Bull. Astr. Soc. India (1993) 21, 491-494

An assessment of far-infrared measurements and their processing

S. K. Ghosh, B. Das, T. N. Rengarajan and R. P. Verma
Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005

Abstract. Three image processing schemes, used for generating far-infrared (FIR) astronomical maps have been compared for their relative merits. Two of these schemes based on the maximum entropy method (MEM) have been developed at TIFR and the third method, viz., "HiRes" is an IPAC product. The data obtained from the TIFR 1m balloon-borne FIR telescope (TBBFT) as well as the survey detectors of the IRAS satellite have been used. The main conclusions are : deconvolved FIR maps obtained by TBBFT (with relatively smaller FOV) achieve the best angular resolution; MEM deconvolution of IRAS AOs achieves resolution comparable to that of HiRes, with less than one fourth amount of computation, although with limited dynamic range.

A large variety of astronomically interesting sources has been spatially mapped in the FIR (12, 25, 60 & 100 μm) by the survey detectors onboard the IRAS. These measurements (AOs) were made with different selectable observational parameters like scan speed, cross-scan step size, FOV, etc. specified by the "Macro" of the observation (Young *et al.* 1985). The most commonly used Macros are DPS, DPM and DSD. Since 1985, the TIFR 1-metre balloon-borne FIR telescope (TBBFT) has also mapped several Galactic star forming regions at 58 and 150 μm with a circular FOV of 2′.4 (Ghosh 1991). The resolution in the intensity maps generated using the above observations not only depend on the instrumental parameters like FOV etc., but also on the deconvolution procedure adopted.

With the aim of assessing their relative merits, the following three processing schemes have been compared : TBMEM, TAMEM and the HiRes. The TBMEM has been developed at TIFR for processing the TBBFT's chopped FIR signals (hereafter pipe I). It is based on the maximum entropy method (MEM; Gull & Daniell 1978) and is described in Ghosh *et al.* (1988). The TAMEM is a self adaptive scheme, also developed at TIFR on similar lines as Skilling & Bryan (1984) but mainly tailored for processing IRAS AO data for any of the Macros (hereafter pipe II; Ghosh *et al.* 1992, 1993). Input to this pipeline are the AO grid data distributed by IPAC (Young *et al.* 1985). An effective Point Spread Function (PSF) for each Macro, is constructed from observations of a point like source (NGC 6543/asteroid). The HiRes package has been developed at the IPAC (hereafter pipe III), based on a Maximum Correlation Method (Aumann *et al.* 1990) and it uses raw detector data and effectively many more instrumental details (like the PSFs of the individual detectors at the IRAS focal plane).

To cover a wide range of FIR morphology and S/N ratio, the astronomical sources have been selected carefully. The Galactic star forming regions : Carina complex (clumpy & diffuse emission), W 31 region (young embedded sources), IRAS 10361 – 5830 (small scale structure), RCW 57 (asymmetric lobes); NGC 4945 (bright edge-on spiral galaxy) and the Circinus galaxy (Seyfert nucleus) are considered in the present study.

Due to lack of space, only a few examples are presented here. Figures 1(a) and (1)b display the region around IRAS 10361 – 5830 through pipe I (58 μm) and pipe II (60 μm) respectively. The maps of the Carina complex at 150 μm (pipe I) and 60 μm (pipe III) are shown in figures 2(a) and 2(b) respectively. In figure 3, the intensity maps (at 12, 25 and 60 μm) of the galaxy NGC 4945 obtained by pipes II and III have been compared.

