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Institiúid Ard-Léinn | Dublin Institute for
Bhaile Átha Cliath | Advanced Studies

Title	DIAS Annual Report 1959-1960
Creators	DIAS, Council
Date	1959
Citation	DIAS, Council (1959) DIAS Annual Report 1959-1960. Communications of the Dublin Institute for Advanced Studies.
URL	https://dair.dias.ie/id/eprint/70/

INSTITIÚID ÁRD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Annual Report of the work of the
Institute and its Constituent
Schools presented by the Council
to the Minister for Education in
respect of the Financial Year

1959-60

Annual Report of the work of the Institute and
its Constituent Schools presented by the Council
for the Financial Year 1959-60

In accordance with the provisions of Section 29 of the Institute for Advanced Studies Act, 1940 (No.13 of 1940), the Council of the Institute has the honour to present to the Minister for Education for submission to the Government a report of the work and activities of the Institute and its Constituent Schools for the financial year ending 31st March, 1960.

The general purpose which it is hoped to accomplish is clearly stated in the Act establishing the Institute, namely, the Institute for Advanced Studies Act, 1940 (No.13 of 1940) and in the Establishment Orders establishing the three Constituent Schools, namely, the Institute for Advanced Studies (School of Celtic Studies) Establishment Order, 1940, the Institute for Advanced Studies (School of Theoretical Physics) Establishment Order, 1940, and the Institute for Advanced Studies (School of Cosmic Physics) Establishment Order, 1947, and need not be referred to here. It is deemed desirable, however, to include in the report for the purposes of record certain particulars about the constitution of the Council of the Institute and of the membership of the Governing Boards of the three Constituent Schools on the 31st March 1960.

The report is presented under the following principal heads:

- I - Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31st March, 1960.
- II - Report of the Governing Board of the School of Celtic Studies
- III - Report of the Governing Board of the School of Theoretical Physics
- IV - Report of the Governing Board of the School of Cosmic Physics

Boards of the three Constituent Schools on the 31st March 1960.

1. THE COUNCIL OF THE INSTITUTE

Chairman:

Right Reverend Monsignor Patrick Browne, M.A., D.Sc., President,
University College, Galway.

Ex-Officio Members:

Dr. Michael Tierney, M.A., D.Litt., President, University College,
Dublin; Dr. Albert J. McConnell, M.A., M.Sc., Sc.D., Provost,
Trinity College, Dublin; Reverend Aubrey Gwynn, S.J., M.A.,
B.Litt. (Oxon.), President, Royal Irish Academy.

Members appointed by the Governing Boards of the Constituent Schools:

Right Reverend Monsignor Patrick Boylan, D.D., M.A., D.Litt.;
Professor Michael A. O'Brien, M.A., Ph.D.; Professor Felix E. W.
Hackett, M.A., M.Sc., Ph.D.; Professor John L. Synge, M.A., Sc.D.,
F.R.S.C., F.R.S.; Professor Ernest T. S. Walton, M.A., M.Sc.,
Ph.D., F.T.C.D.; Professor Cormac Ó Ceallaigh, M.Sc., Ph.D.

2. THE GOVERNING BOARD OF THE SCHOOL OF CELTIC STUDIES

Chairman:

Right Reverend Monsignor Patrick Boylan, D.D., M.A., D.Litt.

Senior Professors:

Michael A. O'Brien, M.A., Ph.D.; Daniel A. Binchy, M.A., Ph.D.,
B.L.; Myles Dillon, M.A., Ph.D.

Appointed Members:

Miss Áine de Paor, M.A., Ph.D.; Reverend John Ryan, S.J., M.A.,
D.Litt.; Reverend Francis Shaw, S.J., M.A.; Éamonn Mac Giolla
Iasachta, M.A., D.Litt.; Ernest Gordon Quin, M.A., F.T.C.D.;
Reverend Donnchadh Ó Floinn, M.A.

3. THE GOVERNING BOARD OF THE SCHOOL OF THEORETICAL PHYSICS

Chairman:

Felix E. W. Hackett, M.A., M.Sc., Ph.D.

Senior Professors:

John L. Synge, M.A., Sc.D., F.R.S.C., F.R.S.; Cornelius Lanczos,
Ph.D.

Appointed Members:

Albert J. McConnell, M.A., M.Sc., Sc.D.; George R. Keating, M.Sc.;
Thomas S. Wheeler, Ph.D., D.Sc., F.R.C.Sc.I.; Reverend James R.
McConnell, D.Sc.; Máirtín Ó Tnúthail, D.Sc.; Patrick Quinlan,
B.E., M.Sc., Ph.D.

Chairman:

Ernest T. S. Walton, M.A., M.Sc., Ph.D., F.T.C.D.

Senior Professors:

Leo W. Pollak, Ph.D.; Cormac Ó Ceallaigh, M.Sc., Ph.D.;
Mervyn A. Ellison, D.Sc.

Appointed Members:

John J. Dowling, M.A., F.Inst.Phys.; Eric M. Lindsey, M.A., M.
Ph.D.; Reverend Patrick J. I. McLaughlin, D.Sc.; Thomas Edwin
Nevin, D.Sc.; Patrick J. Nolan, Ph.D., D.Sc.; John H. J. Pool
M.A., B.A.I., Sc.D.; Mariano Doporto, D.Phys.Sc.; John J. Mc
M.A. (Cantab.), D.Sc., F.Inst.Phys.; Cilian Ó Brocháin, M.Sc.
Ph.D.

5. ADMINISTRATIVE STAFF

Registrar:

Patricia O'Neill.

Senior Clerk:

Maura Devoy, B.A.

Clerks:

Mary A. O'Rourke, B.A.; Janet Dowling.

adopted at its meeting on 8th June, 1960.

1. STAFF, SCHOLARS AND EXTERN RESEARCH WORKERS.

Senior Professors:

Myles Dillon, Director of the School; Michael A. O'Brien;
Daniel A. Binchy.

Professors:

James P. Carney; Miss Cecile O'Rahilly.

Assistant Professor:

Rev. Cuthbert McGrath, O.F.M.

Assistant (Part-time):

Mrs. Nessa Doran.

Research Associates:

Heinrich Wagner; Liam Price.

Technical and Clerical Staff:

Miss Maura Devoy (to 30 September 1959); Miss Máire Breatnach.

Scholars:

Louis Paul Nemo (Roparz Hemon); Máire Ní Cheallacháin (entered
1 October 1959).

Extern Research Workers commissioned by the School:

Mrs. Mary Ellen Carney; Rev. Anselm Faulkner, O.F.M.; Rev. Pádraig
Ó Súilleabháin, O.F.M.; Rev. Bartholomew Egan, O.F.M.; Dr. R. B.
Breatnach; Professor Nils Holmer; Dr. L. Bieler; Professor Séamus
Ó Néill; Mr. Derick Thomson; Signor Mario Esposito; Professor Idris
Foster.

Dr. R. I. Best, Mr. Seán Mac Airt and Professor J. Vendryes died
during the year.

2. RESEARCH.

Professor O'Brien proceeded with revision of the proofs of Volume
IV and copy for Volume V of the Book of Leinster. Volume VI is in
preparation. The final checking of proofs of the first part of his

He is writing a short introduction and making a list of Corrigenda. He continued work on the second and third parts. He also made a study of the Indo-European vocabulary common to Slavonic and Celtic; the results of which will appear in Celtica.

Professor Binchy continued the work of transcribing legal manuscripts. Six hundred folios of his transcript are now in the printer's hands. He also revised and returned to the printer proofs of his edition of Scéla Cano Meic Gartnáin. A revised translation, with notes, of two Old Irish penitential tracts was sent to press, as an appendix to Volume V of Scriptores Latini Hiberniae. He prepared Volume XIX of Ériu for the press and contributed articles on 'The Old Irish Table of Commutations' and on a question of palaeography. He also supervised the work of Miss Morfydd Owen, a visiting scholar who is preparing a thesis on Welsh Law. A study of the Indo-European particle que in Old Irish was written for Celtica.

Professor Dillon was occupied with revision of page-proofs of the Book of Rights and work on the appendixes. The typescript of the Nāṭakalakṣaṇaratnakośa was revised for press. A description of Bodleian MS Laud Misc. 610 was written for Celtica. The text of the Inauguration Rite of O'Connor was transcribed for publication from manuscripts in the Royal Irish Academy. Field-work for the Linguistic Survey was done in south Galway in collaboration with Dr. Tomás de Bhaldraithe. A course in Middle Irish was given during the Michaelmas and Hilary terms. With the help of Professor Donncha Ó Cróinín, he completed a Modern Irish grammar and reader for the Teach Yourself Series.

