Can neutral correlations be explained in the Standard Model?

Peter TINYAKOV

ULB & INR

Igor Tkachev
CERN & INR

ASSUME:

- Energies are measured correctly
- Primary particles are neutral, their fraction is

$$1.5\% < \eta < 3.5\%$$

- Sources are at $\gtrsim 400$ Mpc

SHOW:

NO EXPLANATION EXISTS WITHIN THE STANDARD MODEL

To cross the Galactic magnetic field particle lifetime must be

$$\tau > 10\,\mathrm{s}\left(\frac{m}{1\mathrm{GeV}}\right)\left(\frac{10^{19}\mathrm{eV}}{E}\right)$$

SM candidates:

— neutrino

— photon

— neutron

— atoms

Photon and neutrino

* Photons of energy 10^{19} eV do not reach Earth from 400 Mpc
* Neutrino is not interacting strongly enough to be the primary particle

Neutron

Weak reactions

On neutrino background

$$\sigma \propto G_F^2 E^2$$

rate

$$R \sim 3 \times 10^{-12} \frac{1}{\mathrm{Mpc}}$$

$\Longrightarrow$ out of question: too small

Nuclei photodisintegration

We need the reaction

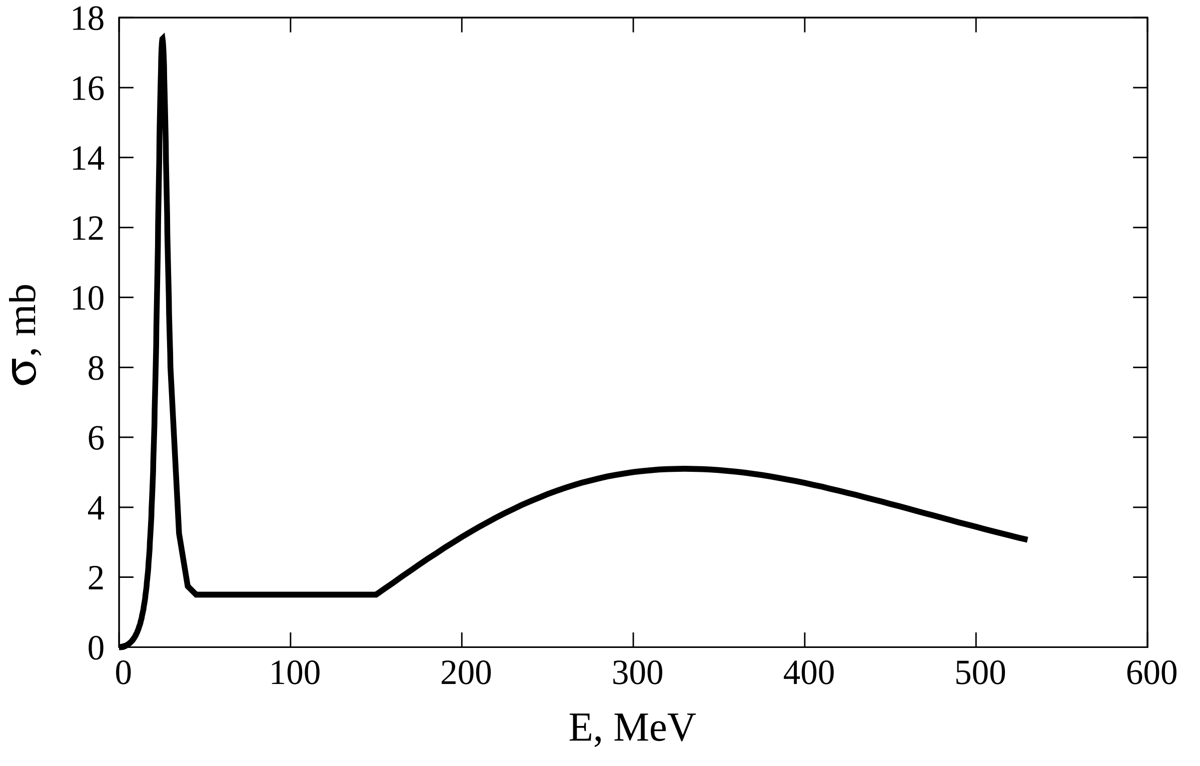
$$A \to A' + \#n + \ldots$$

to occur within 100 kpc from Earth

$$R = \int d^3p\, n(\mathbf{p})(1 - v\cos\theta)\sigma_{\rm NRF}[\gamma p(1 - v\cos\theta)]$$

$$\sim \frac{2\pi}{\gamma^2}\int_0^\infty dp\, n(\mathbf{p}) \int_0^{2\gamma p} d\omega'\, \omega' \sigma_{\rm NRF}(\omega')$$

