The polarization and intensity distribution in the Crab nebula derived from plates taken with the 200-inch telescope by Dr. W. Baade

Woltjer, L.

TABLE 4

Star	Johnson and Morgan			Haute Provence			
	V	B	B-V	Gr	Bl	Gr-Bl	"Wh"
	m	m	m	m	m	m	m
Pleiades 681	9.24	9.79	0.55	9.24	9.79	0.55	9.59
„ 996	7.53	7.61	0.08	7.50	7.59	0.09	7.58
„ 993	9.14	9.30	0.16	9.13	9.31	0.18	9.26
„ 620	9.86	10.40	0.54	9.85	10.41	0.56	
„ 385	10.20	10.92	0.72	10.15	10.86	0.71	
„ 597	8.77	9.94	1.17	8.77	9.93	1.16	9.38
„ 569	7.68	8.92	1.24	7.71	8.94	1.23	
B D +21° 894				10.19	10.44	0.25	10.40

THE POLARIZATION AND INTENSITY DISTRIBUTION IN THE CRAB NEBULA DERIVED FROM PLATES TAKEN WITH THE 200-INCH TELESCOPE BY DR W. BAADE

BY L. WOLTJER

Polarizations and intensities were determined at a large number of points in the Crab nebula with a nearly circular diaphragm of about 5″ diameter on plates taken by Dr BAADE with the 200-inch telescope. The plates were calibrated with the aid of WALRAVEN's photoelectric measures. The accuracy of our results is discussed.

Introduction.

In the autumn of 1955 Dr BAADE took a number of plates of the Crab nebula with the 200-inch telescope. Four of these plates were taken through a polaroid filter. These plates were described by Dr BAADE in *B.A.N.* No. 462. The orientation of the polaroid filter was such that maximum transmission occurred in position angles 0°, 45°, 90° and 135°. Dr BAADE also obtained an interfocal calibration plate of Selected Area 68. The exposure time for all these plates was 20 minutes. Dr BAADE was so kind to send these plates to Leiden together with two plates taken without a polaroid filter and with exposure times of 5 and of 30 minutes and thus enabled us to make a detailed study of the amorphous mass of the nebula. As all plates were taken in the wavelength region 5200 A to 6400 A the contribution of light from the filaments must be very small. In this paper we will give the results of our measurements. A full discussion of the results will be given in a following publication.

The measurement of the plates.

All plates were measured in an iris photometer using a fixed diaphragm and a variable wedge. On all plates we made measurements every half millimeter on the plate in both directions with a nearly circular diaphragm of 0.47 mm diameter. The positive y-axis in our coordinate system points north, the positive x-axis west. The south west component of the central double star is at the origin. As one mm on the plate corresponds to 0.186 minutes of arc the diaphragm has a diameter of about 5″. It was therefore possible to obtain a detailed picture of the nebula.

The calibration.

From a preliminary comparison with WALRAVEN's photoelectric results it appeared that it was not possible to reduce all plates with the same calibration curve. Moreover, the range in brightness of the stars in S.A. 68 was not sufficient to obtain a complete calibration curve. Therefore we decided to use WALRAVEN's photoelectric results for the calibration of all our plates. This implied that we had to assume that the spectrum of the continuum is constant over the nebula. For most photoelectric measurements were made in the photographic region. As the position angles of the maximum of the electric vector are the same for the photoelectric measurements and for the photographic plates, every plate can be calibrated against a corresponding set of photoelectric measurements.

We selected a number of appropriate photoelectric observations which we first corrected for the filamentary light. The filaments are distributed quite unevenly over the nebula, but they are not concentrated so strongly to the centre as the light of the

TABLE I

Polarizations in the Crab nebula. For every point the position angle of the maximum of the electric vector is given in degrees and below it, in italics, the degree of polarization in percent

y \ x	−11	−10.5	−10	−9.5	−9	−8.5	−8	−7.5	−7	−6.5	−6	−5.5	−5	−4.5	−4	−3.5	−3	−2.5	−2	−1.5	−1	−0.5	0	x \ y′
+10.5																								+1′.95
+10																								+1′.86
+9.5																								+1′.77
+9																								+1′.76
+8.5																								+1′.58
+8																						124 *11*	89 *27*	+1′.49
+7.5																				142 *49*	147 *26*	161 *3*	76: *21:*	+1′.40
+7																	123 *37*		143 *35*	147 *45*	161 *30*	7 *12*	62 *15*	+1′.30
+6.5																			172 *24*	176 *30*	176 *39*	176 *29*	59 *11*	+1′.21
+6																93 *28*		149 *6*	2 *19*	2 *26*	10 *28*	12 *24*	175 *17*	+1′.12
+5.5													148 *31*	140 *26*	66 *5*	70 *26*	65 *17*	38 *13*	18 *16*	20 *21*	27 *27*	27 *21*	170 *20*	+1′.02
+5												168: *19:*	164 *24*	166 *28*	15 *10*	49 *21*	36 *15*	32 *7*	33 *17*	39 *12*	39: *14:*	25 *14*	171 *14*	+0′.93
+4.5												150 *7*	167 *18*	173 *19*	11 *6*	19 *11*	14 *16*	15 *16*	15: *12:*	161 *8*	4: *4:*	8 *12*	177 *20*	+0′.84
+4							126 *36*	115 *18*	82 *15*	81 *15*	114 *9*	113: *13:*	126 *5*	178 *5*	38 *5*	1 *10*	4 *15*	1 *16*	179 *20*	171 *16*	164 *17*	167 *18*	171 *21*	+0′.74
+3.5							132 *33*	121 *35*	122 *35*	118 *21*	135 *28*	137 *21*	138 *8*	1 *6*	35: *1:*	11 *5*	7 *15*	3 *21*	1 *27*	172 *27*	167 *30*	163 *35*	166 *28*	+0′.65
+3							127 *59*	122 *51*		136 *47*	143 *30*	139 *22*	11 *6*	143 *11*	140 *3*	175 *1*	21 *12*	23 *18*	4 *21*	165 *30*	165 *35*	163 *42*	160 *38*	+0′.56
+2.5							103 *53*	130 *45*		145 *48*	146 *43*	146 *38*	142 *34*	139 *28*	132 *17*	102 *9*	49 *14*	49 *16*	176 *9*	162 *21*	160 *34*	159 *37*	159: *40:*	+0′.47
+2							118 *90*	112 *69*	133 *57*	151 *51*	149 *54*	145 *48*	144 *40*	140 *45*	132 *30*	112 *22*	91 *22*	73 *5*	159: *8:*	155 *15*	159 *26*	154 *29*		+0′.37

