CMB Temperature From FIRAS Data

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March 11, 2024

I. TASK

Analyse the FIRAS data set. It is the average spectrum of the sky as measured by the FIRAS experiment, which is considered to be a near-perfect blackbody, given by the Planck blackbody law.

Estimate the temperature of the blackbody and the uncertainty of the temperature. One important thing to note is the non-standard frequency units, reported in inverse-centimetres.

We also ask that you perform the analysis using as few external packages as possible, for example avoiding the use of `scipy.minimize` or other "black box" routines.

II. DATA SET

The data set contains five sets of data points.

A. Frequency

The frequency is given in units of inverse-centimetres (cm^{-1}). If desired this can be converted to Hertz through multiplying with $100c$, where $c \approx 3 \cdot 10^8$ m/s is the speed of light.

B. Spectrum

Intensity, as obtained from Planck's blackbody law, given in units of MegaJanskys per steradian (MJy / sr).

III. PLANCK'S LAW OF BLACKBODY RADIATION

Reads

$$B(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{h\nu/(k_B T)} - 1}. \tag{1}$$

In SI units it is expressed as

$$\text{J m}^{-2} \text{ sr}^{-1} = \text{W m}^{-2} \text{ sr}^{-1} \text{ Hz}^{-1}. \tag{2}$$

To convert into MJy / sr multiply with

- 10^{26} for the Janskys ($1\text{Jy} = 10^{-26}\text{W m}^{-2} \text{ Hz}^{-1}$) and
- 10^{-6} for the Mega.