RADIAL DISTRIBUTIONS OF CONSTITUENTS IN M33, THE GALAXY, AND M51

Elly M. Berkhuijsen and Ulrich Klein
Max-Planck-Institut für Radioastronomie, Bonn, FRG

The radial distributions of the surface brightness or column density of thermal and nonthermal radio emission, far-infrared (FIR) emission, blue light, HI and CO in the Sc galaxies M33 and M51 are compared with the corresponding distributions in the Galaxy. Information on the variation of the absorption at Hα and on the variation of the abundance ratio O/H is also shown.

The data are presented in Figure 1. Table 1 gives radial scale lengths L of various disk components (NTH = nonthermal radio continuum, TH = thermal emission, L_B= blue surface brightness, $A_{H\alpha}$= absorption at Hα). The following similarities between the distributions of the disk components of the 3 galaxies may be noted:

a. L(NTH) > L(TH): this may be due to diffusion of relativistic electrons, if the electrons originate in the young population.
L(NTH) ≅ 2L(TH); L(NTH) - L(TH) is largest for M51, which has the strongest magnetic field of the 3 galaxies (Beck, 1983).

b. $L(TH) < L(L_B)$: after correction of $L(L_B)$ for absorption using $A_B = 1.69\ A_{H\alpha}$, $L(TH) \cong 0.8\ L(L_B)$. This suggests that the fraction of massive (ionizing) stars decreases outwards.

c. $L(A_{H\alpha}) \cong 1.3\ L(O/H)$: in M33 correction of $L(A_{H\alpha})$ for the gradient in T_e (Berkhuijsen, 1983) yields $L(A_{H\alpha}) \cong L(O/H)$. Thus the absorption at Hα may be linearly correlated with the element abundance.

d. L(CO) ≅ L(FIR) ≅ 0.5 L(O/H): the gradients in CO and FIR are equal, but they are much steeper than the gradients in O/H and $A_{H\alpha}$. This indicates that the radial distribution of the dust is less steep than that of CO or FIR.

An extensive discussion of this work wil be given elsewhere (Berkhuijsen, 1984; Klein, Wielebinski and Beck, 1984).

H. van Woerden et al. (eds.), The Milky Way Galaxy, 431–434.

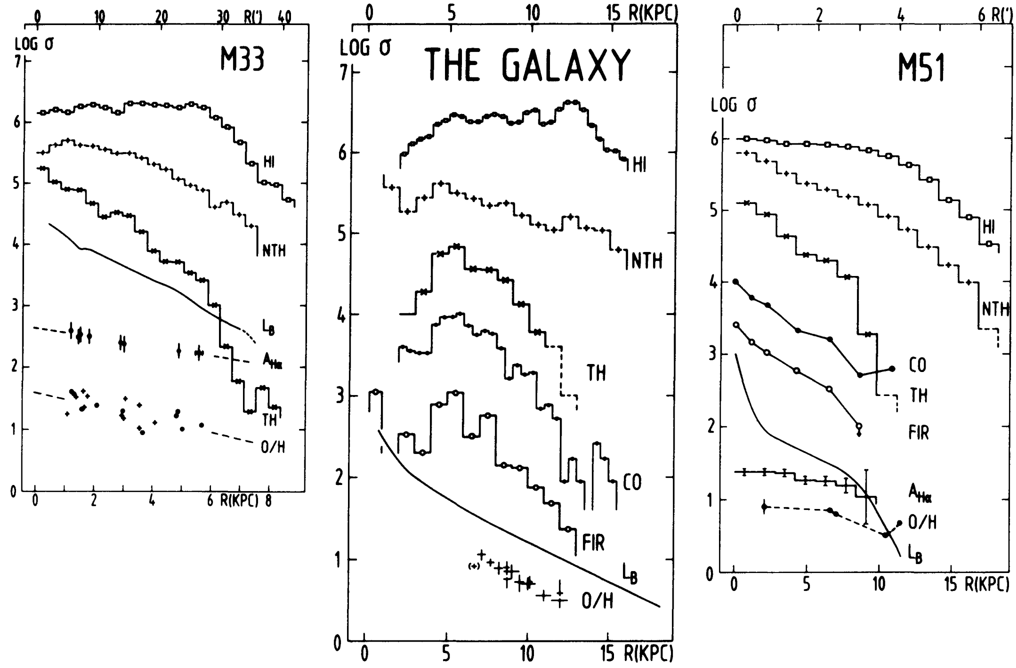

Figure 1. Radial distributions of constituents in M33, the Galaxy and M51. In each case the surface brightness σ is given on a relative scale. Data averaged in circular rings in the plane of the galaxy, centred on the nucleus, are shown as step curves.

M33: HI - column density of neutral hydrogen (Newton, 1980); NTH - surface brightness of nonthermal radio continuum emission at λ6.2 cm, obtained by subtracting the thermal emission from the total emission at λ6.2 cm (Berkhuijsen, 1983); TH - surface brightness of thermal emission at λ6.2 cm, derived from the catalogue of HII regions detected in Hα (Boulesteix et al., 1974). The absorption factor $A_{H\alpha}$ shown below and a calibration factor were applied; L_B- surface brightness of blue light (de Vaucouleurs, 1959); $A_{H\alpha}$- absorption factor of thermal emission between Hα and λ6.2 cm (Berkhuijsen, 1983), assuming $T_e = 10^4$K; O/H - abundance ratio by number, observed in HII regions (circles, Kwitter and Aller, 1981) and supernova remnants (plusses, Dopita et al., 1980).