y \ $-x'$	2′.05	1′.95	1′.86	1′.77	1′.67	1′.58	1′.49	1′.40	1′.30	1′.21	1′.12	1′.02	0′.93	0′.84	0′.74	0′.65	0′.56	0′.47	0′.37	0′.28	0′.19	0′.09	0′	y' \ $-x'$
+ 1.5							131 *57*	111 *79*	90: *20:*	165 *34*	144 *51*	139 *55*	134 *50*	134 *53*	126 *47*	116 *40*	110 *33*	122 *12*	145: *7:*	147 *19*	156: *19:*	154 *21*	150 *24*	+0′.28
+ 1							120 *51*	133 *78*	123 *52*	140 *13*	131 *37*	135: *46:*	124 *50*	115 *41*	112 *45*	109 *45*	110 *36*	112 *20*	150: *7:*	150 *14*	150 *18*	152 *17*	148 *19*	+0′.19
+ 0.5								112 *51*	123 *32*	101 *63*	105 *26*	115 *50*	104 *53*	101 *47*	102 *40*	101 *41*	104 *35*	111 *21*		148: *11:*	135 *14*			+0′.09
0										113 *141*	95 *27*	87 *40*	84: *57:*	87 *45*	94 *37*	94 *39*	103 *27*	112 *13*	158 *5*	146 *5*	135 *15*	134 *22*		0′
− 0.5												56 *54*		72: *53:*	79 *35*	86 *28*	106 *13*	140 *13*	173 *14*	169 *10*	137 *16*	143 *24*		−0′.09
− 1							150 *49*	150 *41*	175 *30*	33 *63*	42 *59*	50: *52*	58 *53*		71 *32*	75 *19*	87 *8*	157 *8*	169 *21*	163 *23*	153 *19*	149: *22*		−0′.19
− 1.5			133: *15:*	138: *40:*		142 *34*	159: *42:*	2 *38*	16 *45*	28 *54*	38 *56*	44 *49*	48: *39:*		61: *26:*	62 *10*	169 *1*	168 *10*	169 *27*	163 *26*	162 *24*	146 *26*	146 *29*	−0′.28
− 2	126 *33*	103 *24*	136 *16*			160 *29*	173 *25*	4 *22*	13 *32*	24 *52*	30 *31*	33 *36*	38 *30*	51 *21*	48 *14*		161 *11*	165 *17*	169 *28*	164 *28*	158 *26*	149 *25*	147 *33*	−0′.37
− 2.5	120 *21*	119 *25*	140: *21:*	148 *25*	161 *20*	156: *23:*	162 *27*	167 *31*	176 *25*	13 *26*		15 *24*	16: *19:*	31 *7*	23 *5*	169 *6*	168 *16*	163 *25*	163 *28*	171 *29*	154 *26*	153 *27*	151 *32*	−0′.47
− 3	123 *13*	132 *16*	143 *21*		147: *26*	148 *27*	149 *30*	152 *24*	161 *18*	1 *17*	0 *22*	171 *22*	179 *15*	165 *15*	154 *15*	165 *19*	158 *24*	163 *30*	162 *28*	171 *26*	159 *24*	161 *19*	155 *37*	−0′.56
− 3.5	78 *8*	125 *16*	130 *25*			140 *28*	141 *31*	145 *24*	157 *19*	100 *9*	177 *19*	169: *24:*	160 *28*	152 *32*	152 *31*		158 *37*	158 *35*	159 *30*	158 *17*	161 *18*	153 *23*	159: *31:*	−0′.65
− 4	66 *15*	95 *11*	115 *23*	132 *27*	140: *31*	142: *31:*	136 *31*	141 *24*	150 *18*	164 *12*	166 *18*	169 *26*	165 *33*	160 *37*	163 *36*	165 *37*	161 *42*	159 *45*	158 *39*	157 *30*	164 *20*	167 *17*	165: *20:*	−0′.74
− 4.5	74 *19*	103 *12*	103: *13:*	137 *20*	144 *34*	139 *30*	142 *32*	137 *35*		149 *25*	152 *27*	160 *26*	177 *21*	3 *27*	176 *32*	175: *37:*	166: *39:*	160: *48:*	157 *45*	159 *40*	164 *32*	173 *28*	170 *22*	−0′.84
− 5			89 *16*	136 *7*	151 *20*	154 *28*	156 *39*	142: *37:*	145 *29*	156 *27*	161 *32*	174 *31*	14 *34*	11 *32*	11 *29*	14 *29*		161 *41*	151 *48*	156 *45*	161 *37*	171 *36*	168 *25*	−0′.93
− 5.5				152 *10*	161 *15*	164 *25*	159 *31*	151 *35*	148 *32*	159 *29*	170 *32*	9 *36*	10 *34*	15 *34*	23 *31*	23: *22:*	5: *20:*	178 *25*	145 *47*			168 *37*	170 *32*	−1′.02
− 6					163: *26:*	162 *30*	156 *38*	151 *40*	148 *38*	153 *31*	160 *30*	164 *32*	179 *20*	35 *22*	47 *15*	60 *18*		160 *20*	148 *27*	152 *28*	160 *42*	158 *43*	167 *39*	−1′.12
− 6.5						168 *42*	166 *43*	162 *49*	164 *49*	163 *33*	158 *40*	163 *34*	171 *20*	66 *22*	63 *22*	72 *18*		29 *9*	31 *21*	159 *16*	156: *53:*	159 *53*	155 *50*	−1′.21
− 7						179 *36*	176 *32*	171 *37*		168 *42*	155 *37*	154 *31*	173 *21*									147 *40*	153 *54*	−1′.30
− 7.5							9 *35*	166 *20*	155 *32*	148 *36*														−1′.40

TABLE I (*continued*)

