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On the Dwindling Supply of the Observable Cosmic Microwave Background Radiation

Authors : Jia-Chao Wang

Abstract : The cosmic microwave background radiation (CMB) freed during the recombination era can be considered as a photon source of small duration; a one-time event happened everywhere in the universe simultaneously. If space is divided into concentric shells centered at an observer's location, one can imagine that the CMB photons originated from the nearby shells would reach and pass the observer first, and those in shells farther away would follow as time goes forward. In the Big Bang model, space expands rapidly in a time-dependent manner as described by the scale factor. This expansion results in an event horizon coincident with one of the shells, and its radius can be calculated using cosmological calculators available online. Using Planck 2015 results, its value during the recombination era at cosmological time t = 0.379 million years (My) is calculated to be Revent = 56.95 million light-years (Mly). The event horizon sets a boundary beyond which the freed CMB photons will never reach the observer. The photons within the event horizon also exhibit a peculiar behavior. Calculated results show that the CMB observed today was freed in a shell located at 41.8 Mly away (inside the boundary set by Revent) at t = 0.379 My. These photons traveled 13.8 billion years (Gy) to reach here. Similarly, the CMB reaching the observer at t = 1, 5, 10, 20, 40, 60, 80, 100 and 120 Gy are calculated to be originated at shells of R = 16.98, 29.96, 37.79, 46.47, 53.66, 55.91, 56.62, 56.85 and 56.92 Mly, respectively. The results show that as time goes by, the R value approaches Revent = 56.95 Mly but never exceeds it, consistent with the earlier statement that beyond Revent the freed CMB photons will never reach the observer. The difference Revert - R can be used as a measure of the remaining observable CMB photons. Its value becomes smaller and smaller as R approaching Revent, indicating a dwindling supply of the observable CMB radiation. In this paper, detailed dwindling effects near the event horizon are analyzed with the help of online cosmological calculators based on the lambda cold dark matter (ΛCDM) model. It is demonstrated in the literature that assuming the CMB to be a blackbody at recombination (about 3000 K), then it will remain so over time under cosmological redshift and homogeneous expansion of space, but with the temperature lowered (2.725 K now). The present result suggests that the observable CMB photon density, besides changing with space expansion, can also be affected by the dwindling supply associated with the event horizon. This raises the question of whether the blackbody of CMB at recombination can remain so over time. Being able to explain the blackbody nature of the observed CMB is an import part of the success of the Big Bang model. The present results cast some doubts on that and suggest that the model may have an additional challenge to deal with.

Keywords : blackbody of CMB, CMB radiation, dwindling supply of CMB, event horizon
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