LETTERS TO PROGRESS IN PHYSICS

On Eddington's Temperature of Interstellar Space and the Cosmic Microwave Background Radiation

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We point out that there were several non-cosmological estimates of the blackbody temperature of interstellar space that predated and that were more accurate than the Cosmic Microwave Background (CMB) Big Bang estimates. They are disregarded and considered coincidental as they are not based on the cosmological Big Bang model. We note the importance of this question, as the energy requirements of the two different explanations (galactic vs cosmological) are substantially different. We also point out that the actual correct explanation can't be determined from the measurements done in our local neighbourhood inside the Milky Way.

The great tragedy of Science – the slaying of a beautiful hypothesis by an ugly fact. Thomas Henry Huxley (1825–1895)*.

1 Introduction

Penzias and Wilson [1], while working at Bell Labs, measured an isotropic Microwave Background Radiation (MBR) of approximately 3 K, while using a sensitive antenna/receiver system under development. Initially, they thought the radio noise resulted from their equipment, but eventually they concluded that the background radiation was real.

Physicist Robert Dicke suggested that the background radiation was the Cosmic Microwave Background (CMB) radiation, believed to result from the Big Bang cosmological model. This interpretation was published in side-by-side letters by Penzias and Dicke in Astrophysical Journal Letters [2]. Penzias and Wilson measured an isotropic Microwave Background Radiation which became the Cosmic Microwave Background (CMB) radiation in the serendipitous communication with Dicke, nowadays the only accepted explanation for the measurement.

However, there were other earlier blackbody† temperature predictions, that were much closer to the initial measurement of Penzias and Wilson, than those from the Big Bang, but they were simply ignored as they did not originate from the Big Bang cosmological model. Interestingly enough, the very fact that the remarkably close blackbody temperature predictions do not originate in the Big Bang model is used against the validity of the other models in predicting a blackbody temperature in agreement with the Penzias and Wilson measurement!

At stake is whether the Microwave Background Radiation is universal and cosmic (i.e. CMB) or galactic in nature (i.e. MBR), with possibly every galaxy having slightly different local blackbody temperatures. The energy requirements of the two different explanations are substantially different. The reality is that this can't be determined from the measurements done in our local neighbourhood (at about 27 000 light-years from the galactic centre) within our Milky Way which is about 100 000 light-years across and about 2 000 light-years thick at the thin stellar disk that we are located in.

2 Eddington's "Temperature of interstellar space"

Assis and Neves in their 1995 paper *History of the 2.7 K Temperature Prior to Penzias and Wilson* [3] provide a review of earlier blackbody temperature determinations, prior to the Big Bang cosmological model temperature estimates of the late 1940s, 1950s and early 1960s which varied between 5 K and 50 K. Their conclusion that "the models based on a Universe in dynamical equilibrium without expansion predicted the 2.7 K temperature prior to and better than models based on the Big Bang" is, understandably so, not very popular.

The best-known earlier blackbody temperature prediction is that of $T = 3.2$ K proposed by Arthur Stanley Eddington in 1926 [5], known as the *temperature of interstellar space* to clearly communicate that it is not related to the CMB, especially since Eddington's estimate was derived before the development of the Big Bang cosmological model. Modern commentators constantly remind us that it is coincidental and that it does not derive from the Big Bang model. We don't want people to see it as an explanation of the MBR that would be an alternative to the CMB Big Bang explanation!

Eddington, in his 1926 book *The Internal Constitution of the Stars* [6], further covered the topic in Chapter XIII, *Diffuse Matter in Space*. He computes an effective blackbody temperature of 3.18 K, but again, this has nothing to do with the 2.725 K blackbody spectrum of the Microwave Background Radiation (MBR), which we know is the Cosmic Microwave Background (CMB). Eddington states:

> The total light received by us from the stars is estimated to be equivalent to about 1000 stars of the

*Wikiquote. Thomas Henry Huxley. In his Presidential Address at the British Association in 1870, last modified 07:40 4 May 2019.

†The estimates are described as blackbody temperatures as the Stefan-Boltzmann blackbody radiation law was used to determine the temperature.

> first magnitude. ... We shall first calculate the energy density of this radiation. ... Accordingly the total radiation of the stars has an energy-density ... $E = 7.67 \cdot 10^{-13}$ erg/cm^3. By the formula $E = aT^4$ the effective temperature corresponding to this density is 3.18° absolute. [6, p. 371]

Eddington thus uses the Stefan-Boltzmann blackbody radiation law to determine the temperature of the blackbody equivalent to the estimated energy density of stellar radiation.

Eddington then attempts to specify a model for the spectrum of his estimated interstellar radiation field, based on his hypothesis of the statistical properties of stellar radiation:

> Radiation in interstellar space is about as far from thermodynamical equilibrium as it is possible to imagine, and although its density corresponds to 3.18° it is much richer in high-frequency constituents than equilibrium radiation of that temperature. [6, p. 371]

On this count, Eddington strayed from the data and that part of his analysis missed the mark.

The near-equality of Eddington's blackbody temperature of space and the CMB is considered a coincidence as "[t]he starlight radiation field is concentrated in galaxies like the Milky Way, which only occupy one part per million of the volume of the Universe, while the CMB fills the entire Universe" [7]. This comment demonstrates exactly the point raised in this Letter, and as we have been pointing out, it is hard for cosmologists to think outside of the CMB paradigm.

We also note several other non-cosmological estimates of the temperature of interstellar space that predate and that were more accurate than the Cosmic Microwave Background (CMB) Big Bang estimates [4]. Regener [8] predicted a value of 2.8 K in 1933 based on an analysis of the energy of cosmic rays arriving on Earth. This is remarkably close to the current best estimate of the value of a thermal blackbody spectrum at a temperature of 2.72548±0.00057 K [9]. Mackellar, following his identification of interstellar molecules [10], obtained the value 2.3 K in 1941, using the levels of excitation of the cyanogen molecule (CN) in intergalactic space [11].

3 Cosmic Microwave Background anisotropy

The CMB (or MBR) is highly isotropic, to roughly one part in 100 000. The spectral radiance contains small anisotropies which vary with the size of the region under examination. This anisotropy requires its own analysis separate from this Letter [12–14].

Suffice to say that advanced digital signal processing is performed on the data (e.g. [15]). A dipole anisotropy caused by the velocity of the Sun of about 370 km/s towards the constellation Leo, as determined from the MBR, is first subtracted from the Doppler shift of the background radiation. The root mean square (RMS) variations of the remainder are only 18 μK [7]. This anisotropy is a characteristic of the Microwave Background Radiation, whether it is of galactic or cosmological origin. Occam's razor favours a galactic origin.

4 Discussion and conclusion

In this Letter, we have pointed out that there were several non-cosmological estimates of the blackbody temperature of interstellar space that predated and that were more accurate than the Cosmic Microwave Background (CMB) Big Bang estimates. They are disregarded and considered coincidental as they are not based on the cosmological Big Bang model. We note the importance of this question, as the energy requirements of the two different explanations (galactic vs cosmological) are substantially different. We also point out that the actual correct explanation can't be determined from the measurements done in our local neighbourhood inside the Milky Way.

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