6453	3.4	$-105.4^{+13.4}_{-5.0}$	$38.4^{+31.4}_{-20.0}$	$194.5^{+15.4}_{-11.6}$	$3.88^{+0.67}_{-1.02}$	$0.94^{+0.28}_{-0.12}$	$0.61^{+0.06}_{-0.17}$	$78.2^{+6.2}_{-8.7}$	54	129	−172906
NGC 6496	4.0	$-36.5^{+52.2}_{-42.3}$	$320.4^{+11.9}_{-24.2}$	$328.0^{+17.3}_{-18.8}$	$9.07^{+1.25}_{-1.05}$	$3.73^{+0.46}_{-0.52}$	$0.42^{+0.07}_{-0.06}$	$31.6^{+3.0}_{-2.3}$	120	1111	−126509
Terzan 9	1.3	$-49.7^{+13.9}_{-2.0}$	$22.2^{+31.0}_{-9.0}$	$76.1^{+8.1}_{-0.7}$	$1.40^{+0.18}_{-0.47}$	$0.06^{+0.07}_{-0.01}$	$0.92^{+0.01}_{-0.14}$	$70.3^{+8.3}_{-21.6}$	16	29	−236057
Djorg 2	2.0	$160.6^{+4.8}_{-5.0}$	$155.1^{+4.3}_{-3.1}$	$227.6^{+3.5}_{-3.1}$	$3.19^{+0.49}_{-0.33}$	$0.89^{+0.21}_{-0.15}$	$0.57^{+0.02}_{-0.04}$	$11.4^{+1.2}_{-1.3}$	42	316	−192751
NGC 6517	4.0	$55.2^{+5.5}_{-20.1}$	$33.1^{+13.3}_{-13.4}$	$72.6^{+5.1}_{-11.1}$	$4.54^{+0.29}_{-0.54}$	$0.23^{+0.12}_{-0.09}$	$0.90^{+0.04}_{-0.05}$	$58.0^{+12.1}_{-10.9}$	50	127	−179281
Terzan 10	2.2	$231.2^{+12.9}_{-20.4}$	$87.0^{+43.9}_{-38.8}$	$343.4^{+18.0}_{-4.3}$	$5.94^{+2.77}_{-1.43}$	$0.68^{+0.44}_{-0.14}$	$0.79^{+0.02}_{-0.05}$	$72.3^{+7.8}_{-7.3}$	76	193	−155422
NGC 6522	0.8	$34.2^{+19.8}_{-13.9}$	$92.3^{+13.0}_{-23.9}$	$213.4^{+6.2}_{-8.5}$	$1.17^{+0.68}_{-0.28}$	$0.23^{+0.37}_{-0.17}$	$0.67^{+0.15}_{-0.15}$	$62.6^{+5.0}_{-2.5}$	16	58	−238519
NGC 6535	4.0	$92.9^{+13.9}_{-0.8}$	$-83.1^{+16.5}_{-5.1}$	$132.5^{+5.6}_{-1.3}$	$4.63^{+0.65}_{-0.03}$	$1.00^{+0.11}_{-0.17}$	$0.64^{+0.08}_{-0.01}$	$159.7^{+1.2}_{-1.4}$	56	−320	−173024