Professor Carney continued his work on an edition of the Old Irish poems in National Library MS Gaelic 50. He did further work in Patrician studies, and is also preparing an edition of poems by Eochaidh Ó hÉódhusa. He acted as editor of a series of Thomas Davis lectures on Early Irish Poetry.

piled the Glossary for her edition of the Stowe Táin. The page-proof of the text was revised. She continued her work upon a new edition of the Fenian tale, Cath Finntrágha.

Rev. Cuthbert McGrath, O.F.M. continued the preparation of the second volume of Dán na mBráthar Mionúr. He has undertaken work on an evaluation of the available material for the lives of the Irish Saints for an encyclopedia to be published by the Pontifical University of the Lateran and the Sacra Congregatio Concilii. He also completed an article on 'Some aspects of the history of the Uí Mhaoil Chonaire family'. Father McGrath has read for the press the work of his colleagues at Dún Mhuire.

Mrs. Nessa Doran corrected the first proofs of fasciculus I (MSS Nos.15-69) of the Descriptive Catalogue of Irish MSS in the National Library and these were returned to the printer. Of the vellum manuscripts (Nos.1-14), which will make up the second fasciculus, she catalogued Nos.2-7, 9-10 and 14.

Professor Heinrich Wagner has been editing the second volume of his Linguistic Atlas. In June 1959 he did some field-work in east Mayo and in March 1960 he made an expedition to the Outer Hebrides for the Linguistic Survey.

Mr. Liam Price worked on the revision of the papers on the place-names of the Baronies of Newcastle and Arklow which it is intended to publish. In October 1959 he commenced work on the compilation of an archive of Irish place-names.

M. Hemon's Historical Dictionary of Breton has made progress. The second volume (B, part 1) appeared during the year and a third will appear this summer. He has undertaken a project of re-editing the classics of Breton literature, and has begun work on a new edition of the Poèmes Bretons du Moyen Age from photostats supplied by the Bibliothèque Nationale.

of Classical Modern Irish. She has undertaken an edition of selected poems by Aodhagán Ó Raithile and done some work on them. She attended Professor Dillon's course in Middle Irish and also attended lectures in Old Irish at University College.

Mrs. Mary Ellen Carney has translated the seven sections of the text of the Aphorisms of Hippocrates into English, prepared the Notes to Text and continued work on the Introduction.

Rev. Anselm Faulkner, O.F.M. continued work on An Bheatha Dhiadha, An Sgáthán Spioradálta and An Bheatha Chrábhaigh.

Rev. Pádraig Ó Súilleabháin, O.F.M. corrected and returned to Printer final proofs of Lucerna Fidelium and prepared Notes and Glossary which were sent to press. He continued his work on an edition of Buaidh na Naomhchroiche.

Rev. Bartholomew Egan, O.F.M. corrected and returned the page-proofs of the text of Graiméir Gaeilge na mBráthair Mionúr.

Dr. R. B. Breatnach completed the Introduction to the second volume of Seana-Chaint na nDéise and revised the first proofs of the text. He continued his field-work and made a number of tape-recordings for the School.

Professor Nils Holmer revised copy for his Gaelic of Kintyre which was sent to press at the end of the period under review.

Dr. L. Bieler completed and sent to press The Irish Penitenti which he is editing in collaboration with Professor Binchy for the Scriptores Latini Hiberniae. He also revised the text and translation of the first volume of Johannis Scoti Opera, edited by Mr. Sheldon Williams, which is to appear in the same series.

Professor Séamus Ó Néill continued work on his edition of Bishop Gallagher's sermons.

proofs of Branwen Uerch Lyr for the Mediaeval and Modern Welsh Series.

Signor Mario Esposito corrected the final proofs of his edition of Itinerarium Symonis Semeonis ab Hybernia ad Terram Sanctam for the Hiberno-Latin Texts series.

Professor Idris Foster continued work on the preparation for press of an edition of Kulhwch ac Olwen for the Mediaeval and Modern Welsh Series. He also read proofs of Mr. Thomson's edition of Branwen and made useful corrections and suggestions.

The First International Congress of Celtic Studies was held in Dublin from the 6th to the 10th July 1959, under the joint auspices of Trinity College, the Royal Irish Academy, University College and the Institute. The burden of organisation fell mainly on the administrative staff of the Institute and the success of the Congress was largely due to their zeal and competence. Scholars from many European countries and from the United States of America came to Dublin. The total enrolment was 250. The following Papers were read by members of the School: M.A. O'Brien, 'Some Irish Etymologies'; D.A. Binchy, 'The End of the Old Order' and 'Indo-European *g₁ke in Old Irish and Old Latin'; M. Dillon, 'The History of the Preverb td'; J. Carney, 'St. Patrick's Journey per desertum'.

Two long-term projects have been further advanced during the year. Dr. Ó Cuív was appointed joint editor with Professor O'Rahilly of the Dictionary of Classical Modern Irish, and, with the accession of Máire Ní Cheallacháin as assistant, some progress was made. It is hoped that even with this small staff the Dictionary will make steady progress. Mr. Liam Price accepted the position of Research Associate and has been devoting much of his spare time to place-name research. It was found possible to provide him with secretarial help, and he has already built up a considerable collection of material, some fifteen thousand cards having been made. The counties of Kilkenny, Carlow and

doing for Co. Wicklow which is now nearing completion.

The widening scope of the work of the School was marked by the publication in January of the first fasciculus of the Lexique étymologique de l'irlandais ancien, and the acceptance for publication of a Grammar of Middle Welsh by Professor Simon Evans. The second fasciculus of the Lexique was in proof before the lamented death of Monsieur Vendryes, and the whole work is in an advanced state of preparation. Another welcome feature is the announcement of several volumes in preparation by distinguished Welsh scholars for the Mediaeval and Modern Welsh Series.

3. STATUTORY PUBLIC LECTURE.

The Statutory Public Lecture was given by Professor J. E. Caerwyn Williams in Trinity College, Dublin, on Friday, 26th February 1960. His subject was Early Welsh Personal Names.

4. LECTURES.

A lecture entitled Zur Darstellung der irischen Grammatik was given by Professor E. Lewy at the School on Monday, 25th May 1959. A lecture entitled 'Recent Research in Scottish Place-Names' was given by Dr. W. Nicolaisen at the School on the 8th March, 1960.

5. EXTERNAL ACTIVITIES.

Professor Binchy read a paper on 'Linguistic and Legal Archaisms in the Celtic Law-Books' at the annual meeting of the Philological Society in London on May 21st, 1959. Professor Dillon gave two lectures in the Thomas Davis Series on Radio Éireann: 'Early Irish Lyric Poetry' and 'The Religion and Social Organisation of the Celts'. He visited the School of Scottish

Linguistic Survey of Scotland for a few days in Argyllshire. Professor Carney edited a sequence of lectures in the Thomas Davis Series and himself gave a lecture on 'The Poems of Blathmac Son of Cú Brettan'.

6. PUBLICATIONS.

a. Books:

Gaeilge Theilinn. By Heinrich Wagner. Published May, 1959.
pp.xv + 356. Price 21/-

Lexique etymologique de l'irlandais ancien - A. By J. Vendryes.
Published jointly with the Centre National de la Recherche
Scientifique, Paris, December 1959. pp.xxiv + 106. Price 17/6d

Irish Sagas. Edited by Myles Dillon. Radio Éireann Thomas Davis
Lectures. Stationery Office, 1959. pp.181. Price 2/6d.

A Genealogical History of the O'Reillys. Edited by James Carney.
An Cumann Sheanchais Bhréifne, 1959. pp.161. Price 12/6d.

Contribution à un Dictionnaire Historique du Breton, Vol.II: B.
By Roparz Hemon. Al Liamm, 1959, Brest.

b. Contributions to Periodicals:

D. A. Binchy: Linguistic and Legal Archaisms in the Celtic
Law-Books. Trans. Phil. Soc., London, 1959.

Cuthbert McGrath, O.F.M.: Notes on Í Dhuinn Family.
Collectanea Hibernica, ii, 13-17, 1959.

1. STAFF AND SCHOLARS

Senior Professors:

John L. Synge, Director of the School; Cornelius Lanczos.

