CHAPTER I. INTRODUCTION

Part I. Anisotropy and Modulation of Galactic Cosmic Rays in Interplanetary Space

1.1. Time variation of cosmic ray intensity. ........................................... 1
1.2. Nature of daily variation and anisotropy of cosmic ray intensity. .......... 2
1.2.1. Day to day variability of anisotropy. ........................................ 3
1.2.2. Isotropic changes of cosmic ray intensity - 'slope effect'. ................. 5
1.2.3. Diurnal and semidiurnal components. ......................................... 6
1.2.4. Local and external sources of anisotropy. .................................... 9
1.3. Solar cycle changes of daily variation. .......................................... 10
1.3.1. Eleven and twenty-two year changes in the daily variation. .............. 10
1.3.2. Possible contribution of sidereal anisotropy. ................................ 12
1.4. Day to day changes - solar terrestrial relationships. ........................ 14
1.4.1. Studies of anisotropy during Forbush decreases. .......................... 18
1.5. Experimental evidence relating to plasma, magnetic fields and galactic cosmic rays in the solar system. ................. 23
1.6. Models of plasma and magnetic fields in the solar system. .................. 28

Part II. Analytical Techniques for a Quantitative Study of the Primary Cosmic Ray Anisotropy

1.7. The determination of the characteristics of cosmic ray anisotropy. .......... 37
1.8. The relation of the variation in the secondaries to the variation of primaries. 38
1.8.1. Effects of the geomagnetic field. 40
1.8.2. Transition effects in the atmosphere. 41
1.8.3. Directional response of cosmic ray detectors. 42

Part III. Statement of the Problem. 44

CHAPTER II. EXPERIMENTAL TECHNIQUES AND PROCESSING OF DATA. 1

Part A. Experimental Techniques. 1

2A.1. Measurement of the intensity of meson component. 1

2A.1.1. Introduction. 1

2A.1.2. The geometry of the apparatus. 1

2A.1.3. Preparation of self-quenched counters. 3

2A.1.4. Electronic circuits. 4

2A.1.4.1. Quenching units. 4

2A.1.4.2. Mixing circuit. 5

2A.1.4.3. Coincidence circuit. 5

2A.1.4.4. Scaling circuits. 6

2A.1.4.5. Automatic photographing device. 7

2A.1.4.6. Power supplies. 10

2A.2. Neutron monitor pile. 12

2A.2.1. Introduction. 12

2A.2.2. Electronic circuit. 13

2A.2.3. Power supplies. 14

Part B. Processing of Data. 15

2B.1. Introduction. 15
- iii -

2B.2. Data reduction. ........................................... 16
2B.2.1. Test of self-consistency of the data. ........... 16
2B.2.2. Normalisation of cosmic ray intensity .......... 17
2B.2.3. Corrections for meteorological effects. ........ 18
2B.2.3.1. Pressure correction. ............................ 18
2B.2.3.2. Temperature correction. ......................... 19
2B.2.4. Elimination of the long-term trend in cosmic ray intensity. ........................................... 21
2B.3. Harmonic analysis. .................................... 23
2B.4. Frequency distributions. ............................ 26
2B.4.1. Moments of histograms. ............................ 27
2B.4.2. The Chi square test. ............................... 27
2B.5. IBM 1620 electronic computer. ..................... 29