NGC 6528	0.7	$-196.6^{+161.9}_{-97.5}$	$112.5^{+0.0}_{-65.9}$	$228.8^{+1.3}_{-1.8}$	$1.04^{+1.13}_{-0.00}$	$0.26^{+0.05}_{-0.16}$	$0.60^{+0.33}_{-0.06}$	$70.0^{+3.5}_{-5.3}$	14	51	−241883
NGC 6539	3.1	$0.5^{+16.3}_{-27.6}$	$117.7^{+5.0}_{-9.7}$	$208.1^{+5.0}_{-18.0}$	$3.39^{+0.30}_{-0.09}$	$1.85^{+0.06}_{-0.18}$	$0.30^{+0.05}_{-0.01}$	$56.1^{+1.4}_{-2.4}$	56	347	−174387
NGC 6540	3.0	$12.7^{+2.2}_{-3.2}$	$147.6^{+7.3}_{-3.9}$	$158.6^{+7.0}_{-4.2}$	$3.09^{+0.45}_{-0.38}$	$1.59^{+0.29}_{-0.20}$	$0.32^{+0.02}_{-0.03}$	$22.0^{+0.5}_{-1.2}$	48	448	−187517
NGC 6544	5.3	$5.8^{+2.3}_{-1.8}$	$5.9^{+14.7}_{-22.5}$	$90.5^{+7.3}_{-6.7}$	$5.72^{+0.15}_{-0.19}$	$0.08^{+0.19}_{-0.01}$	$0.97^{+0.00}_{-0.06}$	$86.3^{+13.9}_{-9.3}$	52	31	−166630
NGC 6541	2.3	$122.9^{+34.0}_{-47.8}$	$192.5^{+21.3}_{-25.8}$	$254.3^{+3.8}_{-7.3}$	$3.79^{+0.50}_{-0.52}$	$1.26^{+0.14}_{-0.17}$	$0.50^{+0.09}_{-0.09}$	$39.7^{+5.7}_{-4.3}$	50	334	−174968
E 280-06	13.8	$30.7^{+10.7}_{-5.7}$	$16.3^{+24.9}_{-15.3}$	$90.5^{+18.7}_{-8.6}$	$14.23^{+1.60}_{-0.47}$	$0.89^{+0.93}_{-0.15}$	$0.88^{+0.03}_{-0.11}$	$77.4^{+11.6}_{-16.0}$	164	210	−109791
NGC 6553	2.4	$45.5^{+14.0}_{-6.3}$	$245.5^{+0.9}_{-3.8}$	$249.7^{+1.3}_{-2.2}$	$3.31^{+0.15}_{-0.38}$	$2.27^{+0.20}_{-0.42}$	$0.19^{+0.04}_{-0.02}$	$7.1^{+2.1}_{-1.0}$	52	588	−179839