y \ x	+0.5	+1	+1.5	+2	+2.5	+3	+3.5	+4	+4.5	+5	+5.5	+6	+6.5	+7	+7.5	+8	+8.5	+9	+9.5	+10	+10.5	+11	x / y′
+10.5													91 *19*										+1′.95
+10						86 *21*	90 *17*	76 *30*	71 *25*	68 *24*	71 *18*	88 *11*	93 *13*	101 *15*			113 *6*	137 *16*	136 *25*				+1′.86
+ 9.5				128 *32*	105 *17*	97 *12*	69 *16*	61 *26*	63 *26*	69 *21*	64: *16:*	77 *6*	83 *8*	87 *10*	78 *12*	94 *10*	106 *12*	160 *20*	145 *28*	164 *31*			+1′.77
+ 9				130 *17*	125 *13*	84 *4*	54 *11*	54 *25*	59 *24*	53 *19*	55 *11*	70 *7*	64 *14*	59 *16*	97 *13*	85 *14*	99 *14*	158 *11*	174 *20*	159 *25*			+1′.67
+ 8.5		77 *15*	150 *10*	146 *11*	157 *6*	29 *18*	30 *22*	35 *25*	30 *18*	17 *11*	40 *21*	62: *7:*	69 *9*	59 *12*	71 *8*	93 *16*	88 *14*	170 *8*	7 *21*	160 *16*	140 *20*		+1′.58
+ 8	81 *46*	56 *23*	37 *17*	169 *8*	25 *11*		17 *17*	1 *12*	17 *10*	161 *4*	144 *9*	90 *3*	75 *7*			94 *11*	96 *12*	28 *1*	165 *18*	170 *28*	139 *18*		+1′.49
+ 7.5	71 *38*		52 *10*	56: *11:*	13 *9*	5 *7*	179 *6*	150 *17*	151 *3*	21 *4*	135: *10:*	94 *6*	96 *9*	73 *15*	61: *17:*			135 *11*	174 *14*	169 *34*	159 *16*		+1′.40
+ 7	68 *23*	82: *16:*	88 *12*	69 *14*	152 *9*	147 *18*	147 *19*	137 *8*	104 *8*	69 *7*	94 *8*	101 *13*	95 *13*	82 *18*	73 *16*	76 *15*	122: *10:*	128 *10*	11 *12*	176: *19:*	25 *3*		+1′.30
+ 6.5	93: *7:*	107 *13*	122 *15*	130 *29*	137 *26*	147 *25*	157 *26*	150: *17:*	122: *10:*	122 *11*	103 *9*	92 *14*	89 *15*	89 *18*	89: *22:*	88 *15*	93 *11*	91 *18*	0 *19*	40 *26*	22 *24*		+1′.21
+ 6	169 *19*	168 *14*	155 *23*	149 *36*	144: *34:*		158 *29*	152 *20*	141 *22*	145 *22*	131: *9:*	101 *12*	85 *13*	94 *16*	107 *16*	68 *10*	60 *9*	61 *23*	47 *44*	39 *43*	31 *32*		+1′.12
+ 5.5	158 *29*	158 *22*	160 *23*	158 *32*	154: *40:*	156: *47:*		155: *32:*	142 *27*	146: *20:*	142 *8*	125 *6*	69 *4*	85 *6*	104 *5*	110 *5*	79 *11*	63 *26*	57 *30*	47 *28*	47: *32:*		+1′.02
+ 5	157 *21*	158 *21*	159 *21*	164 *26*	168 *31*	158 *45*			143 *26*	148 *9*	157 *7*	159: *5:*	148 *5*	159 *5*	111 *3*	84 *11*	76 *21*	73 *29*	72 *12*	44 *28*	40: *37:*	41 *41*	+0′.93
+ 4.5	167 *15*	171 *17*	163 *23*	170 *25*	170 *30*	161 *34*	151 *38*	145 *36*		150 *24*	152 *11*	139 *15*	125 *10*	95 *5*	73 *6*	71 *17*	79 *21*	88 *20*	95 *12*	54 *18*	52 *26*	27 *29*	+0′.84
+ 4	167 *13*	170 *18*	173 *22*	171 *27*	174 *23*	169 *16*	153: *18:*	145 *23*		154 *24*	149 *27*	152 *31*	151 *14*	45 *12*	59 *23*	64 *21*	85 *15*	112 *24*	115 *18*	84 *9*			+0′.74
+ 3.5	163 *17*	164 *19*	176 *25*	175 *27*	176 *24*	6 *20*	5 *12*	159 *13*	147: *26:*	147: *31:*	144: *29*	143 *28*	131 *16*	102 *12*	70 *17*	62 *19*	102 *11*	123 *17*	125 *25*	131 *25*	143 *54*	145 *83*	+0′.65
+ 3	159 *31*	163 *24*	176 *28*	178 *23*	2 *19*	4 *18*	11 *17*	168: *10:*	150 *18*	142 *27*	143: *29:*	145 *24*	136 *10*	79 *8*	63 *9*	5 *6*	164 *2*	133 *11*	127 *27*	136: *40:*	146 *56*	155 *68*	+0′.56
+ 2.5	157 *32*	164 *28*	173 *30*	177 *28*	179 *21*	6 *22*	12 *19*	179 *10*	150 *15*	138: *17:*	142 *16*	157 *15*	169 *5*	155 *3*	179 *6*	162 *16*	3 *8*	163 *2*	127 *19*	141 *43*	152 *53*		+0′.47
+ 2	155 *28*	159 *30*	167 *33*	170: *31:*	169 *21*	4: *1:*	8 *22*	1 *14*	8 *7*	70 *4*	28 *2*	42 *8*	32: *7:*		149 *13*	165 *13*	165: *5:*	141 *14*	148 *18*				+0′.37

y \ +x′	0′.09	0′.19	0′.28	0′.37	0′.47	0′.56	0′.65	0′.74	0′.84	0′.98	1′.02	1′.12	1′.21	1′.30	1′.40	1′.49	1′.58	1′.67	1′.77	1′.86	1′.95	2′.05	+x′ \ y′
+ 1.5	148 *27*	149 *23*	155: *24:*	164 *27*	167 *23*	175 *20*	0 *17*	4: *12:*	30 *8*	47 *20*	50 *15*	72 *12*	60 *9*	105 *11*	132 *8*	145 *9*	168 *13*	3: *10:*	164 *33*				+0′.28
+ 1	140 *27*	139 *26*	148 *19*	170 *19*	163 *16*	165 *20*	179 *18*	29 *7*		45 *14*	45 *23*	44 *12*	120 *4*	126 *13*	137 *20*	162 *10*	3 *27*	169 *50*	164 *72*				+0′.19
+ 0.5	134 *28*	131 *29*	147 *15*	174 *11*	160 *11*	161: *19:*	160 *10*	52 *8*	53 *15*		33 *18*	12 *12*	147 *11*	127 *15*	124 *14*	127 *8*							+0′.09
0	133 *19*	124 *20*	137 *13*	142 *6*	132 *8*	128: *11:*	113 *11*	89: *15:*	71 *19*	55 *21*	29 *20*		172 *19*	137 *23*	120 *27*	114 *33*							0′
− 0.5	140 *18*	131 *14*	126 *14*	105: *5:*	116 *13*	113 *19*	105: *22:*	98 *27*	86 *25*	71 *23*	43 *19*			143 *45*	128 *43*	124 *46*							−0′.09
− 1	142 *21*	143 *18*	132 *15*	121: *14:*	120 *21*	105 *20*	114 *30*	99 *35*	95 *36*		77 *15*	144 *63*	141 *62*	130: *66:*	125 *54*	128 *65*							−0′.19
− 1.5	146 *24*	149 *27*		138 *20*	131 *20*	120: *23:*	111 *27*	107 *39*	104 *44*	101 *45*	118 *26*	151 *53*	146: *48:*	140 *71*									−0′.28
− 2	151 *33*	152 *36*	151 *34*	150 *31*	150 *21*	151: *15:*	120: *16:*	110 *32*		120: *49:*	138 *41*	151 *51*		145: *86:*									−0′.37
− 2.5	154 *43*	156 *46*	158 *40*	158 *39*	161 *37*	168 *31*	168 *19*	138 *15*	126 *33*	132 *43*	147 *56*	158 *66*	167 *40*	136 *50*									−0′.47
− 3	157 *44*	159 *44*	160 *45*	163 *48*	166 *43*	169 *43*	168 *35*	162 *28*	143 *23*	138 *39*	147 *52*	147 *54*	157 *37*	139 *23*									−0′.56
− 3.5	162: *35*	163: *37*	167 *39*	167 *45*	168 *46*	170 *44*		170 *34*	159 *32*	144: *41:*	149: *50:*	145: *57*	143: *32*	139 *21*									−0′.65
− 4	176 *27*	167 *29*	168 *36*	173 *41*	175 *41*	175 *40*	174 *37*	167 *37*	160 *37*	151 *39*	145 *41*		140 *39*										−0′.74
− 4.5	178 *27*	2 *29*	176 *32*	3 *38*	6 *39*	7 *41*	6 *37*	0 *36*	165 *35*	157 *44*	149 *45*	138: *46:*											−0′.84
− 5	175 *24*	7 *31*	12 *29*	13 *31*	16 *41*	16 *37*	7 *34*	171 *42*	165 *55*	160 *49*		145 *45*	134 *44*										−0′.93
− 5.5	173: *21:*	7 *27*	16 *24*	18 *20*	21 *24*	34 *37*	20 *35*	169 *44*	162 *61*	162 *51*	156 *52*	147 *52*	133 *40*										−1′.02
− 6	165 *25*	9 *20*	18 *18*		54 *22*	49 *20*	0 *15*	157 *31*	148 *58*	153 *59*	148 *56*	144 *64*	143 *42*										−1′.12
− 6.5		16 *23*	28 *13*		67 *18*																		−1′.21
− 7	159 *47*	3: *39:*	17: *29:*	45 *16*																			−1′.30
− 7.5	154 *51*	14 *32*	172 *35*																				−1′.40

