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Small thesis on the topic:

# "MirRor world without weak interaction"

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**Moscow, 2019**

**Introduction**

Before 1956 it wasassumed that mirror reflection of the process with any fundamental particle leads to the same process or other process which also does exist in nature. Discovery of parity violation inweak interaction initiated the study of the processes in which this fundamental rule is violated(for instance neutrinos in β- decay have only one polarization).

A P-transformation of coordinate system which describes the P-violating process corresponds to transitionfrom left to right coordinate system or mirror reflection of processes. Such transformation leads to a process that does not exist in nature. On the other hand, the existence of apreferred coordinate system means that the emptyspace-time itselfhas a preferred orientation.

To restore the equivalence of left and right Lee and Yang [1] supposed that all the known particles must have their mirror twins**.** Inthis case the P-inversion must be accompanied by change of ordinary particles by their mirror partners.

The simplest solutionwas to putantiparticle for the role of mirror particle. But due to discovery of CP-violation it was assumed in the paper [2] that ordinary particles have mirror partners which do not coincide with antiparticles.

The easiest way to include the set of mirror particles in our standard model is to add to the – gauge symmetry of standard model the same symmetry but corresponding to mirror particles.

Evolution of the Universe and the cosmological consequence of mirror world without weak interaction are presented inthis work.

There is considered the model of mirror world with symmetries and only first family of fermions which have the same masses as the ordinary u- and d-quarks and which has also the same mass.In electroweak model, masses of quarks and leptons are generatedas result of interaction with Higgs field. This, in turn, is caused by a violation of the SU(2) symmetry. Thus, mirror quarks and leptons are massless. The mass of mirror hadrons is determined by confinement.

Let’s estimate the QCD scale for one family.

The total energy density of multicomponent relativistic gas:

And total entropy:

The scale of QCD we can estimate from:

where Z= <S> - averaged entropy

Pressure for RD stage is .

Then

In ordinary world the Quark-hadron transition scale is But It is takes into account 3 generation of quarks and leptons. If we have only 1, then the ration will be .

So, roughly, eV.

We would have a doubling of some hadron states having a general strong interaction as well as a doubling of atomic states having a general electromagnetic interaction due to additional degrees of freedom. Thus, we have mirror electromagnetic and mirror strong interactions.

**Cosmological consequences**

Let‘s adopt the mirror world model with SU(3)⊗U(1) symmetry with the first generation of fermions. Now we are able to create mirror matter resistant to β - decay. In this case, the neutrons will become stable particles. The mesons and protons will remain stable particles because they decay only by weak interaction. Electrons remain stable owing to conservation of electromagnetic charge as in our world.

Let‘s consider the complete model including mirror particles without weak interaction. The mirror world has the same kinds of interactions excluding the weak but they apply only to mirror particles

A possible interaction between the particles of our world and the particles of mirror world is gravity. Therefore, the mirror and ordinary gravitational interactions will be the same. In addition, kinetic mixing of ordinary and mirror particles is possible.

In the framework of Grand Unified Theory the gauge symmetry

of ordinary and mirror particles is included in a single symmetry group .

Let us assume that in the mirror Universe there is charge symmetry for simplicity.

**Inflation**

To realization the inflation process, it is required to introduce an additional scalar inflaton field into the model which can interacting with particles of matter of the ordinary and mirror world and must decay so that in the post-inflationary period effectively generate the observed number of baryons and leptons of our world and suppress the number of mirror baryons and leptons.

The initial amplitudes of ordinary and mirror inflatons can be different which leads to the formation of a domain structure in the distribution of ordinary and mirror matter under the framework of the chaotic inflation model [5]. In areas where the amplitude of ordinary inflatons is higher after inflation ordinary particles should dominate and the admixture of mirror particles should be exponentially small. Conversely, the dominance of mirror inflatons leads to a low density of ordinary particles after inflation.[6]

**Dark matter candidates**

The main properties dark matter particles must have are:

* Electroneutrality
* Stability (lifetime **[>>]** 14·109 years)
* Nonzero mass

Under these conditions, some mirror particles in the absence of weak interaction can be particles of dark matter, but only if the mass of the mirror substance is much larger than the mass of ordinary particles. This is possible if there was a freezing out of mirror particles.

In particular, mirror baryons can be candidates for the role of dark matter, they can form compact objects with stellar masses and sizes. [6]

**Evolution**

Let us consider how the further evolution of the model of the Universe with the mirror world took place without weak interaction.

