1 - 8 Surface Density of Haloes*

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In study of dark matter density distributions, there are three types of dark matter halo distributions of galaxies and clusters of galaxies. The NFW(Navarro-Frenk-White) profile[1]

$$\rho(r)_{\rm NFW}=\frac{\rho_0}{(\frac{r}{rr_0})(1+(\frac{r}{r_{\rm s}}))^2}, \tag{1}$$

where ρ_0 and $r_{\rm s}$ are paramenters from halo to halo. The Burkert profile is

$$\rho(r)_{\rm Burkert}=\frac{\rho_0}{(\frac{1+r}{r_0})(1+(\frac{r}{r_0})^2)}, \tag{2}$$

and isothermal profile

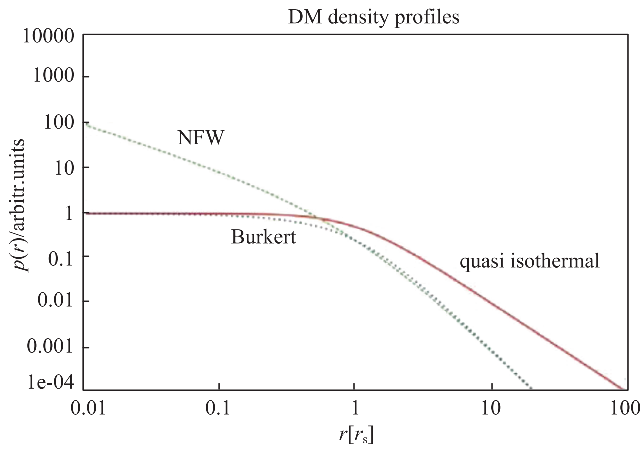

Fig. 1 (color online) show NFW profile (gree dotted line), Burkert profile(bule ditted line)and Quasi ISO profile (read full).

$$\rho(r)_{\rm ISO}=\frac{\rho_0}{(1+(\frac{r}{r_{\rm s}}))^2}, \tag{3}$$

where ρ_0, r_0 is the center density and radius of dark matter halos. The curves of (1), (2) and (3) are shown in Fig.1.

Fig.1 shows that there exist the cored density profile and cuspy problem in the Burkert profile, Quasi ISo profile and NFW profile. To overcome the cored and cuspy problems in dark matter density profile, we introduce a dark matter column density, averaged over the central part of an object[2]:

$$S=\frac{2}{r_\star^2}\int_0^{r_\star} r{\rm d}r\int {\rm d}z\rho_{\rm DM}(\sqrt{r^2+z^2}). \tag{4}$$

The intergral over z extends to the virial boundary of a dark matter halo. We can obtain from (1), (2), (3) and (4)

$$S_{\rm NFW}(R)=\frac{4\rho_{\rm s}r_{\rm s}^3}{R^2}\left[\frac{\arctan\sqrt{R^2+r_{\rm s}^2-1}}{\sqrt{R^2/r_{\rm s}^2-1}}+\log\left(\frac{R}{2r_{\rm s}}\right)\right], \tag{5}$$

$$S_{\rm Burkert}(r_{\rm s})\simeq 0.21\log\left(\frac{M_{200}}{10^{10}M_\odot}\right)+1.79, \tag{6}$$

$$S_{\rm ISO}(R)=\frac{2\pi\rho_{\rm c}r_{\rm c}^2}{R^2}[\sqrt{R^2+r_{\rm c}^2}-r_{\rm c}]. \tag{7}$$

One finds $r_{\rm s}\approx 6.1r_{\rm c}, \rho_{\rm s}\approx 0.11r_{\rm c}$. Comparing the column densities for the NFW and ISO profiles, whose parameters are related through the relation nom written, one obtains

$$\frac{S_{\rm NFW}(r_{\rm s})}{S_{\rm ISO}(6r_{\rm c})}\approx 0.91. \tag{8}$$

Similarly for the Burkert profile and the NFW profile: $r_{\rm s}\approx 1.6r_0$, $\rho_{\rm s}\approx 0.37\rho_0$ and

$$\frac{S_{\rm NFW}(r_{\rm s})}{S_{\rm burkert}(1.6r_0)}\approx 0.98. \tag{9}$$

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The diffierence between the column densities $S_{\rm NFW}, S_{\rm Burkert}$ and $s_{\rm ISO}$ turns out to be less than 10%. Then

$$\frac{S_{\rm NFW}(r_{\rm s})}{S_{\rm burkert}(1.6r_0)} \approx 0.98. \tag{10}$$

$$S_{\rm NFW}(r_{\rm s}) \approx 0.98 S_{\rm Burkert}(1.6r_0) \approx 0.91 S_{\rm ISO}(6r_{\rm c}) \approx 1.89 r_0\rho_0.$$