TABLE 2
The intensity distribution in the Crab nebula

y \ x	−16	−15.5	−15	−14.5	−14	−13.5	−13	−12.5	−12	−11.5	−11	−10.5	−10	−9.5	−9	−8.5	−8	−7.5
+16																		
+15.5																		
+15																		
+14.5																		
+14																		
+13.5																		
+13																		
+12.5																		
+12																		
+11.5																		
+11																		
+10.5																		
+10																		
+ 9.5																		
+ 9																		
+ 8.5																		
+ 8																	2	4
+ 7.5																2	3	6
+ 7															1	3	6	7:
+ 6.5														3	4	9	11	11
+ 6													1	4	6	9	14	14
+ 5.5												1	2	6	8	17	18:	23
+ 5												2	5	7	10	19:	23:	30
+ 4.5											1	3	4	8	11	20	28	36
+ 4											2	3	5	7	11	19	33	34
+ 3.5											1	3	5	10:	10	17	27	40
+ 3											3	3	5	11	11	13	17	32
+ 2.5									3	2	4:	5:	5:	8	10:	15	15	22
+ 2							1	1	2	3	4	6	5	7	10:	10	10	17
+ 1.5							3	1	3	4	5	7	11	12	13:	14	14	14
+ 1						1	5	3	3	5	8	11	13	11	11:	11	18	11
+ 0.5					2	2	5	5	7:	11	12	13:	14:	13:	12	8	7	16
0					3	3:	6	6	10	16	17	17	18	18	14	6	5	7
− 0.5					3	3:	5	7	11:	15	24	26	24	25	17	12	8:	4:
− 1					2	3	5	7	13	22	30	36	33	32	30	18	23	22:
− 1.5					2	2	4	7	21	31	32	49	41	40	44:	32	29	41
− 2					2	5	5	11	28	34	43	64	56	49:	59:	61	57	63
− 2.5			2	3	4:	8	14	27	43	49	58	66	66	68:	70	72	74	75
− 3			5	7	8	13	25	32	48	51	53	61	73	74:	75:	77	75	69
− 3.5			5	7	9	17	25	34	43	51	50	61	67	72:	77:	79	89	85
− 4			3	7	12	19	25	28	35	45	52	62	63	68	81	87	96	91
− 4.5			3	6	15	23	23	28	41	53	56	60	60	69	82	86	90	92
− 5			3:	7:	16	31	27	26	45	49	52	50	56	74	83	91	82	85
− 5.5			4:	9:	14	19	21	23	30	36	37:	38	46	54	69	84	84	85
− 6		4	4	10	14	16	19	19	21	26	34	35	37	38	48	67	71	75
− 6.5	1	4	7	9	12	15	15	14	17	25	30	33:	33:	37	36	46	57	65
− 7	2	4	7	9	12	13	13	13	15	17	22	31	27	31	27	33	49	64
− 7.5	2	3:	7	9	10	11	13	14	13	13	14	15	16	14	20	29	31	48
− 8	2	2	4	7	10	9	10	9	9	11	9	10	10	19	18	20	23	36
− 8.5	2	1	4:	5	6	4	3	6:	6	9	7	7	8	12	16	15	13	17
− 9		1	4	3	3	4	3	4	4	6	8	7	8	10	11	8	9	12
− 9.5			1	2	2	4	3	4	4	4	6	7	6	8	7	8	7	8
−10				2	2	2	2:	2	2	2	5	4	4	5	7	6	5	5
−10.5				1	1	1	3	3	4	3	4	4	4	4	5	4	4	4
−11							3	3	4	2	3	2:	2:	4	3	3	4	4
−11.5							2	3	2	1	1		1	1	2	4	2	3
−12							1		1						2	2	2	3
−12.5																2:	2	3
−13																1	2	5
−13.5																1	1	3
−14																1	1	
−14.5																		
y \ x′	−2′.98	−2′.88	−2′.79	−2′.70	−2′.60	−2′.51	−2′.42	−2′.33	−2′.23	−2′.14	−2′.05	−1′.95	−1′.86	−1′.77	−1′.67	−1′.58	−1′.49	−1′.40

