Gamma rays from WIMP annihilations around the Sun

Sofia Sivertsson
In collaboration with Joakim Edsjö

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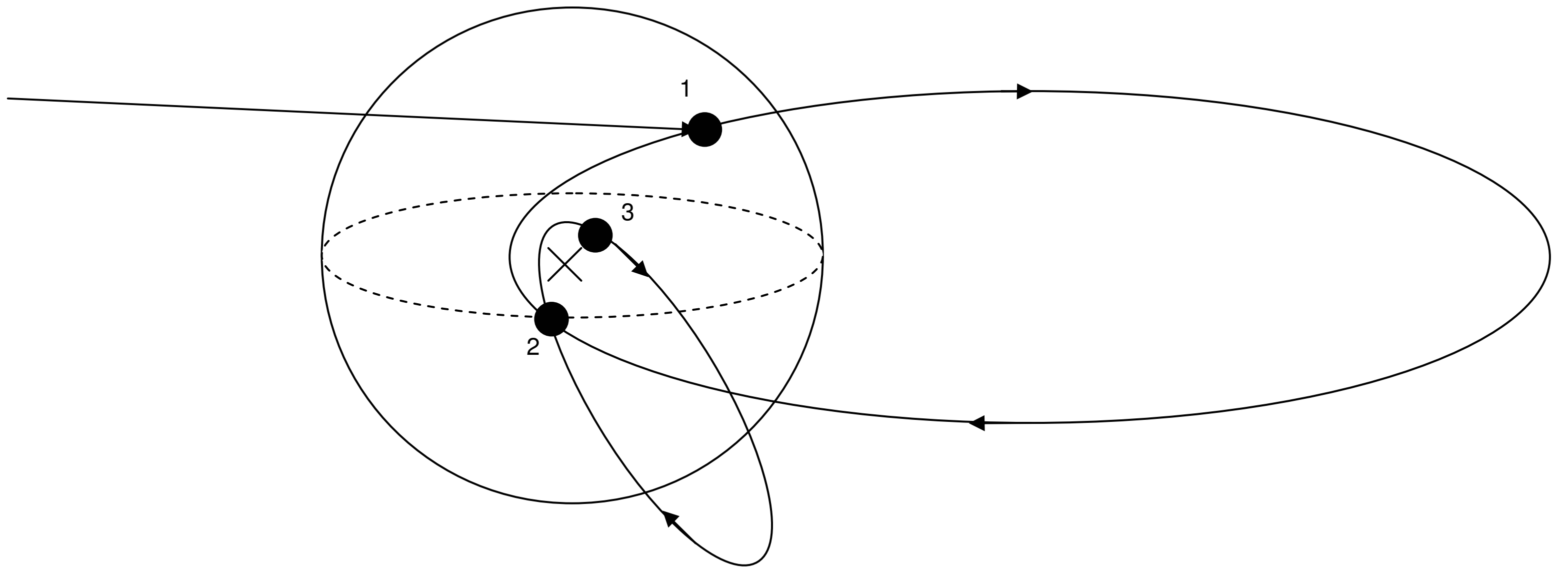
The Milky Way WIMP halo

- The Milky Way has a halo of Dark Matter which the Sun moves in.
- The Milky Way WIMP halo is assumed to have a Maxwell-Boltzmann distribution.
- The halo is assumed to be isotropic, also in the Sun's reference system.

