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# SUNSPOT OBSERVATION FOR THE YEAR 1983

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## ABSTRACT

In sunspot observations made at the University Observatory at Ankara, the Sun is projected on a screen and the borders of the umbra and penumbra of the sunspots seen on the surface are drawn. The heliograhpic coordinates of the sunspot groups delineated are determined for each day.

The sun was observed on only 279 days and a total of 273 sunspot groups were seen on the projected screen in 1983.

In this paper the sunspot groups seen between the solar rotation number 1730 and 1743, inclusive, and their development and the distribution of these sunspot groups in the northern and southern latitudes are given. In addition, the sum of the number of the spot groups in each rotation is also given for each type at the end of their development.

## INTRODUCTION

As in a number of observatories in various countries the sunspot observations have been carried out at the Ankara University Observatory since November 1969. The Observations made during the years 1970–1982 have already been published (Doğan 1982). The equatorially mounted Zeiss Coudé refractor used for these observations has a lens 15 cm in diameter and a focal length of 212 cm; the magnification employed is 53X. The observatory is on a hill 15 km. south of the city of Ankara with the following coordinates (Çöklü, 1959):

| | | |
|---|---|---|
| Latitude | : | $39^\circ\ 50'\ 37''$ |
| Longitude | : | $2^h\ 11^m\ 07^s$ |
| Altitude | : | 1256.69 m. |

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**The Method:** The image of the Sun is made to fall on an adjustable projection screen attached to the telescope. The solar disk formed on the screen has a diameter of 25 cm. The sunspots seen on the disk are counted and the relative number, R, is calculated from;

$$R = k\,(10\,g + f)$$

Where, g : number of observed groups

f : number of observed sunspots

k : coefficient (constant)

In the present work $k=1$ is adopted. The observations made on the Coudé telescope comprise all the sunspots seen on the projected disk. Having drawn the umbral and penumbral borders of the sunspots their heliographic positions are determined with the help of a network of reseau lines and the "American Ephemeris and Nautical Almanac". Each spot group is recorded in order of date through the solar rotation.

The observations for the year 1983 are given in Table–I. The first column is the sunspot group number, the second and third columns give the heliographic coordinates of each group. If a spotgroup was seen on more than one day the coordinate given is the arithmetic mean of all the observations. In the fourth and fifth columns are recorded the first and last day of observation, respectively. The next columns pertain to longitudes from 0° to 90° with respect to the central meridian and show the group development through each solar rotation. The group-development is given according to the Zurich classification (Kuiper, 1953). The letters in the table represent the types of the sunspot groups and the numbers by the letters give the number of sunspots in each group. When enumerating the spots all the umbrae in a penumbra were considered as one spot. A dash in the table means unsuitable weather conditions for observation. The sign (?) denotes a group which was observed at the edge of the disk and which could not be identified in the Zurich classification.

The monthly observations are shown in Table–II. The first column gives the observed number of sunspot groups for each day; the second column is the daily Wolf relative number; the thirth column gives the image quality (1=excellent, 2=fine, 3=fair, 4=poor, 5=very poor). In the last column are the initials of the observers (FY= Fahrettin Yalçın, AA= Abdurrahman Aşır).

TABLE-1
Rotation No= 1730
1982, 23 December - 1983, 19 January

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | +8 | 359 | 1982, XII. 23 | 1982, XII. 28 | | | | | | | | A3 | B6 | B8 | — | — | J1 | |
| 2 | +10 | 356 | XII. 23 | XII. 29 | | | | | | | A4 | B5 | B4 | — | — | G2 | C3 | |
| 3 | —14 | 266 | XII. 23 | 1983, I. 1 | J1 | J1 | J1 | — | — | C7 | C10 | — | — | B4 | | | | |
| 4 | +6 | 209 | XII. 28 | I. 2 | | J3 | H3 | — | — | G6 | H1 | | | | | | | |
| 5 | —18 | 292 | XII. 29 | 1982, XII. 29 | | | | | | | | | B3 | | | | | |
| 6 | —16 | 275 | XII. 29 | XII. 29 | | | | | | | A1 | | | | | | | |
| 7 | +8 | 224 | 1983, I. 1 | 1983, I. 2 | | | | | | | A3 | J1 | | | | | | |
| 8 | +24 | 215 | I. 2 | I. 2 | | | | | | | A2 | | | | | | | |
| 9 | —19 | 190 | I. 2 | I. 10 | | | | | | A4 | — | — | — | — | — | — | — | E5 |
| 10 | —12 | 128 | I. 10 | I. 10 | | | | | | | | | E20 | | | | | |
| 11 | +4 | 116 | I. 10 | I. 10 | | | | | | | | A2 | | | | | | |
| 12 | +3 | 106 | I. 10 | I. 10 | | | | | | A1 | | | | | | | | |
| 13 | +3 | 98 | I. 10 | I. 10 | | | | | | J1 | | | | | | | | |
| 14 | —19 | 27 | I. 10 | I. 23 | J1 | — | — | — | — | — | — | J1 | J1 | C4 | — | — | — | J1 |
| 15 | —9 | 102 | I. 17 | I. 17 | | | | | | | | | | | | | | J1 |
| 16 | 0 | 24 | I. 17 | I. 19 | | | | | | | | B7 | B6 | B3 | | | | |
| 17 | +4 | 360 | I. 17 | I. 25 | | | | | | E13 | E9 | E4 | — | — | — | G2 | — | A1 |
| 18 | —16 | 352 | I. 17 | I. 25 | | | | | C14 | E14 | E12 | — | — | — | C6 | — | J2 | — |
| 19 | +13 | 334 | I. 17 | I. 26 | | | | C4 | C6 | C8 | — | — | — | J1 | — | J1 | A1 | |
| 20 | —14 | 315 | I. 17 | I. 19 | | J1 | J1 | J2 | | | | | | | | | | |

## TABLE-I (Cont'd)
Rotation No= 1731
1983, 19 January – 16 February

| Sunspot group number | Coordinate of the group | | Date of first Observation | Date of last Observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | +4 | 9 | I. 19 | I. 19 | | | | | | | | A1 | | | | | | |
| 2 | —15 | 297 | I. 23 | I. 23 | | | | | | | A1 | | | | | | | |
| 3 | —12 | 262 | I. 25 | I. 26 | | | | | | A3 | A4 | | | | | | | |
| 4 | —9 | 240 | I. 25 | II. 3 | | | | A4 | D8 | — | C15 | — | G6 | C7 | — | J2 | B2 | |
| 5 | +3 | 237 | I. 25 | II. 3 | | | | A1 | D11 | — | E15 | — | C16 | C15 | — | C2 | J1 | |
| 6 | +4 | 212 | I. 25 | II. 4 | | C4 | C6 | — | J2 | — | J2 | J1 | — | J1 | J1 | J1 | | |
| 7 | —16 | 194 | I. 25 | I. 31 | A2 | A4 | — | A1 | — | A2 | B3 | | | | | | | |
| 8 | —13 | 178 | I. 28 | II 4 | | | B10 | — | C13 | C13 | — | B21 | B13 | B12 | | | | |
| 9 | —17 | 166 | I. 30 | II. 9 | | | | D6 | D16 | — | H7 | F9 | F12 | — | — | E11 | H5 | J1 |
| 10 | —17 | 120 | II. 4 | II. 10 | | | | | | D19 | — | — | E15 | E7 | E8 | E8 | | |
| 11 | —10 | 112 | II. 4 | II. 8 | | | | | B2 | — | — | A2 | A1 | | | | | |
| 12 | —8 | 128 | II. 4 | II. 7 | | | | | | A3 | — | — | B3 | | | | | |
| 13 | —14 | 109 | II. 7 | II. 9 | | | | | | | A1 | A1 | A1 | | | | | |
| 14 | +8 | 88 | II. 7 | II. 7 | | | | | A1 | | | | | | | | | |
| 15 | —6 | 105 | II. 8 | II. 9 | | | | | | | | A7 | A4 | | | | | |
| 16 | +1 | 7 | II. 9 | II. 16 | | J1 | A2 | — | — | — | A2 | A3 | A2 | | | | | |
| 17 | +11 | 36 | II. 15 | II. 15 | | | | | | | | | | A1 | | | | |
| 18 | —17 | 302 | II. 15 | II. 21 | | | A1 | A2 | B5 | — | B3 | B5 | B5 | | | | | |

## TABLE-I (Cont'd)

Rotation No: 1732

1983, 16 February – 15 March

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —14 | 267 | II. 16 | II. 22 | A1 | J1 | — | J1 | J1 | J1 | A1 | | | | | | | |
| 2 | —18 | 317 | II. 17 | II. 17 | | | | | | A1 | | | | | | | | |
| 3 | —9 | 247 | II. 17 | II. 28 | J1 | — | J1 | J1 | J1 | J1 | — | — | — | J1 | J1 | J1 | | |
| 4 | —13 | 262 | II. 21 | II. 21 | | | | | | A1 | | | | | | | | |
| 5 | —12 | 258 | II. 21 | II. 21 | | | | | | A1 | | | | | | | | |
| 6 | +12 | 225 | II. 21 | II. 28 | | | J3 | G2 | — | — | — | B14 | B2 | B5 | | | | |
| 7 | —9 | 230 | II. 26 | II. 28 | | | | | | | | B3 | B10 | C5 | | | | |
| 8 | +14 | 180 | II. 26 | III. 6 | | | | | C4 | C5 | C5 | — | — | — | J1 | J1 | A1 | |
| 9 | —16 | 188 | II. 26 | II. 26 | | | | | A2 | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | —14 | 176 | II. 26 | II. 28 | | | | J1 | A4 | A5 | | | | | | | | |
| 11 | —18 | 158 | II. 26 | III. 8 | | | J1 | H1 | J1 | — | — | — | J2 | J2 | J1 | J2 | J1 | |
| 12 | —14 | 183 | II. 27 | II. 28 | | | | | | B5 | B7 | | | | | | | |
| 13 | —17 | 122 | II. 27 | III. 11 | | J2 | D5 | — | — | — | E5 | F20 | F12 | E12 | E8 | E14 | G3 | D7 |
| 14 | —10 | 261 | II. 28 | II. 28 | | | | | | | | | | | | | B2 | |
| 15 | —9 | 137 | III. 4 | III. 10 | | | | | | | D5 | E8 | E8 | E4 | D6 | G3 | J1 | |
| 16 | —12 | 175 | III. 5 | III. 5 | | | | | | | | | | | A4 | | | |
| 17 | —11 | 114 | III. 7 | III. 7 | | | | | | | | | A2 | | | | | |
| 18 | —11 | 106 | III. 7 | III. 7 | | | | | | | | A2 | | | | | | |
| 19 | +22 | 127 | III. 9 | III. 9 | | | | | | | | | | | | A1 | | |
| 20 | —2 | 90 | III. 9 | III. 12 | | | | | | | | | C5 | D5 | D7 | B3 | | |
| 21 | +5 | 88 | III. 11 | III. 11 | | | | | | | | | | | B5 | | | |
| 22 | —7 | 34 | III. 12 | III. 12 | | | | | | | | A5 | | | | | | |

