N75 12741

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MULTICOLOUR FAR INFRARED PHOTOMETRY OF GALACTIC HII REGIONS

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ABSTRACT

Results are presented of far infrared photometric measurements of HII regions in the galactic plane between longitudes 350 and 40 degrees. The results are combined from balloon flights in 1972 and 1973 carried out in cooperation with CNES in the south of France.

INTRODUCTION

The far infrared survey by Hoffmann et al (1971) has shown that a large fraction of the 100μ sources can be identified with galactic HII regions in which strong visual absorption is present. Presumably the dust component in these regions reradiates the absorbed high energy photons from the exciting sources in the infrared thermal region of the electromagnetic spectrum.

The temperature of the dust grains is determined by the energy density in the radiation field, by the absorption efficiency of visual and ultraviolet photons and by the behaviour of the grain emissivity in the infrared.

After the survey by Hoffmann et al (1971) much work has been done on the observations of galactic HII regions in different infrared wavelength bands. A survey of most of the recent observations can be found in the review paper by Wynn-Williams et al (1973).

Our aim was to observe HII regions in two wavelength bands simultaneously. The ratio of the observed fluxes in both wavelength bands is a function of the temperature and emissivity of the dust grains.

INSTRUMENTATION

The photometers consist of multiple reststrahlen reflection filters at pumped liquid helium temperature followed by gallium doped germanium bolometers (Wijnbergen et al 1972). Two filter-detector combinations are located at the cold plate of a helium dewar. Each photometer is fed by a 20 cm parabolic reflective f/5 telescope observing off-axis. Both telescopes are mounted vertically in a balloon gondola and are looking outward via a rocking flat mirror. A 26 degrees rotation of the flat mirror around a horizontal axis driven by a stepper motor allows to scan the sky in elevation while the gondola is oriented in a southern direction by means of a servo control system that senses the local horizontal earth magnetic vector as positional reference. The stability of the servo system is about 0.5 degree. The siderial motion gives rise to a series of scans at different hour-angles. The off-set of the magnetic sensor can be changed in both directions on ground command, thus allowing repeated observations of the same celestial area during a single flight. The

The cooled aperture stop restricts the full field of view on the sky to 30 arc.min. Flight altitude is 4.7 mbar.

CALIBRATION

The final experimental result obtained in photometric observations is dependent on the calibration of the instrument. Absolute calibration is usually hard to achieve. In infrared astronomy planets have been used most often as in-flight calibration standards. A comparison of the infrared signal as observed from the planet yields the observed energy provided that the output of the planet in the appropiate wavelength range is known. To check the consistency of the results an attempt has been made to calibrate the photometers in the laboratory. A vacuum collimator and a thermostated black body have been used to determine the output of the photometer in the relevant wavelength bands. A fit of the laboratory calibration with the observations of Jupiter in the two bands gives a brightness temperature of 140 $\pm$ 5 K for this planet. This value is in good agreement with the results of Aumann et al (1969) and Armstrong et al (1972) and will be used in the further analysis of the data.

The noise equivalent flux densities as observed during the flights was of the order of 2×10^{-22} $Wm^{-2}Hz^{-1}$. This corresponds to a detector noise-equivalent-power of 2×10^{-12} $WHz^{-\frac{1}{2}}$ which is considerably higher than might be expected from the detector specifications and the background photon shot noise contributions. We attribute the excess noise to the effects of mechanically driven parts in the gondola.

OBSERVATIONS

The results reported here have been obtained during flights on June 6, 1972, June 7, 16 and July 2, 1973 from the Tallard balloon launch facility operated by French Space Research Organisation C.N.E.S. The performance of the balloon gondola was satisfactory with the exception of the occurrence of oscillatory motions both in azimuth and elevation. The character and amplitude of this motion varied during flight. Reduction of the observed signals to intensity distribution on the sky is complicated by these residual oscillations.

During each flight observations have been made in two wavelength bands simultaneously. The wavelength bands we have flown up to now are shown in table 1.