Assistant Professor:

Yasushi Takahashi.

Visiting Professors:

E. McLeod; R. J. Duffin.

Technical Assistant:

Miss Evelyn Wills.

Scholars:

L. Bass; C. B. Mast (left August 1959); J. Strathdee (left June 1959); A. Das; D. Judge; G. Papini; Miss D. Roy; W. Kantor (left April 1959); C. Ryan (entered October 1959); Rev. J. Spelman (entered October 1959); H. Shimodaira (entered October 1959); M. O'Connell (entered November 1959).

Student:

L. Ó Raifeartaigh, working with Professor W. Heitler at the University of Zürich (studentship ended September 1959).

2. STUDY AND RESEARCH

Professor Synge continued the work in general relativity described in the last Annual Report. Some of the results were presented in lectures at Milan, Brussels, and Royumont (Paris), and the whole body of material is now in proof in a book on the general theory of relativity. The mathematical method of the world-function has been applied to a number of physical problems; these include the examination of the relations between the directions of emission and return of a signal sent from the earth to an adjacent body, such as an artificial satellite, the problem of free fall, and the spectral shift of gamma-rays recently observed

has led to the evaluation of the three curvatures of the metric tensor of a terrestrial observer. He also studied the problem of creating model universes. Any metric tensor (subject to certain algebraic restrictions) can be interpreted as that of a universe with a certain distribution of density and stress, but a random choice of the metric tensor is likely to yield an unnatural universe having negative densities. To avoid this, a "feed-back" method has been considered, in which one feeds back into the exact field equations the metric tensor given by some initial approximation based on a natural distribution of density.

Dr. Mast continued work on transport laws for vectors and tensors, and extended the idea to cover transport of vectors over subspaces. He tried to connect the quantities defined by such transport with the Gauss-Codazzi equations. In addition to this work, so far incomplete, he had many discussions with Professor Synge on the material of the latter's book on general relativity and read part of the manuscript critically.

Mr. Das derived the equations of spinning charged test-particles in general relativity, following the Fock-Papapetrou approach. This work has now been published. He also formulated a discrete space-time model for quantum field theory, and obtained an S-matrix which is not vitiated by the presence of "serious" divergences. This work is now complete, and will be sent for publication shortly.

Miss Roy continued her work on vortex-wakes. She also obtained a new class of exact solutions of the equations of motion of an incompressible viscous fluid, and investigated the behaviour of the boundary layer in a stream varying periodically with time.

Dr. Newman did research in general relativity, particularly in connection with the algebraic and differential properties of the Riemann tensor in empty space-time. He sought the most general line-elements corresponding to Riemann tensors of Type II Null and Type III.

expansions of uniformly small errors everywhere in the right complex plane, for the well-known Stirling formula for approximation of the gamma function. Convergent expansions for the gamma function have not been given before. An expansion of five terms reduces already the relative error to $5 \cdot 10^{-6}$ at any point of the right complex plane. He developed a universal approach to the theory of linear boundary value problems, irrespective of the nature of the boundary values prescribed, and irrespective of the "type" of the given differential equation. The traditional types of boundary value problems are those which allow a solution in terms of the Green's function. The general approach dispenses with the existence of the Green's function, and obtains the solution even in cases where the Green's function does not exist. The method throws new light on the stability problem of partial differential equations. He also employed the method of trigonometric interpolation to obtain a satisfactory solution for the perturbation problem in the integration of ordinary differential equations, an improvement on the usual method of operating with local expansions, which does not take account of the accumulation of global errors.

Professor Takahashi continued his study of divergence difficulties in quantum field theory, using non-local interactions. He showed, with Dr. E. Arnow and Professor W. Heitler, that there exists a form factor which secures the convergence of the S-matrix. The strict Lorentz invariance is destroyed however, in the sense that the theory is invariant only in the outer region of the elementary particle. In this connection, a general theory of the invariant S-matrix was developed, in co-operation with Dr. S. Kanefuchi. The possibility of a non-invariant S-matrix was also considered, and it was shown that a linear relation between the "invariance deficiencies" leads to the selection rule for the S-matrix element.

Following another line of research, he investigated, with

proposed by Jauch and Rohrlich, which is extensively applied to the theory of dispersion in the Mandelstam representation.

Dr. S. Kamefuchi pursued research in collaboration with Professor Takahashi, on the invariance of the S-matrix. The transformation property of the state vector in the interaction picture was examined in detail, to obtain the necessary and sufficient condition for the S-matrix to be invariant.

Mr. Strathdee continued to work with Professor Takahashi on problems connected with quantum electrodynamics, with particular attention to the subsidiary condition in the interaction picture.

Mr. Judge, working with Professor Takahashi and Dr. Shimodaira, studied the Substitution Law of Jauch and Rohrlich. It was found that a sufficient condition that this law should hold is that the interaction Hamiltonian be a local operator in the sense of Bogoliubov and Shirkov. Mr. Judge is investigating some possible further applications of this theorem.

Dr. Papini calculated the proton-neutron mass difference, by using a form factor obtained by the experiment on proton-electron scattering performed at Stanford. He showed that the mass-difference can be explained as a purely electromagnetic phenomenon.

Mr. Ryan studied weak interactions of elementary particles, especially the β -decay process. The symmetry of the interaction was examined in detail.

Rev. Spelman made a general study of quantum field theory, with special reference to quantum electrodynamics and scattering theory. He also investigated the nuclear form-factors on the basis of electron-nucleon scattering, and is at present pursuing investigations along this line.

Dr. Shimodaira worked with Professor Takahashi and Mr. Judge

He also investigated a possibility of introducing a field with negative norm in order to overcome the divergence difficulties, and proved that such a modification of the theory necessarily leads to the violation of causality. He is at present examining the Rarita-Schwinger field with spin $3/2$, by means of the Stückelberg formalism.

Mr. O'Connell was engaged in studies of the foundations of quantum theory, with particular reference to elementary particle interactions, including the nature of pion-pion scattering in τ -meson decay.

Dr. Iwazare investigated the nucleon-nucleon potential based on the π -meson field theory. He applied the potential to the photo-disintegration of a deuteron.

Dr. Bass studied the theory of measurement in the quantum theory and the formal logical structure of the basic paradoxes, in particular of the thought-experiments of Einstein, Podolsky and Rosen. He delivered a set of special lectures on the subject during Hilary Term in Trinity College, Dublin. He also studied (with Prof. Grainger of Trinity College, Dublin) a mathematical model of a living cell whose respiration is catalysed by an enzyme. The model leads to a set of non-linear ordinary differential equations of the first order. The two main problems they investigated were (a) the reactions of the model to changes in temperature, and (b) the preservation of a steady state of chemical concentrations during the growth of the cell, the chemicals being supplied by diffusion through the surface of the cell.

Dr. Ó Raifeartaigh worked on the S-matrix in the non-local theory of Arnous and Heitler, and collaborated with Professor Heitler and Dr. Arnous in developing this theory. He also studied Jauch and Rohrlich's "Theory of photons and electrons", and Jordan's "Quantenmechanik".

study has application to thermal noise in lumped and distributed networks. Another line of investigation concerned the application of the maximum principle of elliptic partial differential equations to hydrodynamic flows. This study yields qualitative properties of the non-linear equations of general viscous flow. A by-product of the study has been the derivation of explicit solutions of several cases of rotatory flow. This work on hydrodynamics is being written up for publication. Other research started included application of the minimal length principle to networks, and further results on random walks in networks. Professor Duffin took an active part in informal discussions dealing with the following topics: the principle of equivalence, anti-Hamiltonian mechanics, the concept of waves and wave-velocity for the Klein-Gordon equation, the definition of normal modes of motion for non-linear systems, distortion of radio signals in general relativity, Lorentz transformations defined by skewsymmetric matrices, the use of Lienard-Wiechert potentials to obtain the average potential of a charge having a periodic motion, Jacobi's principle as a minimal principle in mechanics, vector fields, and discrete space-time.

3. SEMINARS AND LECTURES

As in previous years the seminar lectures throughout the year were attended by members of staff and students from Trinity College, Dublin, University College, Dublin, and St. Patrick's College, Maynooth, as well as by members of the School of Cosmic Physics.

The following seminar lectures were given (see also Section 6):

Mr. A. Das:

On the exact solutions of combined Maxwell-Einstein field equations.

Spinning charged test-particles in general relativity.

