Remnants of dark matter clumps in the Galaxy

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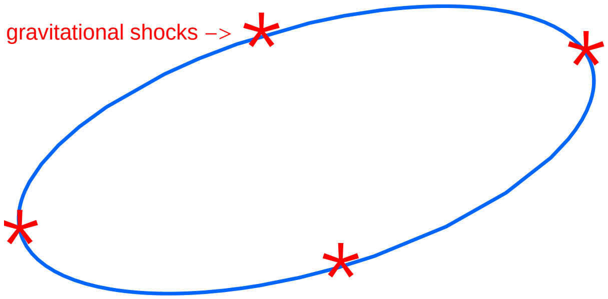


$\sum_j (\Delta E)_j \sim |E|$ - rough criterium for destruction

Gradual mass loss $\longrightarrow$ remnants of clumps. Core size = ?

$R_c/R \simeq 10^{-5}$ *(Gurevich, Zybin, 1995)*

$R_c/R \simeq 0.01$ *(Diemand, Moore, Stadel, 2005)*

$$\rho_{\rm int}(r) \propto r^{-\beta}, \quad \dot{N} \propto \int_0^r 4\pi r'^2 dr' \rho_{\rm int}^2(r')$$

There is no dependence on r if $\beta > 3/2$ and $R_c/R \ll 1$!

Energy gain at one disk crossing:

$$\delta E = \frac{4 g_m^2 (\Delta z)^2 m}{v_{z,c}^2} A(a)$$

Adiabatic correction: $A(a) = (1 + a^2)^{-3/2}$, **where** $a = \omega\tau$

(Weinberg 1994, Gnedin & Ostriker 1999)

Surface mass of the Galactic disk:

$$\sigma_s(r) = \frac{M_d}{2\pi r_0^2} e^{-r/r_0}, \quad M_d = 8 \times 10^{10} M_\odot, \ \ r_0 = 4.5 \text{ kpc}$$

Change of density at radius r:

$$\delta\rho(r) = 2^{5/2}\pi \int_{-\delta\varepsilon}^{0} \sqrt{\varepsilon - \psi(r)}\, f_{\rm cl}(\varepsilon)\, d\varepsilon$$

$$\left(\frac{\delta M}{M}\right)_d \simeq -0.13 Q_d \exp\left(-1.58 S_d^{1/2}\right),\;\; Q_d = \frac{g_m^2}{2\pi v_{z,c}^2 G\bar{\rho}_i},\;\; S_d = \frac{4\pi}{3} G\bar{\rho}_i \tau_d^2$$

Tidal stripping by disk and stars:

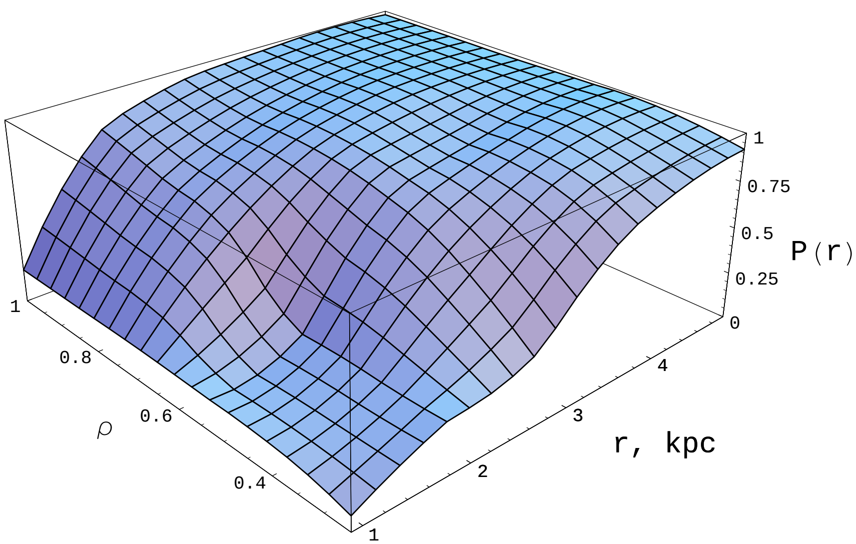
$$\frac{dM}{dt} = \left(\frac{dM}{dt}\right)_d + \left(\frac{dM}{dt}\right)_s$$