Table 1.

flight	wavelength bands	
1972	71 - 95 μ	84 - 130 μ
1973 I	71 - 95 μ	30 - 38 μ
1973 II	71 - 95 μ	114 - 196 μ
1973 III	111 - 154 μ	30 - 38 μ

The transmission characteristics of these bands have been published earlier by Wijnbergen et al (1972).

In the data reduction proces each signal that is clearly distinguishable from the noise is coded according to its amplitude. Using the position information from the scanning mirror, the azimuth error from the servo system, the time recorded simultaneously with the photometer output and the position of the gondola as obtained during flight, each coded signal is transformed to its celestial coordinates. Only those sources that show up on at least 5 successive scans have been analysed. For some sources the number of scans are as high as 100. Due to residual pointing errors the signals attributed to the same source, show variation of amplitude in different scans. The errors quoted in the final results take these uncertainties into account.

Flight 1972. Due to identification problems some numbers given by Olthof and van Duinen (1973) are wrong. A re-analysis of these data has shown that we did not observe M17. It is now clear that this source was outside our scanned area. Also the signals identified with W31 and W33 have been mixed up. As a result the number given for the 84-130μ band for W31 was too high and the number given for W33 was too low. The results of this flight based on the re-analysis have been included in tables 2 and 3.

Flight 1973 I. Due to problems with the low noise amplifier data for the 30-38μ band were unreliable for 2/3 of the flight. Only in the last part of the flight this channel has given reliable results for M17 and Jupiter. Fortunately this did not influence the observations in the 71-95μ band.

Flight 1973 II. A flight without problems. During this flight Jupiter has been observed at elevations 17 and 27 degrees above the horizon to determine residual atmospheric absorption at balloon altitudes. At each elevation several scans through Jupiter have been made. In both cases the mean signal amplitude was the same within the 10% r.m.s. error.

Flight 1973 III. Due to degradation of the system only the strongest sources could be observed.

Results of the above four flights are given in tables 2 and 3. Table 2 gives the observed flux ratio to Jupiter. During all flights Jupiter has been observed for calibration. For the 71-95μ band an average has been taken for the flights during which this filter was included. The same has been done for the observation of M17 in the 30-38μ band. Table 3 gives the observations converted to Wm^{-2} using a black body temperature of 140 K for Jupiter.

DISCUSSION

Hoffmann et al (1971) have observed most of the sources in the wavelength band from 80 to 135μ with a balloon gondola using a differential beam switching technique, while Soifer et al (1972) have observed NGC 6357 and M8 with a cooled rocket telescope using full field chopping.

In general our results are a factor of 3 higher than the results obtained by Hoffmann et al with a 0.2 degree beam. We are tempted to conclude that the surface brightness distribution is generally peaked with an extended background. This conclusion is supported by the observation of Soifer et al of NGC 6357 which shows this source to be extended while Hoffmann et al classify this object as two point sources.

<u>Table 2</u>

Observed flux ratio with respect to Jupiter

Sources	gal. coord.	30-38 μ	71-95 μ	84-130 μ	111-154 μ	114-196 μ
NGC 6334	351.4 + 0.7		0.44 ± 0.05	0.65 ± 0.06	0.59 ± 0.11	0.56 ± 0.14
" 6357	353.1 + 0.7		0.28 ± 0.04	0.40 ± 0.07	0.38 ± 0.07	0.38 ± 0.13
" 6383	355.2 + 0.1		0.07 ± 0.01			0.19 ± 0.07
63.2-0.5	3.2 - 0.5		0.05 ± 0.01			0.13 ± 0.02
M8	6.0 - 1.2		0.11 ± 0.02	0.12 ± 0.02		0.13 ± 0.02
W30	8.5 - 0.3		0.07 ± 0.02	0.12 ± 0.03		0.13 ± 0.02
W31	10.3 - 0.1		0.12 ± 0.02	0.15 ± 0.03		0.19 ± 0.06
W33	13.2 + 0.0		0.15 ± 0.02	0.24 ± 0.04		0.25 ± 0.07
M17	15.1 - 0.7	0.22 ± 0.04	0.53 ± 0.07		0.59 ± 0.11	0.56 ± 0.14
M16	17.0 + 0.8		0.12 ± 0.02			0.19 ± 0.07
W35	18.5 + 1.9		0.07 ± 0.01			0.13 ± 0.06
W39	19.1 - 0.3		0.08 ± 0.03			0.13 ± 0.06
W41	22.8 - 0.3		0.08 ± 0.02			0.19 ± 0.07
W42	25.4 - 0.2		0.08 ± 0.03			0.19 ± 0.07
W43	30.8 + 0.0		0.15 ± 0.03			0.25 ± 0.07
W44	34.3 + 0.1		0.06 ± 0.01			0.19 ± 0.07
W40	28.8 + 3.5		0.10 ± 0.02			0.19 ± 0.07

