Probing the properties of dark matter particles with astrophysical observations

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Stellingen

Behorend bij het proefschrift

Probing the properties of dark matter particles with astrophysical observations

1. Standard Model of particle physics is consistent with all accelerator experiments and does not provide clues for resolution of Beyond the Standard Model phenomena. Cosmological and astrophysical observations contain information about experimental regimes inaccessible to experiments.

   (*Chapter 1*)

2. Addition of 3 sterile neutrinos can explain the dark matter, the neutrino masses and the matter-antimatter asymmetry at the same time in the Neutrino Minimal Standard Model.

   (*Chapters 2, 4 and 5*)

3. Big Bang Nucleosynthesis is the oldest available direct probe of the Early Universe. New particles can influence the process of formation of light nuclei. This puts strong constraints on particles with lifetimes $\gtrsim 0.1\,\mathrm{sec}$.

   (*Chapter 3*)

4. The microscopic properties of dark matter particles imprint detectable signatures in the distribution of matter in the Universe that can be studied using the absorption spectra of distant quasars. Warm Dark Matter candidates can introduce a small-scale smoothing of the density field compared to Cold Dark Matter. This smoothing can be observed as a cut-off in the power spectrum of quasar spectra.

   (*Chapter 5*)

5. Recent high-resolution quasar observations exhibit a cut-off in the Flux Power Spectrum that can be explained by thermal effects or by the presence of Warm Dark Matter. Interpretation of the cut-off requires precise knowledge of the thermal history of the Universe.

   (*Chapter 5*)

6. Contrary to the recent claims that the mass of thermally produced Warm Dark Matter is constrained by Lyman-α forest observations to be $> 3.3\,\mathrm{keV}$, we find that this bound depends on the choice of thermal history. A robust constraint, marginalized over thermal histories sets the thermal WDM relic mass $> 1.9\,\mathrm{keV}$.

   M. Viel *et al.*, "Warm dark matter as a solution to the small scale crisis: New constraints from high redshift Lyman-α forest data," Phys. Rev. D **88**, 043502 (2013).

7. Recent measurements by Becker et al. indicate that reionization might not be completed by $z = 6$, necessitating specific modeling of the influence of inhomogeneities on the Lyman-α forest observables.

   BECKER *et al.*, "EVIDENCE OF PATCHY HYDROGEN REIONIZATION FROM AN EXTREME LYα TROUGH BELOW REDSHIFT SIX", MON. NOT. ROY. ASTRON. SOC. **447** (2015) 3402.

8. There are two types of observations that might yield an indication for Warm Dark Matter.

   A. BOYARSKY, M. DREWES, T. LASSERRE, S. MERTENS AND O. RUCHAYSKIY, "STERILE NEUTRINO DARK MATTER", PROG. PART. NUCL. PHYS. **104**, 1 (2019).

9. Sensitivity projections of the planned Beyond the Standard Model experiments at CERN to heavy neutral leptons are complementary to constraints in the present thesis, potentially covering the parameter space with masses below $\sim 1\,\mathrm{GeV}$.

   J. BEACHAM *et al.*, "PHYSICS BEYOND COLLIDERS AT CERN: BEYOND THE STANDARD MODEL WORKING GROUP REPORT," ARXIV:1901.09966 [HEP-EX].

10. The modern rapidly growing community of researchers generates scientific results at an extremely high rate. This sometimes happens at the detriment of quality and awareness in the community. Formation of isolated cliques and the reproducibility crisis are some of the most important challenges that face modern science. It is important to continue progress on open data initiatives, information management technologies and extend the amount of information shared in publications.

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