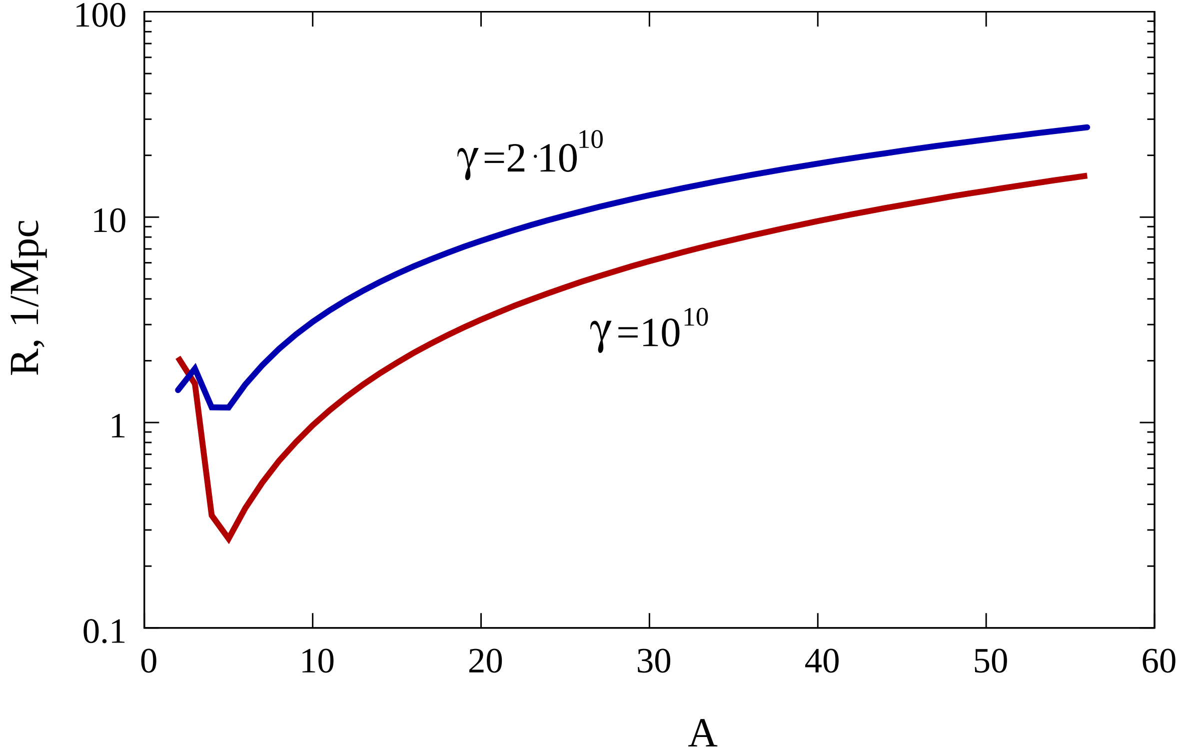
The cross section of photodisintegration is measured, and an analytic parameterization exists.