In Fig. 2, the thick-solid and dashed black lines represent the value of $\log\mu_0 D = 2.15 \pm 0.2$. The cireles correspond to dark matter surface densities obtained using the quoted sample and with differennt methods. The filled symbols represent the averged estimates of $\log\mu_0 D$ when a galaxy was present in more than one soure. The thin solid line represents the result of our model for the surface density when considering galaxies made of only dark matter. The dashed light grey line denotes the surface density obtianed when taking into account all effects considered. For masses lower than $\approx 5\times10^{10} M_{\rm sun}$ and magnitudes brighter than $M_{\rm B} \approx = -1.4$, the surface density is constant. However, a systematic change of the awewege column density $\rho_0 r_o$ as a function of the object's mass is clearly present for langer masses. Such results make, therefore, us safely argue against the constancy or universality of the surface density claimed by Ref. [3] .

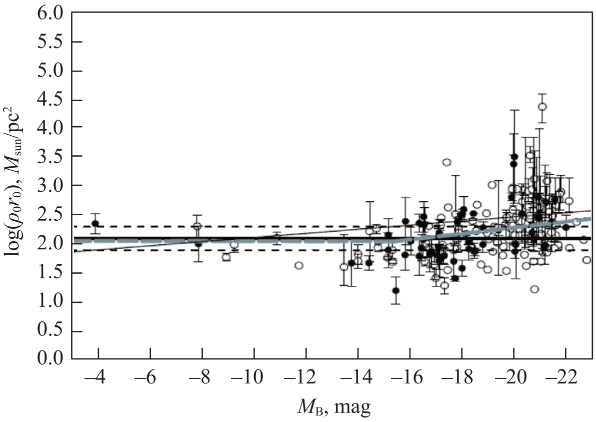

Fig. 2 $\rho_0 r_0$ in units of $M_{\rm sun}/pc^2$ as a function of galaxy magnitude for different galaxies and Hubble types.

References

[1] A. Del Popolo, Modern Physics D, 23(2014)1430005.

[2] A. Del Popolo, X. G. Lee, Baltic Astronomy, 25(2016)195.

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1 - 9 Higgs Portal Dark Matter Models*

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Higgs Portal dark matter have been supposed due to the two facts that dark matter has a gravitational force and has no strong interaction and electromagnetic interaction. A natural logic is the possibility of hiding dark matter. That is, the dark matter does not have the interaction of standard model. Dark matter may be hidden sector. The standard model particles are in the visible sector. The Higgs sector of the Standard Model enjoys a special feature that it can couple to the hidden sector at the renormalizable level. Ref.[1] has discussed the relationship between the standard model and hidden sector. Let H be Higgs field and ϕ, be the "hidden Higgs field" in hidden sector. There are a "Higgs portal" interaction term between H and ϕ as

$$V_{\rm portal} = \lambda_{h\phi} H^+ H \phi^+ \phi. \tag{1}$$

Here the field ϕ of hidden sector corresponds to the gauge symmetry breaking in hidden sector. It is assumed that the hidden sector gives the $S(1)$ or $SU(N)$ gauge symmetry, the matter field of standard model act naturally as the WIMP type matter field. In fact, the matter field and particles of standard model by weak coupling. To describe the standard model of dark matter the lagrangian method has been extended to increase the field in hidden sector lagrangian in standard model, then consider Higgs portal and discrete symmetres.

Scalar dark matter model[2]:Consider a simple field ϕ, the all lagrangian can be written

$$\mathcal{L} = \mathcal{L}_{\rm SM} + \mathcal{L}_{\rm Hidden} + \mathcal{L}_{\rm Portal}, \tag{2}$$

where the $\mathcal{L}_{\rm SM}$ is the lagrangian of standard model and

$$\mathcal{L}_{\rm Hidden} = \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \frac{m_0^2}{2}\phi^2 - \frac{\lambda_\phi}{4}\phi^4 \tag{3}$$