Table 3

Deduced mean fluxes based on T_{BB}(Jup) = 140 K in units of 10^{-9} W m^{-2}

Source	30 -38 μ	71-95 μ	84-130 μ	111-154 μ	114-196 μ
NGC 6334		4.80 ± 0.55	6.20 ± 0.55	2.30 ± 0.45	2.75 ± 0.70
" 6357		3.05 ± 0.45	3.80 ± 0.65	1.50 ± 0.30	1.85 ± 0.60
" 6383		0.75 ± 0.10			0.95 ± 0.35
63.2 - 0.5		0.55 ± 0.10			0.65 ± 0.10
M8		1.20 ± 0.20	1.15 ± 0.20		0.65 ± 0.10
W30		0.75 ± 0.20	1.15 ± 0.30		0.65 ± 0.15
W31		1.30 ± 0.20	1.45 ± 0.30		0.95 ± 0.30
W33		1.65 ± 0.20	2.30 ± 0.40		1.25 ± 0.35
M17	8.30 ± 1.50	5.80 ± 0.75		2.30 ± 0.45	2.75 ± 0.70
M16		1.30 ± 0.20			0.95 ± 0.35
W35		0.75 ± 0.10			0.65 ± 0.30
W39		0.85 ± 0.30			0.65 ± 0.30
W41		0.85 ± 0.20			0.95 ± 0.35
W42		0.85 ± 0.30			0.95 ± 0.35
W43		1.65 ± 0.30			1.25 ± 0.35
W44		0.65 ± 0.10			0.95 ± 0.35
W40		1.10 ± 0.20			0.95 ± 0.35

ACKNOWLEDGEMENTS

These results would not have been obtained without the laborious work, skillfully performed by the technical staff of our department. They actually did the job.

This program is supported by the Dutch commission on Geophysics and Space Research of the Royal Academy of Sciences.

REFERENCES

Armstrong, K.R., Harper, D.A., Low, F.J. 1972, Astrophys.J.Letters 178, L89

Aumann, H.H., Gillespie, C.M., Low, F.J. 1969, ibid 157, L67

Hoffmann, W.F., Frederick, C.L., Emery, R.J. 1971, ibid 170, L89

Olthof, H., Van Duinen, R.J. 1973, Astron. and Astrophys. 29, 315

Soifer, B.T., Pipher, J.L., Houck, J.R. 1972, Astrophys.J. 177, 315

Wijnbergen, J.J., Moolenaar, W.H., De Groot, G. 1972, Proc. 5th ESLAB/ESRIN Symp. on infrared detection techniques for space research, Ed. V. Manno, J. Ring. Publ. Reidel

Wynn-Williams, C.G., Becklin, E.E. 1973, preprint, to be published in P.A.S.P.

DISCUSSION SUMMARY — PAPER 1.6

These flights were made at the French balloon launch facility. In June it is possible to obtain flight durations of approximately eight hours. In the autumn near turn around times, ten-hour flights are possible. It was suggested that longer flights possible from the NCAR facility might justify the added expenses and more complicated logistics.

Observations of Jupiter were used for inflight verification of the instrument filter performance. These measurements indicated that any residual transmission outside the primary bandpass was negligible.

A sensitivity of twenty-thousand-flux units was realized with this instrument.