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Additional sources of ionization in the early universe and the 21 cm line

Evgenii O. Vasiliev[1,2] and Yuri A. Shchekinov[3]

[1]Tartu Observatory, 61602 Tõravere, Estonia
[2]Institute of Physics, University of Rostov, Stachki Ave. 194, Rostov-on-Don, 344090 Russia
email: eugstar@mail.ru

[3]Department of Physics, University of Rostov, Sorge St. 5, Rostov-on-Don, 344090 Russia
email: yus@phys.rsu.ru

Abstract. We consider the influence of decaying dark matter particles and ultra-high energy cosmic rays (UHECRs) on the ability of neutral gas at redshifts $z = 10 - 50$ to emit and absorb in the 21 cm line . We show that the signal in 21 cm is sensitive to properties of decaying particles and UHECRs, and conclude that future radio telescopes (LOFAR, LWA and SKA) are able not only to detect 21 cm signal originated from decaying particles and UHECRs, but discriminate between them as well.

Keywords. early Universe, dark matter, diffuse radiation

Decaying dark matter particles can strongly affect the reionization of the universe (e.g., Chen & Kamionkowski 2004). Additional ionization and heating from such particles before the re-ionization affects also the ability of neutral gas to absorb or emit in 21 cm line. Thus the decaying dark matter can influence the cosmological 21 cm background. We consider three sorts of decaying dark matter particles: long- and short-living particles, as well as ultra-high energy cosmic rays (UHECRs), if they form from decaying superheavy dark matter particles (e.g., Berezinsky *et al.* 1997).

The long-living particles provide permanent heating, so the gas kinetic temperature grows towards lower redshifts. Contrary, in case of the short-living particles the injection rate of heat decreases fastly, when the lifetime of particles becomes comparable with the comoving age of the universe, which manifests in a relatively fast decrease of the kinetic temperature at low redshfts.

The UHECRs produce only Ly-c and Ly-α photons, which give negligible heating, and the major influence on the 21 cm brightness temperature history is through the Wouthuysen-Field effect. We show that long-living and short-living unstable dark matter particles and UHECRs produce fairly distinct dependences of brightness temperature on redshift $T_b(z)$ – the first and the third give negative and positive second derivatives of the curves $T_b(z)$, while the second has $T_b(z)$ with an inflection point. This circumstance may have a principal significance for choosing a strategy for observational discrimination between these sources of ionization.

In the presence of UHECRs 21 cm can be seen in absorption with the brightness temperature $T_b = -(5\text{–}10)$ mK in the range $z = 10\text{–}30$. Decaying particles can stimulate a 21 cm signal in emission with $T_b \simeq 50\text{–}60$ mK at $z = 50$, and $T_b \simeq 10$ mK at $z \simeq 20$. Future radio telescopes (such as LOFAR, LWA and SKA) seem to have sufficient flux sensitivity for detection the signal in 21 cm influenced by decaying particles and UHECRs.

References

Berezinsky, V. S., Kachelrieß, M., & Vilenkin, A. 1997, *Phys. Rev. Lett.*, 79, 4302
Chen, X., & Kamionkowski, M. 2004, *Phys. Rev. D* 70, 043502