NASA ASTROPHYSICS DATA PROCESSING GRANT
FINAL REPORT
Grant number: NAG5-7833

Title: Studies of Dust Emission as Measured by DIRBE and IRAS
Performance Period: 12/15/98 - 12/14/01

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Summary of Research

The main activity supported by this grant was to make the dust reddening map (Schlegel, Finkbeiner, & Davis 1998; SFD98) more useful for optical and microwave astronomy, and to increase our understanding of interstellar dust in general. We completed all the major objectives of the proposal, and we are eagerly awaiting the launch of SIRTF so that we can check one of our most controversial conclusions. According to the ADS abstract service, the above paper has been cited 895 times. A number of authors have claimed the SFD98 dust maps are miscalibrated, but recent work suggests that the calibration is correct, (see below).

The primary goal of this ADP grant was to determine the microwave/sum-mm spectrum of interstellar dust emission by cross-correlating the FIRAS spectra with a model based on the SFD98 dust map. Because of temperature variation, large (factor of two) variations are observed in submillimeter / 100 micron ratio, so a careful accounting of dust temperature data, based on DIRBE 100 and 240 micron channels, was required. Even this improvement was unable to reduce the chi^2 per degree of freedom below 30. Further study revealed that a two-component model, with the two components having different (but reasonable) optical properties, achieved a decrease in chi^2 to less than 2, five times better than the next best fit in the literature (Reach etal 1995). The resulting model uses density and temperature estimates based on DIRBE data, with only 4 global parameters fit using the FIRAS data. This dramatic reduction in chi^2 using only 4 fit parameters may indicate that the model is physically correct - but in any case, it is an acceptable phenomenological model. We have released the appropriate data and software on our website (footnote http://astro.berkeley.edu/dust) to allow users to compute the interstellar dust emission between from 100-3000 GHz (or 100micron - 3mm) with ~15% precision. The paper describing these efforts appeared in ApJ 524, 867. This paper has to date been cited 24 times.

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Another major goal of the proposal was to determine the cosmic IR background (CIRB), the sky brightness produced by unresolved galaxies and any other unexpected sources. The CIRB has been detected by FIRAS (Puget 1996) at 400 micron and DIRBE (SFD98, Hauser etal 1998) at 140 and 240 micron but is difficult to separate from zodiacal dust emission from 5-100 micron.

Since that time, detections have been made at 3.5 micron (Dwek and Arendt 1998) and Gorjian, Wright, and Chary (1999) at 2.2 and 3.5 micron. No unambiguous detections in the 5-100 micron range had yet been published because of the intense foreground zodiacal light.

We explored the Kelsall etal (1998) zodiacal light model in great detail, and were unable to make substantial improvements. However, we detected a significant IR excess in the DIRBE 60 and 100 micron channels in our reanalysis, and we tentatively interpret this signal as a cosmological background. The implications of these measurements for galaxy formation are surprising, and we have examined them, as well as CIRB absorption of TeV gamma-rays, thoroughly. These results were published in ApJ 544, 81 (2000). To date this paper has been cited 16 times.

The 60 micron measurement is somewhat controversial, because it implies a high opacity of the IGM to gamma rays, and makes observations of 20 TeV photons by the HEGRA collaboration difficult to interpret. With the launch of SIRTF in late 2002, a new window will open for the mid IR, and the prospects for resolving this putative 60 micron background are excellent. Deep integrations with SIRTF's 70 micron MIPS channel will either detect this background as resolved sources or demonstrate that it does not exist. We eagerly await this important observation!

The SFD98 dust maps have become a crucial input of many astronomical projects, and it is quite important to understand the relationship between the reddening amplitude as a function of the 100 micron dust emission. Recent work from the SDSS project in which scans were taken in a low galactic latitude region near Orion have provided excellent new data for checking this calibration. By means of the 5 color Sloan photometry, Finkbeiner has been able to isolate F stars at different distances. He finds that for the nearest (brightest) F stars the predicted SFD reddening is an overestimate, but that the reddening estimates converge to the SFD98 calibration as one examines fainter and fainter (more distant) F stars. Since the dust maps measure the integrated column of dust emission, this is an excellent confirmation of the original SFD predictions. The brighter stars are simply in front of some fraction of the dust. This important finding will soon be submitted for publication.

PUBLICATIONS RESULTING FROM NAG5-7833

D. J. Schlegel, D. P. Finkbeiner, & M. Davis, ``Application of SFD Dust Maps to Galaxy Counts and CMB Experiments", in XIVth IAP conference proceedings, May 1998, ``Wide Field Surveys in Cosmology", Y. Mellier & S. Colombi, editors, p.297, (1998)

D. P. Finkbeiner, M. Davis, & D. Schlegel, "Detection of a FIR Excess with DIRBE at 60 and 100 Microns", (2000) ApJ 544, 81

D. P. Finkbeiner, M. Davis , & D. Schlegel, ``Extrapolation of Galactic Dust Emission at 100 Microns to CMBR Frequencies Using FIRAS" (1999) ApJ 524, 867

D. P. Finkbeiner & D.J. Schlegel, "Interstellar Dust Emission as a CMBR Foreground", Invited review in "Microwave Foregrounds", eds. A. de Oliveira-Costa & M. Tegmark (ASP, San Francisco, 1999).

D. P. Finkbeiner, D.J. Schlegel, C. Frank, & C. Heiles, "Tentative Detection of Electric Dipole Emission from Rapidly Rotating Dust Grains", ApJ, 556, 898 (2002).of the dust. This important finding will soon be submitted for publication.

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