Illustration of the WIMP capture process



Gamma ray production

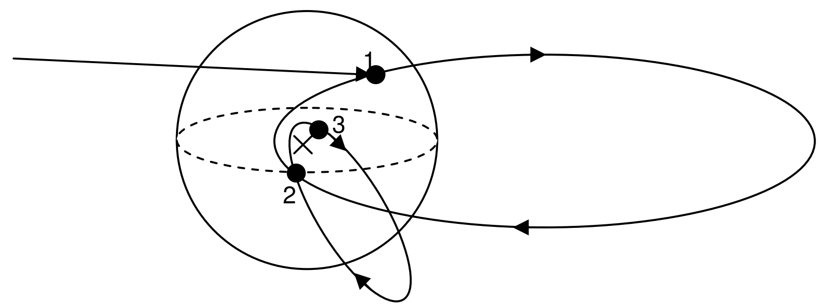
- In the capture process the bound WIMPs produce an overdensity of WIMPs around the Sun.
- WIMP annihilations within this halo around the Sun produces gamma rays.
- This signal has low background since the Sun itself does not produce gamma rays.
- Such gamma rays can be detected by Cherenkov telescopes such as the Milagro detector.

Previous work

- The gamma radiation from the Sun’s WIMP halo has been estimated previously by Strausz and Hooper.
- Strausz comes to the conclusion that the gamma ray signal should be measurable or constrain unknown parameters of the WIMP model.
- Hooper comes to the conclusion that the gamma ray signal is too weak to be detected.
- The aim of this project was to make a more accurate calculation of this gamma ray signal.

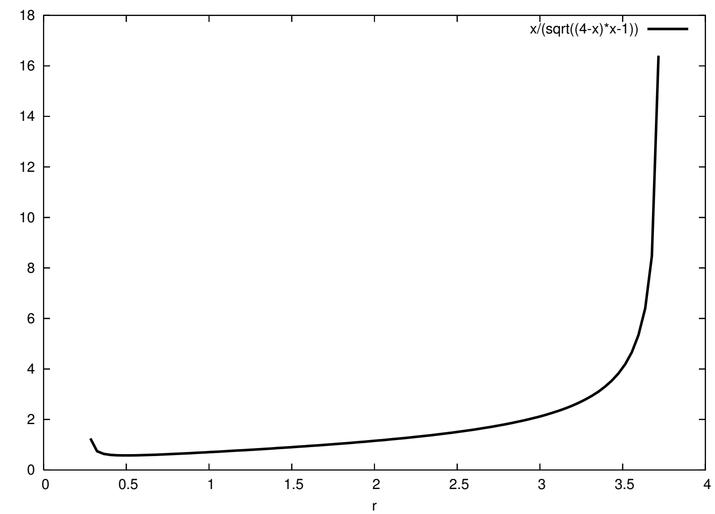
The WIMP capture process

- The WIMP-nucleus cross section is given by a spin dependent and a spin independent cross section.