NGC 6558	1.2	$186.9^{+54.2}_{-253.8}$	$92.6^{+31.0}_{-182.0}$	$209.2^{+1.7}_{-4.5}$	$1.73^{+0.69}_{-1.03}$	$0.28^{+0.22}_{-0.06}$	$0.72^{+0.09}_{-0.44}$	$63.0^{+29.2}_{-5.3}$	20	87	−217130
Pal 7	3.9	$-73.5^{+28.9}_{-4.5}$	$269.5^{+7.0}_{-5.3}$	$280.7^{+3.1}_{-6.4}$	$6.01^{+0.15}_{-0.66}$	$3.55^{+0.22}_{-0.28}$	$0.26^{+0.01}_{-0.04}$	$11.3^{+0.5}_{-0.7}$	86	1042	−147032
Terzan 12	3.6	$-94.3^{+5.3}_{-6.2}$	$172.5^{+9.2}_{-7.9}$	$219.3^{+7.8}_{-3.9}$	$4.42^{+0.45}_{-0.29}$	$2.23^{+0.19}_{-0.19}$	$0.33^{+0.04}_{-0.02}$	$28.5^{+2.8}_{-1.8}$	62	625	−167749
NGC 6569	2.8	$-39.7^{+4.2}_{-7.5}$	$174.1^{+16.9}_{-22.4}$	$180.3^{+16.4}_{-20.9}$	$2.97^{+1.10}_{-0.41}$	$1.85^{+0.70}_{-0.55}$	$0.23^{+0.14}_{-0.04}$	$26.4^{+16.4}_{-12.0}$	56	440	−182361
E 456-78	2.0	$70.8^{+1.1}_{-5.7}$	$198.5^{+7.3}_{-1.1}$	$252.4^{+9.2}_{-0.3}$	$2.89^{+0.47}_{-0.07}$	$1.43^{+0.38}_{-0.07}$	$0.34^{+0.02}_{-0.05}$	$33.6^{+2.2}_{-1.3}$	52	373	−186632
NGC 6584	6.8	$196.8^{+13.3}_{-29.8}$	$98.3^{+36.9}_{-29.3}$	$324.1^{+11.9}_{-28.6}$	$18.01^{+2.13}_{-2.69}$	$1.67^{+0.78}_{-0.37}$	$0.83^{+0.03}_{-0.06}$	$51.8^{+9.9}_{-8.1}$	212	556	−98089
NGC 6624	1.2	$-28.6^{+67.5}_{-15.3}$	$59.7^{+12.4}_{-39.1}$	$136.4^{+10.6}_{-9.3}$	$1.55^{+0.47}_{-0.00}$	$0.17^{+0.00}_{-0.13}$	$0.80^{+0.15}_{-0.00}$	$73.2^{+13.2}_{-9.5}$	20	37	−226410
NGC 6626	3.0	$-27.6^{+4.5}_{-3.3}$	$57.0^{+12.1}_{-10.7}$	$112.7^{+11.5}_{-6.6}$	$3.09^{+0.27}_{-0.31}$	$0.45^{+0.11}_{-0.17}$	$0.75^{+0.09}_{-0.07}$	$60.0^{+5.4}_{-4.4}$	42	169	−193067