* Take

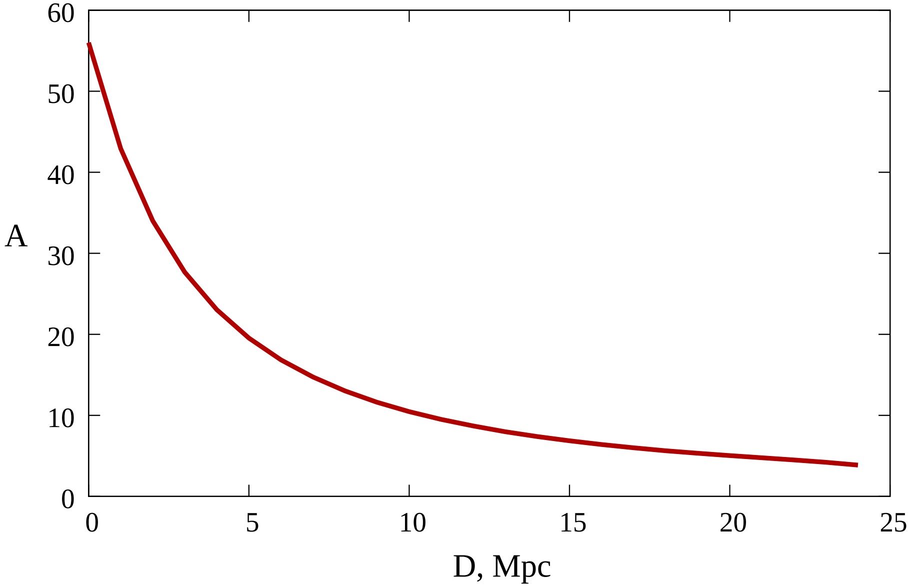
$$\gamma = (1-2) \times 10^{10}$$

* Take only CMB photons (IR background can only make the rate larger)



How does A evolve with the distance from the source?

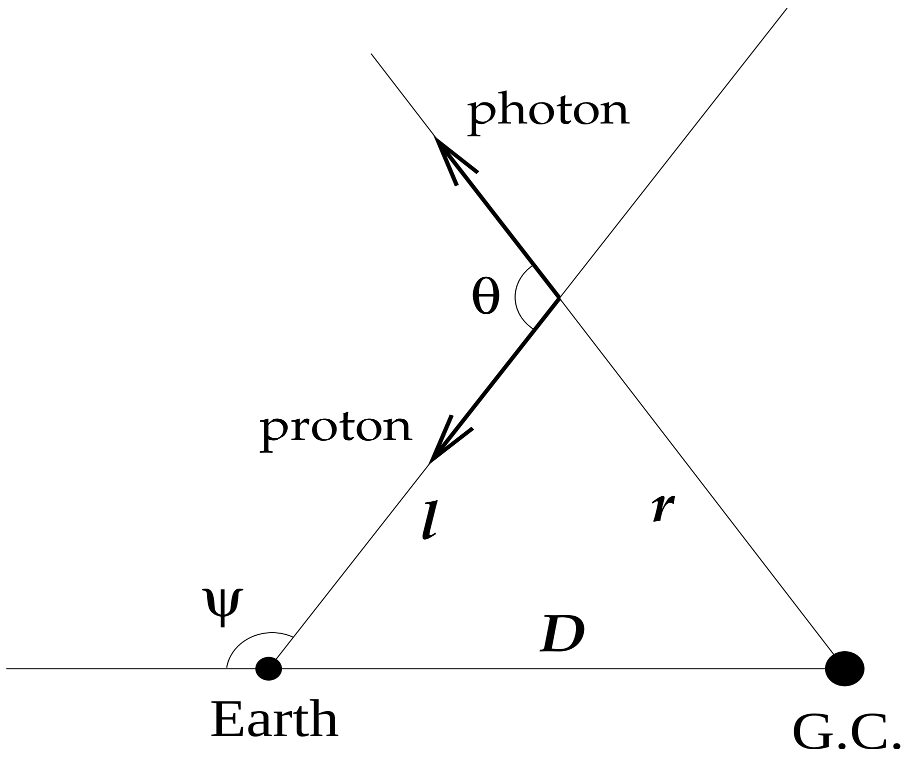
$$\frac{dA}{dt} = -R(A)$$



$\Longrightarrow$ No hope to produce neutrons this way

Neutrons by pion photoproduction on Galactic IR

$$p + \gamma_{\mathrm{IR}} \rightarrow n + \pi^+$$



Galactic IR background

Modeled by the point source at the center

$$n(\mathbf{p}) = \frac{I_0}{r^2}\frac{p^{1.65}}{\mathrm{e}^{-p/T}-1}\delta(\mathbf{n}-\mathbf{n}_0)$$