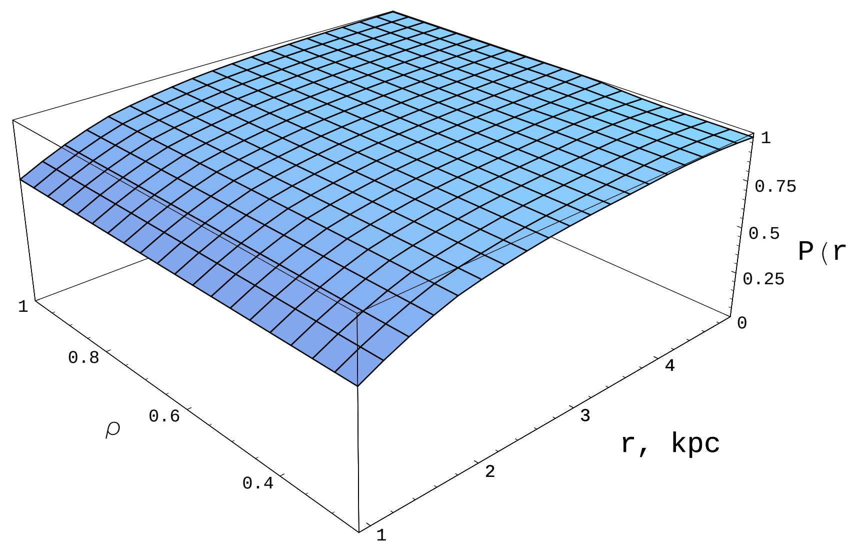
Analytical solution without adiabatic correction:

$$\frac{M(t_0)}{M_i} = \frac{2t_d}{(2t_d + t_s)\exp(2t_G/t_s) - t_s}$$

Annihilation factor:

$$P(x,\alpha)=\frac{4\pi\sqrt{2}}{\tilde{\rho}(x)\sin\alpha}\int\limits_{0}^{1}dp\int\limits_{0}^{\sin\alpha}d\cos\gamma\int\limits_{\psi(x)}^{1}d\varepsilon\,[\varepsilon-\psi(x)]^{1/2}F(\varepsilon)\theta(\mu(t_G)-x_c)$$

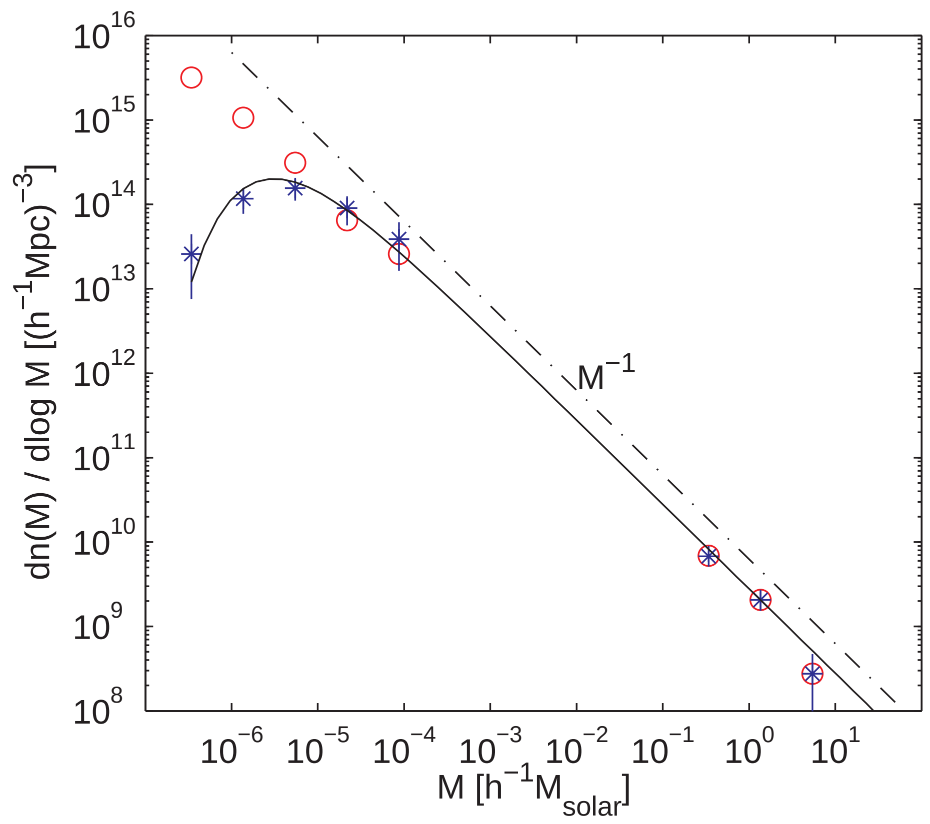




A survival probability or a normalized fraction of DM clumps in the halo which survive the tidal destruction by the stellar disk and the halo stars as a function of distance from the galactic center r and a mean internal clump density ρ in the cases $x_c = 0.1$ and $x_c = 0.05$.

