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A new model for dark halo of spherical galaxies

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A new family of spherical models of mass distribution is suggested. It includes generalized isochrones by Kuzmin, Malasidze, Veltmann (1969, 1970) and models by An & Evans (2006) admitting various central density cusps.

Keywords: Stellar dynamics – methods: analytical – galaxies: modeling – galaxies: haloes – galaxies: structure

1 Introduction

N-body simulations are important in the study of dark matter haloes. Those simulations provide central density cusps, $\varrho \propto r^{-\gamma}$ with $\gamma \simeq 0.5 \sim 1.5$. The profile by Navarro, Frenk & White (1996) ($\gamma = 1$) is used by many authors. Unfortunately, the mass of the model is infinite and truncation of the model is an artificial procedure. Some authors use a model by Hernquist (1990) ($\gamma = 1$), that was suggested earlier by Kuzmin & Veltmann (1972). An and Evans (2006) considered models with central density cusps that generalize isochrone model by Hénon (1959) and model by Kuzmin & Veltmann (1972) discovered later by Hernquist (1990).

In this work we suggest a two-parametric family of models that includes both models by An and Evans (2006) and generalized isochrones by Kuzmin & Malasidze (1969) and Kuzmin & Veltmann (1972) as special cases.

2 The two-parametric generalized isochrone spheres

Let us consider the dimensionless potential–density pair

$$\Phi(r) = \frac{\alpha}{\alpha - 1 + w(r)}, \quad w(r) = (1 + \kappa\, r^p)^{1/p}, \quad \kappa = O(\alpha^p), \tag{1}$$

$$\varrho(r) = \frac{\kappa}{\alpha} \frac{\Phi^2(r)\, r^{p-2}}{w(r)^{p-1}} \left[p + 1 - (p-1)\kappa \left(\frac{r}{w(r)} \right)^p - \frac{2\kappa}{\alpha} \frac{\Phi(r)\, r^p}{w(r)^{p-1}} \right]. \tag{2}$$

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Here $\alpha \in (1, \infty)$ and p are structural parameters. All our models with $0 < p < 2$ are cusped (as models by An and Evans are). It follows from (2).

Many well-known spherical models are special cases of our case (1) (see Table 1).

Table 1 Special cases of our model.

α	p	References
> 0	2	Kuzmin G.G., Malasidze G.A. (1969)
> 0	1	Hernquist L., a 'limiting' model (1972)
$\to \infty$	> 0	Hernquist L., a 'limiting' model (1972)
2	$(0, 2\,]$	An J. H., Evans N. W. (2006)
2	2	Hénon M. (1959)
1	> 0	Veltmann Ü.-I.K. (1979)
1	2	Plummer H.C. (1911)

The circular speed is found to be

$$v^2(r) = \frac{\kappa}{\alpha}\,\Phi^2(r)\frac{r^p}{w^{p-1}(r)}. \tag{3}$$

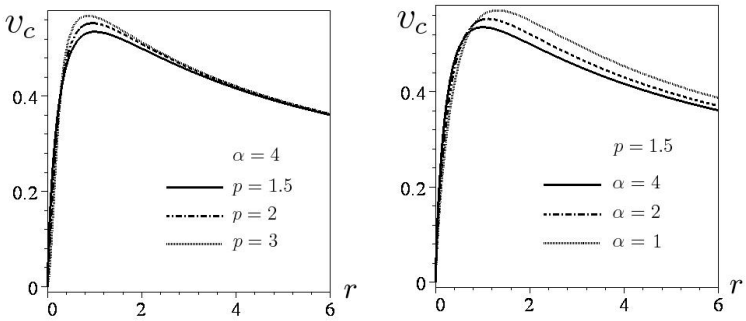


Figure 1 The circular speed of the model.

3 Discussion

It can be obtained from (1) that

$$r(\Phi) = \frac{\left[(\alpha - (\alpha - 1)\,\Phi)^p - \Phi^p\right]^{1/p}}{\alpha\Phi}. \tag{4}$$

Then it is possible to find an augmented density $\varrho(\Phi)$ and calculate an isotropic distribution function. We will not give a cumbersome expression for it. Also anisotropic distribution functions with a constant Binney's anisotropic parameter can be found. But these distribution functions are singular and non-physical. We work over constructing more plausible distribution functions.

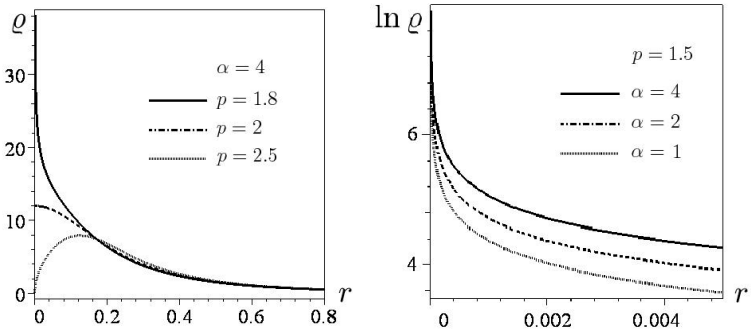


Figure 2 The density profiles of the model. The isochrone with $p = 2$ is cored, the models with $0 < p < 2$ are cusped.

Using the equipotential method (Kutuzov & Ossipkov 1981; Jiang 2000), one can construct axisymmetric generalizations of the suggested model.

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