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Preliminary report

A GALAXY STUDY BY USING THE LINE-DENSITY METHOD

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SUMMARY: The authors calcualte the line (number) density for various cases of spatial distribution concerning the galactic matter. They find that this projecting on the galactic rotation axis can offer an important contribution to achieving a good ramification of galactic subsystems.

1. INTRODUCTION

To study the spatial distribution within a stellar system is the prime task of stellar astronomy. For this purpose, in addition to the volume, number or mass, density, one also introduces the surface and line densities. The latter one for understandable reasons has been rarely used. An example can be found in the paper by Kuzmin and Veltmann (1972). On the other hand there is the question of the subsystems in the Milky Way. It concerns the limits, say, between disc and halo. For example the metal-rich globular clusters have been identified with the galactic disc (e. g. Zinn, 1985). However, there are also alternative views (e. g. Ninković, 1985). By calculating the line number density in projection on the galactic rotation axis Nagl (2000) has demonstrated the clear difference in the spatial distribution between the metal-rich globular clusters and open clusters of the Milky Way. Therefore, in the present paper the approach using the line density will be presented in more details, as well as its application to the Milky Way where this notion will be referred to the projecting on the Milky-Way axis of symmetry (rotation).

2. THEORETICAL BASE

The line mass density - λ_z - is defined as

$$\lambda_z = 2\pi \int \rho(R, |z|) R dR \ , \qquad (1)$$

where $\rho(R, |z|)$ is the corresponding volume density. The formula is given for the case of axial symmetry as the most interesting. For this reason the projecting is done on the axis z - that of symmetry, resp. rotation. The integral is taken over the entire R space. It is clear that, if necessary, the mass densities in the upper formula can be replaced by the corresponding number ones - n_z and n.

There are, of course, two ways in using the line density: to find it empirically or to calculate it on the basis of a given volume density. The intention of the present authors, as already said, is to use the line density in studying the structure of the Milky Way. In their opinion this approach could result in a clearer ramification of the Milky-Way subsystems.

3. RESULTS

In this paper we shall verify some well known density formulae. Due to its simplicity the generalised Schuster density formula (particular form as in Ninković, 1998) has been frequently used in fitting the observational data for the case of spheroidal equidensit surfaces. In such a case one can easily obtain an analytic formula for the line density:

$$\lambda_z = 2\pi\rho(0)q_c^2 Q^{2-i} I \ ,$$

$$I = \int \frac{\eta d\eta}{(1+\eta^2)^{i/2}} \ , \ \eta = \frac{R}{Q q_c}$$

$$Q = (1 + \frac{z^2}{\epsilon^2 q_c^2})^{1/2} \ . \qquad (2)$$

The designations are: ϵ – the axial ratio (generally we consider oblate spheroids so that ϵ is less or equal to 1), q_c – the scale length and i – an integer (not negative, for details Ninković, 1998). The integral I is, as usually, taken over the entire system. Using (2) we can study the dependence on axial ratio for a given value of i.

In addition to the generalised Schuster density formula we also consider two cases of separable formulae

$$\rho(R, |z|) = \rho(0)\exp(-R/A)\exp(-|z|/h) \ ; \qquad (3)$$

$$\rho(R, |z|) = \rho(0)\exp(-R/A_1)[ch(z/h_1)]^{-2} \ . \qquad (4)$$

Clearly A, A_1, h and h_1 are the scale lengths. The first formula appears as the most simple interpretation of the so-called exponential disc (e. g. Freeman, 1970), whereas the second one has been used for the same purpose as somewhat more sofisticated (e. g. Casertano, 1983). The deduction of the expressions for the line density in these cases is self-evident and therefore they are not given here. Since the subject is the exponential discs, which are not truncated, the upper limit of the integral in Eq. (1) is infinity. As in the previous case we use this set of formulae for the purpose of studying the dependence of the line-density behaviour on the scale-length ratios (h/A, etc).