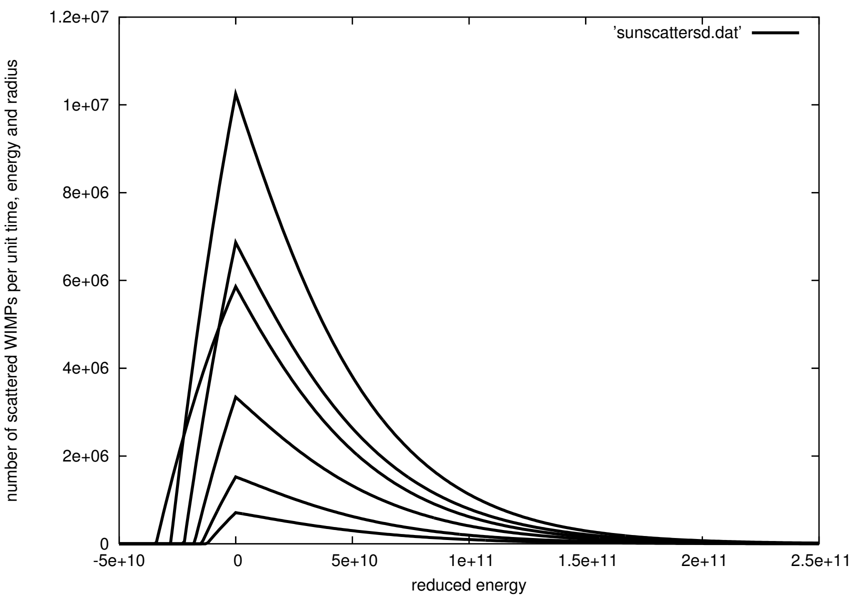


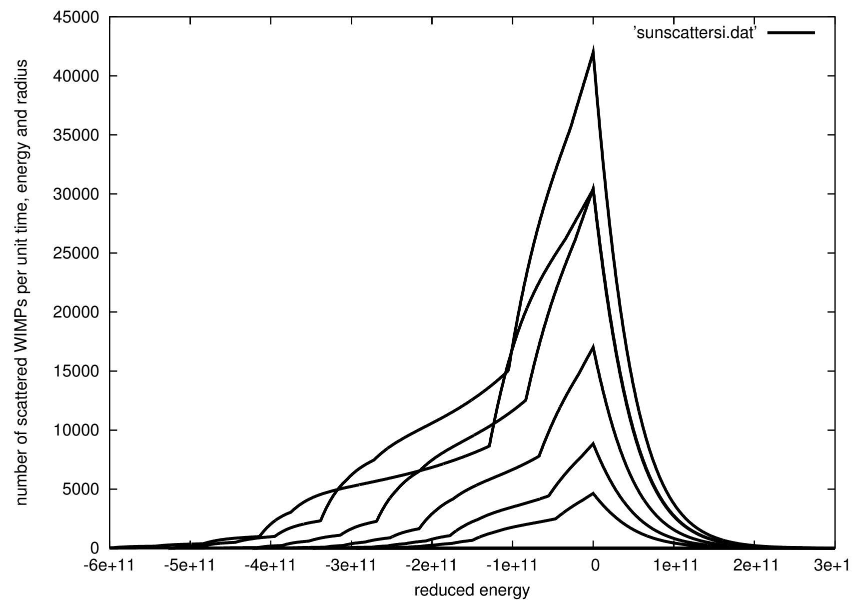
- The spin dependent cross section here only couples to hydrogen, this cross section is also less constrained.

- If a 100 GeV WIMP scatters only off hydrogen it has to scatter at least some 40 times before it is buried inside the Sun.



The WIMPs' distribution after their first scatter in the Sun





The energy distribution of WIMPs after their first scatter in the Sun. The different lines shows the distribution of WIMPs which have scattered at different shells in the Sun, with radius 10%, 20%,…, 60% of the Sun's radius. Here M=100 GeV.

Monte Carlo simulation

- The WIMP density in the Sun's WIMP halo is calculated through constructing a Monte Carlo.
- The Monte Carlo picks WIMPs randomly according to the previously shown distribution and then simulates the WIMPs life until complete capture inside the Sun.
- Uses the average orbit life time.
- The WIMP orbit is not entirely elliptical inside the Sun, which affects the scatter probability.
- The cross section for scatter off heavier nuclei depends on the energy loss.

