



<http://researchspace.auckland.ac.nz>

ResearchSpace@Auckland

Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognise the author's right to be identified as the author of this thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from their thesis.

To request permissions please use the Feedback form on our webpage.

<http://researchspace.auckland.ac.nz/feedback>

General copyright and disclaimer

In addition to the above conditions, authors give their consent for the digital copy of their work to be used subject to the conditions specified on the Library Thesis Consent Form.

356004

TIME VARIATIONS IN COSMIC RAY EXTENSIVE AIR SHOWERS.

A thesis submitted to the University of
New Zealand for the degree of Doctor of
Philosophy.

Candidate: John Richard Storey

1957.

PREFACE.

References to the literature are made in the text by giving the names of the author or authors with the year of publication in brackets. The full reference can be obtained from the alphabetical list at the end of the thesis. Names of authors, year of publication, journal, volume and page are given in that order.

In the figures showing electronic circuits, units for the circuit constants are normally omitted owing to shortage of space. The rules to be followed are: resistances in kilohms unless otherwise stated, capacities in picofarads if the number is greater than unity and microfarads if less than unity.

Symbols used are defined when first introduced in the text. However, to avoid repetition a list is compiled at the beginning of the thesis. Where a symbol has more than one definition it is hoped that the context will make it clear which is to be used.

The experiments to be described were made possible by financial help from the University Grants Committee. The author also wishes to thank the Weather Bureau for meteorological information supplied, Professor P.W. Burbidge for constant interest and encouragement and Mr. W.E. Armstrong for assistance with the 1955 experiment. Special thanks are due to Dr. F.J.M. Farley who originated the work and contributed to every phase of its history.

C O N T E N T S.

	<u>Page</u>
Preface	ii
Index to Figures	v
Index to Tables	vii
List of Symbols	viii
<u>CHAPTER 1.</u>	<u>INTRODUCTION</u>
	1
<u>CHAPTER 2.</u>	<u>DESCRIPTION OF APPARATUS</u>
2.1	The detection of Extensive Air Showers by Coincidences between Spaced Geiger Counters. 5
2.2	The Trays of Geiger Counters 6
2.3	Quenching Circuits for the Counters 8
2.4	The Geiger Voltage Supply 12
2.5	The Scaler 13
2.6	The Coincidence Units 16
2.7	The Mains Monitor 16
2.8	The Recorder 17
2.9	The Geometry of the First Experiment 18
2.10	The First Coincidence Circuit 20
2.11	Performance of the Apparatus During the First Experiment 22
2.12	The Geometry of the Second Experiment 25
2.13	The Second Coincidence Unit 27
2.14	The Resolving Time of the Coincidence Unit and the Spurious Coincidence Rates 30
2.15	Maintenance of Apparatus for the Second Experiment 33
<u>CHAPTER 3.</u>	<u>THE THEORY OF EXTENSIVE AIR SHOWER APPARATUS</u>
3.1	Preliminary Remarks on Shower Theory 37
3.2	Expected Counting Rates 40

C O N T E N T S (Continued)

	<u>Page.</u>
<u>CHAPTER 3.</u> (cont)	
3.3	Theoretical Decoherence Curve for a Triangle of Trays 47
3.4	The most Probable Value of Π to be Associated with each Coincidence Type 47
3.5	The Primary Energies 53
3.6	Theory of the Barometric and Temperature Coefficients 54
<u>CHAPTER 4.</u> THE RESULTS OF THE TWO EXPERIMENTS.	
4.1	Method of Analysis 65
4.2	Standard Errors of Fourier Coefficients 67
4.3	Atmospheric Corrections 70
4.4	Corrections for Variations in Solar Amplitude 78
4.5	The Observed Diurnal Variations 84
4.6	Conclusions 89
<u>CHAPTER 5.</u> REVIEW OF THE LITERATURE ON TIME VARIATIONS OF HIGH ENERGY COSMIC RAYS.	
5.1	Introduction 93
5.2	Sidereal Variations 94
5.3	Discussion of Sidereal Results 98
5.4	Variations in Solar Time 100
<u>CHAPTER 6.</u>	ORIGIN OF COSMIC RAY ANISOTROPIES 103
<u>REFERENCES</u>	
Appendix 1.	Tables of Detailed Results from the Second Experiment.
Appendix 2.	Harmonic Dials for Antisidereal Correction
Appendix 3.	Sample of Recorder Chart and Photographs of Apparatus

INDEX TO FIGURES.