TABLE 2
The intensity distribution in the Crab nebula

−7	−6.5	−6	−5.5	−5	−4.5	−4	−3.5	−3	−2.5	−2	−1.5	−1	−0.5	0	x / y′
									1	1					+2′.98
									2	1	1				+2′.88
									2	1	1	1	1	1	+2′.79
									1	1	1	2	2	2:	+′2.70
									1	1	1	2	2	3:	+2′.60
								1	1	1	1	3	3	5:	+2′.51
								3:	1	1	2	3	3	6	+2′.42
							1	4	4	2:	4:	5	5	9	+2′.33
							1	3	4	3	5	6	7	9	+2′.23
						1	1	2	3	4	5	9	9	12	+2′.14
					2	1	1	1	3	6	7	5	10	15	+2′.05
			1		1	0	2	2	3	7	9	8	7	11	+1′.95
		2	4		2	2	3	5	6	8:	9	6	5	11	+1′.86
		2	5	4:	4	10:	6:	9	10	9:	9	8	7	13	+1′.77
	2	2	4	6:	8	17	11	11	14	16:	15	10	16	21	+1′.67
3	3	4	7	6	8	13	15	19	23	23:	22	20	41	38	+1′.58
6	6	6	6	8	11	13	19	19	22	26	21	34	51	42	+1′.49
6	9	10	9	10	9	18	28	27	24	32	32	35	49	67	+1′.40
10	8	10	13	14:	14	24	36	48	33:	42	55	73	77	93	+1′.30
13	15	14	15	18:	21	32	56	61:	54:	79	101	86	91	124	+1′.21
17	19	19	23	24	30	41	61	73:	94	86	90	101	141	162	+1′.12
26	25	27	22	43	42	53	77	91	78	80	106	146	159	173	+1′.02
40:	38:	31	35	48	66	79	98	89	83	96	126	151:	175	182	+0′.93
44	51	44	44	52	76	101	105	90	103	124:	151	185:	207	201	+0′.84
42	52	53	54	68	84	103	97	103	116	134	172	203	219	217	+0′.74
44	50	54	72:	85	94	96:	104	119	140	177	221	238	237	222	+0′.65
41:	61	65	84	88	95	100	108	131	168	231	264	266	251	263	+0′.56
27:	65	76	85	95	98	104	126	143	176	206	241	266	268	271:	+0′.47
17	42	75	86	99	115	118	135	156	177	200:	214	222	286	286:	+0′.37
16	22	45	87	96	98	126	142	161	164	189:	209	205:	233	299	+0′.28
12	12	19	73	117	102	125	143	160	155	157:	181	204	205	226	+0′.19
16	13	22	39	99	95	109	147	154	149	151:	172:	189	213:	220:	+0′.09
6	13	20	44	88	82	91	131	146	148	150	171	185	237	208:	+0
2	2	26:	56	62:	68	92	125	138	151	158	180	224	212	202:	−0′.09
26:	30:	52	79	74	73:	101	121	137	149	156	187	245	218:	204:	−0′.19
54	66	69	68	68	83:	105:	121	146	162	168	211	269	258	206	−0′.28
63	66	67	65	74	92	105	129:	158	180	179	206	246	255	234	−0′.37
74	75	70:	79	81	92	101	133	156	169	187	209	233	227	248	−0′.47
69	74	75	85	89	90	111	138	159	167	184	194	196	200	212	−0′.56
83	90	93	93	91	88	110	140:	167	187	164	165	170	174	172:	−0′.65
99	106	96	90	92	95	117	147	182	189	187	178	167	166	181:	−0′.74
99:	107	98	89	86	99	127	148:	185:	212:	200	191	177	163	171	−0′.84
99	112	108	106	100	98	106	121	145:	168	173	156	156	131	128	−0′.93
89	98	96	94	91	93	95	91:	101:	112	96	115	117:	101	89	−1′.02
78	91	81	70	60	67	68	65	81	90	58	76	76	84	65	−1′.12
69	70	70	63	52	46	52	53	55:	60:	53	50	54	52	57	−1′.21
58:	58:	56	50	47	42	39	38	35	39	49	38	36	39	42	−1′.30
52	47	36	34	26	29	30	20	22	27	38	31	25	23:	26	−1′.40
32	34	30	25	22	24	25	20:	20:	26	23	18	17:	13	16	−1′.49
17	20	23:	23:	23	21	22	19	19	18	14	13	11	10	16	−1′.58
11	15:	17:	17	16	15	18	16	18	14:	10	10	8	9	13	−1′.67
8:	11	12	12:	12	16	17	18	15	12	10	9	6	8	6	−1′.77
5	6	8	9:	10:	13	13	8	11	11	8	6	5	8	5	−1′.86
4	5	5	8	8	6	9	8	10	8	8:	6:	6	6	5	−1′.95
3	5	5	8	6	5	7	7	9	6	8	5	4:	3	3	−2′.05
3	4	4	4	5	6	9	7	5	7	6	4	2	2	3	−2′.14
2	3	4	5	5	5	5	5	5	4	3	2	2	3	3	−2′.23
2	3	4	3	2	2	3	3	5	3	2	2	1	3	1	−2′.33
2	3	2	2	1	1	2	1	3	3	2	2	1			−2′.42
2	2		1	1		1		2	2	2	2				−2′.51
1			1					1	2	2	3				−2′.60
								1	1:	2	2:				−2′.70
−1′.30	−1′.21	−1′.12	−1′.02	−0′.93	−0′.84	−0′.74	−0′.65	−0′.56	−0′.47	−0′.37	−0′.28	−0′.19	−0′.09	0	y′ / x′

TABLE 2 (*continued*)

y \ x	+0.5	+1	+1.5	+2	+2.5	+3	+3.5	+4	+4.5	+5	+5.5	+6	+6.5	+7	+7.5
+16					1							1			2
+15.5					1				3	1	2	2	2	2	4
+15	2	1:			1		1	2	2	3	4	3	3	4	5:
+14.5	3:	2:	3	2	1	2	2	3	3	3	6	6	6	7	8
+14	4:	2:	3:	2	3	2	3	4	5	7	7	11	11	15	14
+13.5	5	3	2	4:	5	5	6	9	10	11	10	14	15	20	17
+13	4	5:	5	6	7	8	9	12	15	16	14:	16	18	27	25
+12.5	10	8	8	10	9	9	11	13	19	19	18	21	26	33	27
+12	11	12	19	16	14	11	12	13	17	21	21	27	32	32	29
+11.5	11	14	14	14	13	15	16	15:	21	25	26:	32	38	37	35
+11	12	14	13	14	14	17	21	21	29	34	35	37	43	42:	41
+10.5	14:	17	19	20	19	18	30	32	42	46	44	46	55	62	53:
+10	16:	26	29	32	29	35	43	43	51	57	59	64	67	69	68
+ 9.5	20	25	37	49	51	49	59	67	68	73	72	79	78	77	74
+ 9	28	36	52:	71	76	78	84	83	85	77	77	85	83	84	78
+ 8.5	38	46	67	88	95	94	107	106	109	99	94	92	94	91	91
+ 8	54	69	78	101	130	141:	128	115	112	122	127	111	101	103:	114:
+ 7.5	86	85	79	116	153	166:	176	153	149	139	141:	131	119	108	111:
+ 7	105	71	86	136	158	185	204	194	185	160	163	152	135	130	115
+ 6.5	103:	84	108	149	172	198	214	228:	201	185	165	170	153	136	124:
+ 6	147	143	143	178	194:	209:	202	216	212	187	165:	162	150	135	128
+ 5.5	179	184	172	188	218:	222:	198:	182:	172	177:	169	177	165	138	122
+ 5	211	204	197	198	189	187	191:	197:	181	178	163	156:	138	127	113
+ 4.5	222	212	201	194	179	183	181	170	161:	152	120	107	108	107	112
+ 4	248	224	193	194	188	193	174:	165	152:	133	123	110	121	107	103
+ 3.5	242	242	208	216	211	207	199	158	147:	125:	104	96	97	97	96
+ 3	269	254	225	248	221	194	170	153:	136	127	101:	89	100	98	95
+ 2.5	289	278	239	240	222	168	156	123	106	112	113	94	104	109	90
+ 2	288	287	243	229	218	154:	145	120	99	106	107	100	93:	100:	75
+ 1.5	313	294	282:	226	224	175	149	129:	115	102	103	91	85:	87	85
+ 1	311	326	286	237	243	201	158	152	124:	107	96	93	92	95	82
+ 0.5	276	341	274	250	252	212	185	158	132	127	105	91	94	88	79
0	212	275	278	256	213	197:	190	164	146	139	109	74:	78	72	75
− 0.5	192	231	239	231:	197	185	157:	161	156	144	117	42:	58:	62	63
− 1	200	208	199	207:	182	173	160	155	149	128:	67	35	43	53	48
− 1.5	197	183	183:	169	157	163:	162	149	140	111	54	35	38	41	39
− 2	219	185	182	176	176	155:	129:	125	119:	106:	71	35	35:	32	36
− 2.5	242	221	210	187	167	152	131	112	106	93	78	51	37	38	34
− 3	198	187	188	185	174	143	124	105	99	90	72	61	46	44	37
− 3.5	186	192	181	168	152	136	117:	107	92	79	67	57	57	47	30
− 4	160	164	150	144	137	126	103	88	82	68	57	53:	54	45	31
− 4.5	154	127	115	111	101	100	102	89	68	59	48	49	50:	44	31
− 5	131	108	98	94	85	81	83	79	59	49	55:	45	47	44	54
− 5.5	93:	89	77	68	59	70	75	65	58	59	61	50	45	46	47:
− 6	58	65	56	63	59	50	53	49	33	38	46	47	44	42	37
− 6.5	57	46	48	54	49	29	25	30	30	25	37	36	35	37	31
− 7	48	43	42	41	33	19	16	14	29	33	23	25	28	27	27
− 7.5	33	33	32	29	21	19	17	11	11	19	16	20:	22	23	25
− 8	19	23	20	15	17	10	7	9	6	9	13	16:	19	18	20
− 8.5	17	14	14	8	11	9	5	5	5	5	10	12	14	12	14
− 9	17	9	8	9	9	6	5	4	4	3	6:	7	9	8	8
− 9.5	8	5	6	8	10	6	5	4	3	2	3	4	5:	5	5:
−10	6	5	6:	13	10:	6:	5	3	3:	2	3	2	3	3	3
−10.5	4	4	5	11	8:	6:	4	3	3:	3	1	2	1		
−11	6	3	4	4	6	4	4	1	2	2	2	2	1		
−11.5	3	3	3	4	4	2	1	2	3:	2:	2	2	1		
−12	3	1	1	2	2	1	1	2:	3	3	3				
−12.5	1	1	1	2	2	1	1	1	1	1					
−13			1	1	2	2	4	1	1	1					
−13.5			1					1							
−14			1												
−14.5															
y / x′	+0′.09	+0′.19	+0′.28	+0′.37	+0′.47	+0′.56	+0′.65	+0′.74	+0′.84	+0′.93	+1′.02	+1′.12	+1′.21	+1′.30	+1′.40