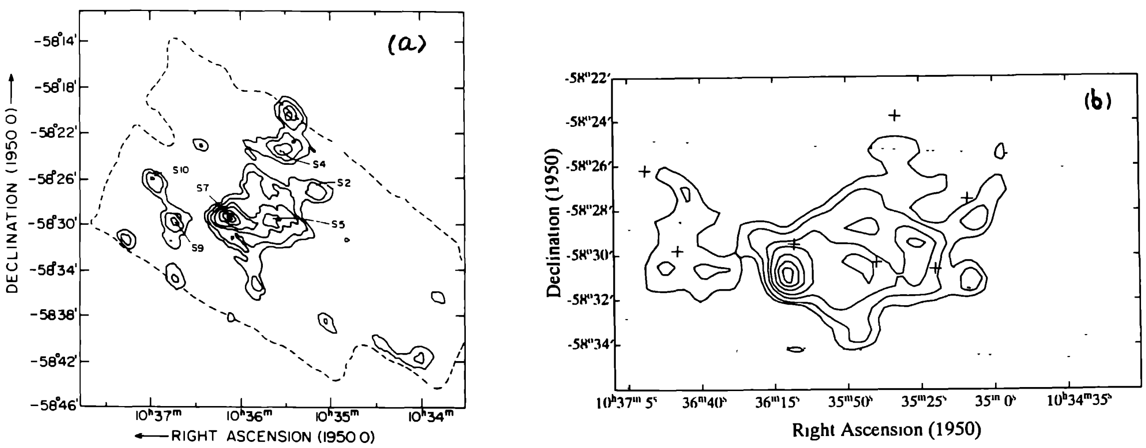

Figure 1. Intensity maps of the star forming region associated with IRAS 10361 – 5830 (a) at 58 μm obtained through pipe I (peak 550 Jy/sq arc min) and (b) at 60 μm processed by pipe II (peak 476 Jy/sq arc min). The contour levels are 0.9, 0.7, 0.5, 0.3, 0.2, 0.1 and 0.05 of the respective peaks.

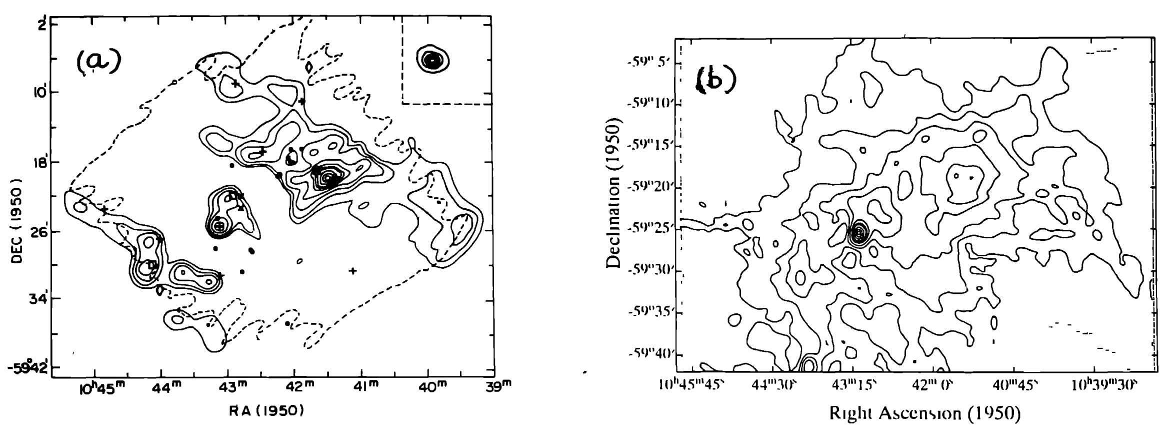

Figure 2. Intensity maps for the Carina complex (a) at 150 μm obtained through pipe I (peak 2000 Jy/sq arc min) and (b) at 60 μm processed by pipe III i.e. IRAS Survey + HiRes (peak 5300 Jy/sq arc min). The contour levels are 0.95, 0.8, 0.6, 0.4, 0.3, 0.2, 0.1, 0.05, 0.025 and 0.01 of the respective peaks.

From the present study (including those sources for which figures are not presented here), the following conclusions can be drawn : (1) Angular resolution of the FIR maps from TIFR balloon-borne measurements and processing is superior to or comparable to the best IRAS (DSD01A Macro using edge-detectors + HiRes processing) products. (2) The pipe II