<u>Figure.</u>		<u>Preceding Page.</u>
1	Block Diagram of an Extensive Shower Recorder	5
2	Circuit for Determining the Recovery Time of a Counter, and a Typical Oscillogram	7
3	Circuit of Counter Tray (First Experiment)	8
4	Circuit of Counter Tray (Second Experiment)	10
5	The Regulated E.H.T. Supply	12
6	The Binary Scaler	14
7	The Mains Monitor	16
8	Perspective View of the Array Used in the First Experiment	18
9	East-West and North-South Elevations of the Lead Collimator	19
10	Coincidence Circuit (First Experiment)	20
11	Propagation of a Negative Step Pulse along a Short Circuited Delay Line	21
12	Tray Geometry for Second Experiment	21
13	The New Coincidence Circuit	27
14	Grid Characteristics of a Triode Unit of a 12AT7	28
15	Resolving Time of the Coincidence Circuit	28
16	Expected Counting Rate for Three Trays in a Triangle.	44
17 and 18	$1/\alpha$, η and Theoretical Barometric Coefficient for Showers Initiated by a Primary Photon	63
19 and 20	$1/\alpha$, η and Theoretical Barometric Coefficient for Showers Initiated by a Cascade of π^0 - mesons.	64
21	Typical Harmonic Dial with all Vectors	81
22	Position of Vectors when Resultant Lies on Major Axis	81
23	Shower Rates and Radio Noise versus Local Sidereal Time (First Experiment)	85
24	123- rate and Surface Temperature versus Solar Time (First Experiment)	86
25	Harmonic Dial Presentation of Published Sidereal Coefficients	94

INDEX TO FIGURES (cont)

<u>Figure</u>		<u>Preceding Page.</u>
26	Frequency Distribution of R for 37 Sidereal Coefficients	97
27	Anistropy in Flux Due to Inhomogeneity in Density	97

INDEX TO TABLES.

<u>Table</u>		<u>Page.</u>
1	Barometric and Temperature Coefficients Calculated by Armstrong	71
2	Barometric and Temperature Coefficients Calculated for Individual Months	72
3	Averages of Monthly Barometric and Temperature Coefficients with Standard Errors	73
4	Sidereal Coefficients obtained from Experiment One	84
5	Vectors in the Harmonic Dial for 123-Coincidences	84
6	Overall Uncorrected Diurnal Coefficients, Experiment Two	87
7	Sidereal Coefficients after Various Corrections	88
8	Summary of Sidereal Variations Reported in the Literature	96
9	Second Harmonics in the Sidereal Diurnal Analyses	97
10	Summary of the Most Precise Sidereal Variations Selected from Table 8	99
11	Solar Variations for High Energy Showers	101
12	Times of Maximum Predicted by Davis	110
13	Directions in Space Significant in Theories of Primary Anisotropy	111

LIST OF SYMBOLS.

A	type A coincidence
A	sensitive area of tray
A	solar vector
B	type B coincidence
B	Modulation amplitude of solar vector
C	type C coincidence
C	true sidereal vector
C	coincidence rate
D	type D coincidence
D	apparent sidereal vector
E	energy
E_0	energy of a primary cosmic ray
g	mutual conductance of a valve
I	cosmic ray intensity
I_0	mean cosmic ray intensity
K	constant term in shower spectrum
r_p	plate resistance of valve
S.E.	standard error
V	variance
X_1	coefficient of sine term in first harmonic
Y_1	coefficient of cosine term in first harmonic
Z_1	amplitude of first harmonic
α	effective area of tray
α	right ascension
β	exponent in decoherence equation
γ	exponent in differential shower spectrum
δ	exponent in integral primary spectrum
δ	declination
η	defined by $\Pi \propto E_0^\eta$
θ	defined by: Tray rate $\propto A^\theta$
θ_1	phase angle of first harmonic
λ	scattering m.f.p. for primary particles
Π	number of particles in shower at given depth
ρ	particle density in number per square metre

LIST OF SYMBOLS (cont)

τ)	resolving time
123)	coincidence types
1234)	
12345)	