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Научная исследовательская работа студента на тему:

Effects of Dark Atom in Structure Formation

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Continuation from last semester

In the early Universe when temperature fell below 1 keV, the rate of expansion started to exceed the rate of energy and momentum transfer from plasma to OHe gas. As a result, OHe decoupled from plasma and radiation and played the role of dark matter on the matter-dominated stage. The averaged baryonic density in the course of structure formation and in galaxies is sufficiently low, making baryonic matter at large scales transparent for OHe.

Formation of OHe

One can formulate the set of conditions under which new particles(in our case OHe) can be considered as candidates to dark matter they should be stable, saturate the measured dark matter density and decouple from plasma and radiation at least before the beginning of matter dominated stage.

Formation of OHe

The easiest way to satisfy these conditions is to involve neutral elementary weakly interacting particles. However it is not the only particle physics solution for the dark matter problem and more evolved models of self-interacting dark matter are possible. In particular, new stable particles may possess new U(1) gauge charges and bind by Coulomb-like forces in composite dark matter species. Such dark atoms would look nonluminous, since they radiate invisible light of U(1) photons.

Formation of OHe

We will consider composite dark matter scenarios, in which new stable particles have ordinary electric charge, but escape experimental discovery, because they are hidden in atom-like states maintaining dark matter of the modern Universe. The main problem for these scenarios is to suppress the abundance of positively charged species bound with ordinary electrons, which behave as anomalous isotopes of hydrogen or helium. This problem is unresolvable, if the model predicts together with positively charged particles stable particles E^- with charge -1, as it is the case for teraelectrons .

Formation of OHe

This problem is unresolvable, if the model predicts together with positively charged particles stable particles E^{-} with charge -1, as it is the case for teraelectrons . As soon as primordial helium is formed in the Standard Big Bang Nucleosynthesis (SBBN) it captures all the free E^{-} in positively charged HeE^{+} ion, preventing any further suppression of positively charged species. Therefore, in order to avoid anomalous isotopes overproduction, stable particles with charge -1 should be absent, so that stable negatively charged particles should have charge -2 only.

Different Models

Elementary particle frames for heavy stable -2 charged species are provided by:

(a) stable "antibaryons" $\bar{U}\ \bar{U}\ \bar{U}$ formed by anti-U quark of fourth generation.

(b) AC-leptons , predicted in the extension of standard model, based on the approach of almost-commutative geometry.

(c) Technileptons and antitechnibaryons in the framework of walking technicolor models (WTC).

(d) Finally, stable charged clusters $\bar{U}_5\bar{U}_5\bar{U}_5$of (anti)quarks $\bar{U}_5$ of 5th family can follow from the approach, unifying spins and charges.

Similarities of these models

Since all these models also predict corresponding +2 charge antiparticles, cosmological scenario should provide mechanism of their suppression, what can naturally take place in the asymmetric case, corresponding to excess of -2 charge species, X^{--} . Then their positively charged antiparticles can effectively annihilate in the early Universe.

After it is formed in the Standard Big Bang Nucleosynthesis (SBBN), 4_{He}screens the , X^{--} charged particles in composite $(He^{++}\ \ X^{--})$ O-helium "atoms". For different models of X^{--} these "atoms" are also called ANOhelium , Ole-helium or techni-O-helium.

How to determine OHe interaction with matter?

In all these forms of O-helium X^{--} behaves either as lepton or as specific "heavy quark cluster" with strongly suppressed hadronic interaction. Therefore O-helium interaction with matter is determined by nuclear interaction of He. These neutral primordial nuclear interacting objects contribute to the modern dark matter density and play the role of a nontrivial form of strongly interacting dark matter

Importance of the study

The active influence of this type of dark matter on nuclear transformations needs special studies and development of OHe nuclear physics. It is especially important for quantitative estimation of role of OHe in Big Bang Nucleosynthesis and in stellar evolution. The composite nature of O-helium dark matter results in a number of observable effects, which I will try to figure out in my future studies.

Thank You !