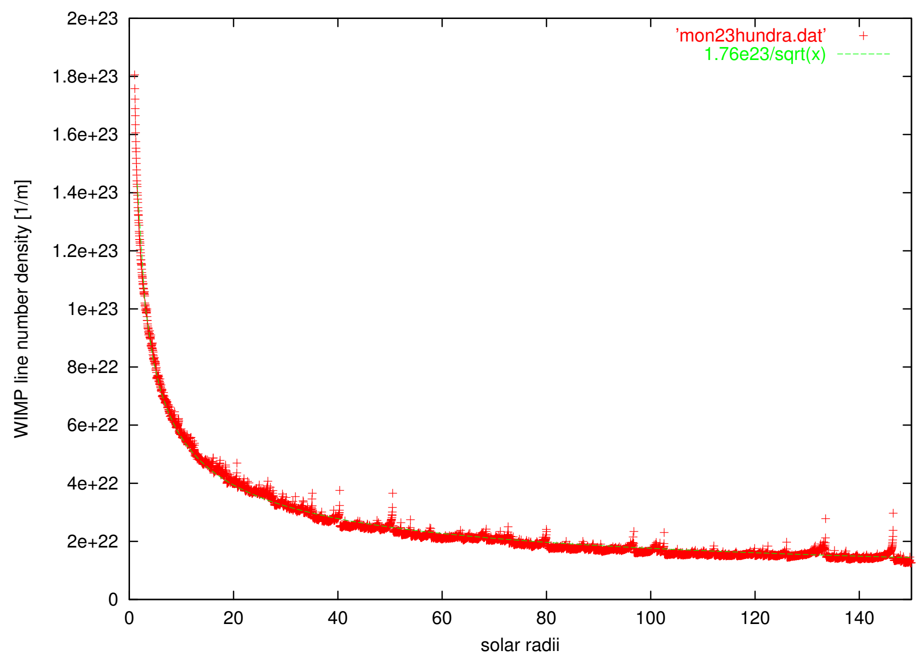
Monte Carlo simulation

- The line number density of WIMPs around the Sun is then calculated for different configurations of the cross sections and WIMP mass.

- The line density fits a curve proportional to

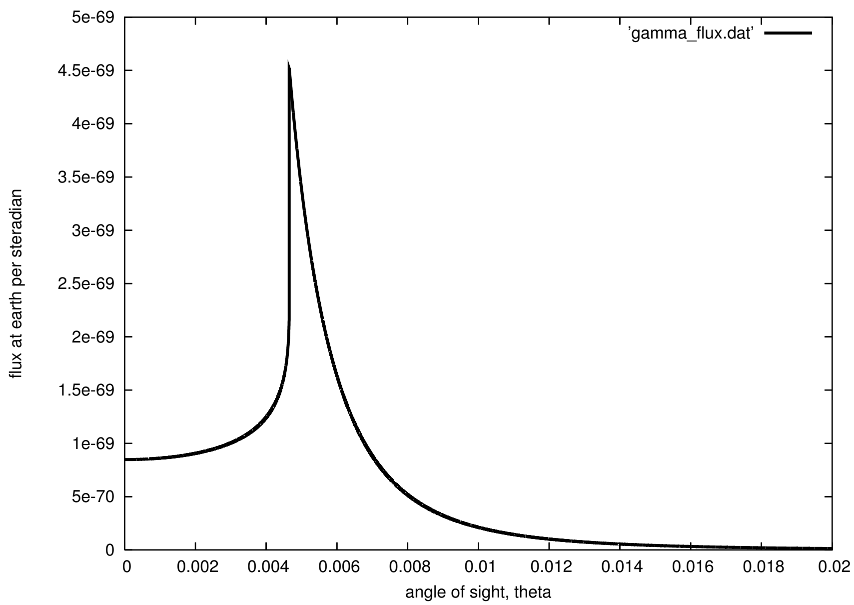
$$\frac{1}{\sqrt{r}}$$

- The WIMP density is independent of the scale of the cross sections.



The gamma ray flux at earth

- Knowing the WIMP density distribution, the gamma ray flux profile from the WIMP halo can be calculated.



Result

- The total gamma ray flux at earth from the WIMP halo around the Sun can then be calculated.

- The flux at earth per square meter per second for different WIMP mass and cross section: $\sigma v = 10^{-32}\,\mathrm{m^3 s^{-1}}$ $N_\gamma = 20$

	$M = 10^2 m_p$	$M = 10^3 m_p$	$M = 10^4 m_p$
$\sigma_{sd} = 10^{-3}$ pb, $\sigma_{sd} = 0$	$5.3 \cdot 10^{-19}$	$6.8 \cdot 10^{-21}$	$3.2 \cdot 10^{-23}$
$\sigma_{sd} = 0$, $\sigma_{si} = 10^{-5}$ pb	$1.1 \cdot 10^{-19}$	$3.7 \cdot 10^{-21}$	$5.5 \cdot 10^{-23}$

The End