Professor R. J. Duffin:

Network models of continuous systems.

Scrutination and extrapolation.

The Rayleigh-Ritz method for dissipative or gyroscopic systems.

Quaternions (3 lectures).

Difference equations.

Professor C. Lanczos:
The vibrations of plates.

Mr. C. Ryan (St. Patrick's College, Maynooth):
CPT invariants.

Mr. J. Strathdee:
A gauge invariant description of the free photon.

Professor J. L. Synge:
Geometrical optics in general relativity.

Professor Y. Takahashi:
Aspects of quantum field theory (4 lectures).
Theory of scattering (6 lectures).

4. STATUTORY PUBLIC LECTURE

A Statutory Public Lecture, under the auspices of the School, was delivered in University College, Dublin, on 29th March, 1960, by Dr. F. A. E. Pirani. His subject was "Old and new ideas about gravitation".

5. VISITING PROFESSORS

During the period under review, there were two visiting professors at the School, as follows:

Professor E. McLeod (Oregon State College), left September

Professor R. J. Duffin (Carnegie Institute of Technology, Pittsburgh) from September 1959 to March 1960.

6. VISITING LECTURERS

Professor L. E. Payne (University of Maryland) lectured in the Seminar on "Inequalities for eigenvalues of membranes and plates" (6 May, 1959).

Professor A. G. Walker, F.R.S., (University of Liverpool) lectured in the Seminar on "Axioms of Cosmology" (13 May 1959).

Dr. J. Iwadare (University of Kyoto) visited the School from 28 November to 31 December, 1959, and lectured in the Seminar on "Present Status of the Nuclear Force Problems" (2, 9, and 16

2 November to 26 November, 1959, and lectured in the Seminar on "Some Properties of the Riemann-tensor in empty space-time" (18 November 1959)

Dr. F. A. E. Pirani (King's College, London) visited the School from 29 to 31 March. He gave the Statutory Public Lecture (see Section 4), and lectured in the Seminar on "Survey of exact solutions of Einstein's field equations" (30 March 1960).

Dr. S. Kamefuchi (Imperial College, London) visited the School from 25 February to 1 March 1960, for research in collaboration with Professor Takahashi.

7. SYMPOSIA

Mathematical Symposia were held on 2-3 April and 21-22 December 1959. The attendances were respectively 58 and 47; this included Professors, Lecturers and Graduate Students from the several Irish Universities, and travelling expenses were paid to totals of £60.3.4 (April) and £58.6.8 (December).

In addition to short communications (previews) the following lectures were delivered:

April:

Professor P. B. Kennedy: Some unsolved problems in classical analysis.

Rev. Prof. J. R. McConnell: Theory of anti-nucleons.

Mr. D. Judge: Parity and its conservation.

Dr. D. Keefe: Some aspects of positive and negative heavy mesons.

Professor C. Lanczos: Linear operators and function spaces.

Rev. Dr. R. E. Ingram: Seismic investigation of faults.

December:

Dr. I. T. Adamson: Homology of groups.

Professor P. B. Kennedy: Subharmonic functions: a survey of applications to complex-function theory.

Professor J. L. Synge: Tensorial conservation laws in general relativity.

Dr. S. Tobin: The Burnside group problem.

Mr. E. C. Dillon: Some problems of concentrated loads in thin

Professor Synge gave three lectures (28, 29 and 30 April, 1959) at the Seminario Matematico e Fisico di Milano; his subject was "Optical Observations in General Relativity and the Generalized Michelson-Morley Experiment". He attended a Colloquium on the Theory of Relativity at the Universitaire Libre de Bruxelles (19-20 June 1959), and read a paper entitled "Some Properties of a World-function". He attended an International Colloquium on Relativistic Theories of Gravitation, at Royumont, France, 21 June to 27 June 1959, and read a paper on "Tensorial Integral Conservation Laws in General Relativity".

Professor Lanczos, Mr. Das, and Mr. Judge attended the St. Andrews Mathematical Colloquium, held from 8 July to 17 July, 1959 at which Professor Lanczos gave five lectures on "Linear Operators and Function Spaces". During the Summer term Professor Lanczos lectured in the Universities of Manchester, Leeds and London, and at King's College, Newcastle-on-Tyne, The National Physical Laboratory, Teddington, and Queen's University, Belfast. From October to March he was on leave of absence from the School, at the University of Wisconsin Computation Center, Madison, Wis. He gave a number of lectures on various topics in advanced applied and numerical analysis: matrices and function spaces, boundary value problems, linear differential operators, curve fitting, and error analysis of large linear systems, at the following places: University of Dayton, (Wright-Patterson Air Base, U.S.A.F., Dayton, Ohio; University of Notre Dame; University of Missouri; Argonne National Laboratory Lemont, Ill.; Sinclair Oil Research Laboratories, Chicago; Midway Computers Corp., Chicago; Oak Ridge National Laboratories; University of Tennessee; University of Wisconsin; University of Michigan; Willow Run Airport Laboratories, Ann Arbor. He lectured on Unified Field Theories at the University of Wisconsin, and gave the Taft Memorial Lectures at the University of Cincinnati, on "Adventures in Space", and "Space and Matter: the World of Relativity". At the

27 to 29 January 1960, Professor Lanczos was awarded the Chauvenet Prize for his paper, "Linear systems in self-adjoint form" (Amer. Math. Monthly 65, 665, 1958).

Professor Takahashi visited the University of Zürich from 24 April to 26 May 1959, and again from 16 September to 20 October 1959, to work with Professor Heitler. While there he lectured on the difficulties of quantum field theory and the structure of elementary particles.

Dr. Shimodaira attended the Conference on High Energy, on 30-31 March 1960, at Liverpool University.

9. PUBLICATIONS

Items marked with an asterisk were recorded as in press in previous reports.

a. Books:

(i) Published:

Principles of mechanics. By J. L. Synge and B. A. Griffith. 3rd edn. McGraw-Hill, New York, 1959.

(ii) In the press:

* Variational principles of mechanics. By C. Lanczos. Article for the Handbook of Engineering Mechanics. McGraw-Hill, New York.

* Linear differential operators. By C. Lanczos. Van Nostrand, London.

* Classical dynamics. By J. L. Synge. Article for Vol.3 of Encyclopedia of Physics. Springer, Berlin.

Relativity: the general theory. By J. L. Synge. North-Holland Publishing Co., Amsterdam.

Mechanics. Analytical dynamics. By J. L. Synge. Two articles for Collier's Encyclopedia, New York.

Cosmic wayfarer. Vol.1. The World of Albert Einstein. Vol.2: The World of Relativity. By C. Lanczos. Prentice-Hall, Englewood Cliffs, New Jersey.

b. Communications of the Dublin Institute for Advanced Studies - Series A, Physics:

None published.

(i) Published:

* J. L. Synge:

A theory of elasticity in general relativity.
Math. Zeitschr. 72, 82, 1959.

The geometry of space-time. Centro Internazionale
Matematico Estivo - Istituto Matematico dell'
Università, Rome, 1958.

The ivory tower of relativity. Review of J. Ahar
The special theory of relativity (Oxford, Clarendon
Press, 1959), New Scientist, 2, 46, 1960.

* C. B. Mast and J. Strathdee:

On the relativistic interpretation of astronomical
observations. Proc. Roy. Soc. A 252, 476, 1959.

* H. S. Green:

Ionic theory of plasmas and magnetohydrodynamics.
Phys. of Fluids 2, 341, 1959.

L. Ó Raifeartaigh, B. Sredniawa and Ch. Terreaux:

The proton-neutron mass-difference according to
meson theory. Nuovo Cim., 14, 376, 1959.

Durga Roy:

Resistance on a circular cylinder due to any number
of vortices lying in two rows. ZAMP 10, 502, 1959.

(ii) In the press, 31 March 1960:

* J. L. Synge:

On some special coordinate systems in general
space-time. Bull. Calcutta Math. Soc.

Optical observations in general relativity.
Rend. dell' Seminario Mat. e Fis. di Milano.

Relativity based on chronometry. Monographs
on Gravitation, Volume dedicated to Professor
Infeld, Inst. of Theoretical Physics, Warsaw.

Some properties of a world-function. Colloquium
on General Relativity, Univ. Libre de Bruxelles,
1959.

Tensorial integral conservation laws in general
relativity. International Colloquium on Relativistic
Theories of Gravitation, Royaumont, France
1959.