# TABLE-1 (Cont'd)

Rotation No: 1733

1983, 15 March – 11 April

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —15 | 357 | III. 15 | III. 17 | | | | | | | | B5 | — | B3 | | | | |
| 2 | —12 | 305 | III. 15 | III. 25 | | | | C7 | — | C17 | C23 | C25 | — | C16 | C17 | C10 | C9 | J2 |
| 3 | —7 | 283 | III. 15 | III. 26 | | C6 | — | C14 | C19 | C16 | — | C8 | C6 | J1 | J1 | C3 | J1 | |
| 4 | —10 | 269 | III. 15 | III. 24 | J1 | — | A1 | J1 | J1 | — | A1 | A1 | A1 | A1 | | | | |
| 5 | +9 | 304 | III. 18 | III. 18 | | | | | | | A2 | | | | | | | |
| 6 | —12 | 233 | III. 18 | III. 24 | J2 | B3 | — | J1 | A3 | A3 | A2 | | | | | | | |
| 7 | —13 | 263 | III. 21 | III. 27 | | | | | | | A4 | A2 | B11 | B8 | B10 | B2 | A2 | |
| 8 | +18 | 266 | III. 25 | III. 27 | | | | | | | | | | | B6 | B5 | B3 | |
| 9 | —11 | 145 | III. 25 | IV. 4 | J1 | J1 | J1 | J1 | B4 | B3 | B3 | A2 | — | B5 | A1 | | | |
| 10 | —23 | 207 | III. 26 | III. 26 | | | | | | | A1 | | | | | | | |
| 11 | —16 | 157 | III. 26 | III. 31 | | | | A3 | B7 | B5 | B5 | A3 | A1 | | | | | |
| 12 | —17 | 126 | III. 26 | IV. 5 | G3 | C7 | C6 | C4 | C6 | C9 | C10 | — | C10 | C5 | C10 | | | |
| 13 | —15 | 167 | IV. 1 | IV. 1 | | | | | | | | | | A1 | | | | |
| 14 | —9 | 38 | IV. 3 | IV. 14 | | B6 | B6 | B9 | — | — | — | — | B14 | B9 | B5 | A6 | A1 | |
| 15 | —7 | 111 | IV. 4 | IV, 4 | | | | | | | | | B2 | | | | | |
| 16 | —15 | 357 | IV 10 | IV. 15 | | | | | | | C18 | C18 | C10 | C7 | C3 | A2 | | |
| 17 | —7 | 342 | IV. 10 | IV. 14 | | | | | A2 | J1 | A1 | A1 | A3 | | | | | |

TABLE–I (Cont'd)

Rotation No: 1734

1983, 11 April – 8 May

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —11 | 340 | IV. 11 | IV. 13 | | | | | | B3 | B5 | B2 | | | | | | |
| 2 | —8 | 285 | IV. 11 | IV. 21 | | B2 | B4 | B9 | C12 | B8 | — | — | B13 | B3 | — | B5 | | |
| 3 | +20 | 271 | IV. 13 | IV. 14 | | | A2 | A2 | | | | | | | | | | |
| 4 | +5 | 234 | IV. 15 | IV. 19 | | A8 | — | — | A4 | B6 | | | | | | | | |
| 5 | —30 | 307 | IV. 18 | IV. 21 | | | | | | | | | | | E11 | E7 | — | G3 |
| 6 | —21 | 206 | IV. 18 | IV. 22 | | | A1 | B2 | — | B4 | A1 | | | | | | | |
| 7 | —11 | 174 | IV. 18 | IV. 30 | J1 | J3 | — | H4 | H3 | H5 | C10 | C13 | G12 | C13 | J1 | J2 | J1 | |
| 8 | —9 | 250 | IV. 19 | IV. 19 | | | | | | | | A2 | | | | | | |
| 9 | +10 | 219 | IV. 19 | IV. 27 | | | | | B5 | — | B10 | B9 | B12 | C9 | C8 | C5 | J1 | |
| 10 | +7 | 234 | IV. 22 | IV. 23 | | | | | | | | | B4 | B4 | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | —15 | 128 | IV. 22 | V. 5 | G4 | G5 | E9 | E11 | F18 | E28 | E24 | D8 | G4 | G3 | — | G3 | A2 | A2 |
| 12 | —4 | 108 | IV. 24 | V. 5 | | J1 | C7 | D9 | C15 | C11 | C9 | C6 | B4 | — | H6 | C7 | C5 | |
| 13 | +15 | 180 | IV. 25 | IV. 25 | | | | | | | | A1 | | | | | | |
| 14 | +9 | 170 | IV. 25 | IV. 25 | | | | | | | A2 | | | | | | | |
| 15 | +15 | 132 | IV. 25 | V. 3 | | | | A3 | C5 | C7 | B22 | B15 | B7 | C5 | — | A1 | | |
| 16 | —14 | 114 | IV. 27 | V. 5 | | | | | A2 | C20 | E20 | D12 | E11 | — | C8 | J1 | J1 | |
| 17 | —8 | 59 | IV. 28 | IV. 30 | | A1 | A2 | A1 | | | | | | | | | | |
| 18 | —9 | 39 | IV. 29 | V. 9 | C4 | C6 | D8 | — | C16 | B17 | B12 | B15 | B15 | B8 | B7 | | | |
| 19 | +12 | 49 | V. 3 | V. 9 | | | | | | B4 | B5 | B6 | J1 | A2 | C8 | B6 | | |
| 20 | —13 | 24 | V. 4 | V. 12 | | | | | | A3 | C6 | C9 | C13 | C6 | C9 | — | A2 | A1 |
| 21 | —29 | 297 | V. 6 | V. 19 | G3 | C5 | E5 | E8 | — | E10 | C13 | C10 | C10 | G6 | J2 | J1 | J1 | J1 |
| 22 | —10 | 299 | V. 6 | V. 19 | J1 | J1 | J1 | C12 | — | C22 | D24 | C24 | D15 | E17 | E13 | G4 | H4 | J1 |
| 23 | —10 | 246 | V. 7 | V. 15 | | | | | A2 | B3 | B10 | — | F18 | F19 | F22 | F13 | E8 | |

TABLE–I (Cont'd)
Rotation No: 1735
1983, 8 May – 5 June

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the groups | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | +8 | 232 | V. 12 | V. 23 | | B6 | B13 | C12 | D14 | C9 | B8 | B5 | B4 | B4 | C4 | C5 | C4 | |
| 2 | —9 | 274 | V. 13 | V. 20 | | | | | | C11 | D8 | C11 | C7 | C3 | C3 | C3 | J1 | |
| 3 | —4 | 255 | V. 14 | V. 14 | | | | | A3 | | | | | | | | | |
| 4 | —26 | 191 | V.15 | V. 27 | J1 | C3 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | |
| 5 | —23 | 179 | V. 16 | V. 26 | | B7 | C4 | D5 | C8 | D7 | D10 | C12 | C6 | B3 | A3 | A1 | | |
| 6 | —20 | 265 | V. 17 | V. 20 | | | | | | | | | | A1 | A1 | — | A1 | |
| 7 | +16 | 156 | V. 17 | V. 29 | J1 | J1 | E8 | E17 | E21 | E27 | E34 | G15 | G10 | G7 | J1 | J1 | J1 | |
| 8 | —4 | 246 | V. 18 | V. 18 | | | | | | | | | A1 | | | | | |
| 9 | —17 | 127 | V. 21 | V.25 | | | A1 | A2 | — | A3 | A2 | | | | | | | |
| 10 | —17 | 115 | V. 21 | VI. 1 | | J1 | B6 | D15 | D9 | D15 | D22 | C15 | C18 | C21 | — | — | C11 | |
| 11 | +14 | 104 | V. 23 | V. 29 | | | A1 | A3 | B4 | B3 | A1 | A1 | A2 | | | | | |
| 12 | —6 | 206 | V. 24 | V. 25 | | | | | | | | | | | | B3 | B2 | |
| 13 | —8 | 128 | V. 26 | V. 29 | | | | | | | | B4 | B2 | C4 | B3 | | | |
| 14 | —1 | 114 | V. 26 | V. 26 | | | | | | | A4 | | | | | | | |
| 15 | —12 | 143 | V. 27 | V. 27 | | | | | | | | | | A1 | | | | |
| 16 | —10 | 38 | V. 27 | VI. 5 | | J1 | C3 | J2 | — | — | C7 | J3 | J1 | J3 | A1 | | | |
| 17 | —9 | 349 | V. 29 | VI. 11 | J1 | — | — | E16 | E30 | F24 | F28 | F32 | — | F32 | F19 | F14 | E8 | E7 |
| 18 | —10 | 53 | VI. 1 | VI. 4 | | | | | | | | A2 | A1 | C5 | A1 | | | |
| 19 | —19 | 349 | VI. 2 | VI. 3 | | | | A2 | A1 | | | | | | | | | |

TABLE-I (Cont'd)