TABLE 2 (*continued*)

+8	+8.5	+9	+9.5	+10	+10.5	+11	+11.5	+12	+12.5	+13	+13.5	+14	+14.5	+15	+15.5	+16	x / y′
2	2	1	4	3	2	2											+2′.98
3	3	3	4	4	4	2	2										+2′.88
6	7	5	5	5	5	3	2										+2′.79
13	6	6	8	6	5	3	3	1									+2′.70
12	9	9	9	9	7	4	3	1									+2′.60
18	13	10	12	12	7	5	4	2	2								+2′.51
22	15	14	14	10	7	5	3	2	2:								+2′.42
26	25	19	13	9:	6	4	4	4	2	1:							+2′.33
33	29	25	17	10	8	5	4	4:	4	2		1					+2′.23
31	31	31:	21	14	11	10	8	5	4	2	1	1					+2′.14
34	31	34	26	21	14	13	10	7	7	5	3	3:	2				+2′.05
45	41	38	35	27	17	16	14	12	9	7	5	4	2				+1′.95
53:	48	47	47	38	25	21	18	15	14	10:	5	4	2				+1′.86
66	58	49	46	39	26	20	22	21	14	12	5	3	2	1			+1′.77
75	64	57	54	46	33	22	22	23	19	14	7	4	2	1			+1′.67
79	58	49	48	54	44	26	23	28	22:	15:	8	5	2:	1	1		+1′.58
89	63	39	43	46	51	33	22	27	24	17	11	5	2	2	2		+1′.49
96	70:	47	37	44	51	36	28	27	29	20	13	9	4	2	2	1:	+1′.40
101	76	57	41:	52	51	33	35	27	28	21	14	12	6	2	2	1:	+1′.30
119	87	67	49	55	37	26	28	31	23	19	13	11	6	5	3	1:	+1′.21
121	90	72	66	49	35	30	28	27	20	19	17	13	9	7	3	1:	+1′.12
108	87	91	76	55	47	43	36	22	25	21:	16	11	8	5	2	1:	+1′.02
99	83	89	80	50	61	50	31	25	24	21	14	10	7	3	1	1:	+0′.93
85	84	90	78	74	66	41	25	20	17	14	12	9	4	2:	1		+0′.84
86	84	92	91	79	59:	36:	20:	16:	15	14	7	5	4	2	1		+0′.74
91	82	94	90	71	52	34	19	15	13	12	7:	5	3	2	1:		+0′.65
90	76	72	73	64	45	37	25	20	16	11	8	4	3	2	1		+0′.56
70	63	59	56	53:	40	30	21	21	18	12	8	4	2	2	1		+0′.47
72	58	47	46	42:	37	31	22	22	18	9	4	4	2	2	1		+0′.37
75	52	46:	42	31	31	31	23	19	15	8	4	4	2	2	1		+0′.28
68	53	44	37	25	23	22	20	15	13	9	4	4	2	2	1		+0′.19
70	33	32	26	23	21	17	13	12	11	7	5	4	2	2	1		+0′.09
61	25	26	21	16	16	11	11	8	8	7	4	4	2	2	1		0
57	28	23:	20	18	11	7	7	4	4	4	3	4	1:	2	1		−0′.09
52	37	22	17	11	10	9	7	6	5	4	3	4	1	2	1		−0′.19
43	32	23	17	15	12	9	7	6	4	4	2	2	2	2	2		−0′.28
38	33	24:	19:	17	15	11	9	6	5	4	2	2	2	2	2		−0′.37
33	30	25	22	17	16	13	9	6	5	4	3	2	2	2	2		−0′.47
29	27	26	23	17	16	12	7	6:	7	5	3	2	2	2	2	1:	−0′.56
28	30	26	20	16	14	10	7	6	6	5	4	3	2	2	2	1:	−0′.65
28	32	24	17	14	12	10	8	7	5	5	4	3	2	2	2	1:	−0′.74
31:	31	23	16	13	13	10	8	6	5	5	3	2	1	2	2	1:	−0′.84
35	31:	23	16	12	13	11	9	6	5	5	3	2	1:	2	2	1:	−0′.93
37	29	22	22	15	11	9	9	8	6:	5:	3	2	1	1	1	1:	−1′.02
32	25	20	18	15	12	9	8	9	7	5:	4	2	2:	1	1	1:	−1′.12
28	26	19	14	13	9	6	9	8	5	5	8	2:	2	1	1	1:	−1′.21
28	20	16	14	12	9	8	9	6:	4	3	7	4:	2	1	1		−1′.30
23	17:	16	13	12	10	10	8	5	4	3	3	4	1		1		−1′.40
29	15	13	13	12	13	9	7	2	2	2:	1	1					−1′.49
16	14	12	13	10	9	7	4	2	1	1	1						−1′.58
9	11:	11	7	9	6	4	3	2	1	2							−1′.67
6:	7	6	4	4	4	3	2	3	1:	4							−1′.77
2	3	2	2	1	2	1	2	2	1:	2							−1′.86
				2	2	1	1	1	2	1							−1′.95
				3	2	1	1	1	2								−2′.05
				2	2	1	2	2	2								−2′.14
				2	2	1:		1	1								−2′.23
				1		1											−2′.33
						3											−2′.42
						1											−2′.51
						1											−2′.6c
						1											−2′.7c
+1′.49	+1′.58	+1′.67	+1′.77	+1′.86	+1′.95	+2′.05	+2′.14	+2′.23	+2′.33	+2′.42	+2′.51	+2′.60	+2′.70	+2′.79	+2′.88	+2′.98	y′ / x′

amorphous mass. Therefore we applied to all photoelectric values obtained without a filter a correction of 0.9 units on WALRAVEN's white scale, estimated from a comparison of his measurements with and without a filter. Statistically this should give a correction of the right amount. As the construction of the calibration curve is a statistical process this should be sufficient.