NGC 6638	2.0	$67.8^{+4.8}_{-23.0}$	$14.0^{+17.6}_{-28.5}$	$73.9^{+4.8}_{-13.3}$	$2.38^{+0.48}_{-0.04}$	$0.04^{+0.10}_{-0.01}$	$0.96^{+0.01}_{-0.07}$	$79.5^{+21.9}_{-15.3}$	20	22	−212068
NGC 6637	1.6	$34.8^{+34.6}_{-11.8}$	$91.0^{+16.7}_{-30.6}$	$129.0^{+16.8}_{-7.0}$	$2.38^{+0.19}_{-0.39}$	$0.08^{+0.50}_{-0.06}$	$0.93^{+0.04}_{-0.34}$	$76.6^{+3.3}_{-7.7}$	22	40	−212500
NGC 6642	1.7	$111.8^{+7.1}_{-11.2}$	$25.1^{+9.2}_{-40.8}$	$124.9^{+8.1}_{-10.4}$	$2.22^{+0.18}_{-0.00}$	$0.07^{+0.04}_{-0.04}$	$0.94^{+0.03}_{-0.03}$	$45.8^{+69.3}_{-2.9}$	24	36	−215457
NGC 6652	2.5	$-53.8^{+4.6}_{-6.1}$	$27.9^{+22.4}_{-20.4}$	$185.9^{+6.7}_{-10.5}$	$4.17^{+0.48}_{-0.30}$	$0.10^{+0.11}_{-0.05}$	$0.95^{+0.03}_{-0.04}$	$76.1^{+10.3}_{-8.8}$	38	42	−183595

Table 4 - continued

Name	d_{GC} [kpc]	Π [km s^{-1}]	Θ [km s^{-1}]	V_{tot} [km s^{-1}]	apo [kpc]	peri [kpc]	ecc	incl. θ [deg]	T_r [Myr]	L_Z [kpc km s^{-1}]	E [km^2 s^{-2}]
NGC 6656	5.2	$175.8^{+1.0}_{-3.8}$	$200.7^{+3.3}_{-2.2}$	$302.7^{+6.1}_{-4.0}$	$9.83^{+0.48}_{-0.56}$	$3.06^{+0.17}_{-0.17}$	$0.53^{+0.00}_{-0.01}$	$33.0^{+2.5}_{-1.6}$	126	1044	−125471
Pal 8	5.3	$-20.8^{+17.8}_{-12.4}$	$116.6^{+22.2}_{-20.5}$	$122.1^{+23.6}_{-21.3}$	$5.57^{+0.82}_{-0.59}$	$1.79^{+0.74}_{-0.38}$	$0.51^{+0.07}_{-0.10}$	$23.0^{+3.3}_{-3.8}$	72	593	−160020