Rotation No: 1736

1983, 5 June – 2 July

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —8 | 273 | VI. 5 | VI. 17 | E5 | — | E15 | E25 | E30 | E27 | E35 | E28 | E28 | — | — | J1 | J1 | |
| 2 | —17 | 345 | VI. 7 | VI. 9 | | | | | | | | | C5 | J3 | B3 | | | |
| 3 | —10 | 303 | VI. 7 | VI. 7 | | | | | | A1 | | | | | | | | |
| 4 | —10 | 252 | VI. 7 | VI. 13 | | J2 | A2 | A4 | C6 | C3 | C6 | C9 | | | | | | |
| 5 | —26 | 180 | VI. 12 | VI. 19 | J1 | J1 | — | — | J1 | A1 | A1 | A1 | | | | | | |
| 6 | +10 | 232 | VI. 13 | VI. 13 | | | | | | | A1 | | | | | | | |
| 7 | —6 | 173 | VI. 16 | VI. 19 | | | | | C9 | B7 | B10 | B5 | | | | | | |
| 8 | —12 | 155 | VI. 16 | VI. 25 | | | | C5 | C8 | D14 | C12 | C13 | — | C9 | D9 | C3 | B3 | |
| 9 | +14 | 158 | VI. 16 | VI. 24 | | | | E12 | E17 | E17 | E12 | C14 | — | H4 | C4 | J1 | | |
| 10 | +12 | 120 | VI. 19 | VI. 28 | | | | A3 | B6 | — | B11 | D16 | E12 | C17 | C5 | J1 | J1 | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | +15 | 104 | VI. 19 | VI. 29 | | | A4 | C12 | — | D25 | E16 | E11 | E21 | D9 | C7 | D5 | C3 | |
| 12 | +16 | 88 | VI. 19 | VI. 26 | J1 | B3 | — | C8 | B8 | B9 | B2 | B2 | | | | | | |
| 13 | —9 | 69 | VI. 20 | VI. 28 | J2 | — | C14 | B8 | B8 | B6 | A3 | B10 | A4 | | | | | |
| 14 | +10 | 75 | VI. 23 | VII. 2 | | | | | A2 | B2 | A4 | C6 | C6 | C9 | B6 | B12 | B5 | J1 |
| 15 | +2 | 40 | VI. 23 | VI. 27 | | A1 | A1 | A1 | A1 | A1 | | | | | | | | |
| 16 | —4 | 141 | VI. 25 | VI. 26 | | | | | | | | | | | | B2 | J1 | |
| 17 | —19 | 87 | VI. 25 | VI. 25 | | | | | | | A1 | | | | | | | |
| 18 | —7 | 357 | VI. 25 | VII. 6 | J1 | C4 | D8 | E13 | E8 | E14 | D10 | G4 | B6 | — | B6 | A1 | | |
| 19 | +6 | 82 | VI. 27 | VI. 27 | | | | | | | | | A2 | | | | | |
| 20 | —16 | 341 | VI. 28 | VII. 8 | | A4 | C3 | C4 | C7 | J2 | J2 | — | J1 | J1 | J1 | J1 | | |
| 21 | —6 | 11 | VI. 30 | VI. 30 | | | | | | | A2 | | | | | | | |

TABLE–I (Cont'd)
Rotation No: 1737
1983, 2 July – 29 July

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —18 | 280 | VII. 2 | VII. 13 | | J1 | D6 | — | E22 | E22 | E8 | C18 | G18 | C7 | E13 | — | E6 | |
| 2 | —8 | 266 | VII. 3 | VII. 14 | | B4 | — | C14 | C17 | C11 | C22 | H17 | H9 | C5 | — | B4 | J1 | |
| 3 | —5 | 281 | VII. 6 | VII. 10 | | | | | | A1 | A2 | A7 | A4 | A1 | | | | |
| 4 | —15 | 217 | VII. 6 | VII. 18 | J1 | J1 | J1 | H1 | H3 | G5 | — | H1 | C4 | — | J2 | J1 | J1 | |
| 5 | +6 | 257 | VII. 11 | VII. 11 | | | | | | | | | A1 | | | | | |
| 6 | —11 | 159 | VII. 11 | VII. 19 | J1 | — | J1 | C7 | — | D13 | B11 | B11 | B6 | | | | | |
| 7 | —12 | 212 | VII. 13 | VII. 18 | | | | | | | | B7 | C4 | — | J1 | J1 | J1 | |
| 8 | —6 | 193 | VII. 13 | VII. 13 | | | | | | A3 | | | | | | | | |
| 9 | —10 | 185 | VII. 13 | VII. 13 | | | | | | A1 | | | | | | | | |
| 10 | +12 | 127 | VII. 13 | VII. 25 | J1 | C3 | — | C5 | C5 | C5 | C4 | J1 | J1 | J1 | J1 | J2 | A1 | |
| 11 | +16 | 162 | VII. 14 | VII. 20 | | | | | | B4 | — | C4 | C4 | B2 | J1 | B2 | | |
| 12 | +14 | 110 | VII. 14 | VII. 21 | J1 | — | J1 | A2 | A1 | A1 | A3 | A2 | | | | | | |
| 13 | +6 | 163 | VII. 16 | VII. 16 | | | | | | | A4 | | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | —8 | 142 | VII. 16 | VII. 24 | | | | | | A1 | B7 | A1 | B9 | C16 | C13 | D21 | D13 | J1 |
| 15 | —4 | 133 | VII. 18 | VII. 21 | | | | | | | A3 | B10 | A2 | B5 | | | | |
| 16 | —6 | 97 | VII. 19 | VII. 27 | | | | A2 | A3 | A2 | B9 | C5 | C10 | D9 | E6 | J1 | | |
| 17 | +9 | 83 | VII. 19 | VII. 27 | | | | A2 | B2 | C6 | D7 | C13 | C16 | B12 | A7 | J3 | | |
| 18 | +7 | 95 | VII. 20 | VII. 27 | | | | | | A7 | D11 | D17 | E18 | E18 | E16 | E10 | E5 | |
| 19 | —6 | 32 | VII. 21 | VII. 25 | | A1 | A1 | A1 | A1 | A1 | | | | | | | | |
| 20 | —8 | 83 | VII. 24 | VII. 25 | | | | | | | | | B2 | A1 | | | | |
| 21 | —9 | 60 | VII. 25 | VII. 25 | | | | | | | | A3 | | | | | | |
| 22 | —17 | 338 | VII. 25 | VIII. 2 | | J1 | J1 | J1 | J1 | A3 | — | A4 | B5 | A1 | | | | |
| 23 | —14 | 30 | VII. 26 | VII. 26 | | | | | | | A1 | | | | | | | |
| 24 | —7 | 22 | VII. 27 | VII. 27 | | | | | | | | A1 | | | | | | |
| 25 | —16 | 16 | VII. 28 | VII. 29 | | | | | | | | A1 | B6 | | | | | |
| 26 | —8 | 291 | VII. 28 | VIII. 9 | | E8 | E16 | — | F26 | F45 | F52 | F38 | F40 | F24 | F26 | F14 | J2 | J1 |

TABLE-I (Cont'd)

Rotation No: 1738

1983, 29 July – 25 August

| Sunspot group number | Coordinate of the group | | Date of first observation | Date cf last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —6 | 334 | VII. 29 | VII. 29 | | | | | | A2 | | | | | | | | |
| 2 | —20 | 281 | VII. 29 | VIII. 9 | | G2 | — | C2 | J1 | J1 | J1 | J3 | J1 | Ji | J1 | J1 | J1 | |
| 3 | +15 | 6 | VII. 31 | VIII. 2 | | | | | | | | | | B8 | C7 | G3 | | |
| 4 | —5 | 279 | VII. 31 | VIII. 4 | | | | C6 | B6 | A3 | A2 | A2 | | | | | | |
| 5 | —21 | 339 | VIII. 1 | VIII. 5 | | | | | | | | | A2 | J3 | A5 | A4 | A2 | |
| 6 | +2 | 233 | VIII. 2 | VIII. 5 | | J1 | J1 | A1 | A1 | | | | | | | | | |
| 7 | —15 | 246 | VIII. 5 | VIII. 8 | | | | | | A3 | A2 | B4 | B3 | | | | | |
| 8 | —4 | 154 | VIII. 7 | VIII. 19 | J1 | E15 | E30 | F28 | F39 | F 49 | F56 | F38 | F31 | F12 | E9 | E7 | J1 | |
| 9 | —3 | 118 | VIII. 11 | VIII. 15 | | A1 | A1 | A1 | A1 | A1 | | | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | +8 | 116 | VIII. 11 | VIII. 21 | | J1 | J1 | J1 | J1 | C3 | J1 | B2 | B3 | A4 | — | J2 | | |
| 11 | +18 | 87 | VIII. 12 | VIII. 21 | | A1 | J1 | J1 | J1 | J1 | C4 | B2 | B9 | A2 | A2 | | | |
| 12 | —16 | 111 | VIII. 13 | VIII. 17 | | | | B5 | A4 | A3 | B3 | A3 | | | | | | |
| 13 | —5 | 112 | VIII. 14 | VIII. 14 | | | | | A1 | | | | | | | | | |
| 14 | —13 | 98 | VIII. 16 | VIII. 16 | | | | | | A1 | | | | | | | | |
| 15 | —2 | 102 | VIII. 17 | VIII. 17 | | | | | | | A1 | | | | | | | |
| 16 | +14 | 16 | VIII. 18 | VIII. 22 | J1 | J1 | J1 | A2 | B6 | | | | | | | | | |
| 17 | +14 | 8 | VIII. 20 | VIII. 22 | | | C4 | A2 | A3 | | | | | | | | | |
| 18 | 0 | 56 | VIII. 22 | VIII. 22 | | | | | | | | | A1 | | | | | |
| 19 | —7 | 49 | VIII. 22 | VIII. 22 | | | | | | | | B9 | | | | | | |
| 20 | —14 | 27 | VIII. 22 | VIII. 22 | | | | | | | A2 | | | | | | | |
| 21 | —8 | 341 | VIII. 22 | VIII. 29 | | | B3 | A1 | A4 | A5 | A15 | D9 | D7 | B4 | | | | |
| 22 | +23 | 94 | VIII. 23 | VIII. 24 | | | | | | | | | | | | | G2 | G2 |
| 23 | —8 | 32 | VIII. 24 | VIII. 24 | | | | | | | | | A1 | | | | | |

TABLE-I (Cont'd)