At every point where we had selected a photoelectric observation we computed a wedge reading by averaging all our wedge readings in an area equal to the area of WALRAVEN's diaphragm. In this way we obtained a large number of calibration points for every plate. It appeared that, except for low intensities, all calibration curves are straight lines. This is in agreement with the results of HOLMBERG [1]) for photographic plates of this kind. For the polarization plates the linear part of the calibration curve begins at an intensity of about 70 in our units. Therefore we fitted by least squares straight lines to the calibration points for intensities above 90. For smaller intensities free-hand curves were drawn through the points, in which also a few points from the calibration plate of S.A. 68 could be included, because all calibration curves were almost identical for low intensities.

The two plates taken without a polaroid filter were treated separately. They were calibrated in the same way as the polarization plates, but in addition a number of WALRAVEN's observations with green filter and large diaphragm were included. This was necessary as the thirty-minute plate reaches to the edge of the nebula, where the photoelectric measurements without filter are not very reliable because of the relatively large contribution by the filaments. In the construction of the calibration curves these points received five times the weight given to the small-diaphragm points.

The plate with the thirty-minute exposure cannot be used for the central part of the nebula, whereas the five-minute plate does not give reliable results for the fainter regions; there is, however, a small region where both can be used. Straight lines were fitted to the calibration points, with the extra condition that the plates should fit together in the region of overlap.

The polarizations.

At every point in the nebula where the intensity is not too small we have measurements for four orientations of the polaroid at our disposal. In principle three are sufficient to determine the intensity, the degree of polarization P and the position angle of the maximum of the electric vector q. The most correct procedure would be to solve the four equations for the three unknowns by least squares. However, this would involve a considerable amount of work, as polarization measurements were made for nearly a thousand points in the nebula. Therefore we solved the unknowns directly from the four measurements, which is much more convenient. The formulae used are the same as those given by WALRAVEN.

The results for the polarizations are shown in Table 1, where we give for every point the position angle of the electric vector in degrees, and below it, in italics, the degree of polarization in percent. A colon denotes cases where only three measurements were used, or where the result might be influenced by nearby stars or plate defects. In Figure 1 the polarizations are shown graphically against a photograph of the nebula. The length of each line corresponds with the degree of polarization, while its orientation indicates the direction of the electric vector.

The intensity distribution.

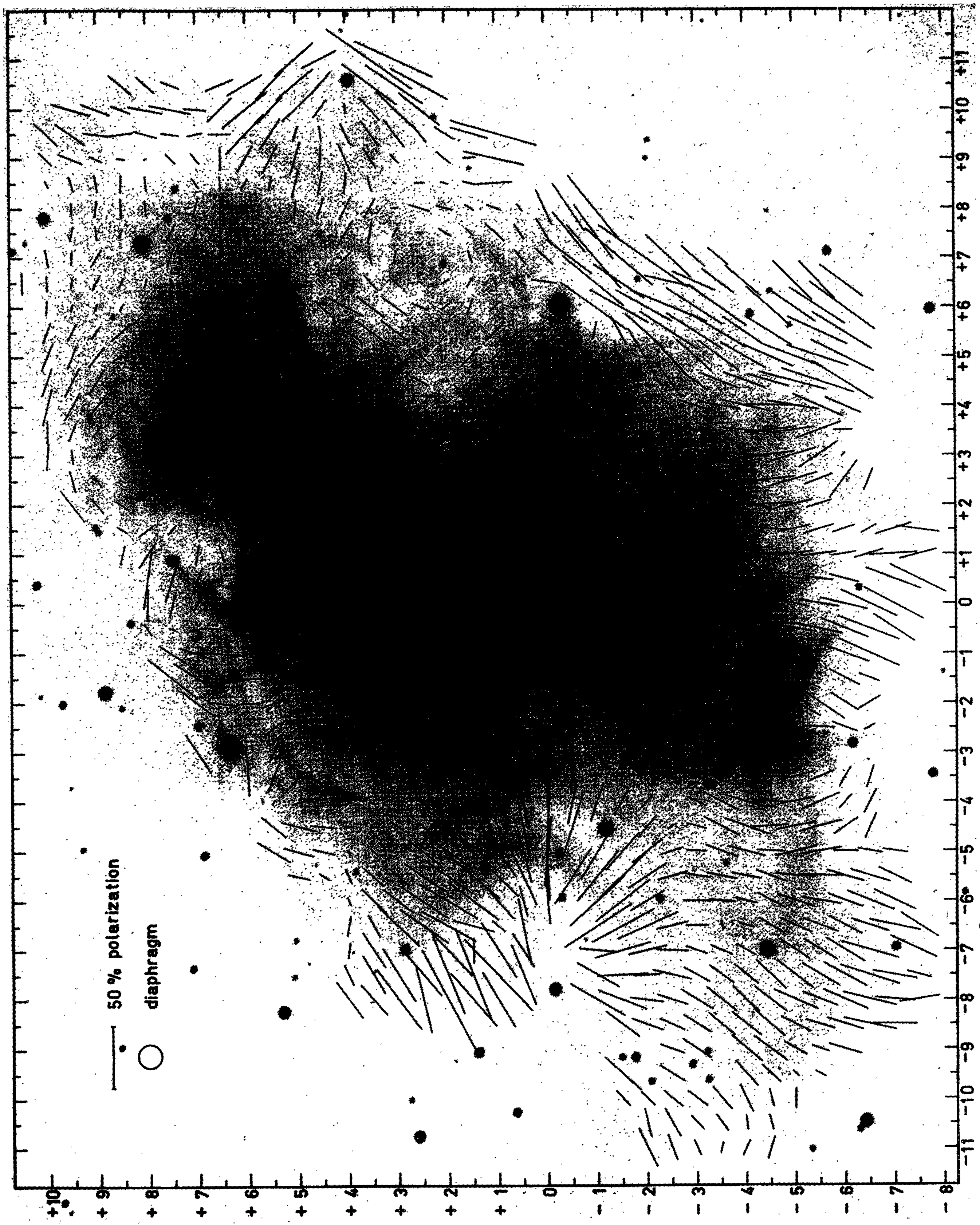
To obtain the best values of the intensities in the nebula the results of all plates were included. After making extensive comparisons of the different plates it appeared that the following combination gives the most reliable results. For intensities smaller than 91 only the thirty-minute plate has been used. For intensities between 91 and 114 the measures on the polarization plates were used. For larger intensities we combined the results from the polarization plates and the five-minute plate, giving double weight to the polarization plates. Combining our results in this way we use only the straight parts of the calibration curves and we have no systematic differences in the overlapping regions. The final intensities are given in Table 2. A map of isophotes projected against the nebula is shown in Figure 2. These isophotes are given for every 25 intensity units, but the isophotes for 1, 5 and 10 units are also shown. Our unit of intensity corresponds to 1.89 of the green filter units used by WALRAVEN.

The accuracy of the results.

