Cosmomicrophysics exam

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Ticket 8

1 Indirect detection of dark matter. WIMPs

WIMP - Weakly Interacting Massive Particles.

Annihilation and decays of DM as a source of CR

Stable DM particles can annihilate: $X\overline{X} \to e^+e^- + ..$

Metastable neutral particles can decay: $X \to e^+e^- + ...$

Metastable double charged particles can decay to same sign leptons: $X^{++} \to l^+l^+$

PAMELA + AMS-02 — positron anomaly (PA) - significant excess of positrons in CR. One of the explanation are pulsars, but they can not give such trend as demonstrated in the Figure 1.

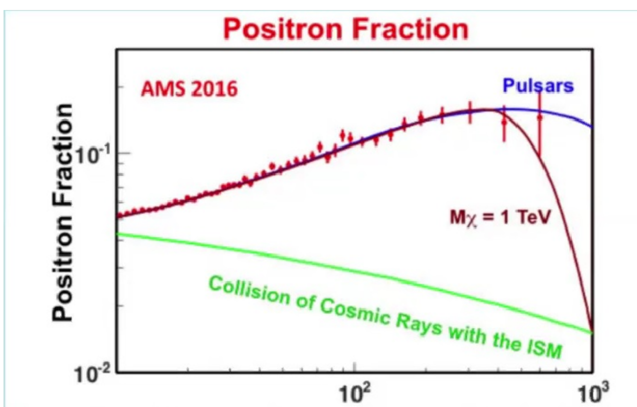

Figure 5. The current AMS positron fraction measurement compared with three theoretical models.

Figure 1: AMS positron fraction spectra

One of the main constraints on DM explanation of PA is the one set by gamma observations such as IGRB and gamma-signal from Galactic Center (GC). If the DM particles produce the SM charged particles in the final state, then such process inevitably creates accompanying photons due to final state radiation (FSR) as well as secondary ones due to interactions of the mentioned charged particles with the interstellar medium. And it was shown, that simple DM halo models created to explain PA lead to gamma-ray overproduction and contradiction with IGRB data obtained by Fermi-LAT.

Possible solutions to this problems are DM models with modified spatial distribution such as "dark disk model", developing by our scientific group.

WMAP, PLANCK - Study of relic radiation

AMANDA, IceCube, ANTARES - Neutrino observatories. Search annihilation product of dark matter particles in massive objects, e.g. Sun, GC

WIMP detection experiments: DAMA/Libra (modulations), CDMS-II (phonons), Xenon-100 (liquid-gas)

2 Baryosynthesis

Idea: If certain conditions are combined in a Universe that originally had an equal number of particles and antiparticles, an excess of particles over antiparticles can be achieved.

Sakharov, Kuzmin:

- $\Delta B \neq 0$
- $CP \neq 1$
- such processes must be non-equilibrium

Such conditions may be held in GUT.

Let's consider equal numbers of leptoquarks and antileptoquarks. Let them have the following non-equilibrium decay modes:

- $X \to qq, r$
- $X \to \overline{q}l, 1-r$
- $\overline{X} \to q\overline{q}, \overline{r}$
- $\overline{X} \to q\bar{l}, 1-\overline{r}$

Here, $r \neq \overline{r}$ — branchings. CPT = 1 $\to$ full lifetime of X and $\overline{X}$ is the same.

So, we get asymmetry in decay products:

$$n_B - n_{\overline{B}} \sim (r - \overline{r})n_X \tag{1}$$

Separately in SM the necessary baryonic excess is not obtained, because:

- CP-violation is too small
- for non-equilibrium Higgs mass must be ~ 50 GeV

Therefore, without going beyond the standard model excess is not guaranteed.

There is an ability to provide needed excess with help of mirror world.

If there is a non-equilibrium of transitions from the ordinary world to the mirror world and back, then some part of antiparticles can be thrown into the mirror world, and get an excess of particles.

And in the mirror world there is no way of knowing where is the particle and where is the antiparticle. So let's call what is in excess a mirror particles.