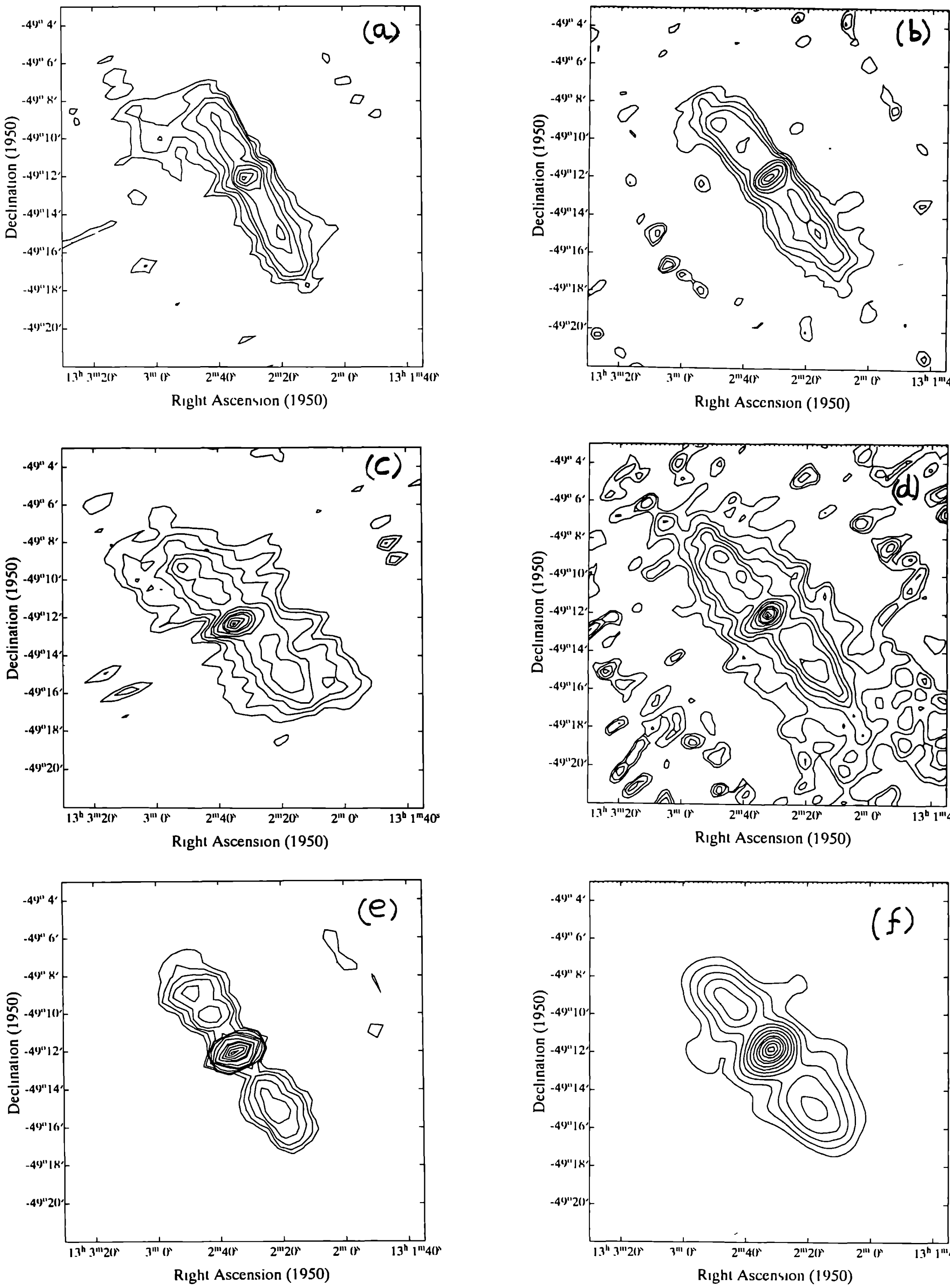

Figure 3. Intensity maps (at 12, 25 & 60 μm) for the spiral galaxy NGC 4945 processed through pipe II (a, c, e) and through pipe III (b, d, f) respectively. The contour levels are sequenced as . 0 9, 0.7, 0.5, 0 3, 0.2, 0 1, 0.05, 0.025, 0.0125, 6.25E-3, 3.13E-3 and 1.56E-3 of respective peaks The contours below the effective dynamic range of a map are suppressed. The peaks are 4 8, 4.9, 18.5, 27.6, 408 and 345 Jy/sq arc min. for a, b, c, d, e and f respectively.

processing of IRAS AO grids (already averaged over detectors) achieves comparable angular resolution at 60 μm and only slightly poorer resolution at 100 μm as compared to that of HiRes which begins from the detailed raw detector data. (3) The processing II is computationally inexpensive by a factor $\gtrsim 4$ compared to HiRes but the dynamic range is limited to ~200. (4) HiRes achieves far superior dynamic range (~ 1000) of the final map. (5) The above implies that for astronomical sources with high *S/N*, it is not necessary to undertake elaborate HiRes processing to resolve moderately bright features.

References

Aumann H. H., Fowler J. W., Melnyk M., 1990, AJ, 99, 1674.

Ghosh S. K., 1991, Ind. Jour. Rad. & Sp. Phys., 20, 241.

Ghosh S. K., Bisht R. S., Iyengar K. V. K., Rengarajan T. N., Tandon S. N., Verma R. P., 1992, ApJ, 391, 111.

Ghosh S. K., Iyengar K. V. K, Rengarajan T. N., Tandon S. N., Verma R. P., Daniel R. R., 1988, ApJ, 330, 928.

Ghosh S. K., Verma R. P., Rengarajan T. N., Das B., Saraiya H. T., 1993, ApJS, 86, 401.

Gull S. F., Daniell G. J., 1978, Nature, 272, 686.

Skilling J., Bryan R. K., 1984, MNRAS, 211, 111.

Young E. T., Neugebauer G., Kopan E. L., Benson R. D., Conrow T. P., Rice W., Gregorich D. T., 1985, A User's Guide to the IRAS Pointed Observation Products, IPAC Preprint Pre-0008N.