1. Introduction

1.1. *COBE FIRAS* Data Overview

The Far Infrared Absolute Spectrophotometer (*FIRAS*) is a cryogenically cooled Michelson interferometer. It operated for 10 months of the *COBE* mission and mapped 99% of the sky, with 60% of the sky observed twice 6 months apart. It uses bolometer detectors and is calibrated absolutely by an external blackbody. The frequency coverage extends from 1 to 97 cm^{-1} (30 to 2910 GHz).

The spectral range of the *FIRAS* data includes most of the energy of the cosmic microwave background radiation, emission from interstellar dust, and the major far infrared cooling lines of the interstellar gas. The cosmological measurements to date have been reported by Mather *et al.* (1990), Mather *et al.* (1994), Fixsen *et al.* (1994a), Wright *et al.* (1994), Fixsen *et al.* (1996) (included as Appendix A), and Fixsen *et al.* (1997a), based on a calibration described by Fixsen *et al.* (1994b) (included as Appendix C). They include limits on the cosmological μ and Y parameters of 9.0×10^{-5} and 1.5×10^{-5} respectively. The lines detected include the rotational sequence of CO from the $J = 1 - 0$ transition up to the $J = 7 - 6$ transition, as well as two lines of [C I], two of [N II], and one of [C II]. These lines are very widespread, and the [C II] line is highly correlated with the dust emission. The [N II] lines are also correlated with the dust emission but the correlation is not as tight, presumably due to the higher ionization potential of the nitrogen, chemical abundance gradients, and differences in excitation conditions. The water vapor line at 37.136 cm^{-1} (1113.3 GHz) is detected in absorption against the Galactic center. Analyses of these data on dust and lines have been published by Wright *et al.* (1991), Petuchowski and Bennett (1993), Bennett *et al.* (1994) (included as Appendix D), Reach *et al.* (1995), Dwek *et al.* (1997), and Shafer *et al.* (1997).

In this release of *FIRAS* data, we include the following: skymaps of spectra that have been calibrated and that have had post-calibration offsets removed; uncertainties and errors associated with these skymaps; maps of the emission at frequencies of known emission lines, including the CO rotational ladder from the $J = 1 - 0$ transition to the $J = 7 - 6$ transition, the lines of [C I], [C II], and [N II], and several undetected lines; a map of the cosmic microwave background temperature; and maps of the Galactic dust spectra.

We refer to the process of removing post-calibration offsets as “destriping”; we also provide skymaps of spectra that have been calibrated but not destriped, together with the calibration models that were used and their associated errors.

The calibrated spectra were derived from averaged, or “coadded” interferograms. We include these interferograms in the data release as they are a suitable basis for certain kinds of recalibration strategies that would avoid the Fourier transformation into spectra. They may also be used to investigate deviations of blackbody spectra from Planck spectra, or to search for inconsistent data and other indications of improper action by the instrument or the analysis software.

We provide the original time-ordered interferograms and engineering data. These may be examined to search for time-dependent infrared phenomena and may also be used in studies of the aurora. The auroral electron current heated the *FIRAS* antenna (sky horn) quite substantially at certain times, far exceeding the temperature regulator capability for stabilization. The distribution of cosmic ray glitches is reported directly from the flight microprocessor.

1.2. Pass 4 Improvements In Data Products

This version (4) of the *FIRAS* Explanatory Supplement is specific to, and part of, the "Pass 4" data products, produced and released at the end of 1997. These products superceed all earlier released *FIRAS* products. They are the final deliveries to the community from the COBE project team.

The "Pass 4" data have significant changes in comparison to the earlier "Pass 3" data, derived from bug fixes and fundamental changes in the production algorithms. The process of using neighbors in the coaddition process (Section 4.3) allowed the inclusion of an additional 15% of the data. An error in the template formation was found and corrected. Further improvements in the calibration (Section 5), including padding which allowed a 20% improvement in resolution. Refinements in destriping and error analysis reduced the systematic errors. The net effect of all of these improvements is a factor of 2 reduction in the uncertainty in comparison to Pass 3. In addition, the Pass 4 release includes a number of ancillary data sets, which give values of some astrophyscially interesting quantities derived from the *FIRAS* data (Section 8).

1.3. Explanatory Supplement Organization

The *FIRAS* Explanatory Supplement is organized in the order of *FIRAS* data processing, beginning with the ingested data from the spacecraft telemetry, and ending with the results of the scientific analyses of the Galactic spectral lines, dust, and cosmic background temperature map. Sections 1-3 provide a general overview of the mission. Section 4 describes the processing the *FIRAS* data receive before they are calibrated, while section 5 describes the calibration and its application. Removal of post-calibration offset errors, or "destriping", is described in section 6; section 7 is a description of our error analysis. Algorithms for modeling Galactic spectral lines, Galactic dust, and cosmological parameters are described in section 8. Section 9 describes the various reference data sets that were used in the course of *FIRAS* processing, and section 10 offers advice for reading and using the *FIRAS* delivered project data sets in both FITS and native VAX binary formats.