Rotation No: 1739

1983, 25 August – 22 September

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–29 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | +15 | 12 | VIII. 25 | VIII. 26 | | | | | | | | | B5 | A2 | | | | |
| 2 | —9 | 7 | VIII. 25 | VIII. 26 | | | | | | | | A1 | A2 | | | | | |
| 3 | +15 | 6 | VIII. 25 | VIII. 25 | | | | | | | | A3 | | | | | | |
| 4 | —12 | 295 | VIII. 25 | VIII. 31 | | | A3 | A1 | A1 | A3 | A1 | B5 | A2 | | | | | |
| 5 | —7 | 285 | VIII. 25 | IX. 6 | | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 | J1 |
| 6 | —15 | 305 | VIII. 26 | VIII. 26 | | | | A1 | | | | | | | | | | |
| 7 | +2 | 348 | VIII. 27 | VIII. 28 | | | | | | | | | A2 | B3 | | | | |
| 8 | —5 | 311 | VIII. 29 | VIII. 29 | | | | | | | | A3 | | | | | | |
| 9 | —3 | 293 | VIII. 29 | VIII. 30 | | | | | | | B4 | B3 | | | | | | |
| 10 | —16 | 285 | VIII. 29 | VIII. 30 | | | | | | A4 | A1 | | | | | | | |
| 11 | —13 | 281 | VIII. 30 | VIII. 30 | | | | | | | A2 | | | | | | | |
| 12 | +11 | 212 | VIII. 30 | IX. 5 | J1 | J2 | J2 | J2 | A3 | B2 | A1 | | | | | | | |
| 13 | +4 | 269 | VIII. 31 | VIII. 31 | | | | | | | A1 | | | | | | | |
| 14 | 0 | 260 | VIII. 31 | VIII. 31 | | | | | | A1 | | | | | | | | |
| 15 | —8 | 329 | IX. 1 | IX. 2 | | | | | | | | | | | | G3 | J1 | |
| 16 | —3 | 296 | IX. 1 | IX. 1 | | | | | | | | | | A1 | | | | |
| 17 | +9 | 225 | IX. 2 | IX. 10 | | | | | | B5 | B8 | C11 | C15 | D19 | D11 | D12 | D9 | J1 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | —11 | 197 | IX. 2 | IX. 2 | | | A1 | | | | | | | | | | | |
| 19 | —9 | 177 | IX. 3 | IX. 10 | | | J2 | J1 | B2 | B3 | B2 | B8 | B13 | B7 | | | | |
| 20 | —2 | 162 | IX. 4 | IX. 8 | | | J1 | A1 | A1 | A1 | A1 | | | | | | | |
| 21 | —8 | 147 | IX. 4 | IX. 15 | | J1 | J2 | J3 | J3 | C4 | C3 | J2 | J1 | A1 | B8 | C7 | B2 | |
| 22 | +16 | 143 | IX. 5 | IX. 6 | | A1 | A2 | | | | | | | | | | | |
| 23 | —21 | 137 | IX. 7 | IX. 9 | | | | A1 | A1 | A1 | | | | | | | | |
| 24 | +9 | 169 | IX. 9 | IX. 10 | | | | | | | | A3 | A6 | | | | | |
| 25 | +6 | 123 | IX. 10 | IX. 11 | | | | | | A1 | B5 | | | | | | | |
| 26 | +11 | 116 | IX. 11 | IX. 11 | | | | | | A2 | | | | | | | | |
| 27 | —6 | 177 | IX. 12 | IX. 12 | | | | | | | | | | | | A2 | | |
| 28 | —19 | 134 | IX. 12 | IX. 13 | | | | | | | | A4 | A1 | | | | | |
| 29 | —25 | 107 | IX. 12 | IX. 12 | | | | | | A1 | | | | | | | | |
| 30 | —10 | 60 | IX. 13 | IX. 21 | | | | A3 | C4 | C7 | D10 | D17 | C16 | — | B7 | B3 | | |
| 31 | —20 | 136 | IX. 15 | IX. 15 | | | | | | | | | | | | A1 | | |
| 32 | —1 | 124 | IX. 16 | IX. 16 | | | | | | | | | | | | A1 | | |
| 33 | —8 | 130 | IX. 17 | IX. 17 | | | | | | | | | | | | | A1 | |
| 34 | —7 | 336 | IX. 17 | IX. 28 | J1 | J2 | — | J2 | C3 | J2 | A1 | A2 | — | B3 | C4 | G2 | | |
| 35 | —4 | 82 | IX. 18 | IX. 18 | | | | | | | | | | | B4 | | | |
| 36 | +16 | 36 | IX. 21 | IX. 21 | | | | | | | | | | A2 | | | | |

TABLE-1 (Cont d)

Roration No: 1740

1983, 22 September – 19 October

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–68 | 78–90 |
| 1 | —13 | 301 | IX. 22 | IX. 24 | | | | A3 | A3 | A3 | | | | | | | | |
| 2 | —18 | 266 | IX. 22 | X. 4 | | C6 | E8 | E14 | E10 | E14 | E21 | E15 | E22 | — | E14 | E9 | E7 | D4 |
| 3 | +11 | 304 | IX. 25 | IX. 25 | | | | | | | A2 | | | | | | | |
| 4 | —14 | 241 | IX. 26 | IX. 26 | | | A1 | | | | | | | | | | | |
| 5 | —17 | 280 | IX. 29 | IX. 29 | | | | | | | | | A1 | | | | | |
| 6 | —10 | 233 | X. 1 | X. 1 | | | | | | | | A1 | | | | | | |
| 7 | +8 | 131 | X. 2 | X. 15 | J3 | E9 | E9 | E16 | E26 | — | F29 | F35 | E20 | E16 | E11 | E7 | — | J1 |
| 8 | +19 | 137 | X. 2 | X. 6 | A2 | J2 | J2 | A2 | A2 | | | | | | | | | |
| 9 | +14 | 190 | X. 3 | X. 4 | | | | | | | B6 | B2 | | | | | | |
| 10 | +13 | 112 | X. 4 | X. 16 | J1 | J1 | J1 | — | C3 | C7 | C8 | C13 | C6 | C4 | — | J1 | A1 | |
| 11 | —13 | 145 | X. 6 | X. 13 | | | | | | A5 | — | A3 | — | B3 | D7 | D5 | A5 | |
| 12 | —6 | 92 | X. 6 | X. 12 | | A1 | — | D6 | B7 | B8 | B6 | B3 | | | | | | |
| 13 | +21 | 74 | X. 8 | X. 19 | | | A1 | B7 | D7 | C11 | C9 | C14 | — | E6 | E14 | E13 | E13 | E4 |
| 14 | —12 | 118 | X. 9 | X. 13 | | | | | | | A2 | B7 | D10 | B11 | A2 | | | |
| 15 | —11 | 24 | X. 11 | X. 20 | | J1 | J1 | J1 | — | J1 | B2 | A1 | A1 | A1 | A1 | | | |
| 16 | —5 | 15 | X. 12 | X. 22 | | G2 | G2 | — | G2 | G3 | C3 | C12 | C3 | C4 | J1 | J1 | | |
| 17 | —15 | 332 | X. 16 | X. 18 | | | A1 | A1 | A1 | | | | | | | | | |
| 18 | —12 | 355 | X. 18 | X. 20 | | | | | | | A3 | B4 | A1 | | | | | |

## TABLE-I (Cont'd)

Rotation No: 1741

1983. 19 October – 15 November

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —6 | 256 | X. 21 | X. 25 | | A1 | J1 | — | — | A1 | | | | | | | | |
| 2 | —21 | 331 | X. 25 | X. 25 | | | | | | | | | | | | A1 | | |
| 3 | —5 | 212 | X. 27 | X. 28 | | | | | A3 | A1 | | | | | | | | |
| 4 | —16 | 223 | X. 28 | X. 28 | | | | | | | A2 | | | | | | | |
| 5 | —16 | 217 | X. 30 | XI. 1 | | | | | | | | A1 | B7 | B3 | | | | |
| 6 | +14 | 87 | XI. 2 | XI. 12 | J1 | — | J1 | J1 | — | — | — | — | J1 | J1 | J1 | | | |
| 7 | —19 | 91 | XI. 4 | XI. 13 | | | | A6 | C6 | — | — | — | — | C4 | C4 | B4 | A1 | |
| 8 | —15 | 82 | XI. 4 | XI. 10 | | | B9 | B10 | — | — | — | — | A1 | | | | | |
| 9 | —11 | 64 | XI. 5 | XI. 13 | | B3 | — | — | — | — | A4 | B6 | A1 | A3 | | | | |
| 10 | —14 | 109 | XI. 10 | XI. 11 | | | | | | | | | | | A4 | A4 | | |
| 11 | —19 | 27 | XI. 10 | XI. 14 | | | | | A1 | A1 | A1 | — | A1 | | | | | |
| 12 | —9 | 5 | XI. 13 | XI. 17 | | | | | | A3 | B4 | — | C13 | C6 | | | | |

TABLE-I (Cont'd)

Rotation No: 1742

1983, 15 November – 12 December

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | −11 | 330 | XI. 16 | XI. 20 | | | | | | | C5 | J4 | — | — | A1 | | | |
| 2 | +16 | 128 | XI. 28 | XI. 28 | | | B7 | | | | | | | | | | | |
| 3 | +8 | 100 | XII. 1 | XII. 1 | | | | A5 | | | | | | | | | | |
| 4 | −2 | 24 | XII. 5 | XII. 7 | | J1 | — | A1 | | | | | | | | | | |
| 5 | −13 | 15 | XII. 7 | XII. 15 | | | | C5 | B7 | — | B20 | B35 | B16 | — | C3 | B5 | | |
| 6 | −10 | 59 | XII. 10 | XII. 11 | | | | | | | | | | A2 | A1 | | | |
| 7 | +11 | 55 | XII. 10 | XII. 12 | | | | | | | | | | D7 | D4 | D4 | | |
| 8 | −8 | 17 | XII. 10 | XII. 10 | | | | | | | A1 | | | | | | | |
| 9 | +1 | 334 | XII. 10 | XII. 17 | | | C5 | C5 | C12 | — | C5 | C9 | C11 | B5 | | | | |

## TABLE-I (Cont'd)

Rotation No: 1743

1983, 12 December – 1984, 9 January

| Sunspot group number | Coordinate of the group | | Date of first observation | Date of last observation | Development of the sunspot groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EAST | | | | | | | WEST | | | | | | |
| | B | L | | | 90–78 | 78–65 | 65–52 | 52–39 | 39–26 | 26–13 | 13–0 | 0–13 | 13–26 | 26–39 | 39–52 | 52–65 | 65–78 | 78–90 |
| 1 | —14 | 290 | XII. 12 | XII. 17 | | A1 | — | B3 | A2 | A1 | B3 | | | | | | | |
| 2 | —11 | 267 | XII. 14 | XII. 23 | | A1 | A3 | C9 | D12 | — | — | — | — | C9 | J1 | | | |
| 3 | —6 | 6 | XII. 17 | XII. 17 | | | | | | | | | | | | | J1 | |
| 4 | +12 | 115 | 1984, I. 2 | 1984, I. 5 | | | | | | | | | | B7 | C10 | D10 | C4 | |
| 5 | —10 | 20 | I. 7 | I. 7 | | | | | | | | A2 | | | | | | |
| 6 | —13 | 8 | I. 7 | I. 7 | | | | | | | B5 | | | | | | | |
| 7 | —5 | 359 | I. 7 | I. 7 | | | | | | A1 | | | | | | | | |
| 8 | —2 | 325 | I. 7 | I. 12 | | | | A3 | A2 | J1 | — | A1 | A3 | | | | | |
| 9 | —5 | 315 | I. 7 | I. 13 | | | J1 | J2 | J3 | — | J2 | A2 | A1 | | | | | |

