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TREATING SURFACE BRIGHTNESS PROFILES IN THE FIELDS OF GLOBULAR CLUSTERS

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Abstract. A discussion concerning the relationship between the surface brightness and surface mass density in the fields of globular clusters is given. It si found that a surface brightness profile obeying the King formula should be only slightly corrected to yield the profile of the surface mass density.

1. INTRODUCTION

Globular clusters are usually treated by applying King's model (e. g. King 1962) . However, this formula offers no analytical expression for the potential of a cluster. Therefore, the present authors have examined another formula describing the mass distribution within a globular cluster (Ninković and Valjarević 2007). On the other hand, the observable in the field of a globular cluster is its surface brightness, not the surface density. These two quantities may be proportional to each other, but as will be shown below the necessary prerequisite is to have a constant mean mass of a star, i. e. the constant mean apparent magnitude. The problem is that within a globular cluster we expect the mass segregation to take place. This phenomenon has a consequence that stars of higher masses tend to be concentrated closer to the cluster centre and vice versa. Unfortunately, masses of stars cannot be measured directly. The only way is to estimate them using their brightness. Fortunately, all stars of a globular cluster have the same distance modulus so that their apparent magnitudes are just the absolute ones shifted by the value of the distance modulus constant for the cluster as a whole. Also, since the chemical composition is practically the same, its influence on the mass-luminosity relation is constant for all stars.

2. SURFACE DENSITY AND SURFACE BRIGHTNESS PROFILES WITHIN A GLOBULAR CLUSTER

The second problem to be addressed here is the ratio of the surface brightness and the surface density. This will be explained by using the following equations .

The integrated brightness of a globular cluster is given

$$m_{int} = 2\pi \int I'(r')r'dr'$$

Here the spherical symmetry is also assumed, r' is the distance to the cluster centre in projection onto the tangential plane; I' is the surface brightness which is here expressed in terms of the solar flux, contrary to the widely used practice to give it in magnitudes per unit of solid angle (square arc minute) The reason is that for the purpose of the present work the use of magnitudes introduces some difficulties. The magnitude is not an additive quantity, unlike the flux which possesses the property of being additive.

The surface brightness I' is given as a product, $I'=n'E_m$, where n' is the surface number density and E_m the mean flux of a star; both are functions of ' as I'. However, the surface number density can be expressed as the quotient of the surface (mass) density and the mean mass of a star. By equating these two ratios one easily reaches the following formula

$$S=(m_m/E_m)\ I' . \tag{1}$$

The designations used are: S – surface density, m_m mean mass, the others already defined above. This formula is very important since it enables us to convert the dependence I' (r') found observationally into S(r') which is more important in theoretical studies. For the purpose of carrying out this conversion one should know the two mean values – the mean mass and the mean flux. If there were no mass segregation, these two quantities would be constant (independent of r'). It is clear that the brightness of a cluster star depends on its mass. This is the well-known mass-luminosity relation. This relation is affected by the chemical composition of stars and the luminosity class. It is most reliable for stars of the Main Sequence. Due to this the mass segregation causes the mean mass of a star to be variable, more precisely to have a gradient.

As a consequence the mean brightness of a star will also have a gradient. The mean brightness can be estimated from the distribution of apparent magnitudes of cluster stars over the solid angle occupied by the cluster.

3. PROCEDURE

For the beginning the present authors have undertaken a number of simulations where hypothetical globular clusters are used. As the input data we use the total mass of the cluster, its age and chemical composition and the distribution of initial masses of stars . The age and chemical composition contribute to establish the distribution of the actual masses of stars, as well as that of their luminosities, i. e. fluxes if an assumed distance modulus is applied. The distributions of actual masses and fluxes yield the gradient of the mean mass and mean flux. Finally by applying formula (1) we convert a given profile of surface brightness into the corresponding profile of surface density. In our simulations we assume that the dependence of the surface brightness on the radius r' follows the King formula (King 1962). As said above, in the absence of the mass segregation the dependences on r' of both the surface density and surface brightness would be identical.

However, since the mass segregation is taken into account in our simulations, these two profiles will not be identical. Under the conditions of the present simulations one finds that the King profile requires *an insignificant correction only* to reflect the surface density profile obtained here.

4. COMMENTS ON THE MASS DISTRIBUTION

In principle a given surface density offers possibility to determine the corresponding volume one. This is the mass distribution within a cluster. Our intention is to study in details some constraints concerning the mass distribution. We have carried out some simulations where we used a formula giving the gravitational potential of a globular cluster proposed earlier by one of us. This formula also yields a density (via Poisson equation) which vanishes at a finite distance to the cluster centre (Ninković 2003) .

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References

King, I.: 1962, *Astron. J.,* **67**, 471.
Ninković, S.: 2003, *Serb. Astron. J.*, **166**, 39.
Ninković, S. and Valjarević, A.: 2007, *Serb. Astron. J.*, **174**, 43.