NGC 6681	2.0	$220.8^{+47.2}_{-168.3}$	$55.4^{+116.0}_{-46.5}$	$287.5^{+6.1}_{-5.1}$	$4.48^{+0.25}_{-0.40}$	$0.66^{+0.35}_{-0.21}$	$0.74^{+0.08}_{-0.13}$	$83.8^{+4.7}_{-6.2}$	52	36	−167768
NGC 6712	3.6	$145.8^{+4.5}_{-7.9}$	$25.8^{+10.3}_{-23.7}$	$208.2^{+8.8}_{-11.9}$	$5.46^{+0.13}_{-0.31}$	$0.18^{+0.07}_{-0.11}$	$0.94^{+0.03}_{-0.03}$	$78.5^{+11.2}_{-5.0}$	56	93	−168544
NGC 6715	18.6	$232.4^{+8.8}_{-2.5}$	$48.7^{+13.9}_{-15.0}$	$316.9^{+9.1}_{-10.1}$	$56.40^{+7.61}_{-16.26}$	$14.84^{+0.67}_{-2.45}$	$0.58^{+0.04}_{-0.06}$	$80.7^{+3.0}_{-2.5}$	906	850	−48159
NGC 6717	2.5	$-9.5^{+26.4}_{-0.7}$	$116.2^{+8.5}_{-6.4}$	$119.2^{+9.1}_{-6.0}$	$2.82^{+0.12}_{-0.44}$	$0.72^{+0.14}_{-0.16}$	$0.59^{+0.06}_{-0.08}$	$32.4^{+4.8}_{-0.9}$	36	251	−195762
NGC 6723	2.6	$100.1^{+30.5}_{-175.0}$	$-178.3^{+383.5}_{-0.0}$	$207.9^{+6.4}_{-5.6}$	$3.13^{+0.25}_{-0.12}$	$1.84^{+0.20}_{-0.16}$	$0.26^{+0.05}_{-0.04}$	$90.2^{+7.6}_{-9.2}$	40	−2	−175356
NGC 6749	5.0	$-22.9^{+22.9}_{-7.7}$	$110.1^{+8.2}_{-11.5}$	$112.5^{+6.9}_{-10.4}$	$5.08^{+0.10}_{-0.46}$	$1.55^{+0.15}_{-0.29}$	$0.53^{+0.05}_{-0.04}$	$3.3^{+0.9}_{-0.1}$	62	556	−167068
NGC 6752	5.5	$-23.5^{+5.7}_{-2.1}$	$179.2^{+2.4}_{-6.8}$	$190.2^{+2.3}_{-6.9}$	$5.67^{+0.35}_{-0.18}$	$3.57^{+0.22}_{-0.22}$	$0.23^{+0.02}_{-0.01}$	$23.7^{+1.1}_{-1.2}$	82	931	−147164
NGC 6760	5.0	$92.2^{+12.5}_{-12.9}$	$146.7^{+1.2}_{-14.8}$	$173.9^{+3.4}_{-13.9}$	$5.57^{+0.06}_{-0.43}$	$2.16^{+0.00}_{-0.35}$	$0.44^{+0.06}_{-0.01}$	$6.1^{+0.9}_{-0.1}$	72	724	−158732