## TABLE – II

| JANUARY | | | | | FEBRUARY | | | | | MARCH | | | | | APRIL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Number of groups | Wolf's number | Image quality | Obser- ver | Date | Number of groups | Wolf's number | Image quality | Obser- ver | Date | Number of groups | Wolf's quality | Image number | Obser- ver | Date | Number of groups | Wolf's number | Image quality | Obser- ver |
| 1 | 4 | 55 | 4 | A.A. | 1 | – | – | – | – | 1 | – | – | – | – | 1 | 3 | 43 | 3 | F.Y. |
| 2 | 4 | 48 | 4 | A.A- | 2 | 5 | 83 | 3 | F.Y. | 2 | 4 | 53 | 5 | F.Y. | 2 | – | – | – | – |
| 3 | – | – | – | – | 3 | 5 | 76 | 4 | F.Y. | 3 | – | – | – | – | 3 | 3 | 51 | 3 | F.Y. |
| 4 | – | – | – | – | 4 | 6 | 109 | 4 | F.Y. | 4 | – | – | – | – | 4 | 4 | 54 | 4 | F.Y. |
| 5 | – | – | – | – | 5 | – | – | – | – | 5 | 5 | 85 | 4 | F.Y. | 5 | 2 | 39 | 4 | F.Y. |
| 6 | – | – | – | – | 6 | – | – | – | – | 6 | 4 | 62 | 4 | F.Y. | 6 | – | – | – | – |
| 7 | – | – | – | – | 7 | 6 | 93 | 4 | F.Y. | 7 | 5 | 72 | 4 | F.Y. | 7 | – | – | – | – |
| 8 | – | – | – | – | 8 | 5 | 71 | 5 | F.Y. | 8 | 3 | 45 | 4 | F.Y. | 8 | – | – | – | – |
| 9 | – | – | – | – | 9 | 5 | 65 | 5 | F.Y. | 9 | 4 | 63 | 4 | F.Y. | 9 | – | – | – | – |
| 10 | 6 | 90 | 4 | F.Y. | 10 | 2 | 30 | 3 | F.Y. | 10 | 3 | 39 | 5 | F.Y. | 10 | 3 | 64 | 3 | F.Y. |
| 11 | – | – | – | – | 11 | – | – | – | – | 11 | 3 | 49 | 3 | F.Y. | 11 | 5 | 83 | 3 | F.Y- |
| 12 | – | – | – | – | 12 | – | – | – | – | 12 | 2 | 28 | 4 | A.A. | 12 | 5 | 75 | 3 | F.Y. |
| 13 | – | – | – | – | 13 | – | – | – | – | 13 | – | – | – | – | 13 | 6 | 87 | 3 | F.Y. |
| 14 | – | – | – | – | 14 | 1 | 12 | 4 | F.Y. | 14 | – | – | – | – | 14 | 5 | 71 | 3 | F.Y. |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | – | – | – | – | 15 | 3 | 35 | 3 | F.Y. | 15 | 4 | 59 | 3 | F.Y. | 15 | 3 | 48 | 4 | F.Y. |
| 16 | – | – | – | – | 16 | 3 | 35 | 4 | F.Y. | 16 | – | – | – | – | 16 | – | – | – | – |
| 17 | 7 | 111 | 3 | F.Y. | 17 | 4 | 48 | 4 | F.Y. | 17 | 4 | 75 | 4 | F.Y. | 17 | – | – | – | – |
| 18 | 6 | 97 | 3 | F.Y. | 18 | – | – | – | – | 18 | 5 | 97 | 3 | F.Y. | 18 | 5 | 80 | 4 | F.Y. |
| 19 | 7 | 104 | 4 | F.Y. | 19 | 3 | 35 | 4 | F.Y. | 19 | 4 | 85 | 3 | F.Y. | 19 | 7 | 98 | 4 | F.Y. |
| 20 | – | – | – | – | 20 | 3 | 37 | 4 | F.Y. | 20 | – | – | – | – | 20 | – | – | – | – |
| 21 | – | – | – | – | 21 | 6 | 72 | 4 | F.Y. | 21 | 5 | 80 | 4 | F.Y. | 21 | 5 | 76 | 4 | F.Y. |
| 22 | – | – | – | – | 22 | 3 | 34 | 5 | F.Y. | 22 | 5 | 79 | 3 | F.Y. | 22 | 5 | 71 | 3 | F.Y- |
| 23 | 5 | 61 | 3 | F.Y. | 23 | – | – | – | – | 23 | 5 | 76 | 3 | F.Y. | 23 | 4 | 66 | 3 | F.Y. |
| 24 | – | – | – | – | 24 | – | – | – | – | 24 | 5 | 71 | 3 | F.Y. | 24 | 4 | 69 | 3 | A.A. |
| 25 | 8 | 98 | 3 | F.Y. | 25 | – | – | – | – | 25 | 5 | 72 | 3 | F.Y. | 25 | 7 | 115 | 3 | F.Y. |
| 26 | 6 | 94 | 4 | F.Y. | 26 | 7 | 96 | 3 | F.Y. | 26 | 7 | 86 | 3 | F.Y. | 26 | 5 | 99 | 3 | F.Y. |
| – | – | – | – | – | 27 | 8 | 110 | 3 | A.A. | 27 | 5 | 70 | 3 | F.Y. | 27 | 6 | 126 | 2 | F.Y. |
| 28 | 5 | 93 | 4 | F.Y. | 28 | 9 | 126 | 3 | F.Y. | 28 | 3 | 42 | 3 | F.Y. | 28 | 6 | 139 | 2 | F.Y. |
| 29 | – | – | – | – | | | | | | 29 | 3 | 43 | 3 | F.Y. | 29 | 7 | 130 | 3 | F.Y. |
| 30 | 6 | 105 | 4 | F.Y. | | | | | | 30 | 3 | 42 | 3 | F.Y. | 30 | 7 | 107 | 4 | F.Y. |
| 31 | 6 | 115 | 4 | F..Y | | | | | | 31 | 3 | 43 | 3 | F.Y. | | | | | |

## TABLE - II (Cont'd)

| MAY | | | | | JUNE | | | | | JULY | | | | | AUGUST | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Number of groups | Wolf's number | Image quality | Obser-ver | Date | Number of groups | Wolf's number | Image quality | Obser-ver | Date | Number of groups | Wolf's number | Image quality | Obser-ver | Date | Number of groups | Wolf's number | Image quality | Obser-ver |
| 1 | 5 | 81 | 3 | A.A. | 1 | 4 | 76 | 3 | F.Y. | 1 | 3 | 52 | 2 | F.Y. | 1 | 6 | 126 | 3 | F.Y. |
| 2 | – | – | – | – | 2 | 4 | 76 | 3 | F.Y. | 2 | 4 | 48 | 3 | F.Y. | 2 | 7 | 134 | 3 | F.Y. |
| 3 | 6 | 98 | 3 | F.Y. | 3 | 4 | 71 | 3 | F.Y. | 3 | 4 | 58 | 3 | F.Y. | 3 | 5 | 97 | 3 | F.Y. |
| 4 | 6 | 95 | 3 | F.Y. | 4 | 3 | 62 | 3 | F.Y. | 4 | – | – | – | – | 4 | 5 | 100 | 2 | F.Y. |
| 5 | 6 | 92 | 3 | F.Y. | 5 | 3 | 68 | 3 | F.Y. | 5 | 4 | 83 | 2 | F.Y. | 5 | 5 | 81 | 3 | F.Y. |
| 6 | 5 | 79 | 3 | F.Y. | 6 | – | – | – | – | 6 | 6 | 103 | 3 | F.Y. | 6 | 3 | 59 | 2 | F.Y. |
| 7 | 6 | 98 | 3 | F.Y. | 7 | 5 | 105 | 3 | F.Y. | 7 | 5 | 73 | 4 | F.Y. | 7 | 4 | 60 | 2 | F.Y. |
| 8 | 6 | 91 | 3 | F.Y. | 8 | 4 | 89 | 4 | F.Y. | 8 | 5 | 99 | 3 | F.Y. | 8 | 4 | 61 | 2 | F.Y. |
| 9 | 6 | 112 | 3 | F.Y. | 9 | 4 | 91 | 4 | F.Y. | 9 | 4 | 80 | 2 | A.A. | 9 | 3 | 62 | 2 | F.Y. |
| 10 | – | – | – | – | 10 | 3 | 71 | 3 | F.Y. | 10 | 4 | 60 | 3 | F.Y. | 10 | 1 | 38 | 3 | F.Y. |
| 11 | 4 | 92 | 4 | F.Y. | 11 | 3 | 75 | 3 | F.Y. | 11 | 5 | 75 | 3 | F.Y. | 11 | 3 | 71 | 2 | F.Y. |
| 12 | 5 | 113 | 3 | F.Y. | 12 | 4 | 77 | 3 | F.Y. | 12 | – | – | – | – | 12 | 4 | 92 | 2 | F.Y. |
| 13 | 5 | 130 | 3 | F.Y. | 13 | 4 | 79 | 4 | F.Y. | 13 | 8 | 104 | 3 | F.Y. | 13 | 5 | 114 | 2 | F.Y. |
| 14 | 6 | 121 | 3 | F.Y. | 14 | – | – | – | – | 14 | 7 | 94 | 3 | F.Y. | 14 | 6 | 106 | 2 | F.Y. |
| 15 | 6 | 118 | 3 | F.Y. | 15 | – | – | – | – | 15 | – | – | – | – | 15 | 5 | 89 | 2 | F.Y. |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 6 | 101 | 3 | F.Y. | 16 | 5 | 78 | 3 | F.Y. | 16 | 8 | 111 | 3 | F.Y. | 16 | 5 | 68 | 3 | A.A. |
| 17 | 8 | 103 | 4 | F.Y. | 17 | 5 | 84 | 3 | F.Y. | 17 | 7 | 101 | 3 | F.Y. | 17 | 5 | 69 | 3 | F.Y. |
| 18 | 9 | 112 | 3 | F.Y. | 18 | 4 | 82 | 2 | F.Y. | 18 | 8 | 105 | 3 | F.Y. | 18 | 4 | 53 | 2 | A.A. |
| 19 | 7 | 96 | 3 | F.Y. | 19 | 7 | 108 | 3 | F.Y. | 19 | 8 | 115 | 2 | F.Y. | 19 | 4 | 55 | 2 | A.A. |
| 20 | 6 | 91 | 4 | F.Y. | 20 | 6 | 110 | 3 | F.Y. | 20 | 8 | 116 | 3 | F.Y. | 20 | 3 | 37 | 2 | A.A. |
| 21 | 6 | 98 | 3 | F.Y. | 21 | – | – | – | – | 21 | 8 | 121 | 2 | F.Y. | 21 | 4 | 48 | 3 | A.A. |
| 22 | 6 | 113 | 3 | F.Y. | 22 | 6 | 131 | 3 | F.Y. | 22 | 6 | 116 | 2 | F.Y. | 22 | 6 | 84 | 2 | A.A. |
| 23 | 6 | 121 | 3 | F.Y. | 23 | 8 | 144 | 3 | F.Y. | 23 | 6 | 111 | 2 | F.Y. | 23 | 2 | 23 | 3 | A.A. |
| 24 | 7 | 107 | 3 | F.Y. | 24 | 8 | 127 | 3 | F.Y. | 24 | 7 | 121 | 2 | F.Y. | 24 | 3 | 37 | 2 | A.A. |
| 25 | 7 | 107 | 3 | F.Y. | 25 | 10 | 158 | 3 | F.Y- | 25 | 8 | 124 | 2 | F.Y. | 25 | 6 | 78 | 2 | A.A. |
| 26 | 7 | 112 | 2 | F.Y. | 26 | 8 | 111 | 3 | F.Y. | 26 | 5 | 75 | 2 | F.Y. | 26 | 6 | 82 | 2 | A.A. |
| 27 | 7 | 92 | 3 | F.Y. | 27 | 7 | 105 | 3 | F.Y. | 27 | 5 | 61 | 3 | F.Y. | 27 | 4 | 53 | 2 | A.A. |
| 28 | 5 | 77 | 2 | F.Y. | 28 | 6 | 96 | 3 | F.Y. | 28 | 3 | 40 | 3 | F.Y. | 28 | 4 | 54 | 3 | A.A. |
| 29 | 6 | 90 | 3 | F.Y. | 29 | 4 | 60 | 3 | F.Y. | 29 | 5 | 79 | 2 | F.Y. | 29 | 6 | 77 | 2 | A.A. |
| 30 | – | – | – | – | 30 | 4 | 72 | 3 | F.Y. | 30 | – | – | – | – | 30 | 6 | 73 | 2 | A.A. |
| | | | | | | | | | | 31 | 5 | 96 | 3 | F.Y. | 31 | 5 | 57 | 3 | A.A. |

