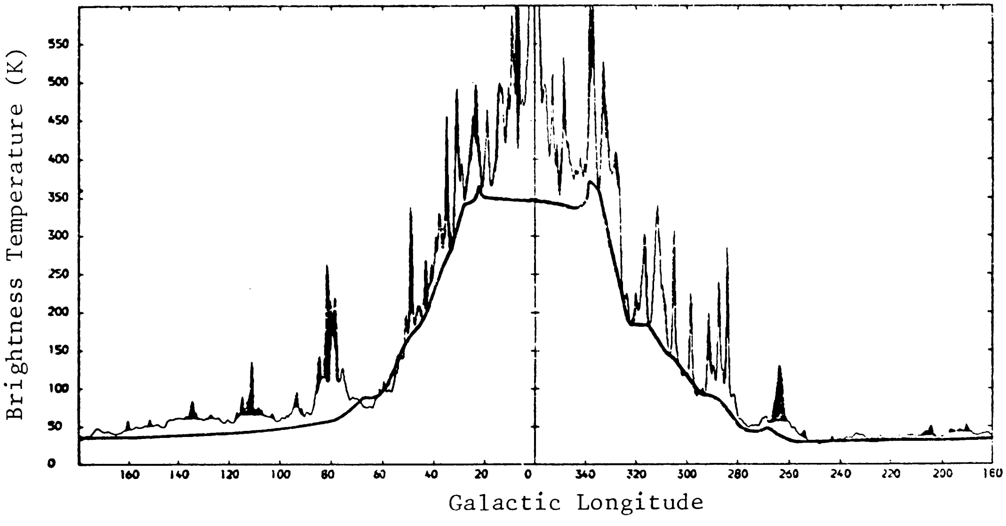
THE LARGE-SCALE DISTRIBUTION OF SYNCHROTRON EMISSIVITY IN THE GALAXY

S. Kearsey, J.L. Osborne and S. Phillipps
Department of Physics, Durham University, U.K.
C.G.T. Haslam, C.J. Salter and H. Stoffel
Max-Planck-Institute for Radioastronomy, Bonn, F.R.G.

The all-sky radio continuum map at 408 MHz presented at this symposium by Haslam et al. can be interpreted in terms of the large-scale 3-dimensional distribution of synchrotron emissivity in the Galaxy when due allowance is made for the thermal emission. Its derivation from a 2-dimensional map must involve a number of assumptions so it is instructive to compare the results of alternative approaches (described in detail in forthcoming papers by the present authors). In both cases the variation of emissivity in the galactic plane is obtained from the observed intensity profile at $b=0^{\circ}$ and then the z-variation is chosen to give the best fit to the complete map. The observed profile is shown in the figure with and without the contributions of catalogued supernova remnants and HII regions.



The profile along the galactic plane
Upper line: observations with contributions from identified discrete sources blacked in. Heavy line: the fit from the unfolding method with allowance for the thermal and extragalactic emission.

G. Setti, G. Spada, and A. W. Wolfendale (eds.), Origin of Cosmic Rays, 223–224.

The first is an unfolding technique. The galactic plane is divided into logarithmic spiral sections and it is assumed that for each the form of the radial variation of emissivity, $\mathcal{E}(R)$, is the same. By an iterative method the azimuthal variation of emissivity from one section to the next is determined from the observed profile. The method, while similar to that of Kanbach and Beuermann(1979), differs from it in taking continuous spiral sections around the Galaxy rather than unfolding the two halves of the plane independently. The assumed pitch angle, p, was varied: $p=12^{\circ}$ gave an unfolded emissivity with the sharpest features. Equally good fits are obtained with $\mathcal{E}(R)\propto R^{-1.9}$, $\propto\exp(-R/3.9\mathrm{kpc})$ or $\propto\exp(-(R/7.9\mathrm{kpc})^{2})$. The figure shows the fit for the exponential case. The unfolding applies only for $90^{\circ}-p>l>270^{\circ}-p$ and the fit has been made to the lower envelope of the observed profile. (In external galaxies the ridge lines of emissivity wander so that it is unrealistic to attempt a fit of the peaks to a smooth spiral structure). For the outer half of the plane the line results from an extrapolation extending to R=15 to 20kpc, dependent on the form of $\mathcal{E}(R)$, to fit the observed anticentre value. For $|l|<20^{\circ}$ a fit to the profile cannot be obtained, indicating that the spiral structure is not present for $R\lesssim3.6$ kpc. The heavy line indicates the emission for R>3.6 kpc only. A free parameter is the ratio of the strengths of the regular magnetic field along the spirals and the irregular, isotropic component. The fitting is not very sensitive to this provided that the ratio is $\lesssim 1$. The results place the sun in an interarm region with a local emissivity of 2.5 to 3 K kpc^{-1}. This would be given by equally strong regular and irregular fields of $\sim$2.7 μG.

The second method is an extension of the work of Brindle et al. (1978) which used the earlier 150 MHz all-sky map. Here the basic structure of the Galaxy is taken to be known from a combination of the model of Georgelin and Georgelin (1976) within the solar circle and the HI arms without. The predictions of the density wave relate the synchrotron emissivity to it. Free parameters are the ratio of regular to irregular field and the underlying radial dependence of the emissivity. To reproduce the assymmetric form of the longitude profile for $|l|<30^{\circ}$ the spiral arms are required to emerge from an elliptical ring having axes of length 4 and 5 kpc. The emission from the $l\sim80^{\circ}$ region is provided by a local sub-arm which passes within 0.5 kpc of the sun in the anticentre direction. Apart from these non-spiral features the overall distribution of emission in the plane is similar to that from the unfolding technique. The sun is again in an interarm position with a similar local emissivity.

References

Brindle, C., French, D.K., and Osborne, J.L.: 1978 MNRAS 184, 283.
Georgelin, Y.M., and Georgelin, Y.P.: 1976 Astr. Astrophys. 49, 57.
Kanbach, G., and Beuermann, K.: 1979 Proc. 16th Int. Cosmic Ray Conf. 1, 75.