Observational tests of the microwave background radiation

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Abstract

When Penzias & Wilson discovered the Microwave Background Radiation (MBR) and published their findings in the *Astrophysical Journal*, an accompanying paper by Dicke et al. claimed the cosmological nature of the discovery and established one of the key foundations of the standard Hot Big-Bang model. Here I investigate a diametrically opposed possibility, namely, an MBR with a local origin.

1 Introduction

The concept of a "cosmic" microwave background radiation is introduced in the standard Big-Bang model in a *ad hoc* fashion. In spite of that, it is sometimes taken as a proof of the model. But the MBR may not be cosmic in the first place. Therefore there is a real necessity of investigating other causes or sources for it. The present paper considers a *local* origin for the radiation (see more details in Soares 2006).

Following the discovery of the MBR, Penzias & Wilson published their findings in the 142nd volume of ApJ, in 1965. An accompanying paper, by Dicke et al. claimed the *cosmic* nature of the phenomenon, establishing therefrom the key foundation of the Big Bang cosmological model. They have in fact appropriated themselves of the discovery without leaving any room for other tentative interpretations of the finding.

But why, at that time, *immediately* cosmic?

In principle, there is no reason to believe that the MBR is of cosmological origin, except if one is willing *to accept* a coordinated set of theoretical propositions – with no firm and definitive observational bases – only in order to legitimate a given cosmological model.

The plan of the present paper is as follows. In section 2, the magnetic bottle scenario for a local MBR is presented and features of a related physical model are summarized. Section 3 discusses observational tests of a local MBR. In section 4, final remarks are presented.

2 The Microwave Background Radiation and the magnetic bottle scenario

Let us then consider a *local* approach to the Microwave Background Radiation (MBR). Earth's magnetosphere is seen as a *magnetic bottle* whose walls are made by solar wind particles trapped along the magnetic lines of the Earth field. A minute fraction of Sun's light reflected by the Earth surface is caught within such a bottle and is thermalized through Thomson scattering on the bottle walls. The first consequence is that one would expect that the thermalized radiation should exhibit a *dipole anisotropy*, given the nature of Earth's magnetic field. And that is precisely what was observed by the COBE satellite from its 900-km altitude orbit.

Although WMAP, the *Wilkinson Microwave Anisotropy Probe*, sits far away from Earth, at the Lagrangean L2 point of the Sun-Earth system (see WMAP electronic page at the URL `http://map.gsfc.nasa.gov/m_mm/ob_techorbit1.html`, which means about 1.5 million km from Earth, that is not enough for it to be released from the magnetic influence from Earth.

It is located precisely and deep inside the bullet-shaped magnetopause, which extends to 1000 times the Earth radius or more – approximately 10 million km (see `http://www-spof.gsfc.nasa.gov/Education/wmpause.html` for details of the magnetopause).

Figures 1 and 2 display the same geometry, as far as the Sun-Earth system is concerned. It is clear from the figures that as the Earth revolves about the Sun the Lagrangean point L2 – thus WMAP – sits all the time inside Earth's magnetopause.