C. Lanczos:

Some properties of the Riemann-Christoffel curvature
tensor. Monographs on Gravitation, Volume dedicated
to Professor Infeld, Inst. of Theoretical Physics,
Warsaw.

Integration of ordinary differential equations. Three papers as Publications of the Mathematics Research Center, U.S. Army, Madison, Wis.

- D. Judge, H. Shimodaira and Y. Takahashi:
On the substitution law in quantum field theory.
Proc. Roy. Irish Acad., A.
- E. Arnous, W. Heitler and Y. Takahashi:
On a convergent non-local field theory. I.
Nuovo Cim.
- S. Kamefuchi and Y. Takahashi:
Invariance of the S-matrix. Nuclear Phys.
- H. Shimodaira:
Some remarks on fields with negative propagators in quantum field theory. Nuclear Phys.
- L. Ó Raifeartaigh:
The S-matrix in the non-local theory of Arnous and Heitler. Helvetica Phys. Acta.
- W. Heitler, E. Arnous and L. Ó Raifeartaigh:
On a convergent non-local field theory. II. Nuovo Cim.
- R. J. Duffin and D. H. Shaffer:
Asymptotic expansions of double Fourier transforms.
Duke Math. J.
- R. J. Duffin and Z. Nehari:
A note on biharmonic functions.
- A. J. Das:
Spinning charged test-particles in general relativity.
Progr. Theor. Phys.

A. Astronomical Section.

1. STAFF AND SCHOLARS

Senior Professor:

M. A. Ellison.

Chief Assistant:

M. J. Smyth (to 30 June 1959);
J. H. Reid (appointed 16 November 1959).

Assistant:

J. H. Reid (to 15 November 1959).

Research Assistant (Royal Society I.G.Y. Bursary):

Miss S. M. P. McKenna.

Technical and Clerical Staff:

Mrs. M. Connolly; Mr. P. Murphy.

Scholar:

Ian Elliott (entered 16 November 1959).

2. SOLAR RESEARCH

Solar Patrol:- Observations with the spectrohelioscope were carried out on 64 days at fixed hours (16^h00^m - 18^h00^m in summer 12^h00^m - 14^h00^m in winter) as a contribution to the flare patrol organized for I.G.C. 1959. Drawings of the solar disk in white light were made on 84 days.

The recorder which gives the integrated level of radio atmospherics on a frequency of 27 Kc/s has been in continuous operation and 87 sudden enhancements of atmospherics (S.E.A's.) were recorded. Early in the year the frequency was changed to 24 Kc/s and a second receiver, similar in circuit design to

two instruments provide a valuable check on the previous records for sudden ionospheric disturbances. The records of S.E.A's. and flares have been despatched monthly to the three World Data Centres.

A direct recording H-magnetograph, constructed by Askania-Werke A.G., was delivered in November. In this instrument the magnet deflection is converted by a split photocell into current which is registered on a recording micro-ammeter. It has the advantage over photographic recording that it supplies immediate visual evidence of the occurrence of solar flare effects (crochets) and of the onset of magnetic storms. The magnetograph will be calibrated in γ by reference to the Valencia magnetograms.

Lyot H α Heliograph at the Cape:- During the second year of its operation this instrument has supplied films of chromospheric phenomena on 258 days (76 per cent of possible) with a total of 1403 observing hours (calendar year 1959). Exposures were normally made at 1-minute intervals during the 7 hour (07^h00^m - 14^h00^m) daily schedule. The 35mm films were developed at the Cape and despatched weekly to Dunsink.

Here the films have been projected on Stonyhurst disks 11.5 inches in diameter, such that 1^o (heliographic) at the centre of the disk is equivalent to 0.1 inch. Flares and active prominence regions have been examined and classified and the records have been sent in monthly to the Data Centres. In all, 849 flares were counted, being classified as follows: 6 of Class 3, 61 of Class 2, 307 of Class 1 and 475 of Class 1⁻. There were 52 cases of active prominence regions, 71 examples of surges both limb and disk and 11 examples of disparitions brusques. Phenomena of special interest have been noted for further study.

For the photometry of the films suitable modifications were made to the Eichner iris diaphragm astrophotometer of the Observatory. Photographic densities are converted into light intensities by

each frame.

Light-curves of 30 flares have been plotted during the year. The criterion of selection was the completeness of the available records of the associated sudden ionospheric disturbances observed in the British Isles. Comparisons of the development curves of the flares and S.I.Ds. have been prepared for publication.

Solar spectrograph:- Dr. M. J. Szyth has investigated the possibility of detecting the red (λ 6374) coronal line as an absorption line in the disk spectrum. A few spectra were taken in the 1st and 2nd orders of the concave grating, of active regions of the disk, but these showed no trace of the line. Photoelectric scans also gave negative results.

Plans have been made to modify the spectrograph to enable it to photograph the spectra of fine solar details, such as prominences and flares. For this purpose a 6-inch plane diffraction grating has been delivered by the Bausch and Lomb Optical Co. and two 6 $\frac{1}{2}$ -inch spherical mirrors by Cox, Hargreaves and Thomson Ltd. The reconstruction is now under way.

I.G.Y. Annals:- Much time has been devoted to planning and arranging for the analysis and publication of selections of the I.G.Y. solar activity data. Solar Activity results will comprise six volumes of the Annals of the I.G.Y. now being published by Pergamon Press. The preparatory work for the Daily Solar Maps, to be printed in four colours, is well under way at the six co-operating Data Centres. Maps D₁ are in charge of Centre A at Boulder and D₂ in charge of Fraunhofer Institute, Freiburg. The first specimen maps were printed in November.

3. STELLAR RESEARCH

28-inch reflector:- An experimental integrating feedback amplifier, based on the low leakage of polystyrene film condensers

with promising results. By integration over a period of the order of one minute, the effect of stellar scintillation is largely removed, without the complication of a photon-counting photometer.

Astrophotometer:- Some preliminary measures were made of open cluster plates, taken by Dr. V. C. Reddish and Mr. J. H. Reid with the 16/24-inch Schmidt telescope at Edinburgh, in continuation of their work on the magnitude luminosity functions of clusters.

4. CONFERENCES

Professor Ellison attended in August at Stockholm Observatory, Saltsjöbaden, the meeting of the Administrative Council of the Boyden Observatory. He was later present at the Fifth Conference of the International Commission for Optics in Stockholm. In his capacity as I.G.Y. Reporter for Solar Activity, Professor Ellison attended in May the last meeting of the Special Committee for the International Geophysical Year in Paris, and in November the first meeting of the International Committee for Geophysics held at the Hague.

5. VISITORS

The Observatory has been open to the public as usual on the first Saturday of each month from September to April. The 12-inch South refractor was available to members of the Dublin Centre of the Irish Astronomical Society. Visiting scientists included Charles F. Hagar, Dr. E. M. Lindsey, Dr. Helen Dodson Prince, Professor Harlow Shepley and Teodoro Vives, S.J.

6. LIBRARY

Considerable progress has been made with arrears of binding. Some 641 volumes have been bound of those periodicals which are most frequently consulted.

A bronze bust of the late Sir Edmund Whittaker (Director of Dunsink

been mounted on a mahogany plinth with name plate.

7. PUBLICATIONS

Contributions to Periodicals:

- M. A. Ellison:
A Unique Photograph of the Sun. *Discovery*, 20, 282, 1959
The Sun. *Discovery*, 21, 6, 1960.
- J. H. Reid:
Distribution of Sightline Velocities in Solar Disk and Limb Phenomena. *Journal British Astronomical Association*, 70, 1960.
- V. C. Reddish and J. H. Reid:
Red Magnitude Luminosity Functions of old Population I Clusters. *Lige Colloquium on Stellar Structure and Evolution (1959)*

In the press, 31 March 1960:

Dunsink Observatory Publications, Vol. I:

- M. A. Ellison, Susan M. P. McKenna and J. H. Reid: Cape Lyot Heliograph Results. I. Light-curves of 30 Solar Flares relation to Sudden Ionospheric Disturbances.
- M. A. Ellison (Editor):
Daily Maps of the Sun for each day of the International Geophysical Year (Volumes D₁ and D₂). *Annals of the I.G.Y.* Pergamon Press.