The Galaxy: HI - column density of neutral hydrogen (Burton and Gordon, 1978); NTH - surface brightness of nonthermal radio continuum emission at λ74 cm (408 MHz), obtained by deconvolving the observed emission at b = +3°, 0° and -3° for all longitudes (Beuerman et al., 1983); TH - production rate of Lyc photons per unit area of compact HII regions and ELD HII regions (Güsten and Mezger, 1983); CO - column density of $^{12}C^{16}O$ (Gordon and Burton, 1976); FIR - surface brightness of far - infrared emission (Boissé et al., 1981); L_B- surface brightness of blue light, based on a two-component model (de Vaucouleurs and Pence, 1978); O/H - abundance ratio by number, observed in HII regions as compiled by Güsten and Mezger (1983). NTH and L_B refer to all longtitudes, other curves to northern longtitudes only.

M51: HI - column density of neutral hydrogen (Shane, 1975); NTH - surface brightness of nonthermal radio continuum emission at λ2.0 cm (Klein, 1981); TH - surface brightness of thermal emission at λ2.0 cm, derived from radio spectral-index maps (Klein, 1981); CO - column density of CO (Scoville and Young, 1983); FIR - surface brightness of far-infrared emission (Smith, 1982); L_B - surface brightness of blue light (Okamura et al., 1976); $A_{H\alpha}$- absorption factor of thermal emission between Hα and λ2.0 cm (Klein, 1981), derived from the Hα map of Tully (1974) and the radio map at λ2.0 cm assuming $T_e = 10^4$K; O/H - abundance ratio by number as compiled by Pagel and Edmunds (1981).

Table 1. Radial scale lengths L(kpc)

Constituent	M33	Galaxy	M51
HI	-27 ± 11	-132 ± 324	9.1 ± 0.8
NTH	2.0 ± 0.3	5.7 ± 0.5[a]	6.9 ± 0.6
TH	1.2 ± 0.1	2.3 ± 0.2	2.7 ± 0.2
CO	-	2.2 ± 0.2	3.9 ± 0.9
FIR	-	2.2 ± 0.2	3.6 ± 0.2
L_B	1.76 ± 0.04	4.1 ± 0.3[a]	4.6 ± 0.4
$A_{H\alpha}$	5.6 ± 0.4	-	9.8 ± 1.3
O/H	4.3 ± 1.0	4.2 ± 0.4	7.6 ± 1.6
Range in R (kpc)	$1 \lesssim R \lesssim 6$	$5 < R < 12$	$2 \lesssim R \lesssim 10$

a) All longitudes; other L for northern longitudes only

REFERENCES

Beck, R.: 1983, in IAU Symp. 100, "Internal Kinematics and Dynamics of Galaxies", ed. E. Athanassoula, Reidel, Dordrecht, p. 159
Berkhuijsen, E.M.: 1983, submitted to Astron. Astrophys.
Berkhuijsen, E.M.: 1984, in preparation
Beuermann, K., Kanbach, G., Berkhuijsen, E.M.: 1983, preprint
Boissé, P., Gispert, R., Coron, N., Wijnbergen, J.J., Serra, G., Ryter, C., Puget, J.L.: 1981, Astron. Astrophys. 94, 265
Boulesteix, J., Courtès, G., Laval, A., Monnet, G., Petit, H.: 1974, Astron. Astrophys. 37, 33
Burton, W.B., Gordon, M.A.: 1978, Astron. Astrophys. 63, 7
de Vaucouleurs, G.: 1959, Astrophys. J. 130, 728
de Vaucouleurs, G., Pence, W.D.: 1978, Astron. J. 83, 1163
Dopita, M.A., D'Odorico, S., Benvenuti, P.: 1980, Astrophys. J. 236, 628
Gordon, M.A., Burton, W.B.: 1976, Astrophys. J. 208, 346
Güsten, R., Mezger, P.G.: 1983, to appear in "Vistas in Astronomy"
Klein, U.: 1981, Ph.D. Thesis, Wilhelms-Universität Bonn
Klein, U., Wielebinski, R., Beck, R.: 1984, in preparation

Kwitter, K.B., Aller, L.H.: 1981, Monthly Notices Roy. Astron. Soc. 195, 939
Newton, K.: 1980, Monthly Notices Roy. Astron. Soc. 190, 689
Okamura, S., Kanazawa, T., Kodaira, K.: 1976, Publ. Astron. Soc. Japan 28, 329
Pagel, B.E.J., Edmunds, M.G.: 1981, Ann. Rev. Astron. Astrophys. 19, 77
Scoville, N., Young, J.S.: 1983, Astrophys. J. 265, 148
Shane, W.W.: 1975, in "La Dynamique des Galaxies Spirales", ed. L. Weliachew, Paris, CNRS, p. 157
Smith, J.: 1982, Astrophys. J. 261, 463
Tully, R.B.: 1974, Astrophys. J. Suppl. 27, 415

Leiden students and alumni at dinner. Left to right: Walterbos, Hermsen, Bloemen, Van Driel (now at Groningen), Schwering, Lub. Foreground: Waller; background: Hu and Salukvadze. LZ