CHAPTER III. RESULTS AND DISCUSSION. ..................... 1

Part A. The Response of Meson and Neutron Detectors to Anisotropy of Cosmic Ray Intensity. 1
3A.1. Introduction. ........................................... 1
3A.2. The response of a detector to cosmic ray flux. .... 4
3A.2.1. Zenith angle response of cosmic ray detectors. 4
3A.2.1.1. Meson telescopes. ............................... 4
3A.2.1.2. Neutron monitors. ............................... 7
3A.2.2. Multiplicity. ........................................ 8
3A.2.3. Asymptotic directions. ............................ 11
3A.2.4. Cut-off rigidities. ................................ 12
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3A.3</td>
<td>Response of detectors to cosmic ray anisotropy.</td>
<td>13</td>
</tr>
<tr>
<td>3A.3.1</td>
<td>The nature of primary anisotropy.</td>
<td>13</td>
</tr>
<tr>
<td>3A.3.2</td>
<td>Variational coefficients.</td>
<td>14</td>
</tr>
<tr>
<td>3A.3.3</td>
<td>Application to the study of daily variation.</td>
<td>16</td>
</tr>
<tr>
<td>3A.4</td>
<td>Comparison of the response characteristics of different detectors.</td>
<td>18</td>
</tr>
<tr>
<td>3A.5</td>
<td>The effect of opening angles of cosmic ray telescopes.</td>
<td>28</td>
</tr>
<tr>
<td>3B.1</td>
<td>Study of the Anisotropy of Cosmic Ray Intensity outside the Influence of the Geomagnetic Field.</td>
<td>30</td>
</tr>
<tr>
<td>3B.2</td>
<td>The method of best fit.</td>
<td>32</td>
</tr>
<tr>
<td>3B.2.1</td>
<td>Determination of the anisotropy beyond the influence of the geomagnetic field.</td>
<td>32</td>
</tr>
<tr>
<td>3B.2.2</td>
<td>Determination of the variation spectrum.</td>
<td>35</td>
</tr>
<tr>
<td>3B.2.3</td>
<td>Check for consistency of the calculations.</td>
<td>38</td>
</tr>
<tr>
<td>3B.2.4</td>
<td>Normalisation of the strength of the anisotropy for various variation spectra.</td>
<td>39</td>
</tr>
<tr>
<td>3B.3</td>
<td>Study of the day to day changes of the anisotropy.</td>
<td>40</td>
</tr>
<tr>
<td>3B.3.1</td>
<td>Peak to peak strength in space.</td>
<td>40</td>
</tr>
<tr>
<td>3B.3.2</td>
<td>Energy spectrum.</td>
<td>41</td>
</tr>
<tr>
<td>3B.3.3</td>
<td>Directions of maximum and minimum of anisotropy.</td>
<td>43</td>
</tr>
<tr>
<td>3B.4</td>
<td>Conclusions.</td>
<td>45</td>
</tr>
<tr>
<td>3C.1</td>
<td>Long-term Changes of Daily Variation during the Period 1958-62.</td>
<td>47</td>
</tr>
<tr>
<td>3C.2</td>
<td>Introduction.</td>
<td>47</td>
</tr>
</tbody>
</table>
3C.2. Long-term changes in the direction of maximum of anisotropy. 49
3C.2.1. \( T_{\text{max}} \) at high latitude stations. 49
3C.2.2. \( T_{\text{max}} \) at low latitude stations. 52
3C.2.3. \( T_{\text{max}} \) in space. 54
3C.3. The long-term changes in the direction of minimum of cosmic ray intensity. 55
3C.4. Long-term changes of \( T_{\text{max}}-T_{\text{min}} \). 58
3C.5. Long-term changes of the energy dependence of the anisotropy. 59
3C.5.1. The long-term changes in the ratio of peak to peak amplitudes obtained at a pair of stations. 59
3C.5.2. Detailed study of the variation spectrum. 62
3C.5.2.1. Determination of the variation spectrum using both the diurnal and the semidiurnal components. 62
3C.5.2.2. Determination of the variation spectrum using the diurnal component only. 63
3C.5.2.3. Unambiguous determination of the variation spectrum. 64
3C.6. Long-term changes of the strength of the anisotropy. 66
3C.6.1. Change in peak to peak amplitude measured by the network of detectors. 66
3C.6.2. The change in the strength of anisotropy beyond the influence of the geomagnetic field. 68

CHAPTER IV. SUMMARY AND CONCLUSIONS 1

4.1. Study of Cosmic Ray Anisotropy on Individual Days. 1
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>Study of the change of anisotropy from day to day.</td>
<td>1</td>
</tr>
<tr>
<td>4.3</td>
<td>Study of the change of anisotropy from year to year.</td>
<td>2</td>
</tr>
<tr>
<td>4.4</td>
<td>Conclusions.</td>
<td>3</td>
</tr>
</tbody>
</table>

References.                                                                 | 1 - xi