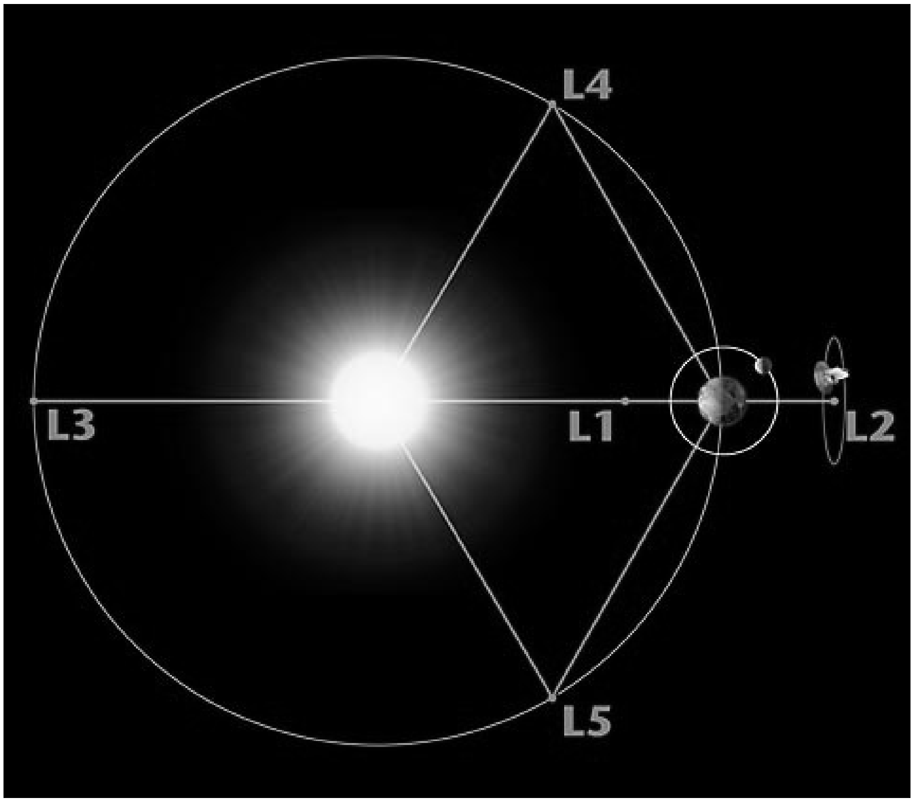

Figure 1: Lagrangean points of the Sun-Earth system. WMAP satellite is shown at point L2. (Image credit: Wilkinson Microwave Anisotropy Probe electronic page.)

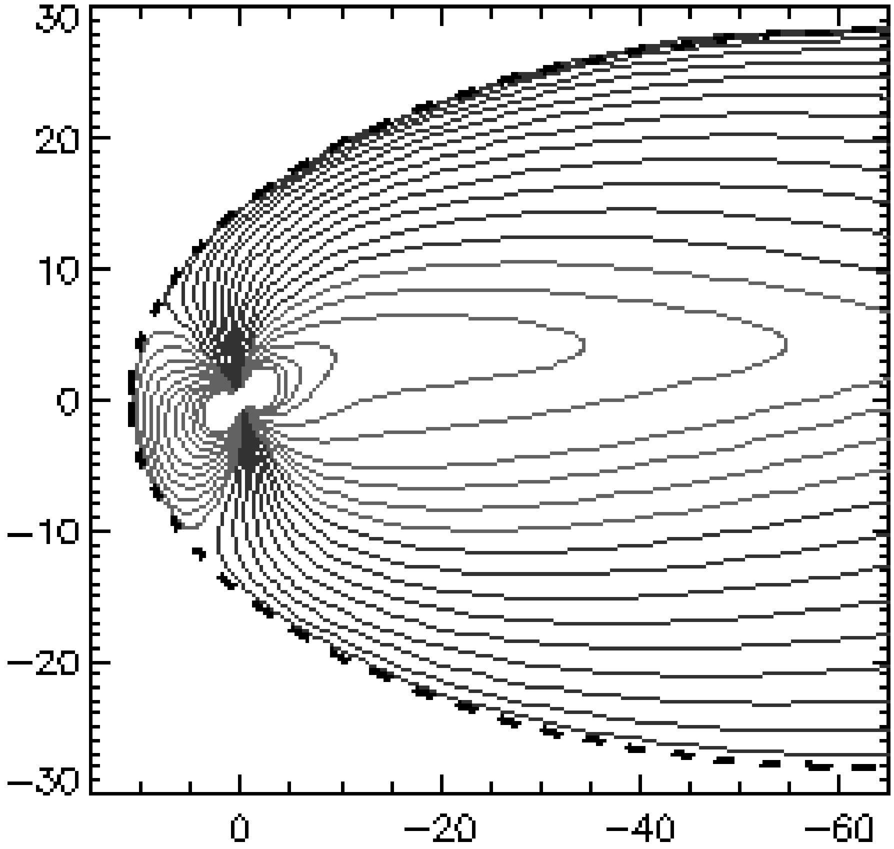

Figure 2: A view of Earth's magnetopause. The bullet-shaped magnetopause is always along the Sun-Earth direction (coordinates in Earth radii). The magnetopause extends to up to 1000 Earth radii. L2 is inside the magnetopause at about 230 Earth radii. (Image credit: "The Exploration of the Earth's Magnetosphere", an educational web site by David P. Stern and Mauricio Peredo.)