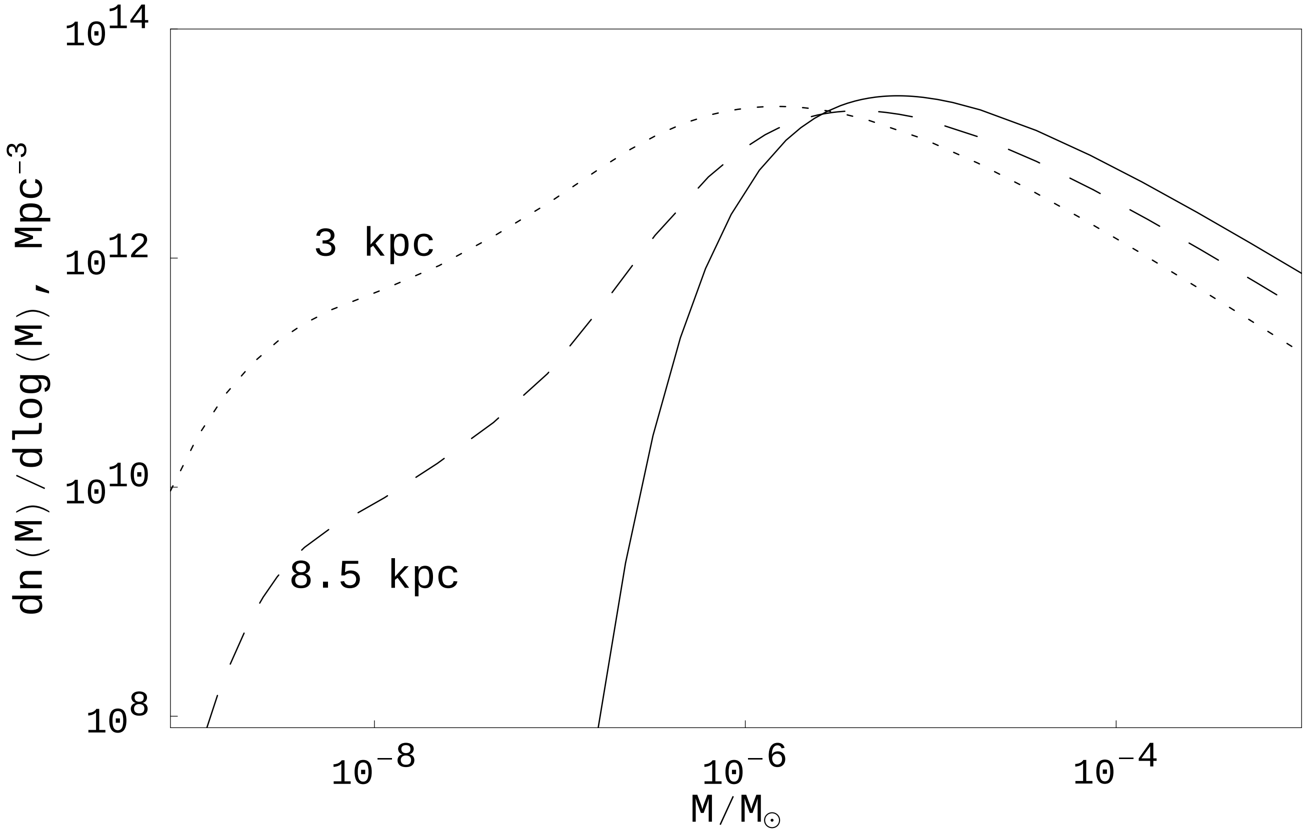
Mass function of clumps:

