PROCEEDINGS OF SCIENCE

Observations of Anomalous Dust

Richard John Davis,[*] R.D. Davies
University of Manchester, Jodrell Bank Observatory
Macclesfield, Cheshire SK11 9DL, UK
E-mail: rjd@jb.man.ac.uk

C. Dickinson, K.M. Gorski
Caltech
Pasadena CA, USA

A.J. Banday, T.R. Jaffe
Max-Planck-Institut
Garching, Germany

Abstract

In our study of the free-free, dust and synchrotron foreground components in the WMAP data we have chosen a selection of fields which are intended to have minimal cross-contamination from other components. Each of the 3 components has been quantified in terms of a mean value of the emissivity in each of the 5 WMAP bands. We have made studies of the anomalous dust emission on and off the plane. There is clear evidence for a range of the emissivity of up to 2.5

1. Introduction

WMAP data when combined with ancillary data on free-free, synchrotron and dust allow an improved understanding of the spectrum of emission from each of these components. Here we examine the sky variation at intermediate latitudes using a cross-correlation technique. In particulare we compare the observed emission in 15 selected sky regions to three "standard" templates (Davies et al. 2006).

[*] Speaker

PoS(CMB2006)032

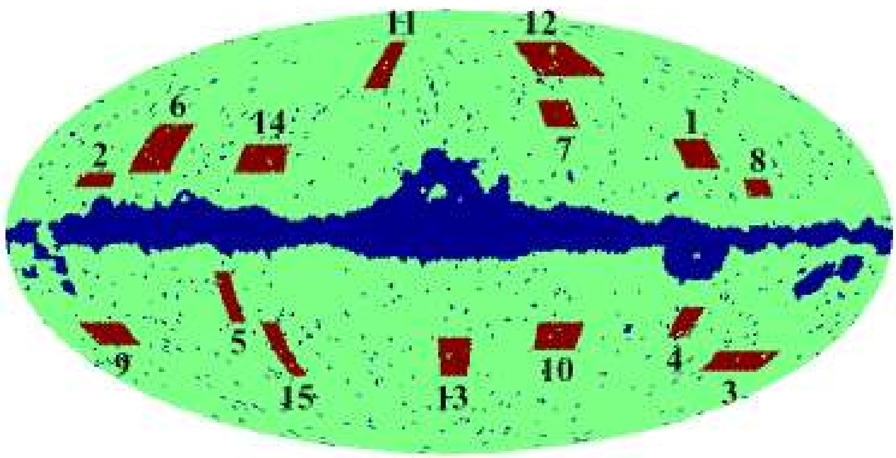

Fig. 1 Full-sky showing 15 selected regions

Field No.	Dominant Emission	Longitude Range	Latitude Range	Description.
1	Free-free	$245^\circ - 260^\circ$	$+21^\circ - +31^\circ$	Northern edge of Gum Nebula.
2	Free-free	$140^\circ - 155^\circ$	$+15^\circ - +20^\circ$	Disc-like structure above Galactic plane.
3	Free-free	$200^\circ - 230^\circ$	$-41^\circ - -48^\circ$	Eridanus complex - within southern Gould Belt
4	Free-free	$250^\circ - 260^\circ$	$-25^\circ - -35^\circ$	Southern edge of Gum Nebula
5	Free-free	$90^\circ - 97^\circ$	$-13^\circ - -30^\circ$	Below plane in northern sky.
6	Dust	$118^\circ - 135^\circ$	$+20^\circ - +37^\circ$	$l = 125^\circ$ dust spur, NCP region (the "duck").
7	Dust	$300^\circ - 315^\circ$	$+35^\circ - +45^\circ$	Outer edge of northern Gould Belt system.
8	Dust	$227^\circ - 237^\circ$	$+12^\circ - +18^\circ$	Above plane in southern sky.
9	Dust	$145^\circ - 165^\circ$	$-30^\circ - -38^\circ$	Orion region in southern Gould Belt.
10	Dust	$300^\circ - 320^\circ$	$-30^\circ - -40^\circ$	Below plane southern sky.
11	Synchrotron	$33^\circ - 45^\circ$	$+50^\circ - +70^\circ$	Middle section of North Polar Spur.
12	Synchrotron	$270^\circ - 310^\circ$	$+55^\circ - +70^\circ$	Outermost section of North Polar Spur.
13	Synchrotron	$350^\circ - 5^\circ$	$-35^\circ - -50^\circ$	Southern bulge in synchrotron sky.
14	Synchrotron	$70^\circ - 90^\circ$	$+20^\circ - +30^\circ$	A "weak" northern spur.
15	Synchrotron	$76^\circ - 84^\circ$	$-30^\circ - -50^\circ$	A southern spur.