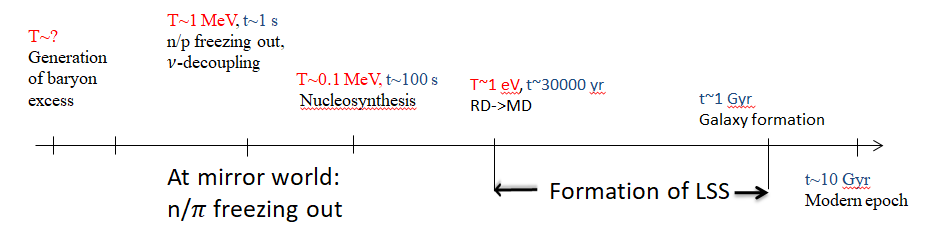


Figure 3 – Thermal evolution of the Universe

The next phase of the Universe evolution after the inflation is the reheating. During this phase an active birth of high-energy particles and their thermalization occurred. [10]

The birth of particles in the mirror world occurs during this period, as in the case of particles of the ordinary world, due to rapid oscillations of the inflaton field near the minimum potential.

Let us consider the process of freezing out stable particles of the model. In this case, neutrons, protons, charged pions and electrons (positrons) remain stable.

Let’s calculate the equilibrium number density of nonrelativistic particle by formula [11]:

Let's estimate the freezing out temperature from the following considerations.

The freeze out condition is:

Where number density, relative velocity, cross-section of interaction.

We can express the freeze out moment from equation of the Universe expansion law and the mass density expression. At the freeze out time, where

,

Where , GeV.

And the temperature of freeze out estimated from the approximate expression:

Then get:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | , MeV |  |
|  |  | 41,785 | 1,384 |
|  |  | 305.9*7*4 | 1,667 |
|  | 31.584 | 0.153 | 1.42 |

For a proton, due to the almost equality of masses, we get the same values as for the neutron.

So the freeze out of the neutron to proton ratio in the mirror world occurs by the following reactions:

At the first second there is a freezing out of relativistic neutrinos in our world. This process is due to the fact that the neutrino decouples, since the rate of neutrino interaction

,

And expansion rate . However, in a mirror world without weak interaction, a neutrino cannot be born in reactions, as well as scattering on electrons and annihilate since such processes go through a weak interaction. Hence, we obtain that mirror neutrinos are not initially present in the equilibrium state, so the decoupling of mirror neutrinos does not occur.

In the mirror world, the birth of neutrinos occurs only in a gravitational way. Due to this their concentration should be extremely small and the mass should be of the order of ~kT (1 sec) since in the mirror world there is only the first generation of leptons, the oscillations between different flavors of mirror neutrinos does not exist, but we can assume that the oscillations occur between our world and the mirror with one generation. In this case, the mirror electron neutrino may be a candidate for the role of sterile neutrino.

The density of ordinary and mirror radiation is different at the RD stage due to different equilibrium temperatures.

The observed abundance of 4Не is

Уobs = (28 ±12)%

The freezing out the ratio of neutrons and protons number in the ordinary matter after the first second of expansion the contribution of mirror photons and mirror electron-positron pairs should be taken into account in the full density. However, given the assumption that the equilibrium temperature in the mirror world was lower the contribution of mirror photons is suppressed and the contribution of electron-positron pairs is significantly less than that of other stable particles.

At the matter dominant stage the Large Scale Structure of the Universe (LSS) is formed. The influence of mirror matter on LSS is possible only in the case of large scale mirror domains corresponding to the mass scale:

or large scale islands distribution of baryons. In this case the mirror baryon islands have to look like voids which have not Galaxies from ordinary matter.

The pions are stable in the mirror world. They participate in charge exchangereactions which generating protons and neutrons. Thus, mirror nuclei can play the role of dark matter particles, since such nuclei must remain stable.

The mirror weakless Universe enters the nucleosynthesis phase with approximately equal numbers of protons and neutrons. If the visible baryon-to-photon ratio were the same as in our Universe, then it is easy to estimate that nearly all protons and neutrons get absorbed into helium. [13]

In our case, the electron number density is much smaller then charged pion number density. This fact leads to pion atoms formation (negative charged pion is bound with nuclei).

**Conclusion**

Thus, in the model of the mirror world without weak interaction with the first generation of fermions, charged pions, all leptons, protons and neutrons remain stable. And also the process of annihilation of neutrinos by weak interaction is impossible, therefore their number becomes small.

Mirror baryons can be candidates for the role of the dark matter. But also it can be mirror nuclei consisting of negative charged pion bounding with nuclei because abundance of pions in primary plasma is high and much more then abundance of electrons and pion is bound with nuclei much earlier, than recombination with mirror electrons takes place.

Mirror neutrinos are not initially present in the equilibrium state, so the decoupling of mirror neutrinos does not occur.

The mirror world model does not affect the amount of primary helium concentration.

The influence of mirror matter on the Large Scale Structure of the Universe is possible in the case of large-scale mirror domains or Large Scale Island distribution of baryons.

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