NGC 6779	9.3	$154.8^{+2.2}_{-3.2}$	$-14.7^{+3.6}_{-3.2}$	$184.6^{+5.9}_{-3.8}$	$12.43^{+0.58}_{-0.24}$	$0.26^{+0.13}_{-0.10}$	$0.96^{+0.01}_{-0.02}$	$100.9^{+1.7}_{-2.6}$	134	−135	−119696
Terzan 7	15.3	$260.0^{+3.8}_{-8.1}$	$25.5^{+21.8}_{-16.2}$	$320.0^{+8.1}_{-13.8}$	$42.89^{+6.33}_{-5.89}$	$12.78^{+1.18}_{-0.96}$	$0.54^{+0.04}_{-0.05}$	$85.7^{+2.7}_{-4.0}$	668	335	−56545
Pal 10	6.6	$-56.4^{+22.8}_{-3.7}$	$186.0^{+18.4}_{-6.0}$	$195.5^{+16.7}_{-8.8}$	$7.05^{+0.17}_{-0.45}$	$4.02^{+0.74}_{-0.30}$	$0.27^{+0.02}_{-0.07}$	$7.6^{+0.5}_{-0.7}$	100	1234	−138495
Arp 2	21.2	$242.8^{+7.0}_{-6.5}$	$67.6^{+8.9}_{-15.1}$	$310.6^{+15.5}_{-14.5}$	$65.12^{+20.28}_{-13.15}$	$17.78^{+1.23}_{-1.04}$	$0.57^{+0.07}_{-0.06}$	$77.9^{+2.5}_{-1.1}$	1094	1256	−43628
NGC 6809	4.1	$-198.9^{+5.2}_{-1.6}$	$76.3^{+17.5}_{-6.4}$	$220.1^{+4.2}_{-2.6}$	$5.74^{+0.27}_{-0.32}$	$1.19^{+0.27}_{-0.01}$	$0.66^{+0.00}_{-0.07}$	$67.3^{+2.9}_{-3.9}$	76	266	−154417
Terzan 8	19.1	$268.7^{+9.9}_{-4.2}$	$37.3^{+16.5}_{-11.0}$	$315.4^{+12.3}_{-5.8}$	$58.54^{+13.79}_{-8.09}$	$16.04^{+1.17}_{-1.06}$	$0.57^{+0.05}_{-0.03}$	$83.9^{+1.8}_{-2.1}$	958	584	−46785
Pal 11	8.1	$-15.9^{+17.0}_{-22.6}$	$138.6^{+6.6}_{-19.9}$	$139.7^{+8.0}_{-17.3}$	$8.16^{+0.31}_{-0.70}$	$3.47^{+0.21}_{-0.80}$	$0.40^{+0.09}_{-0.03}$	$26.6^{+3.8}_{-1.3}$	108	1013	−132057