Table 1 Details of the 15 selected regions

PoS(CMB2006)032

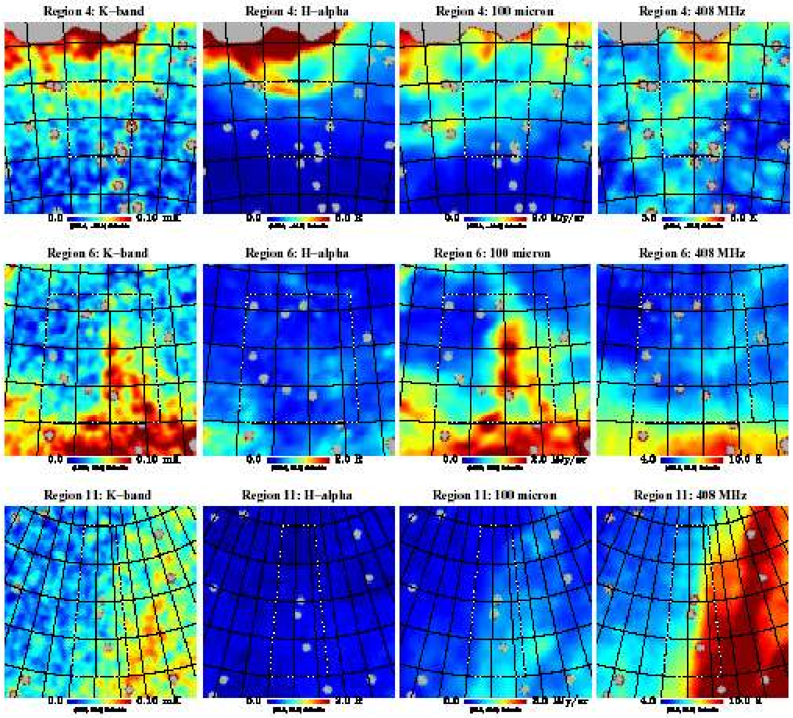

Figure 3. Maps of region 4 (Hα (free-free) dominated; *top* row), region 6 (dust dominated; *middle* row), and region 11 (synchrotron dominated; *bottom* row). From left to right are maps at *WMAP* K-band, Hα, SFD98 100 μm dust intensity and 408 MHz. Galactic coordinates are shown. Each map, with a pixel resolution $N_{side} = 256$, covers a $25° \times 25°$ area with 1° resolution. The dotted black/white line delineates the actual areas used for the T–T plots and cross-correlation analyses. Grey-areas are the standard *WMAP* Kp0 mask and extragalactic sources mask.

Fig. 2 Maps of regions 4, 6 11 at K Band, H-alpha for free-free, 100 microns for dust and 408 MHz for synchrotron.

2. Analysis of the 15 regions

Fig. 1 shows the position of the 15 selected regions overlaid on the Kp2 intensity mask and source mask (700 sources in total) used by the WMAP team (Bennett et al. 2003). Fig.2 shows 3 regions (regions 4, 6 and 11) with an ILC-subtracted K-band, Hα, 100 micron and 408 MHz data. The dominant foreground in each region (see Table 1) is clearly seen along with the correlated emission at K-band. The anomalous emission associated with dust is clearly detected in most of the 15 fields studied. Fields that are only weakly contaminated by synchrotron, free-free and CMB are studied; the anomalous emission correlated well with the Finkbeiner et al. (1999) model 8 predictions (FDS8) at 94 GHz, with an effective spectral index between 20 and 60 GHz, of beta ~-2.85. Furthermore, the emissivity varies by a factor of ~2 from cloud to cloud.

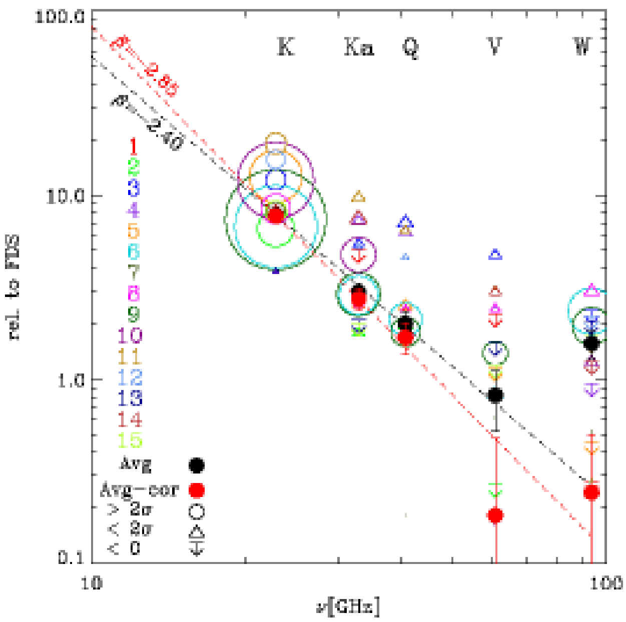

Fig. 3 Summary of dust emissivities (antenna temperature units relative to FDS8 at 94 GHz

Our analysis of the WMAP data indicates strongly that the dust-correlated emission at the low WMAP frequencies has a spectrum which is compatible with spinning dust; we find no evidence for a synchrotron component correlated with dust. The importance of these results for the correction of CMB data for Galactic foreground emission is discussed.

Further work is required to understand the origin of this variation in dust emissivity by using other physical properties of dust such as its size and temperature. New data in the critical radio frequency range 5-15 GHz will be vital for a clearer definition of the anomalous dust spectrum. Polarisation data will be particularly important for understanding the physical mechanism that produces the anomalous emission which is expected to be polarized at different levels (e.g. Draine & Lazarian 1999). For example, spinning dust emission is expected to be only weakly polarized, whereas the synchrotron emission is known to be highly polarised.

References

[1] Bennett C.L. et al., 2003, ApJS, 148, 97
[2] Davies R.D. et al., in press 2006
[3] Draine B.T., Lazarian A., 1999, ApJ, 512, 740
[4] Finkbeiner D.P., Davis, M., Schlegel D.J., 1999, ApJ, 524, 867 (FDS)
[5] Lazarian A., Draine B.T., 2000, ApJ, 536, L15