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Models of Hot Dark Matter and their phenomenological consequences

Description for the general public

Explanation of the Dark Matter (particles which interact gravitationally and at most weakly with the known elementary particles) origin in the Universe is one of the major challenges of contemporary cosmology and particle physics. Evidences of the Dark Matter existence can be found in all astrophysical scales: from the galaxy scale, through the scale of galaxy clusters, to the cosmological one (embracing the whole visible Universe). The latest results indicates that the Dark Matter gives approximately 27% contribution to the total amount of energy density – from theory of relativity it is known that matter is also a form of energy. This is much in comparison to 5% of the known matter. Hence, there is much to discover.

For the last few decades, much attention has been paid to the so-called Cold Dark Matter (CDM). Being massive (hence, in the early Universe – slow and "cold"), electrically neutral, it can successfully account for the lacking 27% of energy density in the Universe. Astrophysical observations indicate, however, that CDM models do not explain well e.g. a matter distribution in the galactic cores. However, lighter and faster particles can solve this problem – we call them a Warm Dark Matter (WDM). It turns out that neither CDM nor WDM cannot address another problem. Relic radiation measurements (being remnants of the Big Bang) suggest, in indirect way, that there may exist another type of very fast Dark Matter particles, resembling neutrinos. An attempt to explain their existence is a so-called Hot Dark Matter (HDM), which, similarly to CDM and WDM, does not interact in ordinary way with the known particles, however, due to small mass resembles the behavior of these very fast particles. Thus, perhaps we need more than one kind of Dark Matter to completely understand our Universe.

In my research project, I will focus on the most promising models of HDM. To this purpose, it will be necessary to find a proper form of equation governing the evolution of HDM particles in the early Universe. It will be also crucial to set down predictions of selected models (their phenomenology) in the context of astrophysical data and signals from particle collisions in Large hadron Collider (LHC). Especially interesting in this light are models containing both HDM and and CDM/WDM sectors – they are more phenomenologically motivated because explain more phenomena. If the analyzed models will not be satisfactory enough, I plan to propose their modifications. Extremely important will be also a forthcoming experiments, which will allow to unambiguously state whether these hypothetical particles indeed exists.