NGC 6838	7.0	$39.1^{+11.2}_{-9.3}$	$204.3^{+3.0}_{-4.4}$	$211.7^{+1.9}_{-2.2}$	$7.26^{+0.27}_{-0.36}$	$5.00^{+0.13}_{-0.26}$	$0.18^{+0.04}_{-0.02}$	$11.6^{+1.3}_{-0.9}$	112	1423	−132307
NGC 6864	14.6	$-98.7^{+9.2}_{-15.1}$	$18.3^{+17.9}_{-11.4}$	$111.3^{+16.0}_{-7.3}$	$16.41^{+1.30}_{-0.40}$	$0.52^{+0.75}_{-0.30}$	$0.94^{+0.03}_{-0.08}$	$61.3^{+14.2}_{-15.2}$	186	209	−103615
NGC 6934	12.7	$-288.8^{+16.9}_{-16.4}$	$103.1^{+21.6}_{-13.1}$	$330.0^{+15.2}_{-10.1}$	$40.86^{+4.85}_{-5.19}$	$2.52^{+0.62}_{-0.45}$	$0.88^{+0.03}_{-0.03}$	$23.4^{+5.5}_{-1.7}$	520	1204	−63341
NGC 6981	12.8	$-154.5^{+28.3}_{-12.3}$	$-4.0^{+8.5}_{-13.1}$	$230.0^{+7.8}_{-18.0}$	$22.25^{+1.10}_{-2.63}$	$0.36^{+0.15}_{-0.19}$	$0.97^{+0.01}_{-0.02}$	$107.8^{+14.0}_{-31.5}$	252	−35	−89722
NGC 7006	38.5	$-140.4^{+4.6}_{-10.3}$	$-32.5^{+11.8}_{-20.5}$	$167.9^{+13.2}_{-5.5}$	$56.30^{+7.87}_{-3.51}$	$2.90^{+2.34}_{-0.98}$	$0.90^{+0.03}_{-0.06}$	$132.9^{+18.6}_{-13.2}$	760	−1170	−52073
NGC 7078	10.6	$8.2^{+6.8}_{-8.1}$	$118.3^{+6.8}_{-7.7}$	$121.6^{+7.1}_{-7.8}$	$10.64^{+0.07}_{-0.66}$	$3.55^{+0.18}_{-0.38}$	$0.50^{+0.03}_{-0.03}$	$28.3^{+2.2}_{-1.5}$	140	1119	−119947
NGC 7089	10.4	$170.0^{+7.2}_{-8.1}$	$-18.5^{+10.7}_{-7.9}$	$243.0^{+9.5}_{-11.9}$	$18.81^{+1.33}_{-1.22}$	$0.59^{+0.00}_{-0.37}$	$0.94^{+0.04}_{-0.00}$	$118.8^{+6.8}_{-18.9}$	214	−147	−97640
NGC 7099	7.2	$-32.3^{+14.9}_{-13.2}$	$-55.5^{+6.6}_{-22.4}$	$126.2^{+14.6}_{-5.8}$	$8.19^{+0.59}_{-0.39}$	$0.99^{+0.53}_{-0.00}$	$0.78^{+0.00}_{-0.08}$	$119.0^{+5.7}_{-4.2}$	94	−234	−137480
