

RADIOCONTINUUM IN NEARBY GALAXIES

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The observed radiocontinuum in galaxies is the addition of thermal and nonthermal emissions. Thermal emission, due to hot gas ionized by stars, has a flat spectrum and is best observed at high radio frequencies. The nonthermal emission, due to relativistic electrons spiralling in magnetic fields of a galaxy, has a steep spectrum and dominates at lower radio frequencies. Relativistic electrons can originate in supernovae, pulsars, X-ray sources and OB-stars. The nonthermal emission process offers an additional possibility since the radio emission is linearly polarized. We can use the observations of polarized radiation to trace the magnetic fields in galaxies.

Observations of our Galaxy at lower radio frequencies led to a disk-halo model. In the disk we find numerous individual sources: supernova remnants, HII regions. These are best studied with arcminute angular resolution at higher radio frequencies (e.g. 5 GHz survey of Haynes et al., 1978, or 4.9 GHz survey of Altenhoff et al., 1979). The large scale radiocontinuum structure of the Galaxy is best revealed in all sky surveys, made with a degree resolution at lower radio frequencies (e.g. 150 MHz survey of Landecker and Wielebinski, 1970, and 408 MHz survey of Haslam et al., 1980). As seen in Figure 1 the contours of the 408 MHz radiocontinuum show clearly the disk component, the tangential points of the local spiral arm (Cygnus X at $\ell=80^\circ$ and Vela X at $\ell=260^\circ$) as well as many 'spurs' at high galactic latitudes. These 'spurs' are considered to be nearby features, possibly supernova remnants in our neighbourhood. Flare-like origin of these features cannot, however, be excluded. In addition to a uniform extragalactic component, there exists an electron halo around our Galaxy which however needs detailed analysis techniques (e.g. Webster, 1978) for its confirmation.

To study nearby galaxies in radio continuum we need at least arcminute resolution and a great receiver sensitivity. Aperture synthesis radio telescopes are responsible for most of the information at the lower frequencies. Care must be taken with synthesized maps often to restore the missing low order components correctly. High frequency maps of nearby galaxies come now from the 100-m Effelsberg radio telescope. At 10.6 GHz ($\lambda=2.8$ cm) the 1.2 arcmin beam is matched with a millikelvin r.m.s. noise capability. Some nearby gala-

xies could be studied at a number of frequencies from 150 MHz to 23 GHz. A sample of radio maps of galaxies is shown in Figures 2 and 3.

The study of a galaxy at a number of frequencies allowed the separation of thermal and nonthermal emission. A study of a sample of nearby galaxies by Klein and Emerson (1980) led to the conclusion that the thermal emission is less dominant than previously suspected, making out only some $\sim 20\%$ of the total at 10.6 GHz. Also the mean spectral index is 0.7 ± 0.15 ($S_{\nu} \propto \nu^{-\alpha}$) for this sample. Similar spectral index was found for radio galaxies, so that possibly very similar physical processes are at work. Similar studies by Hummel (1980) on a larger sample of smaller (and more distant) galaxies confirmed the above conclusions and showed that the disk radio power is directly related to optical luminosity. Thus the sources of relativistic electrons seem to be distributed more like the old disk population and not like young OB-stars. A more general conclusion of Hummel (1980) is that density waves don't seem to play a dominant role in the radio emission in galaxies.

The observations of edge-on galaxies allow us to study the electron halo problem. Now that some five galaxies could be studied at a number of frequencies we are able to say that some radio continuum is seen away from the disk and that the spectral index increases with distance above the plane. This increase can be due both to ageing of the particles and in the decrease of magnetic field. Such electron halos however are not going to retain the electrons but shed them into the intergalactic space.