TABLE – II (Cont'd)

| SEPTEMBER | | | | | OCTOBER | | | | | NOVEMBER | | | | | DECEMBER | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Number of groups | Wolf's number | Image quality | Obser-ver | Date | Number of groups | Wolf's number | Image quality | Obser-ver | Date | Number of groups | Wolf's number | Image quality | Obser-ver | Date | Number of groups | Wolf's number | Image quality | Obser-ver |
| 1 | 4 | 47 | 3 | A.A. | 1 | 2 | 35 | 2 | F.Y. | 1 | 1 | 13 | 3 | F.Y. | 1 | 1 | 15 | 4 | F.Y. |
| 2 | 5 | 60 | 3 | A.A. | 2 | 3 | 44 | 3 | F.Y. | 2 | 1 | 11 | 3 | F.Y. | 2 | – | – | – | – |
| 3 | 4 | 54 | 2 | A.A. | 3 | 4 | 64 | 3 | F.Y. | 3 | – | – | – | – | 3 | – | – | – | – |
| 4 | 6 | 77 | 3 | A.A. | 4 | 5 | 68 | 4 | F.Y. | 4 | 3 | 46 | 3 | F.Y. | 4 | – | – | – | F.Y. |
| 5 | 7 | 93 | 3 | F.Y. | 5 | 3 | 49 | 3 | F.Y. | 5 | 4 | 60 | 3 | F.Y. | 5 | 1 | 11 | 4 | F.Y. |
| 6 | 6 | 89 | 3 | F.Y. | 6 | 5 | 85 | 2 | F.Y. | 6 | – | – | – | – | 6 | – | – | – | – |
| 7 | 5 | 68 | 3 | F.Y. | 7 | – | – | – | – | 7 | – | – | – | – | 7 | 2 | 26 | 4 | F.Y. |
| 8 | 5 | 76 | 2 | F.Y. | 8 | 5 | 92 | 2 | F.Y. | 8 | – | – | – | – | 8 | 1 | 17 | 4 | F.Y. |
| 9 | 5 | 79 | 2 | F.Y. | 9 | 5 | 108 | 2 | A.A. | 9 | – | – | – | – | 9 | – | – | – | – |
| 10 | 5 | 67 | 3 | F.Y. | 10 | 6 | 117 | 2 | F.Y. | 10 | 6 | 75 | 4 | F.Y. | 10 | 5 | 85 | 3 | F.Y. |
| 11 | 3 | 38 | 3 | A.A. | 11 | 7 | 134 | 2 | F.Y. | 11 | 5 | 66 | 3 | F.Y. | 11 | 4 | 85 | 3 | F.Y. |
| 12 | 4 | 48 | 2 | F.Y. | 12 | 8 | 128 | 2 | F.Y. | 12 | 4 | 47 | 4 | F.Y. | 12 | 4 | 73 | 3 | F.Y- |
| 13 | 3 | 42 | 2 | F.Y. | 13 | 7 | 105 | 2 | F.Y. | 13 | 3 | 37 | 3 | F.Y. | 13 | – | – | – | – |
| 14 | 2 | 31 | 2 | F.Y. | 14 | – | – | – | – | 14 | 2 | 25 | 3 | F.Y. | 14 | 4 | 52 | 4 | F.Y- |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 3 | 40 | 3 | F.Y. | 15 | 5 | 61 | 3 | F.Y. | 15 | – | – | – | – | 15 | 4 | 59 | 3 | F.Y. |
| 16 | 2 | 31 | 2 | F.Y. | 16 | 5 | 71 | 3 | F.Y. | 16 | 2 | 38 | 4 | F.Y. | 16 | 3 | 51 | 3 | F.Y. |
| 17 | 3 | 49 | 2 | F.Y. | 17 | 4 | 60 | 2 | F.Y. | 17 | 2 | 30 | 4 | F.Y. | 17 | 4 | 61 | 3 | F.Y. |
| 18 | 3 | 52 | 2 | A.A. | 18 | 5 | 80 | 2 | F.Y. | 18 | – | – | – | – | 18 | – | – | – | – |
| 19 | – | – | – | – | 19 | 4 | 52 | 2 | F.Y. | 19 | – | – | – | – | 19 | – | – | – | – |
| 20 | 2 | 29 | 3 | F.Y. | 20 | 3 | 36 | 2 | F.Y. | 20 | 1 | 11 | 4 | F.Y. | 20 | – | – | – | – |
| 21 | 3 | 38 | 3 | F.Y. | 21 | 2 | 22 | 2 | F.Y. | 21 | – | – | – | F.Y. | 21 | – | – | – | – |
| 22 | 3 | 41 | 3 | F.Y. | 22 | 2 | 22 | 2 | A.A. | 22 | – | – | – | F.Y. | 22 | 1 | 19 | 3 | F.Y. |
| 23 | 3 | 42 | 2 | F.Y. | 23 | – | – | – | – | 23 | – | – | – | F.Y. | 23 | 1 | 11 | 4 | F.Y |
| 24 | 3 | 49 | 3 | F.Y. | 24 | – | – | – | – | 24 | – | – | – | F.Y. | 24 | – | – | – | – |
| 25 | 2 | 32 | 2 | F.Y. | 25 | 2 | 22 | 3 | F.Y. | 25 | – | – | – | – | 25 | – | – | – | – |
| 26 | 3 | 48 | 3 | F.Y. | 26 | – | – | – | – | 26 | – | – | – | – | 26 | – | – | – | – |
| 27 | 2 | 45 | 2 | F.Y. | 27 | 1 | 13 | 3 | F.Y. | 27 | – | – | – | F.Y. | 27 | – | – | – | – |
| 28 | 2 | 37 | 3 | F.Y. | 28 | 2 | 23 | 3 | F.Y. | 28 | 1 | 17 | 3 | F.Y. | 28 | – | – | – | F.Y- |
| 29 | 2 | 43 | 2 | F.Y. | 29 | – | – | – | F.Y. | 29 | – | – | – | – | 29 | – | – | – | F.Y. |
| 30 | – | – | – | – | 30 | 1 | 11 | 2 | F.Y. | 30 | – | – | – | – | 30 | – | – | – | F.Y. |
| | | | | | 31 | 1 | 17 | 2 | F.Y. | | | | | | 31 | – | – | – | F.Y. |

The distribution of the sunspot groups in 5 degree latitude intervals is shown in Table–III. and Figure–1.

As seen in figure–1 the distribution of the spot groups is different in the two hemispheres.

TABLE – III

1983 (between the rotations numbered 1730 and 1743).

| Latitude | Northern hemisphere | Southern hemisphere |
|---|---|---|
| 0° – 5° | 18 | 25 |
| 6 – 10 | 23 | 65 |
| 11 – 15 | 26 | 56 |
| 16 – 20 | 10 | 35 |
| 21 – 25 | 4 | 7 |
| 26 – 30 | + – | + 4 |
| | 981 | 192 |

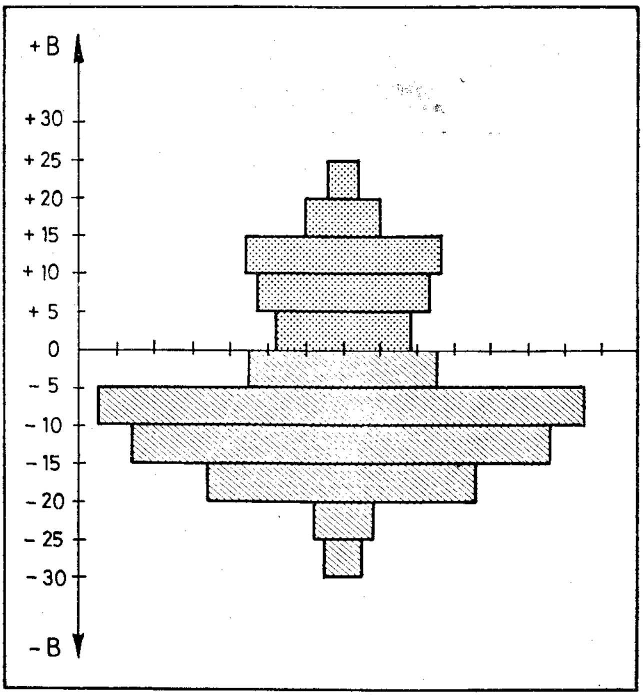

Fig. 1. The Distribution of the Spot groups in two hemispheres.