8. PERSONAL

Dr. M. J. Smyth, Chief Assistant (1954-59), resigned his post and left on June 30 to become Lecturer in Astronomy in the University of Edinburgh. Mr. J. H. Reid, Assistant, was promoted to Chief Assistant as from November 16. Miss S. M. P. McKenna, Research Scholar, was awarded the degree of M.Sc. by University College, Dublin. She was appointed to hold a Royal Society I.C.S. Bursary on August 1 and continued to work at the Observatory on the analysis of the Cape Lyot heliograph results. Mr. Ian Ellis, a graduate of Trinity College, Dublin, was appointed Research Scholar as from November 16. The post of Assistant remained unfilled.

1. STAFF AND SCHOLARS

Senior Professor:

C. Ó Ceallaigh.

Professor:

C. B. A. McCusker (to 31 August 1959).

Assistant Professors:

R. H. W. Johnston; K. Imaeda (appointed 16 November 1959).

Technical and Clerical Staff:

Miss C. Inight, Mr. J. Daly, Miss N. Leahy, Miss D. Kelly,
Miss C. Duff, Miss P. Hayden, Miss E. Smith.

Scholars:

D. E. Page; M. J. O'Connell (to 31 October 1959); M. A. Shaukat
(left 31 August 1959); K. Imaeda (to 15 November 1959); Miss M.
Kazuno (entered 1 February 1960).

2. RESEARCH WORK

The work using the photographic plate and counter techniques was continued throughout the year 1959-60.

The results of the investigations by the European Collaboration on the interaction of negative K-mesons, referred to in last year's report, have since been published and the three papers embodying the results are listed in Section 8. The work on the relative frequencies and the form of the decay-spectra of the three-body modes of K-decay has concluded. It has not been found profitable to continue with the exposures available at present. The results are being analyzed in preparation for publication.

The work of K. Imaeda and M. A. Shaukat on the study of the direct decay of π^0 mesons secondary to K-decay has been published in Nuovo Cimento, and analysis of the material has been continued by K. Imaeda.

in high-energy interactions by detection of the electron-pairs produced by materialisation of the γ -rays emitted in the decay of K^+ and the work shows promise.

The perennial question of the existence of a heavy meson of mass ~ 1400 me, evidence for which was first put forward by members of the Bristol Group, has claimed attention during the past year. It was pointed out by members of the Rochester Group that it was possible that a particle occurs in nature having the following decay

$$D^+ \rightarrow K^0 + \pi^+ + Q \quad (1)$$

In addition, an example of an apparent K^+ -decay scheme in which the secondary π^+ meson had energy 60 Mev, has been reported by Grear, Prowse and Baldo-Ceolin. They have described a similar event in which π^+ , secondary to what appeared to be K^+ -decay at rest, had kinetic energy 62 Mev. Setting $Q = 60$ Mev in the above equation, the mass of the hypothetical D^+ becomes 1389 me, a value in good agreement with that of the Bristol 1400 me particle. Because of this, it was suggested to us by D. Evans of Bristol University that it might prove profitable to re-examine our K^+ material with a view to picking out events which would correspond to the description

$$D^+ \rightarrow K^+ + \pi^0 \quad (2)$$

The expected range of the K^+ would be 3 mm and the primary particles of some 3000 K^+ -events were examined for evidence of secondary

A careful search was made in the region where particles of mass ~ 1400 me would be expected to come to rest, for events having characteristics which would satisfy the dynamics of equations (1) or (2), but none was found. The experiment enables us to place an upper limit to the ratio of production of D^+/K^+ at 6.3 Gev of ~ 1 C.E.R.N.

The new 25 Gev proton synchrotron went into operation on the 23rd January 1960, and proved capable of producing a circulating beam of 28 Gev. During the financial year Professor Ó Ceallaigh

at the CERN Machine. Already three stacks exposed to an elastically momentum-analysed beam have arrived in Dublin, one of which, a 5 Gev positive beam, has been used by R. H. W. Johnston to study the possibility of distinguishing between pions and protons by blob-counting methods. In view of the difference in ionization, ~ 6 per cent, it was considered to be uneconomic of time to attempt separation using these methods, but it appears possible to do so using automatic methods of estimating mean gap length. These are at present being developed.

Automatic Differencing Engine.

A machine for automatic differencing having a keyboard input has been built by R. H. W. Johnston and for the past five months has been in satisfactory operation. By means of this, the operation of finding the mean absolute difference from readings of multiple-scattering of ionizing tracks can be carried out in 10 minutes in comparison with 25 minutes required to difference the same track using ordinary arithmetical methods.

Schein Stack.

Through the kindness of the late Professor M. Schein, a portion of a very large stack flown at a mean altitude of 90,000 feet was made available gratis to various research groups outside the United States, and through the courtesy of Professor C. F. Powell of the University of Bristol and his collaborators, we have been invited to collaborate in the study of this stack. A preliminary meeting at CERN to discuss the allocation of the plates was attended on 24 February 1960 by K. Imaeda acting on behalf of the School. A final meeting for this purpose was deferred until the plates have been delivered to Europe and is expected to take place in June 1960.

Ionization Calibrations.

The work of Alexander and Johnston has been extended by ionization measurements beyond the minimum using the tracks of pions having the following energies 0.45, 0.65, 1.20, 4.30 Gev, normalisation being

plates of sufficient energy to ensure that their ionization was indistinguishable from that corresponding to the plateau. By means of this work, the ionization of singly-charged particles in photographic emulsion has now been studied over the whole range which is likely to be used in practice. The results have been compared with the theory of Sternheimer.

Cosmic Ray Time Variations Experiment.

Work on the cosmic-ray showers has been continued under the supervision of Professor C. B. A. McCusker; at Jamaica by Dr. R. J. Reid and at Dublin by Mr. D. E. Page. As noted in last year's report, the aim of the experiment has been to examine the structure and variation with time of local and penetrating cosmic-ray showers and showers of high electron-density in order to obtain information concerning (a) Nuclear interactions of very high energy, (b) The origin of cosmic radiation, (c) Movements of the upper atmosphere. During the period under review, the stations at Jamaica and Dublin working in association with that which has been established by Professor McCusker and his associates at Sydney, have gathered valuable information on the following:

1. The lateral structure of various components of extensive air showers.
2. The variation in intensity over the sky, of the primary particles causing extensive air showers at sea level.
3. The variation with solar time of the rate of detection of showers of very high density.

Since 1954, attempts have been made in Dublin to locate any sources of high intensity which appear in the sky. As the earth rotates, our penetrating shower detectors and associated cloud chambers scan a belt of sky approximately 30° wide on either side of declination 5° N. Similar observations have been made for such belts centred about declinations 34° S at Sydney and 18° N at Jamaica.

R.A. and $40-50^{\circ}$ N declination. This has been observed both at Lublin and at Jamaica. The probability that the high number of events appearing in this region could arise by chance has been calculated to be 4 in 10,000. If the intensity of the source remains constant over the period needed to collect the necessary information, it will be possible to enhance the statistical weight of the conclusions by further observation. It is possible, however, that the source intensity is not constant. This possibility has been borne in mind in planning the installation at Sydney. It has been designed to have an extremely high collecting rate and is expected to prove useful in the further study of the effect.

The most fruitful investigation has been that on the solar variations of very high density showers. These show a very marked semi-diurnal variation with amplitude sometimes as large as 25 per cent. Several facts have been noted: (i) The phase of the oscillation is clearly correlated with Solar Activity (Relative Sunspot Numbers). The phase changed abruptly in 1956 and 1959, i.e. just before and just after the Sunspot maximum of late 1957. (ii) The amplitude of the oscillation becomes a minimum at the Sunspot maximum. (iii) The amplitude is greater in summer than in winter. (iv) It is suggested that the effect arises from a semi-diurnal variation of the height of the first interaction. It is known that the atmosphere below 30 km oscillates in this way. Some theoreticians have suggested that above 30 km the oscillation is out of phase with that which takes place at lower altitudes. It is also known that Solar activity has profound effects on the atmospheric structure. (v) In view of these findings the work may be expected to yield valuable information on the problem of oscillations of the upper atmosphere.

3. CONFERENCES

Rochester Conference 1959 Kiev, U.S.S.R.: Professor Ó Ceallaigh attended, by invitation, the 9th Annual International Conference on High Energy Physics held at Kiev, Ukraine, U.S.S.R. from 15-25 July 1959. The work of Inaeda and Shaukat which demonstrated the emission

$$K_{\beta\beta} \rightarrow e^+ + \gamma + \pi^0$$

was reported at this Conference. Professor McCusker attended, on invitation, the I.U.P.A.P. Conference on Cosmic Radiation held at Moscow July 6-11, 1959 and presented two papers on the work in progress at the stations operated under the United States Air Force Contract AF 61(052)-163.