For all points used in the calibration we compared the polarizations found photoelectrically by WALRAVEN with the values computed for these points by averaging our results. The systematic difference in position angle for points where the degree of polarization is larger than 10 percent and where the intensity is larger than 68 units on our scale was found to be $q_{pg} - q_{pe} = 1^\circ.1 \pm 1^\circ.0$, and thus can be neglected. The root mean square difference in the individual position angles for these points is $\pm 5^\circ.9$. This gives us a combination of the errors in both results. Large

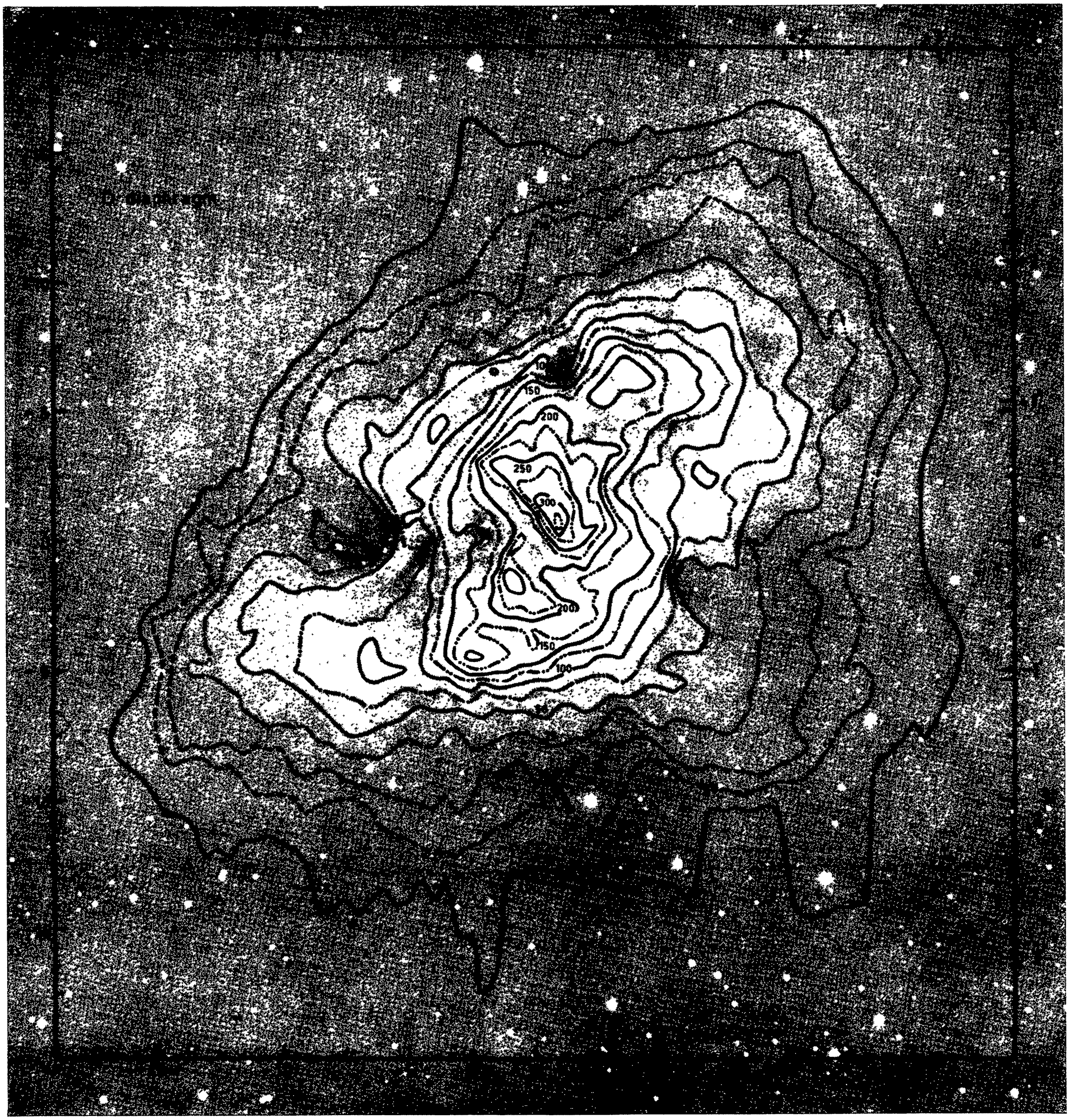
[1]) E. HOLMBERG, *Lund Medd* Ser. II, No. 128, 1950.

Figure I



Polarizations in the Crab Nebula, measured photographically

FIGURE 2



Photographic isophotes in the Crab Nebula systematic errors are not to be expected as the intensities on the polarization plates were calibrated with aid of the photoelectric measures.

Because in our calibration a correction for the influence of the filaments was applied to WALRAVEN's results, our degrees of polarization are somewhat larger than his. After correcting the photoelectric results in the same way there is no systematic difference in the degrees of polarization. The root mean square difference between the photographic and photoelectric results is $\pm$ 4.2 percent. As the correction for filamentary light is a statistical one it seems likely that most of the deviations are in the corrected photoelectric results. Up to here the discussion only refers to the comparison of the photoelectric results and an average of our results. It can be shown that, if we assume the mean error in the intensity from every polarization plate to be μ, the mean error in the degree of polarization is approximately 70 μ/I percent and the mean error in the position angle is about 2000 $\mu/\rho I$ degree, where I denotes the total intensity. It will be found that μ is about 6 for intensity values larger than 114. Thus for an intensity of 150 we expect for our individual results a mean error of 2.8 percent in the degree of polarization and when the degree of polarization is 20 percent a mean error of 4.0 degrees in the position angle.

The systematic difference of the intensity from the polarization plates minus that from the five-minute plate is + 2 units, and thus can be neglected. For individual points the root mean square difference between the two is $\pm$ 4 units for intensities larger than 114. This indicates mean errors in the intensities from the individual polarization plates of about 6 units. There is also no systematic difference between the polarization plates and the thirty-minute plate, the root mean square deviation for individual points between 91 and 114 being $\pm$ 5. These results would indicate mean errors of about $\pm$ 3 in our final intensities. However, there is some uncertainty caused by a systematic difference between $I_0 + I_{90}$ and $I_{45} + I_{135}$ in the western part of the nebula, where the values of the first quantity are up to fifteen percent larger than those of the last one. But this difference does not seem to have had much effect on the polarizations or on the average intensities from all four plates as we do not find systematic deviations in this region with the intensities from the other plates or with the photoelectric polarizations. For intensities below 90 units we expect mean errors of about five percent in the intensity, increasing in the fainter parts of the nebula.

The integrated magnitude of the nebula.

One intensity unit in Table 2 is equivalent to 1.89 of the units in WALRAVEN's table for the green intensities and therefore corresponds to 0.775 stars of the 25th magnitude per square second of arc. When we add all numbers in our table we find a sum of 1.442×10^5 units. Observing that there is one number in the table for every $(0.093)^2$ square minutes of arc we find for the integrated visual magnitude of the nebula $8^m.64$. As WALRAVEN's green intensities are in the MORGAN-JOHNSON system, our value for the magnitude of the nebula is also in this system. OORT and WALRAVEN [1]) found for the photographic magnitude of the nebula $9^m.14$ and a colour equivalent to a G2 star. Adopting therefore a colour index of $0^m.64$ for the integrated nebula we find a visual magnitude of $8^m.50$. The agreement between the two values is reasonable in view of the difficulties caused by the filamentary lines and the peculiar spectral distribution in the continuum.

My most sincere thanks are due to Dr W. BAADE for putting these valuable plates at my disposal and thus making this investigation possible. I wish also to thank Prof. J. H. OORT, who suggested this investigation, and Dr TH. WALRAVEN, who allowed me to use his unpublished data, for valuable discussions.

[1]) J. H. OORT and TH. WALRAVEN, *B.A.N.* **12**, 285 (No. 462), 1956.