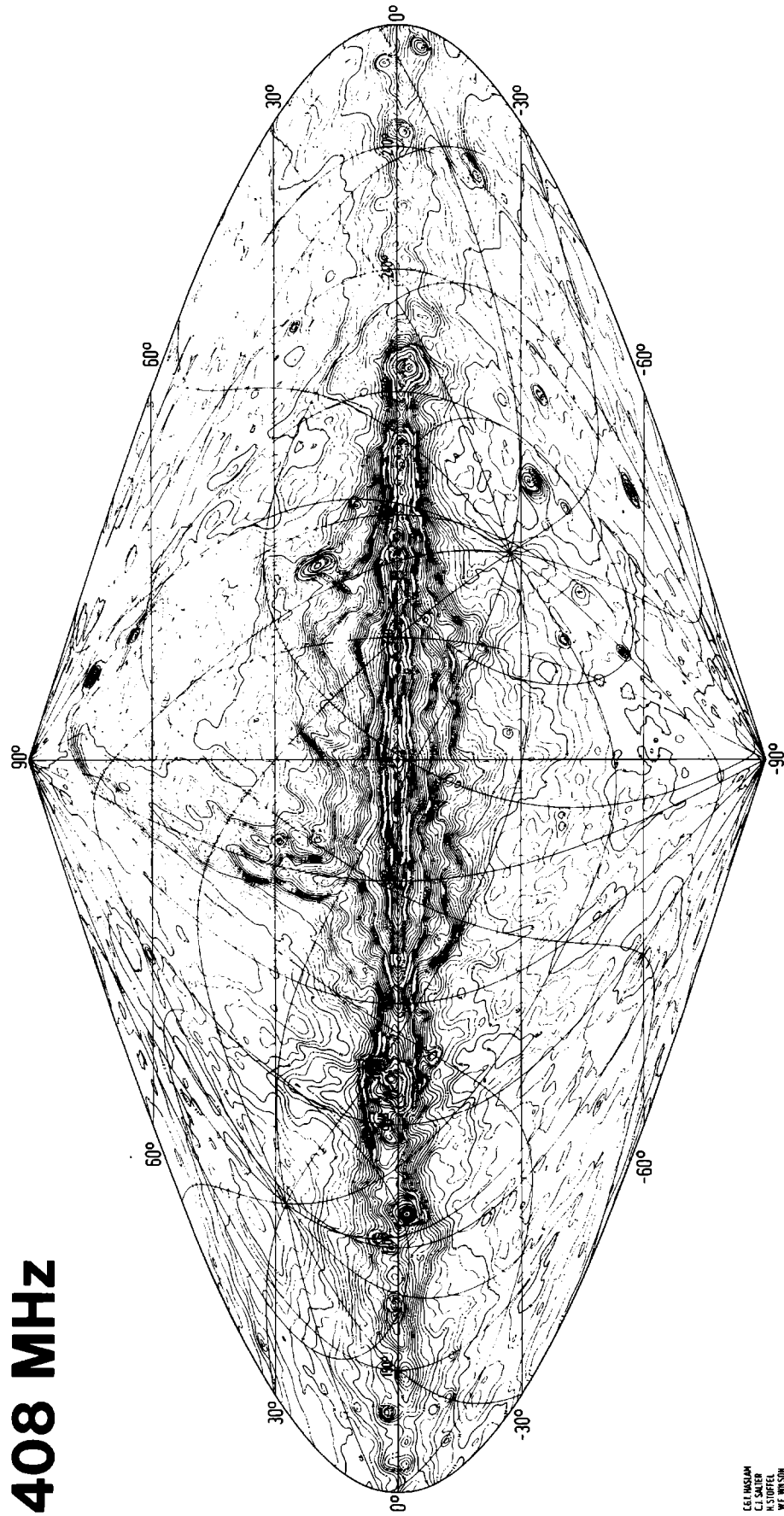
The linear polarization has now been mapped in five nearby galaxies. As an example in Figure 4 we see the result for M31. All the maps show the same pattern: The E-vectors are perpendicular to the spiral arms implying a rather uniform field along the spiral arms. This is an important results since so far we had only a few clues on the distribution of magnetic fields in galaxies. In view of the fact that density waves seem not to play a dominant role in the radiocontinuum emission, magnetic fields may be the answer.