IR luminosity within solar orbit is measured,

$$L_G = 2\times 10^{10} L_\odot = 8\times 10^{36}\mathrm{W}$$

$$\Longrightarrow I_0 = \frac{L_G}{60.3T^{5.65}}; \qquad T = 23.3^\circ\mathrm{K}$$

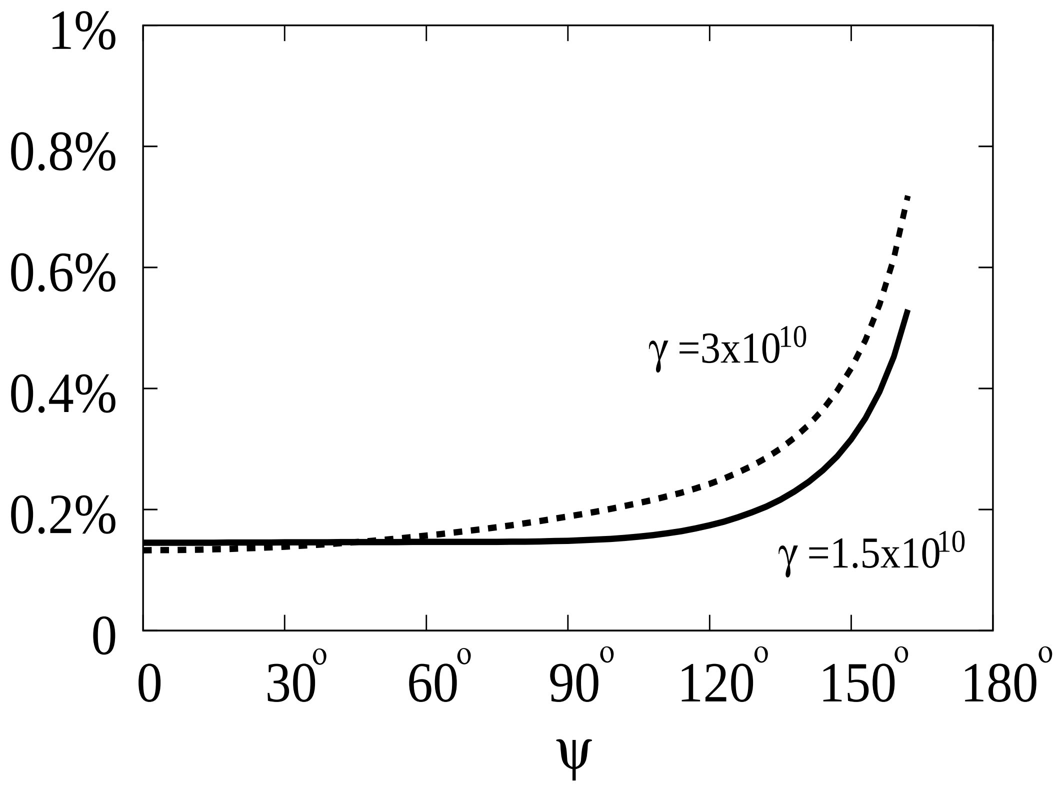
$$P = \frac{1}{60.3}\frac{L_G}{T}\int_0^\infty dl \frac{\mathrm{e}^{-l/\lambda}}{r^2}(1 - v\cos\theta)\,\langle\sigma\rangle(T_{\mathrm{eff}}),$$

where

$$\langle\sigma\rangle(T) = \frac{1}{T^{4.65}}\int \frac{\epsilon^{3.65}\sigma(\epsilon)d\epsilon}{\mathrm{e}^{\epsilon/T} - 1}$$

and

$$T_{\mathrm{eff}}(\theta) = \gamma(1 - v\cos\theta)T$$



⟹ **An order (only!) of magnitude too small**

Atoms

Rate of formation by creating the e^+e^-–pair and dressing

$$R_{\text{formation}} \sim 10^{-5}\frac{1}{\text{Mpc}}.$$

Rate of decay on CMB:

$$R_{\text{decay}} \sim 100\frac{1}{\text{Mpc}}.$$

$\Longrightarrow$ **Fraction of atoms is too small**

CONCLUSIONS

* There seem to be no explanation within the SM
* The neutron production on the Galactic IR background came closest – only about an order of magnitude too small.