The Physical Society Liverpool Meeting: The meeting of the Physical Society devoted to High and Low Energy Nuclear Physics was attended by Professors Ó Ceallaigh, Johnston and Imaeda, Mr. E. I. and Miss M. Kazuno. Professor Ó Ceallaigh acted as Chairman of two sessions.

4. INSTRUMENTS AND WORKSHOP

In addition to the work of servicing and replacement of the mechanism of the scanning and measuring microscopes, and the giving of technical help necessary to maintain in running order the cosmic ray time variation experiment, Mr. Daly has undertaken the construction of a special photometric device. This is to be used in conjunction with a microscope, for determining the density of the tracks in cosmic-ray jets. For this purpose, he paid a visit of one week to the H. H. Wills Physical Laboratory where the photometer has been developed to see it in operation and to discuss with them the constructional problems involved.

5. SEMINARS

During the year the following Seminars were given by visiting scientists.

Dr. M. G. K. Menon:

Cosmic Ray Research Projects at the Tata Institute, Bombay.

Professor R. Hofstadter (Stanford University):

The Electromagnetic Structure of the Proton and Neutron.

Dr. J. Nishimura (Tokyo):

Recent Experiments on High Energy Cosmic Ray Detectors in Japan

Mr. P. H. Fowler (Bristol):

The Study of the Gamma Ray Spectrum of Cosmic Radiation.

Dr. H. Muirhead (Liverpool):

The Muon Capture Process.

Talks were also given by Dr. K. Inaeda and Professor R. H. W. John

6. PUBLICATIONS

C. B. A. McCusker:

Measurement of Primary Directions in Extensive Air Showers.
Phys. Rev. 116, 181, 1959.

C. B. A. McCusker, D. E. Page and R. J. Reid:

The Directional Properties of an Extensive Air Shower.
Phys. Rev. 116, 177, 1959.

European K^- - Collaboration.

B. Bhownik, D. Evans, D. Falla, F. Hassan, A. A. Kamal, K. K. Nagpaul and D. J. Prowse (Bristol); M. René (Brussels); G. Alexander, R. H. W. Johnston and C. Ó Ceallaigh (Institute for Advanced Studies, Dublin); D. Keefe (University College, Dublin); E. H. S. Burhop, D. H. Davis, R. C. Kumar, W. B. Lasich, M. A. Shaukat and F. R. Stannard (University College, London); M. Bacchella, A. Bonetti, C. Dilworth, G. Cecchialini and L. Scarsi (Milano); M. Grilli, L. Guerriero, L. von Lindern, M. Merlin and A. Salandín (Padova & Milano):

The Interaction and Decay of K^- Mesons in Photographic Emulsion.

Part I. General Characteristics of K^- Interactions and Analysis of Events in which a Charged π -Meson is Emitted.
Nuovo Cimento 13, 690, 1959.

Part II. The Emission of Hyperons from K^- -Interactions at Rest. Nuovo Cimento 14, 315, 1959.

D. Evans, F. Hassan, K. K. Nagpaul and D. J. Prowse (Bristol); M. René (Brussels); G. Alexander and R. H. W. Johnston (Institute for Advanced Studies, Dublin); D. Keefe (University College, Dublin); D. H. Davis, W. B. Lasich, M. A. Shaukat and F. R. Stannard (University College, London); A. Bonneti and C. Dilworth (Milano); M. Merlin and A. Salandín (Padova):

Part III. The Life time of the K^- -Meson. Nuovo Cimento 15, 873, 1960.

K. Inaeda and M. A. Shaukat:

The Nature of the Neutral Particles Emitted in K_s^0 Decay.
Nuovo Cimento 14, 493, 1959.

1. STAFF AND SCHOLARS

Senior Professor:

Leo W. Pollak.

Professor:

Thomas Murphy.

Research Assistant:

Arvids Leons Metnieks (under U. S. Air Force Contract).

Research Associate:

Rev. G. McGreevy.

Senior Technical Assistant:

Thomas J. Morley.

Technical and Clerical Staff:

Miss Nessa Falconer; Miss Margaret Ryan; Mr. Kevin Bolster;
Mr. Martin Cotter.

2. INVESTIGATIONS, EXPERIMENTAL AND FIELD WORK

a. Professor L. W. Pollak and Co-workers:

Shortly after publishing the new calibration of photo-electric nucleus counters (Pollak & Metnieks, Reference ii in Section 3, Publications) we were approached by the Meteorological Branch of the Physical Sciences Division of the U.S. Army Laboratories at Fort Monmouth, N.J. to carry out a calibration for very low concentrations such as occur over the ice of Greenland. In previous calibrations the concentrations less than 500 nuclei/cm^3 were obtained by interpolation. The concentration of 106 samples was determined with the photographic counter and the corresponding extinctions with the photo-electric counter. In order to join this calibration for very low concentrations with that of higher ones an intrinsic calibration over the whole range of concentration

This intrinsic calibration also appeared necessary in view of the use of photo-electric counters in the dynamic method for determining the apparent diffusion coefficient of a polydisperse aerosol. This requires the measurement of the concentrations at the entrance and the exit of the diffusion battery with the same accuracy. The 1960 calibration curve and the extensive calibration table which is based on 16 very reliable absolute 'fundamental points' should satisfy the demand for a calibration uniformly accurate over the whole range. The change over to a convergent light-beam now adopted prevents 'scintillation' with very low concentrations and ensures long-term agreement between counters of identical construction.

The influence of heterogeneity on the determination of the apparent diffusion coefficient by the dynamic method was investigated for polydisperse aerosols with various Gaussian particle size distribution (Pollak and Metnieks, Ref.iii). The results of a theoretical investigation carried out by Pollak and Metnieks in Dublin and of experiments made by Rich and Pollak in the laboratories of the General Electric in Schenectady, N.Y., U.S.A. are published in Ref.iv of Section 3. It is shown that for normal conditions as is to be expected in practice, the 'equivalent radius' deduced by applying Boltzman's law to the charge distribution on a population of particles represents a very good estimate of the average size of submicron particles in polydisperse aerosols.

A new instrument for determining the apparent diffusion coefficient of aerosols has been constructed (Pollak and Daly, Ref.v). This consists of a diffusion battery without end-pieces or connecting tubing built into the fog-tube of a photo-electric condensation nucleus counter. The elimination of the end-pieces and connecting tubing removes any 'end-effects' and diffusion losses in these parts of the diffusion batteries used hitherto and reduces the volume of the diffusion apparatus to that of its channels, thus minimising the lag in the response of the battery. A preliminary application of the instrument in room air

efficient, as determined by the dynamic method, depends on the rate of air-flow used.

A continuously sensitive diffusion cloud chamber for studying the behaviour of ice nuclei has been devised by Professor Pollard and an experimental model built in our workshop. Up to now the vertical separation of the 0°C and -40°C levels in the diffusion cloud chambers used for the study of ice nucleation is about 10 cm. Owing to this steep vertical temperature gradient the temperatures at the various levels had to be measured by thermocouples attached to calibrated micrometer heads and the effects of nucleation were observed or photographed by viewing perpendicularly to an intense beam of light passing horizontally through the chamber.

The new idea makes it possible to reduce the temperature gradient manifold and assigns to each temperature range a small compartment. In addition to avoid convection currents in the compartments, a novel arrangement is introduced so that the temperature at the floor of each compartment is lower than that at top. The crystals forming in the small compartments are recorded on coated slides.

b. Professor T. Murphy:

The computation of the gravity data was continued and brought up to date, so that now there is a complete coverage of gravity values for Ireland south of the line from Dublin to Galway.

The gravitational effect of the Leinster granite is well determined and this, together with other associated positive anomalies should yield the sought-for information concerning crustal structure. The results and their analysis have been presented at a Geophysical discussion of the Geological Society of London on January 27, 1960, by Professor Murphy. The necessity for carrying out a general survey before interpreting details was brought out at this meeting (cf. Nature 185, 939, 1960).

rocks of widely different densities, which have been found to occur, complicates the gravity picture. Assistance has been given to J. Farrar of Birmingham University, for his detailed gravity work in this region. In return, Farrar's complete results have been placed at our disposal.