The Earth magnetosphere has a complex structure with variable electron densities in multiple layers around a neutral sheet at its mid-plane. The tail boundary – the magnetopause – can reach 500-1000 Earth radii (Figure 2).

A simple model for the blackbody cavity may, in a first approximation, neglect anisotropies in the thermal spectrum (Soares 2007). The magnetopause is modeled as a cylindrical cavity with its axis – the z-direction – running along the Sun-Earth direction. Being R the polar radius, the electron density $n(z, R)$, averaged over the azimuthal angles, is a well-known observed quantity. Microwave photons are Thomson scattered inside the cavity till thermal equilibrium is attained in a time-scale much shorter than Earth's age. The precise source of the microwave photons is not critical since there are many possibilities. The most obvious is the long wavelength tail of the solar spectrum; far infrared photons from Earth itself might be another possibility (see below the discussion of radio thermal emission from solar system planets). Anisotropies are considered with a more realistic electron density distribution (Soares 2007).

3 Observational tests

As long as one considers a local MBR, a plethora of observational tests come to light. Three major tests are discussed here.

3.1 Non earthly MBR probe

A straight consequence – easily testable – is that the background radiation from other "magnetic bottles" – other planets – will be different, with a different thermal spectrum, possibly non thermal and even nonexistent. A probe orbiting another solar system planet like Mars, Venus, etc, would verify the hypothesis.

3.2 MBR anisotropy time variation

The Earth magnetotail oscillates about its axis during the yearly revolution around the Sun by as much as 5 to 20 degrees (Eastman 2006). This introduces a measurable time variation on MBR anisotropies. An observational program that measures the MBR at different phases of Earth's orbit would detect such variations.

3.3 Planetary thermal glow

The importance of radio thermal emission from planets is twofold. First, thermal emission may be the source of background radiation photons, and, second, the thermal glow may be the exterior manifestation of the background radiation itself. That is, the radiation which is interpreted as a "cosmic" background radiation when measured from within the planetary environment – the magnetic bottle – is observed as a thermal glow from the outside.

There are many antecedents in observing thermal glows from planets in the radio-wave range. Mercury has a thermal 400 K glow and Venus was found to have an approximate 500 K glow by Mayer et al. (1958a). Radio emission from Mars and Jupiter at 3.15 cm and 9.4 cm are reported by Mayer et al. (1958b). A blackbody temperature of 210 K was found for Mars and 140 K for Jupiter.

A reasonable prediction is that if one looks at the right wavelength range, one should be able to find the magnetic bottle signature of planetary emission. Thus, the detection of Earth's 3 K thermal emission from the *outside* would be a strong indication of a local MBR.

4 Concluding remarks

The next MBR anisotropy probe, NASA's Planck satellite, is scheduled for launch in 2007. Again, it is planned to sit at Lagrangean L2 point, just like WMAP (see briefing of Planck mission at `https://www.esa.int/Enabling_Support/Operations/Planck`).

It would be a great opportunity to test the validity of the magnetic bottle scenario if Planck's observation site is moved to outside the earthly environment. The immediate suggestion is a stationary point on a Mars orbit, with the probe being obscured from solar radiation by the planet, similar to the Sun-Earth-WMAP configuration.

Planck will measure, like WMAP did, background anisotropies. To measure the background radiation spectrum a COBE-like probe should be sent to Mars, with replicas of COBE's three instruments, FIRAS, DMR and DIRBE. The goal is to measure Martian background radiation spectrum and its anisotropies, just like COBE did on Earth.

The obvious prediction is that the thermal background – if it is indeed thermal – will be totally different from the 3 K spectrum observed from Earth's magnetic bottle.

The MBR investigation would be considerably enriched by the following crucial observational tests:

1. time variability of the MBR on the scale of fraction of a solar year, and

2. measurement of the MBR in another planetary environment.

Both tests are unthinkable in the framework of a MBR with a *cosmic* origin but are quite natural experiments from the point of view of a local origin for the MBR.

5 References

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