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408 MHz

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Figure 1: The 408 MHz survey convolved to a 2° resolution
(Haslam et al., 1980)

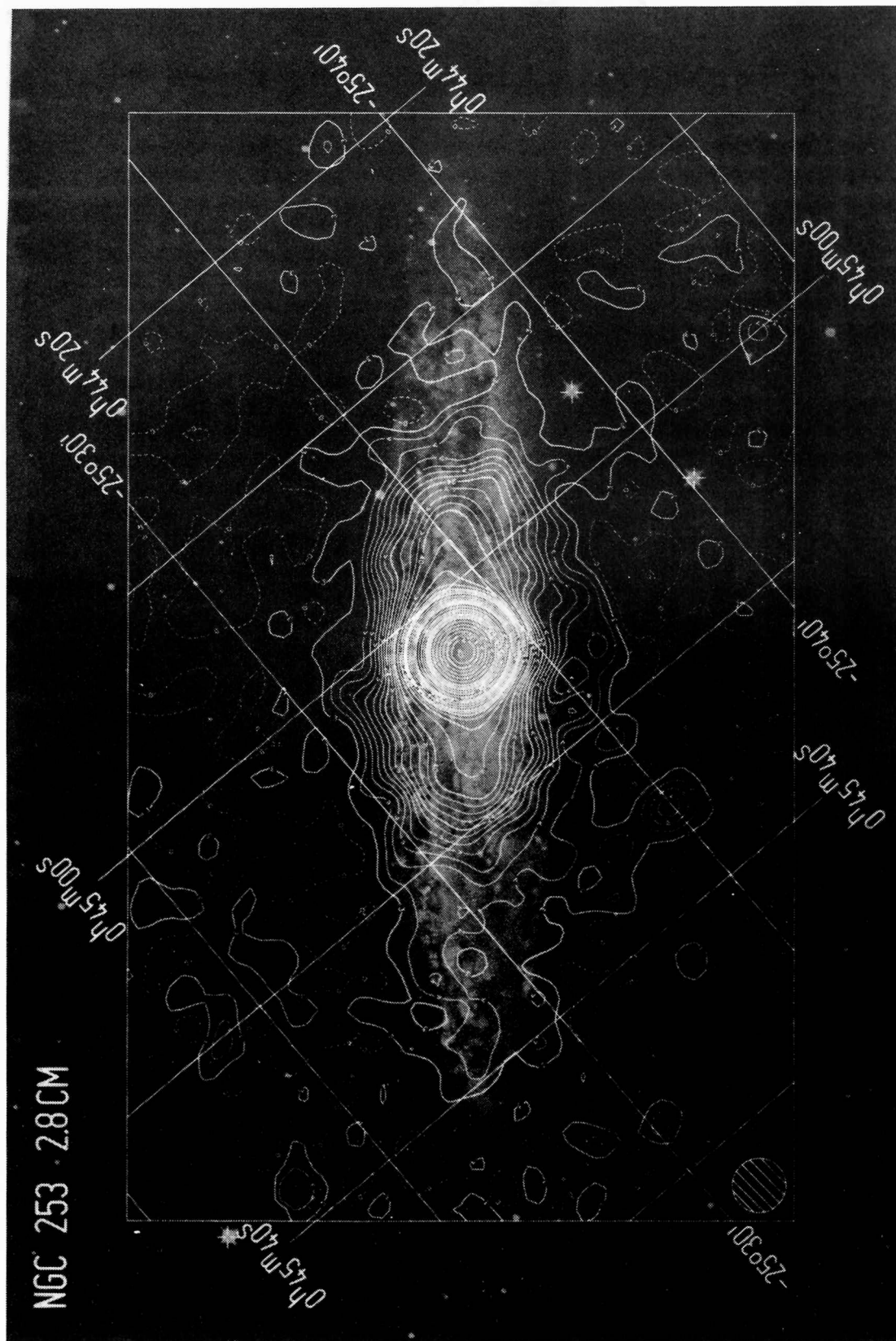
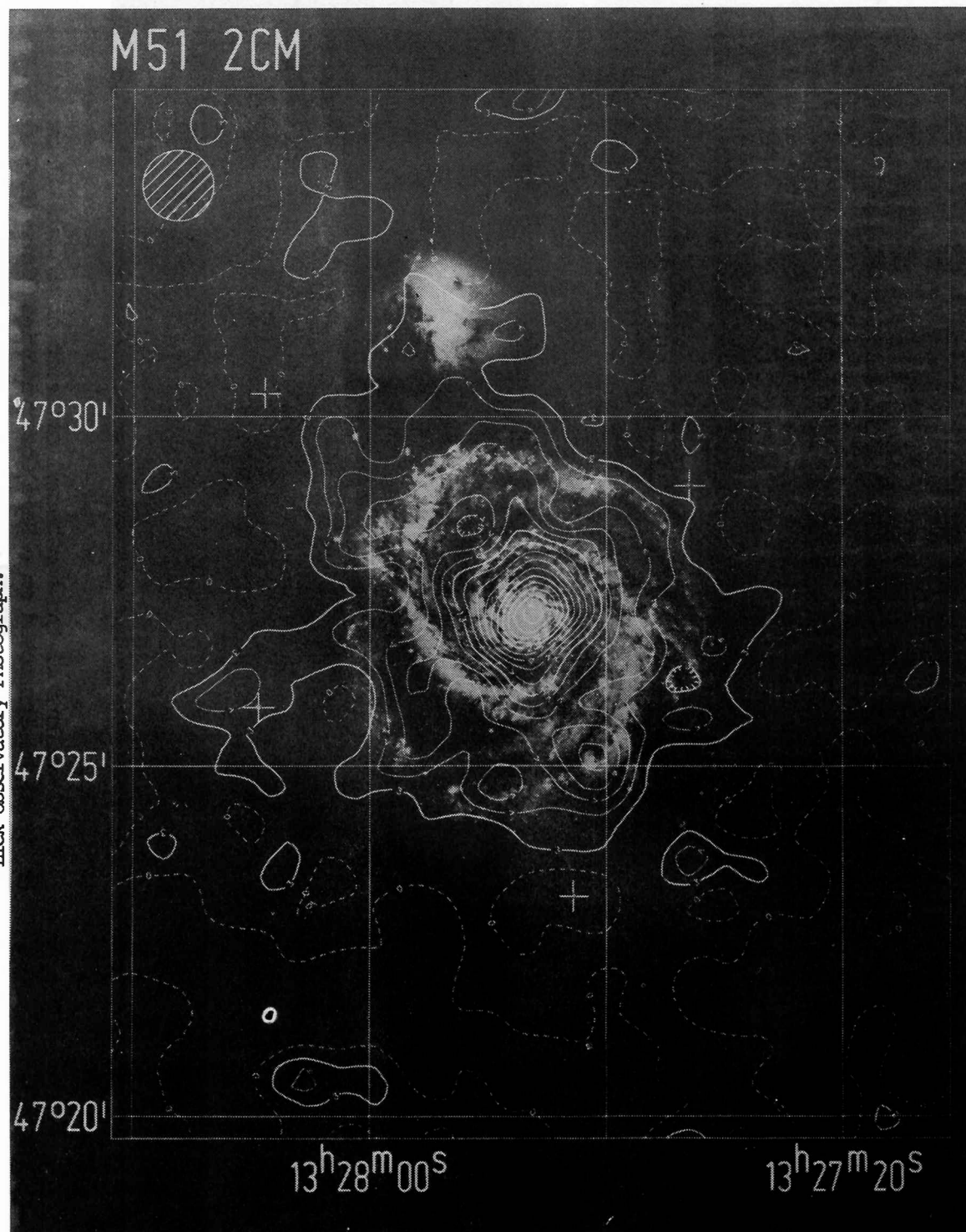