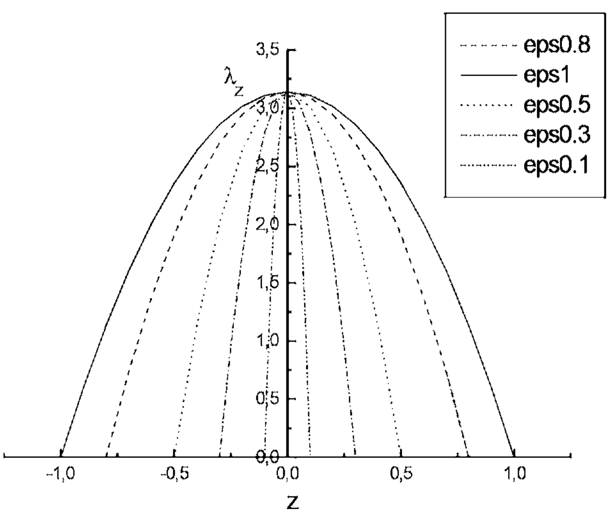

Fig. 1. *A line-density plot for the case of generalised Schuster density law (Eq. (2), $i = 0$); eps is the axial ratio, the units are $\pi\rho(0)a^2$ for λ_z and a for z, a is the limiting semimajor axis of the system (note that for the homogeneous spheroid the system volume is finite).*

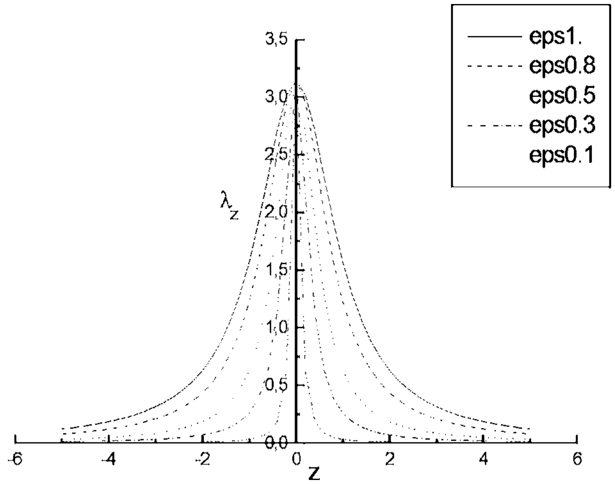

Fig. 2. *A line-density plot for the case of generalised Schuster density law (Eq. (2), $i = 4$); eps is the axial ratio, the units are $\pi\rho(0)q_c^2$ for λ_z and q_c for z.*

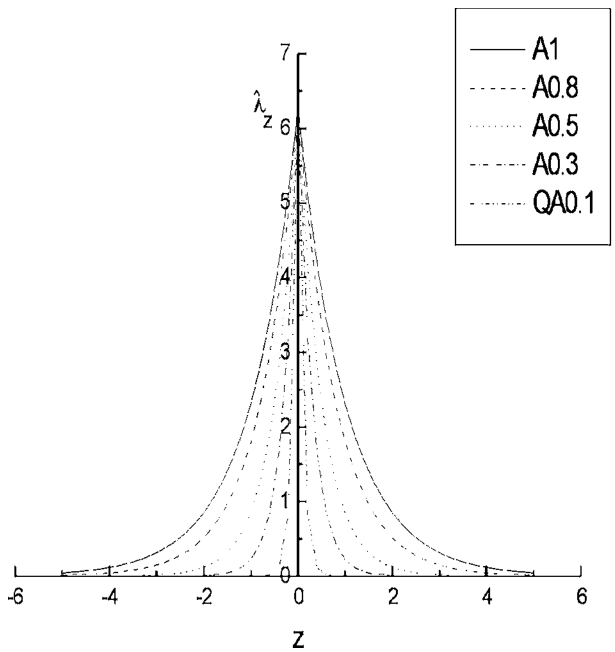

Fig. 3. *A line-density plot for the case of simple exponential density law (Eq. (3)); the units are $2\pi\rho(0)A^2$ for λ_z and A for z.*