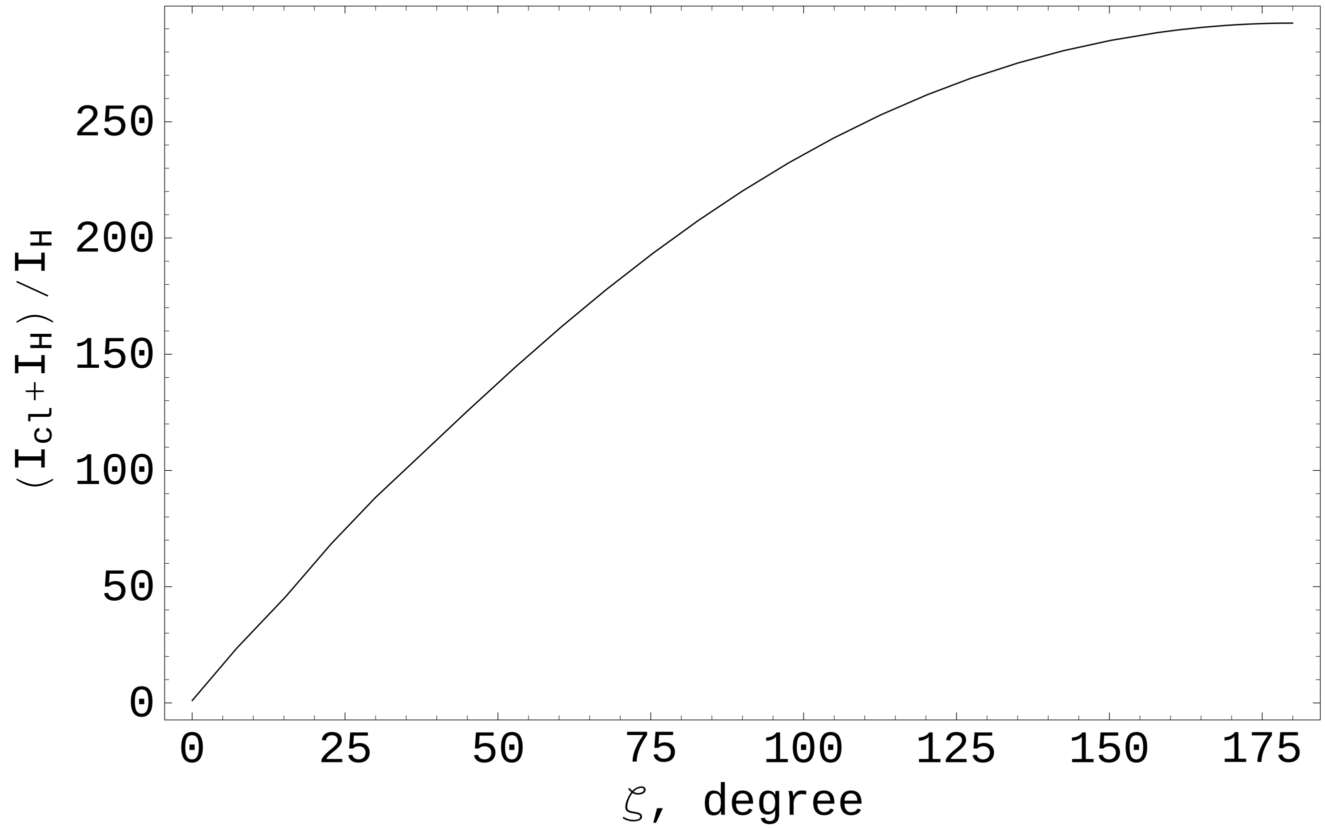
$$\xi_{\rm int}\frac{dM}{M} \simeq 0.02(n+3)\,\frac{dM}{M}$$ *(Berezinsky, Dokuchaev and Eroshenko, 2003)*



(Diemand, Moore & Stadel, 2005)

Transformation of the mass function:





The amplification of the annihilation signal $(I_{\rm cl} - I_{\rm H})/I_{\rm H}$ as function of the angle between the line of observation and the direction to the Galactic center.

• Conclusion:

In spite of small survival probability of clumps, they give the major contribution to the annihilation signal (in comparison with unclumpy DM). The amplification is in the range from several to several hundreds and even thousands in dependence of perturbational spectrum and minimum mass. The result is general. It depends on DM properties only through $M_{\rm min}$.

There is a possibility of surviving of the remnants of dark matter clumps in the Galaxy. They contribute to the amplification of dark matter annihilation signal in the Galactic halo.