Of the 273 spot groups, 81 were seen in the northern and 192 in the southern solar hemispheres.

According to our observations in 1983 no sunspots were seen on 88 days in the northern and 7 days in the southern solar hemisphers and 13 days on the whole disk. The longest spotless interval was 2 days in the south and 11 days in the north and 6 days on the whole disk.

According to Table–IV the relative number of spots reached a maximum in the northern hemisphere in June, in the southern hemisphere and on the whole disk in May. On the other hand the number of spots were a minimum in the southern hemisphere, in the northern hemisphere and on the whole disk in November.

TABLE - IV

The distribution of the monthly sunspot groups and monthly relative numbers in the northern and southern solar hemispheres

| Month | Number of observation days | Number of spot groups | | | Relative number of sunspots | | |
|---|---|---|---|---|---|---|---|
| | | in the north | in the south | total disk | in the north | in the south | total disk |
| January | 12 | 31 | 39 | 70 | 452 | 619 | 1071 |
| February | 18 | 17 | 67 | 84 | 221 | 946 | 1167 |
| March | 24 | 12 | 87 | 99 | 156 | 1360 | 1516 |
| April | 22 | 22 | 85 | 107 | 367 | 1424 | 1791 |
| May | 27 | 41 | 120 | 161 | 695 | 2045 | 2740 |
| June | 26 | 49 | 84 | 133 | 844 | 1562 | 2406 |
| July | 27 | 52 | 104 | 156 | 781 | 1640 | 2421 |
| August | 31 | 46 | 94 | 140 | 549 | 1689 | 2238 |
| September | 28 | 23 | 77 | 100 | 370 | 1055 | 1425 |
| October | 27 | 41 | 56 | 97 | 755 | 760 | 1515 |
| November | 19 | 7 | 35 | 42 | 83 | 393 | 476 |
| December | 13 | 9 | 26 | 35 | 148 | 417 | 565 |
| Total | 279 | 350 | 874 | 1224 | 5421 | 13910 | 19331 |
| Daily mean | | 1.25 | 3.13 | 4.38 | 19.43 | 49.85 | 69.28 |

Table–V shows the frequency distribution of the spot types according to K.O. Kiopenheuer through the solar rotations in 1983.

As seen in the Table–V the most and the least frequent spot groups formed in 1983 were type A and type H respectively.

TABLE - V

| Rotation No | Spot Types | | | | | | | | | Total number of spot groups |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | J | |
| 1730 | 4 | 3 | 3 | – | 4 | – | 2 | – | 4 | 20 |
| 1731 | 7 | 4 | 2 | 1 | 2 | 1 | – | – | 1 | 18 |
| 1732 | 9 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 22 |
| 1733 | 3 | 8 | 3 | – | – | – | 1 | – | 2 | 17 |
| 1734 | 5 | 4 | 5 | 2 | 4 | 2 | 1 | – | – | 23 |
| 1735 | 7 | 2 | 4 | 4 | 1 | 1 | – | – | – | 19 |
| 1736 | 6 | 1 | 7 | 2 | 4 | – | – | – | 1 | 21 |
| 1737 | 9 | 4 | 4 | 3 | 3 | 1 | – | 1 | 1 | 26 |
| 1738 | 8 | 4 | 4 | 1 | – | 1 | 3 | – | 2 | 23 |
| 1739 | 21 | 8 | 1 | 2 | – | – | 2 | – | 2 | 36 |
| 1740 | 6 | 3 | 1 | 3 | 2 | 1 | 1 | – | 1 | 18 |
| 1741 | 5 | 3 | 2 | – | – | – | – | – | 2 | 12 |
| 1742 | 3 | 1 | 3 | 1 | – | – | – | – | 1 | 9 |
| 1743 | 2 | 2 | – | 2 | – | – | – | – | 3 | 9 |
| | 95 | 50 | 41 | 22 | 21 | 8 | 11 | 2 | 23 | 273 |

## ACKNOWLEDGMENT

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# INVESTIGATION OF DEFECT CONTRIBUTION TO SPIN SUSCEPTIBILITY

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## ABSTRACT

Enhancement of the spin susceptibility due to the presence of defects in simple metals and metallic alloys is investigated by means of phase shift calculations. It has been concluded that point defects play an effective role for metals of valency two, on the other hand for metals of valency one and for metallic alloys, such as NiB, extended defects should be considered.

## INTRODUCTION

In the course of studies on binary Ni–B alloys, the occurrence of particle size dependent magnetic susceptibility of NiB phase was observed (Mutlu and Aydınuraz, 1987). Preliminary theoretical approach pointed out that this dependence can be attributed to the intrinsic defects (vacancies, cluster of vacancies, etc.) present in this metallic alloy. Generally point defects and impurities have significant influence both on transport and magnetic properties of metals (Van Vucht et al., 1985 and Rizzuto, 1974). The aim of the present work is to investigate only the effect of intrinsic lattice defects on the spin paramagnetism of simple metals and metallic alloys.

Presence of a defect in a metal can be represented by a repulsive potential from which the conduction electrons are scattered (Zeeger, 1963). Since the density of electrons in metals is much higher than in semiconductors, quantum mechanical partial wave analysis must be

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used for the scattering problem under consideration. In the presence of a scattering center $\delta_l$ phase shift of the $l$ th partial wave is different from zero and extra density of states introduced by scattering of electrons from this center is given by White (1983):

$$g(E) = \frac{2}{\pi} \sum_{l=0}^{\infty} (2l+1) \frac{d\delta_l}{dE} . \tag{1}$$

In the case of resonance scattering phase shifts are given by the relation,

$$\delta_l = \tan^{-1} [\Gamma/(E_0 - E)], \tag{2}$$

which leads to a Gaussian type of density of states for s-wave scattering (White, 1983):

$$g(E) = \frac{2}{\pi} \frac{\Gamma}{(E-E_0)^2 + \Gamma^2} , \tag{3}$$

where $\Gamma$ is the width of the resonance and $E_0$ is the resonance energy.

Since Pauli spin paramagnetic susceptibility of a metal is proportional to the density of states at the Fermi level, an enhancement in the spin susceptibility can be expected to occur depending on the quantity $(d\delta_l/dE)E_F$ of equation (1). In other words, if the energy of the resonant scattered electrons by lattice defects overlaps the Fermi energy of the metal, an increase in the density of states at the Fermi level can occur leading to an enhancement in the spin susceptibility.

## PHASE SHIFTS

As pointed out by Seeger (1963), an intrinsic defect distorts the lattice much more than an impurity does. A lattice defect, therefore, can not be treated as a weak perturbation. Thus the use of Born approximation in the phase shift calculations is not valid here. Relation between the type of the scattering potential with the energy dependence of $\delta_l$ implies the exact knowledge of the phase shifts and hence the requirement of the solution of the radial wave equation,

$$\frac{d^2R_l}{dr^2} + \frac{2}{r} \frac{dR_l}{dr} + \left\{ \frac{2m}{\hbar^2} [E-V(r)] - \frac{l(l+1)}{r^2} \right\} R_l = 0 \tag{4}$$

which can analytically be solved only for very simple potentials V(r) (Schiff, 1968).

By use of spherical Bessel and Neumann functions it can be showed that (Schiff, 1968) the phase shifts, for $\iota \leq 2$, are given by the following relations:

$$\tan \delta_0 = \frac{x - (1+\gamma_0 a)\tan x}{x \tan x + 1 + \gamma_0 a}$$

$$\tan \delta_1 = \frac{(2+\gamma_1 a)x - (2 - x^2 + \gamma_1 a)\tan x}{(2+\gamma_1 a)x \tan x + 2 - x^2 + \gamma_1 a} \tag{5}$$

$$\tan \delta_2 = \frac{(9-x^2+3\gamma_2 a)x - [9-4x^2 + (3-x^2)\gamma_2 a]\tan x}{(9-x^2+3\gamma_2 a)x \tan x + 9 - 4x^2 + (3-x^2)\gamma_2 a},$$

where a is the width of the potential, $x = ka = a\sqrt{2mE/\hbar^2}$ and $\gamma_\iota$ is the ratio of slope to the interior ($r<a$) wave function:

$$\gamma_\iota = \left(\frac{1}{R_\iota}\ \frac{dR_\iota}{dr}\right)_{r=a} . \tag{6}$$

We can now obtain the phase shifts for different types of scattering potentials representing the defects in metals.

a) Screened Coulomb Potential:

This type of potential can be used to represent a point defect (vacancy) in a metal (Seeger, 1963):

$$V(r) = A\ e^{-\lambda r}/r, \tag{7}$$

where A is a positive coefficient and $\lambda$ is the screening constant. The order of $\lambda$ is $10^8$ cm$^{-1}$ and we can assume that V(r) is negligible for $r \geq a$, since the order of a is about few Å (typical size of an atom). Using this approximation, which does not change the essential features of resonance scattering (Fig. 1), one can solve equation (4) in the serial form:

$$R_\iota(r) = \sum_{n=1}^{\infty} b_n\ r^{n+\iota+1}. \tag{8}$$

Equation (6) then gives $\gamma_\iota = (\iota + 1)/a$ which in turn leads to the phase shifts whose variation with x is shown in Fig. 1.