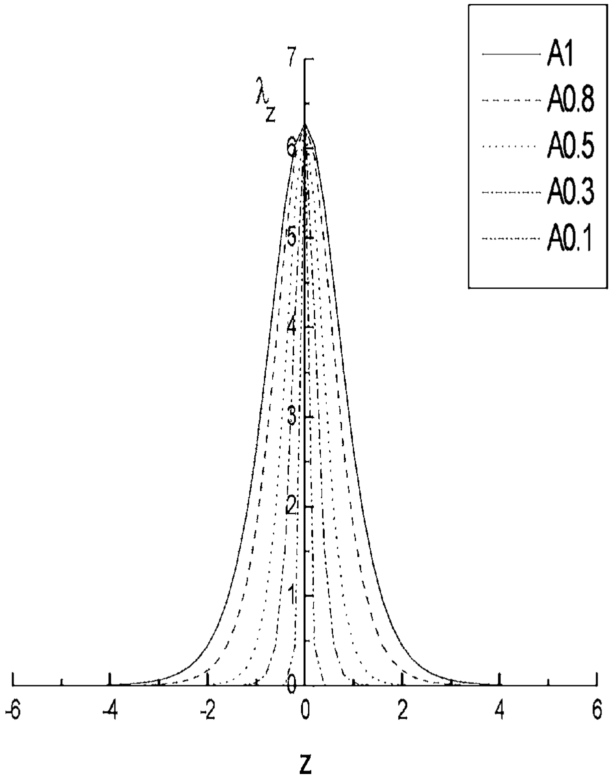

Fig. 4. *A line-density plot for the case of alternative exponential density law (Eq. (4)); the units are* $2\pi\rho(0)A_1^2$ *for* λ_z *and* A_1 *for* z.

The results of our calculations are presented in the figures. Fig. 1 illustrates the situation for the homogeneous sphere ($i = 0$, Eq. (2)). The authors are fully aware that this case is hardly realistic and the purpose of its including is to make the presentation more illustrative only. Figure 2 also concerns Eq. (2), but the particular case is $i = 4$. This case is much more realistic (for more details Ninković, 1998). Finally Figs. 3 and 4 treat the two exponential distributions (Eqs. 3 and 4), respectively. As clearly seen, the line mass distribution (in projection on the symmetry axis) closely resembles the Dirac delta-function in all cases corresponding to very flattened systems. In particular, those are cases when the axial ratio (Figs. 1 and 2), resp. the ratios h/A and h_1/A_1 become less than 0.1.

4. DISCUSSION AND CONCLUSIONS

The cases presented in the Figures can be compared to the situations in which real objects of, say, the Milky Way, are counted and their distribution in projection on the main axis of this galaxy is studied. In this connexion one should say that the assigning of galactic objects to a given subsystem is not simple (e. g. Marochnik and Suchkov 1984 - ch. 1-3). In view of this our proposal is to use the line-density plots for the purpose of resolving this problem. It is clear that such an approach is possible if one treats a group of kindred objects only, i. e. it is not applicable to individual ones. A nice example can be found in Nagl's (2000) paper where the empirical line-density plots are given for the case of globular, resp. open, star clusters. In those cases when the line-density plot closely resembles the Dirac delta-function we assign the group of objects under study to the galactic disc. If the given plot indicates a weaker concentration towards the galactic plane as in Figs. 1-4 for higher axial ratios, i. e. ones of the scale parameters (h/A, ...), then the group is assigned to the galactic halo.

It should be pointed out that in principle the resolving whether a galactic object is to be assigned to the halo or to the disc can be followed with many difficulties. Therefore, our standpoint is that the first thing in making distinction between these two subsystems is the spatial distribution, i. e. kinematics (if studied individually), not the physical characteristics, since an overlaping in the, say, metallicity is quite possible (e. g. Nagl, 2000). On the other hand the flattening level for the disc and halo is essentially different which is very clearly reflected in the examples presented here in Figures.

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ПРОУЧАВАЊЕ ГАЛАКСИЈЕ УЗ КОРИШЋЕЊЕ МЕТОДА ЛИНИЈСКЕ ГУСТИНЕ

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Претходно саопштење

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