RECENT SURVEYS OF THE GALACTIC CONTINUUM RADIATION

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RESUMEN. En 1982 se publicó el relevamiento de todo el cielo en 408 MHz de Bonn que hasta la fecha representa el mapa más exacto de todo el cielo en radiofrecuencias. El relevamiento de Bonn del cielo boreal en 1420 MHz será completado con observaciones con la antena de 30 m de Argentina. La comparación de ambos relevamientos permite efectuar estudios de índice espectral con gran precisión. Las observaciones de complejos de emisión térmica y no térmica sobre el plano galáctico requieren una resolución angular elevada. El telescopio de 100 m de Effelsberg ha sido utilizado previamente para relevamientos del plano galáctico en 1420 MHz y 4875 MHz. En la actualidad se realizan observaciones de alta sensibilidad en 2965 MHz, las que han permitido detectar nuevas remanentes de supernova.

ABSTRACT. In 1982 the Bonn 408 MHz all-sky survey was published, which up to now represents the most accurate radio map of the whole sky. The companion 1420 MHz Bonn survey of northern sky will be extended to the highest frequency all-sky survey by observations with an Argentina 30-m dish. Comparison of both surveys allow spectral index studies of high accuracy. Observations of the confusing thermal and nonthermal emission complexes along the Galactic plane need high angular resolution. The Effelsberg 100-m telescope has previously been used at 1420 MHz and 4875 MHz for surveys of the Galactic plane. At present high sensitivity observations at 2695 MHz are carried out, which have shown several previously unrecognized supernova remnants.

I. INTRODUCTION

Radio continuum emission is received from relativistic cosmic ray electrons radiating in the interstellar magnetic field. At high frequencies thermal emission is an additional component. Multifrequency observations are needed to separate the different thermal and nonthermal components in the line of sight. Studies of the galactic continuum radiation need two types of observations. Considering our unfavourable position inside the Galaxy absolutely calibrated all-sky surveys are needed to study the general structure of our Galaxy. The strong concentration of objects in the disk, however, requires high resolution observations of the Galactic plane to separate the different components.

II. ALL-SKY SURVEYS

As shown in Table 1 the 408 MHz survey is so far the all-sky survey with the highest angular resolution and sensitivity. Beside the concentration of strong emission in the Galactic centre region and along the plane arising from the disk and spiral arm complexes, various large loops, spurs, supernova remnants and HII regions are visible outside the plane region. A physical interpretation of all these features needs spectral index information. These will be provided by combination with a survey at 1420 MHz (see Table 1) which matches the 408 MHz survey in angular resolution and sensitivity, considering even steep nonthermal features with β up to 3 ($T_B \sim \nu^{-\beta}$). The sensitivity for thermal emission at 1420 MHz is higher, of course. First results from spectral studies of the northern sky may be summarized as follows:

(a) the general spectral index outside of known local features is near β = 2.7,

(b) the radio loops I and III and some spurs have steeper spectral indices (β ∿ 3) than their surroundings.

(c) an intensive local feature located in the Cassiopeia-Perseus region (ℓ ∿ 115° to ∿ 165°) shows a spectral break above 820 MHz which may be connected to the break of the local electron spectrum near 10 GeV (Kallas et al., 1983),

(d) there is a clear tendency of a flattening of the spectral index towards cold regions in high galactic latitudes (Kupczack 1983).

TABLE 1

Large-scale Radio Continuum Surveys

Telescope	Frequency [MHz]	HPBW [°]	ΔT_B [K]	Coverage	Reference/Status
Parkes 64 m, Cambridge Array	150	≥2.2	25	all sky	Landecker and Wielebinski, 1970
Effelsberg 100 m, Jodrell Bank 76 m, Parkes 64 m	408	0.85	2	all sky	Haslam, Salter, Stoffel and Wilson, 1982
Dwingeloo 25 m	820	1.2	0.5	northern sky, δ ≥-8°	Berkhuijsen, 1972
Stockert 25 m	1420	0.6	0.05	δ ≥ +20° δ ≥ -19°	Reich, 1982 reduction stage
Argentina 30 m	1440	0.5	0.05	δ ≥ -90°	observations started

If the latter finding is interpreted as typical for the galactic halo emission, it would be different to observations of nearby galaxies which show steeper spectral indices in the halo than in the disk. The contribution of steep spectrum loops and spurs to the halo emission, however, is unclear up to now.

It seems unlikely today that higher frequency all-sky surveys will be carried out which match the 408 MHz and 1420 MHz surveys in sensitivity and angular resolution. The observing time for such a project will take several years even with the best equipment available. Present observations at high frequencies are restricted to the regions of stronger emission along the Galactic plane and some selected regions outside.

III. RECENT SURVEYS OF THE GALACTIC PLANE

The strong emission along the Galactic plane has been mapped since the early days of radio astronomy. Comparison of the many different maps published so far demonstrates the progress in antenna design, receiver sensitivity and reduction software. The Effelsberg 100-m telescope has been used at 4875 MHz by Altenhoff *et al.* (1978) to map the Galactic plane between 357° ≤ ℓ ≤ 60°, $|b| \leq 1°$ with a high resolution of 2!6. At present the Nobeyama 45-m telescope is used at 10.2 GHz to map a similar area with the same resolution (Sofue *et al.*, 1983). Both surveys outline thermal emission complexes and compact HII regions quite well. Supernova remnants (SNRs) however can be better identified at longer wavelengths. A fast survey at 21 cm wavelength with the Effelsberg 100-m telescope of the area 93° ≤ ℓ ≤ 162°, $|b| \leq 4°$ (Kallas and

Reich 1980) shows up several new SNRs with apparent diameters of ∿ 1°(e.g. Reich *et al.*, 1979; Reich and Braunsfurth 1981). At present observations at 2695 MHz are carried out which at least will cover the Galactic plane visible from Effelsberg in the range $|b| \leq 5°$. The angular resolution is about 4!3, the sensitivity is ∿ 40 mK T_B, and linearly polarized emission is observed simultaneously. A first section ($358° \leq \ell \leq 76°$, $b = 1°5$) is completed and will be published in the near future (Reich *et al.*, in preparation). Two new plerionic-type SNRs (Reich *et al.* 1984) and two shell-type objects seen in projection to the Galactic centre region (Reich and Furst 1984) have been confirmed so far by additional high frequency observations.

The Effelsberg data will be combined with current 2.7 GHz observations at the Stockert 25-m telescope, where the Galactic plane is observed in a range $|b| \leq 20°$ with a resolution of 19' (Reif *et al.*, 1984). The method of observation is the Nodding-Scan technique (Haslam *et al.*, 1974), which allows quite accurate corrections for atmospheric and ground radiation effects, so that the large-scale structure can be mapped with high reliability. Comparison with the existing surveys at longer wavelengths will outline spectral index variations more pronounced due to the large frequency interval. A determination of the thermal-to-nonthermal emission ratio can hopefully be done with greater accuracy than before.

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