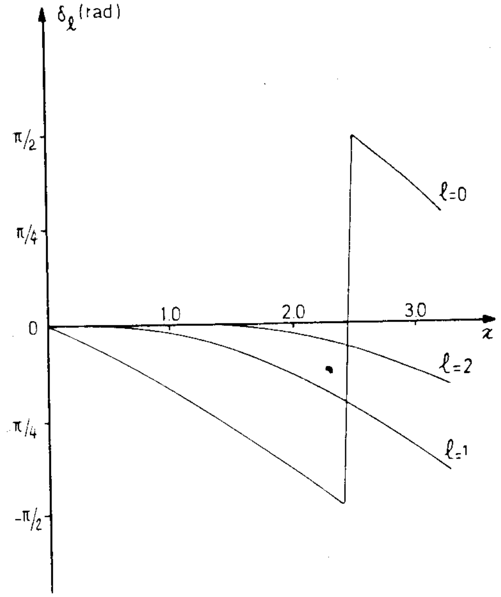

Fig.1. Dependence of phase shifts with respect to x for free electrons scattered from screened Coulomb potential.

b) Constant Repulsive Potential:

A cluster of vacancies or a dislocation can be represented by a potential barrier of,

$$V(r) = \begin{cases} +V_0, & r < a \\ 0 & r > a, \end{cases} \tag{9}$$

where the height of the potential can be determined as the sum of the Fermi energy $E_F$ and the work function W of the metal (Dexter, 1956). For $V_0 > E$ the solution of (4), which is exact, leads to the phase shifts whose variation with respect to x is shown in Fig. 2.

c) Rigid Sphere:

It is known that when the vacancies cluster together, holes or voids can be formed in the lattice (Swanson, 1982). A void can be treated as a rigid sphere of radius a, because the free electrons are unable to penetrate into the void. In that case $R_l(a) = 0$ and hence $\gamma_l = \infty$ in Eq. (7). Replacing $\gamma_l$ in (5) by $\infty$ then gives the phase shifts as a function of x whose plots are shown in Fig. 3.

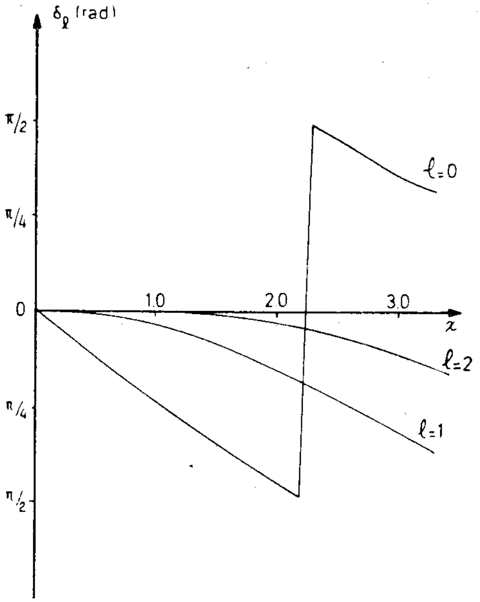

Fig.2. Dependence of phase shifts with respect to x for free electrons scattered by constant repulsive potential ($V_o$ = 12 eV, a = 2 Å).

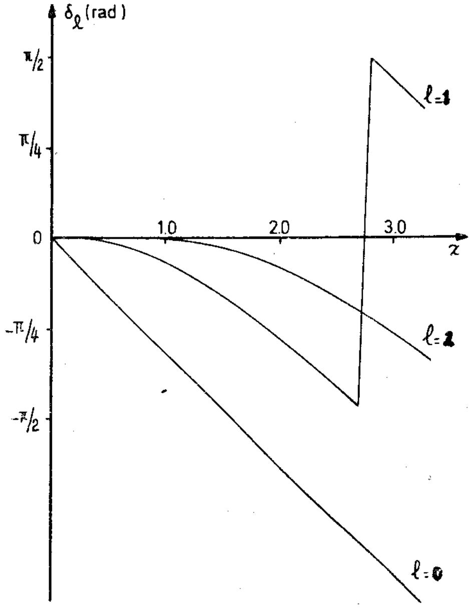

Fig.3. Variation of phase shifts with x for free electrons scattered by rigid sphere.

## RESONANCE SCATTERING IN SIMPLE METALS

From the figures 1,2 and 3 it is clearly seen that variation of $\delta_\iota$ with x is quite similar for different types of scattering potentials. A resonance scattering occurs where the phase shift increases through $\pi/2$. This means that $\iota$ th partial wave is in resonance with the scattering potential.

However, location of the resonance energy $E_0$ depends critically on the parameters (a,$V_0$, etc.) of the potential representing the defect in the metal under consideration. On the other hand, as mentioned before, an increase in the spin susceptibility is to be expected only if $E_0$ is close to $E_F$. In order to bring an understanding of the defect contribution to spin susceptibility, resonance energies were calculated for some simple metals employing the potentials discussed and these energies are given in Table 1 together with the corresponding $E_F$ values.

## RESONANCE SCATTERING IN METALLIC ALLOYS

As in simple metals, defects in metallic alloys can also be considered as scattering centers whose contribution to spin susceptibility should be taken into account. Additional density of states for a binary alloy X–Y is given by Faulkner (1982):

$$g(E) \propto \sum_{\iota} (2\iota+1) \left[ \frac{d\delta_\iota^X}{dE} + \frac{d\delta_\iota^Y}{dE} \right]. \tag{10}$$

Scattering of electrons by X or Y or a complex combination of XY defects may lead to phase shifts whose resonance energies do not differ much from $E_F$ of the alloy. Since very recently an experimental evidence became available (Mutlu and Aydınuraz, 1987), we have applied this approach to NiB binary metallic alloy.

It is usually accepted that rigid band model is valid for NiB (Bakonyi et al., 1984) and therefore one can calculate the Fermi energy of this alloy in a similar way to those of simple metals. Number of free electrons per atom in NiB is in between 1.5 and 1.8 (Kostetskiy and L'vov, 1972), that is, the band structure is $d^{10}\,(sp)^{1,5-1,8}$ . This leads to the Fermi energy of 7.6–8.6 eV for this phase.

It could be thought that possible B or Ni vacancies or clusters of these could cause lattice defects in this alloy. Furthermore, substitu-

Table 1. Resonance energies for free electrons scattered by different types of repulsive potentials in simple metals (Here, potential width is chosen as $a = n^{1/3} r_0$, where n is the number of vacancies in the cluster and $r_0$ is the radius of the sphere whose volume is the atomic volume).

| Metal | $r_0$(Å) | W(eV) | $E_F$(eV) | $E_0$(eV) Resonance Energies | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Screened Coul. pot. | Const.rep.pot. | | Rigid sphere | |
| | | | | | n=2 | n=3 | n=2 | n=3 |
| Li | 1.732 | 2.90 | 4.72 | 7.67 | 4.91 | 3.12 | 6.26 | 4.78 |
| Na | 2.110 | 2.75 | 3.23 | 5.17 | 2.95 | 1.95 | 4.22 | 3.22 |
| K | 2.618 | 2.30 | 2.12 | 3.36 | 1.78 | 1.20 | 2.74 | 2.09 |
| Rb | 2.809 | 2.16 | 1.85 | 2.92 | 1.51 | 1.02 | 2.38 | 1.82 |
| Cu | 1.412 | 4.64 | 7.00 | 11.54 | 7.29 | 4.65 | 9.42 | 7.19 |
| Ag | 1.598 | 4.63 | 5.48 | 9.01 | 5.25 | 3.44 | 7.35 | 5.61 |
| Au | 1.593 | 5.31 | 5.51 | 9.07 | 5.08 | 3.37 | 7.40 | 5.65 |
| Mg | 1.770 | 3.66 | 7.13 | 7.34 | 3.68 | 2.51 | 5.99 | 4.57 |
| Ca | 2.280 | 2.87 | 4.68 | 4.43 | 2.08 | 1.44 | 3.61 | 2.76 |
| Ba | 2.491 | 2.70 | 3.65 | 3.71 | 1.74 | 1.20 | 3.03 | 2.31 |
| Be | 1.256 | 4.98 | 14.14 | 14.59 | 7.74 | 5.21 | 11.91 | 9.09 |
| Zn | 1.539 | 4.62 | 9.39 | 9.72 | 4.91 | 3.34 | 7.93 | 6.05 |
| Cd | 1.732 | 4.22 | 7.46 | 7.67 | 3.78 | 2.59 | 6.26 | 4.78 |
| Al | 1.582 | 4.25 | 11.63 | 9.19 | 4.29 | 2.98 | 7.50 | 5.73 |
| In | 1.839 | 4.12 | 8.60 | 6.80 | 3.08 | 2.15 | 5.55 | 4.24 |
| Sn | 1.862 | 4.42 | 10.03 | 6.64 | 2.85 | 2.01 | 5.42 | 4.13 |
| Pb | 1.936 | 4.25 | 9.37 | 6.14 | 2.62 | 1.85 | 5.01 | 3.82 |

tional occupation of B atoms on Ni sites can also be a sort of defect in the lattice (Katayama et al., 1979). Using the defects of these types, the resonance energies have been calculated and tabulated in Table 2.

## DISCUSSION

Some important conclusions can be derived by the comparison of resonance energies and Fermi energies listed in Table 1 and Table 2. It can at least be concluded that for metals of valency 2 (Mg, Ca, Ba, Be,

Table 2. Resonance energies for NiB ($E_F$ = 7.6–8.6 eV).

| Lattice defect | $r_0$(Å) | $E_0$(eV) | | | |
|---|---|---|---|---|---|
| | | n=1 | n=2 | n=3 | n=4 |
| B vacancies | 1.222 | 15.41 | | | |
| Ni vacancies | 1.378 | 12.12 | | | |
| Cluster of B vancies | 1.222 | | 12.58 | 9.60 | 7.92 |
| Cluster of Ni vacancies | 1.378 | | 9.89 | 7.55 | 6.23 |
| For B atoms at O-J lattice sites | 1.520 | | 8.13 | | |

Zn, Cd) point defects, for metals of valency 1 (Li, Na, K, Rb, Cu, Ag, Au) and for NiB extended defects are effective on their spin susceptibilities. On the other hand one can not consider such a contribution for simple metals of higher valency (Al, In, Sn, Pb), since the relaxation effects related to the defects most probably play a more important role in these metals (Flores and March, 1981).

Furthermore, we can expect a considerable contribution to $g(E_F)$ and hence to spin susceptibility, only for a very sharp and narrow resonance width since $g(E_F) \propto 1/\Gamma$ for $E_0 = E_F$ in Eq. (3). One can readily state that the fulfillment of these conditions for a certain metal is quite difficult and therefore it is more likely to expect a defect contribution to spin susceptibility only for metals and metallic alloys which possess weak spin paramagnetism.

Another important point is the defect type and their concentration in the metal under consideration, because the change in the spin susceptibility due to the presence of defects is directly proportional to defect concentration (Kohn and Luming, 1963). For this reason if the concentration of a certain type of defect is not high enough a change in the spin susceptibility can not be observed even if the conditions related to $E_0$ and $\Gamma$ were satisfied.

Self interstitials are the other important aspects of distortions in a lattice and one should investigate their effects on the spin susceptibility. Unfortunately very little known about this type of defects (Koehler, 1982) and therefore no attempt has been made to attack this problem in the present work.

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