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Site evaluation and RFI spectrum measurements in Portugal at the frequency range 0.408–10 GHz for a GEM polarized galactic radio emission experiment

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Abstract

We probed for radio frequency interference (RFI) at three potential galactic emission mapping experiment (GEM) sites in Portugal using custom made omnidirectional disconic antennas and directional pyramidal horn antennas. For the installation of a 10-m dish dedicated to the mapping of polarized galactic emission foreground planned for 2005–2007 in the 5–10 GHz band, the three sites chosen as suitable to host the antenna were surveyed for local radio pollution in the frequency range 0.01–10 GHz. Tests were done to look for radio broadcasting and mobile phone emission lines in the radio spectrum. The results show one of the sites to be almost entirely RFI clean and showing good conditions to host the experiment.

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Keywords: Radio frequency interference; Site testing; Cosmic microwave background; Polarization

1. Introduction

Cosmic microwave background (CMB) cosmology made a huge leap forward from COBE maps (Smoot et al., 1992) towards high-resolution map-making. The data returned from recent and planed experiments (MAXIMA, Boomerang, DASI, CBI, VSA, NASA's WMAP and ESA's Planck Surveyor satellite, among others (Bennet et al. (2003), Dickinson et al. (2004), Mason et al. (2003)) offer a direct glimpse into the physics at the surface of last scattering, providing constraints on cosmological parameters and tests of theories of large scale structure formation and favoring the inflationary paradigm. Obscuring our view of the CMB are extragalactic and galactic foregrounds and the maximum cosmological information can only be obtained if the foregrounds are optimally extracted. Different physical components along the line of sight can be separated from the underlying cosmic signal by using a priori knowledge of their spectral a spatial characteristics, given a sufficiently dense sampling in frequency and spatial position. Typically, diffuse galactic emission is dominated by

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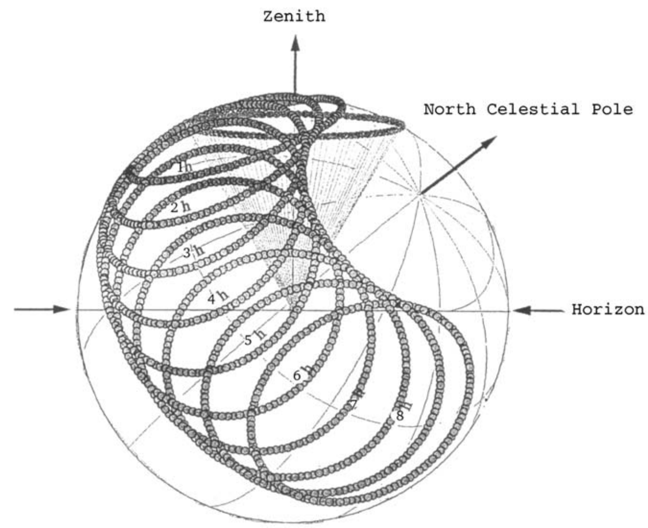
synchrotron radiation below 60 GHz and by thermal dust emission above 60 GHz (da Costa et al., 2003). Recently, CMB polarization is currently being detected (DASI – 2002, WMAP – 2003) see (Leitch et al., 2002; Kovac et al., 2002; Bennet et al., 2003; Kogut et al., 2003) and will constitute for the next decade the best probe of early Universe's physics.

Yet, while theoretically, foreground amplitudes would be generically distinguished by observing the different emission components where they are dominant, there are no reasonably known templates accounting for their amplitudes and effects. While for CMB total power (temperature) the foreground amplitudes can be reasonably estimated, the amplitude of polarized foregrounds like synchrotron or spinning dust is not known accurately.

1.1. Current GEM project

To address the problem of foreground estimation, the Galactic Emission Mapping project started as an international collaboration (http://aether.lbl.gov for detailed information) operating a portable 5.5-m dish with extensions to a 10-m surface capable of measuring the galactic emission at several latitudes in a wide range of frequencies (Torres et al., 1993, 1996). To integrate for large sky areas and since sensitivity is more important than resolution, GEM scanning strategy consists on an slow azimuthal dish rotation until the required sensitivity is attained (see Fig. 1). The resultant maps obtained at several locations would then be merged to produce templates covering large areas of the sky with constant angular resolution from 408 MHz up to 10 GHz and good absolute calibration of the zero-level of the maps.

With foreground cartography as one of the main tasks currently being pursued by CMB teams, the GEM project is evolving towards the measurements of galactic synchrotron polarization at higher frequencies 5–10 GHz (Tello et al., in preparation). Originally, the Berkeley team has developed a compact and portable 5.5-m diameter radio telescope antenna, which has been used for the total intensity observations. Observations were made from different locations, like near Bishop, California (fall 1993 through fall 1994), Villa de Leyva, Colombia (close to the equator 1995) and is currently operating at Cachoeira Paulista, Brazil (Tello, 1999; Tello et al., 1992) having now covered most of the southern hemisphere in 1.4 and 2.3 GHz. To also cover the northern hemisphere, and thus produce a template of most of the sky, one needs a good site in the northern hemisphere with suitable conditions for clima, RFI and infrastructure capabilities. Thus, Portugal was surveyed to find a suitable location to host a second antenna to complement the original GEM southern hemisphere maps. The GEM working frequencies were chosen because below 20 GHz, atmosphere contribution is negligible (Brandt, 1994). Also, for polarization measurements, besides water lines around 22 GHz, oxygen only contaminates polarization measurements for frequencies higher than 60 GHz, where oxygen molecular rotational modes may be an important concern for ground experiments (Hanany and Rosenkranz, 2003; Pardo).



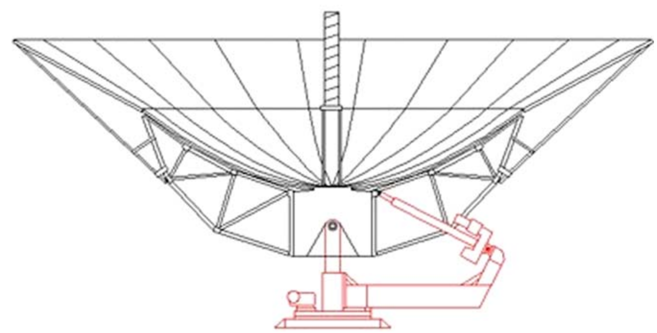


Fig. 1. Top figure represents a schematic view of the scanning strategy: azimuthal dish rotation for a given elevation. Bottom figure is a scheme of scanning instrument and mounting.

1.2. RFI sources

Radio observations need above all sites with no radio frequency interference (RFI). Perhaps, the biggest threat lies on Global System for Mobile Communications (GSM) networks, meaning frequency dispute with radio astronomers. GSM mobile phone networks use several bands around 900 MHz, 1.8 GHz and the near future Universal Mobile Telecommunications System (UMTS) to be shortly implemented will use several 2.1 GHz bands. Other telecommunications concerns are radio broadcast emissions, analog and digital television broadcast emissions, aeronautical communications – mainly along air corridors and airports, satellite communications (communications, meteorological and GPS) and amateur radio services, these using theoretically a wide range of bands from 3.5 to 250 GHz. Besides telecommunications, recent wireless computer networks use heavily the 2.37 GHz band with prospects for a near future 5 GHz upgrade. Also,