Figure 2: A $\lambda 2.8$ cm radio map of NGC 253 (U. Klein) superimposed on an ESO Schmidt Plate.

Figure 3: A $\lambda 2$ cm radio map of M51 (U. Klein) superimposed on a Lick Observatory Photograph.



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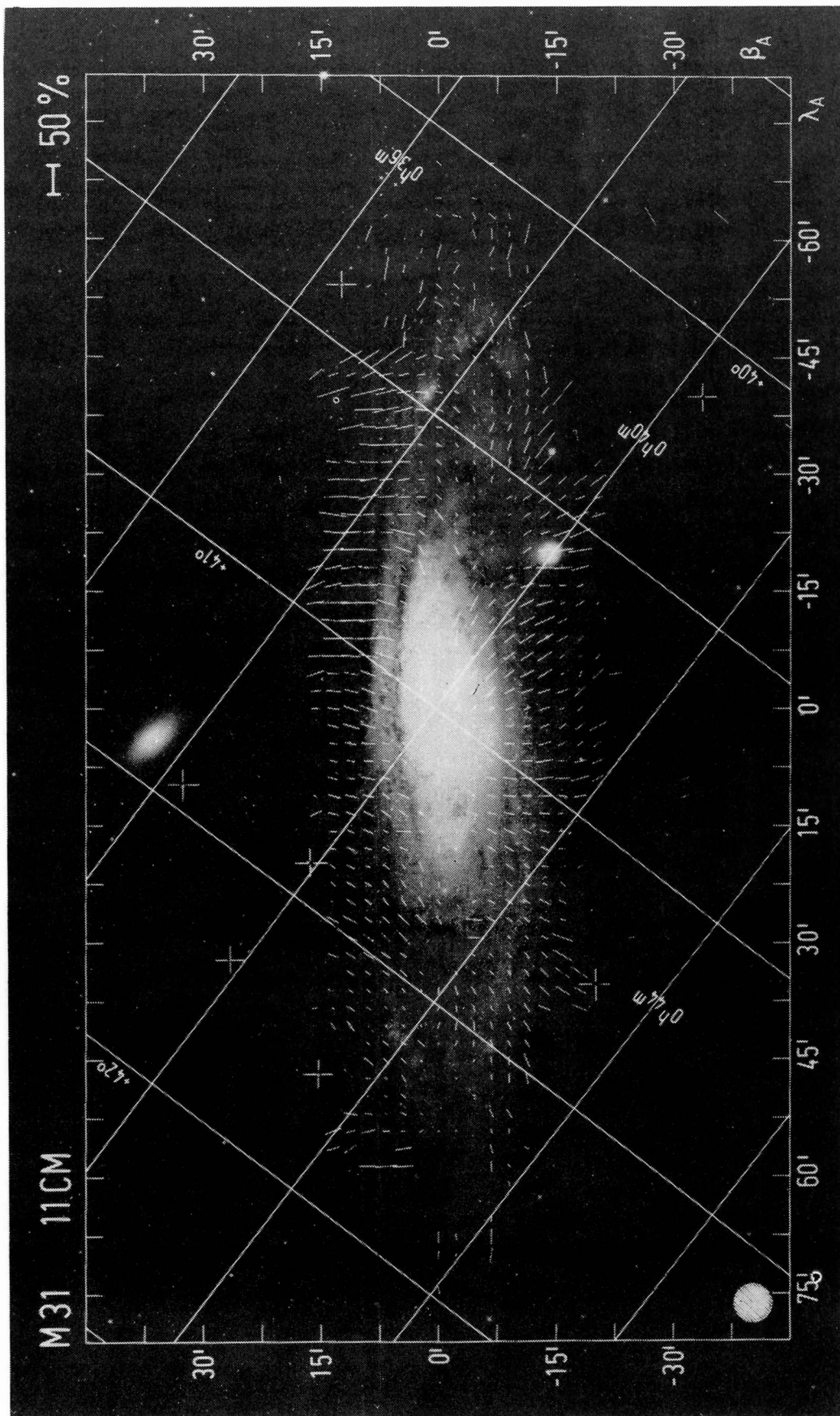


Figure 4: The E-vectors of the nonthermal emission of M31 at λ_{11} cm (R. Beck) superimposed on a Hale Observatories Plate (A.G. de Bruyn).