Pal 12	15.7	$145.9^{+27.4}_{-39.5}$	$304.2^{+21.1}_{-32.9}$	$356.3^{+21.7}_{-33.7}$	$72.03^{+27.89}_{-30.24}$	$15.49^{+0.16}_{-1.03}$	$0.65^{+0.08}_{-0.15}$	$67.4^{+0.6}_{-2.6}$	1178	2142	−41826
Pal 13	27.0	$267.8^{+14.8}_{-8.3}$	$-77.6^{+14.0}_{-19.7}$	$289.4^{+15.5}_{-8.4}$	$87.09^{+19.82}_{-9.52}$	$8.26^{+2.36}_{-0.99}$	$0.83^{+0.01}_{-0.02}$	$114.9^{+3.5}_{-5.1}$	1346	−1586	−38661
NGC 7492	25.4	$-86.7^{+13.4}_{-18.8}$	$-12.6^{+3.5}_{-9.2}$	$108.2^{+15.8}_{-11.1}$	$28.15^{+2.46}_{-1.68}$	$3.14^{+1.86}_{-0.97}$	$0.80^{+0.05}_{-0.08}$	$94.7^{+3.0}_{-1.6}$	350	−120	−77041

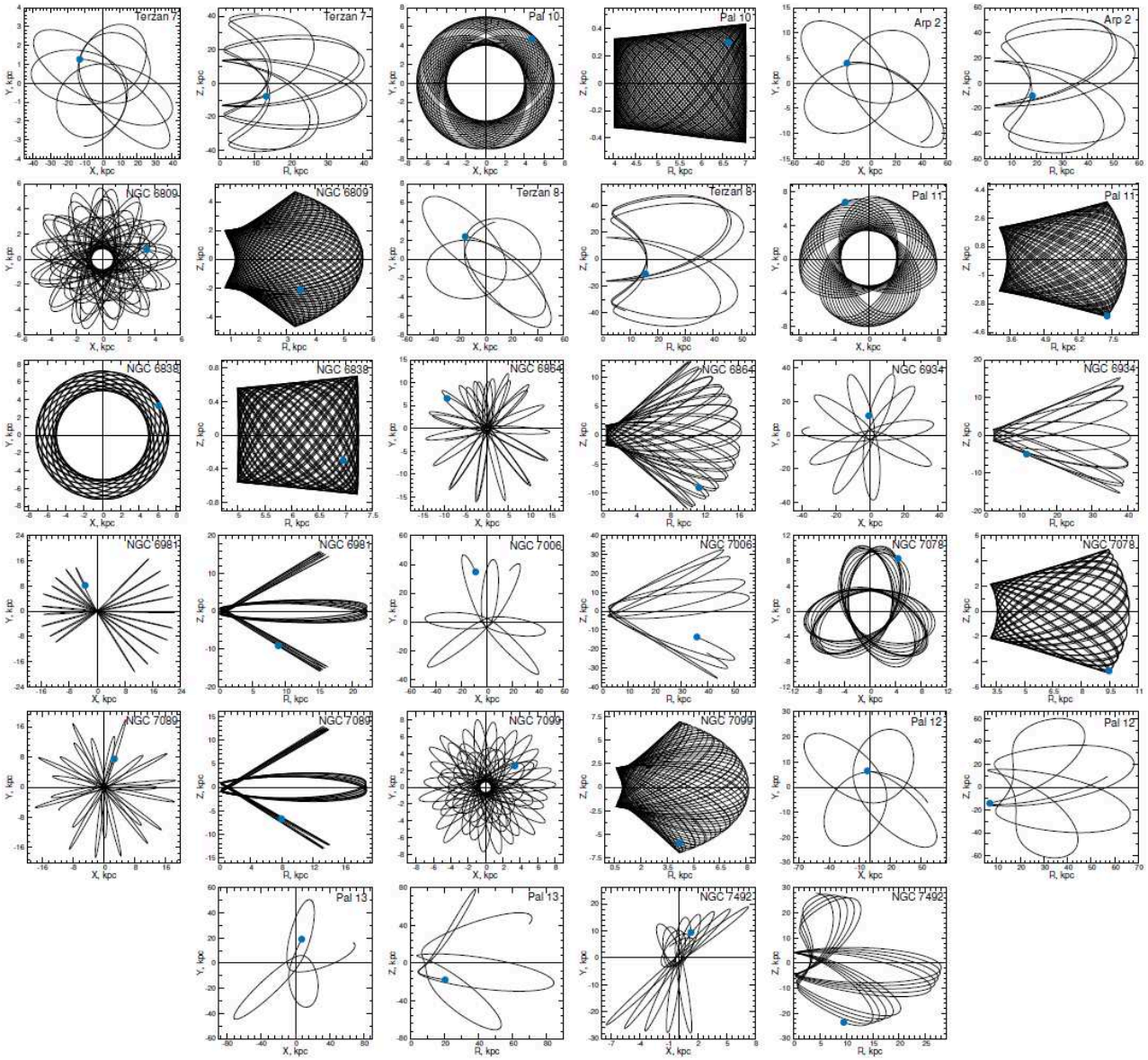

Figure 2 - continued

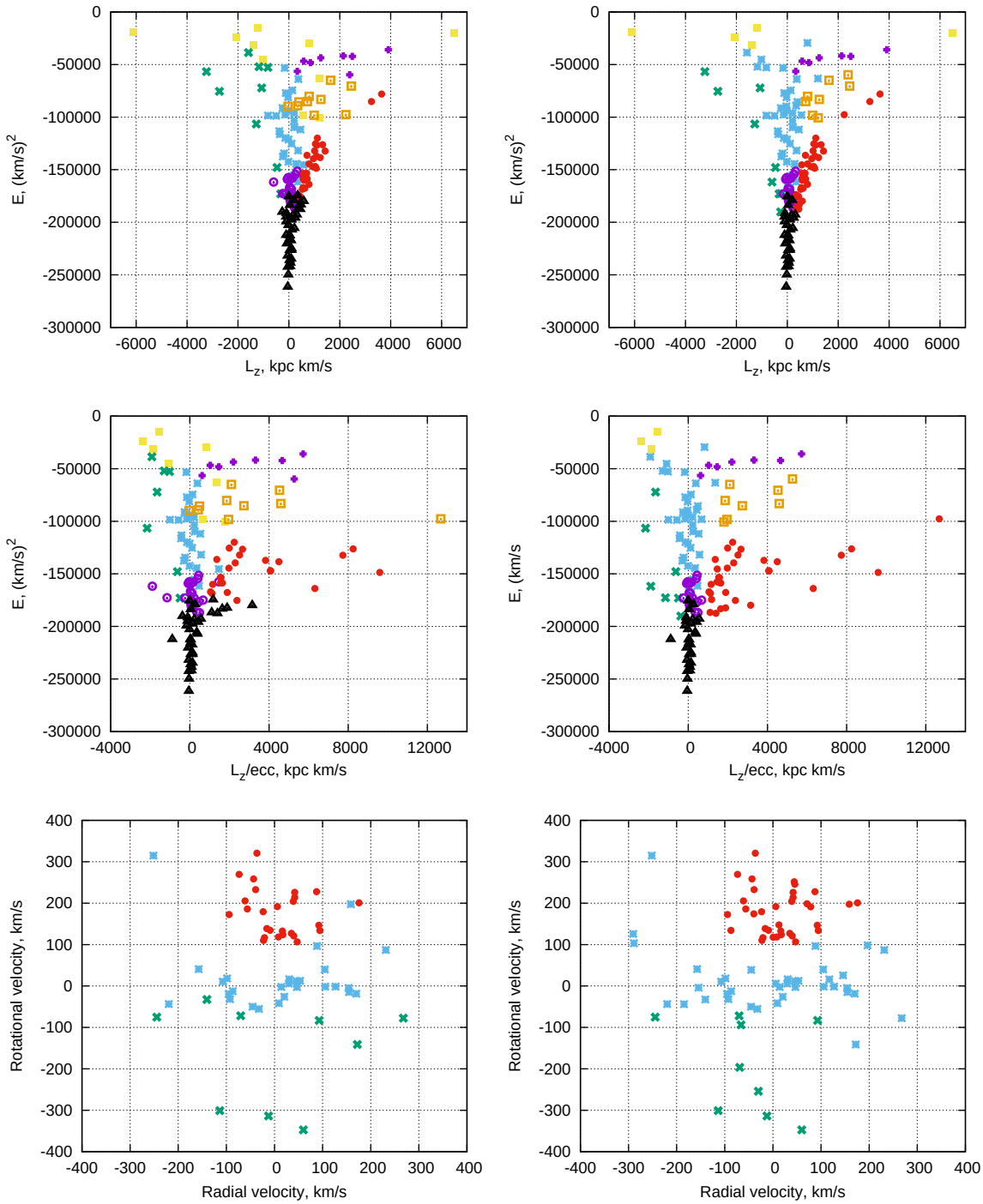

Figure 3. The "L_Z – Energy" (top panel), "L_Z/ecc – Energy" (middle panel) and "Radial velocity – Rotational velocity" (bottom panel) diagrams for GCs. Classification by Massari et al. (2019) (left-hand panels); the modified classification (right-hand panels). Colour-coded according to their belonging to different subsystems (red symbols mark the disk, black is for the bulge, blue is for Gaia-Enceladus (Gaia-Sausage), orange for Helmi Streams, green for Sequoia, violet crosses for Sagittarius, yellow for the high-energy group, violet circles for the low-energy group. For visualisation purposes, clusters E 1 with extremely negative L_Z has not been plotted.