A gravity survey has been commenced in Northern Ireland by parties from the Geological Survey of Great Britain. In order to keep the work in Ireland homogeneous, their base station network was connected with ours. New bases have been added to our network and some measurements have been taken by Professor Murphy in Donegal to assist their work.

Comparisons between the gravity meters used were carried out over the Macclesfield base line and the problem of determining the errors in gravimeter readings necessary for network adjustments was investigated and the results incorporated in a paper (cf. Section 3 - Publications). This problem has been discussed at the meeting of the International Gravity Commission in Paris in September which Professor Murphy attended (See Geophysical Journal, London 3, 122, 1960).

The study of 'hidden' granite masses and their effect on the gravity field was continued in south-west Ireland. On the request of Irish and British geologists the results of this work are in course of publication in the form of a Gravity Map. The printing of this map has been carried out by the Ordnance Survey Office.

As doubts have arisen regarding the value of rock densities here, additional density determinations of Irish rocks are being made.

A portable short period seismograph has been constructed by Rev. R. E. Ingram and Professor Murphy for use at an outstation, the site of which is being selected by experiment.

c. Research Associate Rev. G. McGreevy:

Fr. McGreevy has evaluated five years measurements of circum-global radiation made on the roof of 5, Merrion Square in Dublin with

these remarkably simple instruments is very good over the whole period and that they are most suitable and convenient for climatological stations.

d. The equipment for investigating the effect of temperature and pressure on the counting of nuclei has been procured by or constructed in the workshop of the Section. It consists e.g. of a cooling cabinet with refrigerating unit on trolley so that a new copy of our photoelectric nucleus counter fitted with remote control of its taps can be exposed to temperatures down to -30°C and of three cylindrical steel containers up to 270 litres content capable of withstanding over- and underpressure of 1 atm.

The research reported above has been supported in part by the Geophysics Research Directorate of the United States Air Force, the U.S. Army Research and Development Liaison Group and the General Electric Co., Schenectady, N.Y.

3. PUBLICATIONS

- i L. W. Pollak:
Counting of condensation nuclei and applications of the counting results.
International Journal of Air Pollution, London, Vol. I, 1959, pp.293-306.
- ii L. W. Pollak and A. L. Metnieks:
New calibration of photo-electric nucleus counters.
Geofisica Pura e Applicata, Milano, Vol.43, 1959/II, pp.285-301.
- iii L. W. Pollak and A. L. Metnieks:
The influence of air-flow on the determination of the diffusion coefficient of heterogeneous aerosols by the dynamic method.
Ibidem, Vol.44, 1959/III, pp.224-232.
- iv T. A. Rich, L. W. Pollak and A. L. Metnieks:
Estimation of average size of submicron particles from the number of all and uncharged particles.
Ibidem, Vol.44, 1959/III, pp.233-241.
- v L. W. Pollak and J. Daly:
A diffusion battery without end-pieces or connecting tubing.
Ibidem, Vol.45, 1960/I, pp.249-257.

instructions for use together with calibration and auxiliary Tables.
Geophysical Bulletin No.16 of the Meteorological and Geophysical Section, School of Cosmic Physics, Dublin, April 1959.

- vii T. Murphy:
The changes of sensitivity and drift rate of a Worden gravimeter with time and temperature.
Geofisica Pura e Applicata, Milano, Vol.43, 1959/II, pp.209-217.
- viii G. McGreevy:
The circum-global radiation in Dublin.
Ibidem, Vol.44, 1959/III, pp.265-270.
- ix A. Giso:
The general problem of dynamical meteorology - An introduction to numerical weather forecasting.
Geophysical Bulletin No.17 of the Meteorological and Geophysical Section, School of Cosmic Physics, Dublin, July 1959.

In Course of Printing:

- L. W. Pollak and A. L. Metnieks:
Intrinsic calibration of the photo-electric nucleus counter Model 1957 with convergent light-beam. Technical (Scientific) Note No.9, Contract USAF 61(052)-26 and Supplemental Agreement No.1, Dublin, April 1960.
- T. Murphy:
The computation of gravity differences from observations with a Worden gravimeter and the resultant errors.
Geofisica Pura e Applicata, Milano.
- T. Murphy:
Gravity Anomaly Map of Ireland, Sheet 5 - South West.
Geophysical Bulletin No.18 of the Meteorological and Geophysical Section, School of Cosmic Physics, Dublin, April 1960.

4. U.S. AIR FORCE CONTRACT AF 61(052)-26 and Supplemental Agreement No.1

Lt. Col. A. C. Trakowski, USAF, Chief, Physics Division and
Lt. Col. W. L. Jones, USAF, Project Officer, of the European Office,
Air Research and Development Command, Brussels visited the laboratory
of the Section on March 7, 1960.

From the discussion it follows that the contract will be extended
at least up to 30 April 1961.

Quotation from Col. Jones' letter of 14th March 1960: "Col.
Trakowski and I enjoyed the visit with you and the fine tour of your

interesting week's tour".

5. U.S. ARMY CONTRACT DA-91-591-EUC-1282

On 17 August 1959 Contracting Officer Capt. George L. Nuger visited the Section for discussion of the plan of work. The Contract signed by the American authorities in Frankfurt a.M. on behalf of the United States Government was received by the Registrar of the Institute on 1 September 1959. The Contract is concluded in the first instance for one year from November 1, 1959.

Preliminary measurements made with the novel diffusion cloud chamber for studying ice nuclei showed that its principle is correct.

6. COLLABORATION WITH RESEARCH LABORATORY OF GENERAL ELECTRIC COMPANY IN SCHENECTADY, NEW YORK

As a result of Professor Pollak's invitation to advise and help in setting up certain experiments and in interpreting the results, he visited the Schenectady Laboratories in June and July 1959. During this stay he was acquainted with the most recent applications of the photo-electric nucleus counter and was permitted to work with the not yet declassified recording photo-electric nucleus counter of the G.E. In brief, the problem in which the Company is interested is the comparison of a new method, designed in Schenectady, with our diffusion method for determining the size spectrum of nuclei: The Company have constructed in their works a new diffusion battery which Professor Pollak has suggested, an electric filter for the joint investigation. These valuable instruments and other equipment have been presented by the American firm to the Section.

No expenditure has been incurred by the Institute in connection with this visit.

16th April 1959: Professor S. K. Runcorn, Director, Physics Department, King's College, University of Durham: Recent advances in Palaeomagnetism.

8th, 11th & 12th May 1959: Professor Antonio Gao, Paris and Lisbon: The general problem of dynamical meteorology (An introduction to numerical weather forecasting).

13th November 1959: Dr. R. S. Scorer, Imperial College, London:
(i) The study of natural turbulence, (ii) Air pollution in cities.

4th February 1960: Professor L. W. Pollak, School of Cosmic Physics, Dublin: A month with the General Electric, Schenectady, N.Y.

8. MISCELLANEOUS

(i) On 20 August 1959 Professor Pollak inspected, in connection with the U.S. Air Force Contract, various climatic and underpressure chambers in the Meteorological and Geophysical Institute of the University of Frankfurt a.M. If required, the Institute in Frankfurt is ready to place these chambers at our disposal. No expenditure has been incurred by the Institute in connection with this visit.

(ii) On request, the Meteorologische Institut der Technischen Hochschule in Karlsruhe, the Zentralanstalt für Meteorologie und Geodynamik in Wien and the Nucleation Section, Division of Physical Chemistry, Melbourne have been supplied recently with the workshop drawing of our photo-electric nucleus counter Model 1957 and the 'Instruction' for its use, care and maintenance (Geophysical Bulletin No.16).

Karlsruhe and Vienna have constructed the counter according to our specification. With a grant of the Research Council of West Germany the Assistant of the Karlsruhe Institute (Dr. Schulz) will in the near future transfer their copy of our counter to Dublin for standardisation and to acquaint himself with its operation and application.

(iii) Dr. E. Shalmon, Health Physics Department, Atomic Energy Commission, Tel-Aviv (Israel) visited the Section on 3rd and 4th

equipment for condensation nuclei research.

(iv) In a letter received from General Electric, Schenectady N.Y. on 29 February 1960 Professor Pollak was informed that a contract is being prepared by their Instrumentation Engineering Physics and Analysis Laboratory in which money is allotted for consultation with him and financing basic experiments in Dublin.

(v) Assistance as outlined below was given by Professor Murray on request to the following:-

(a) The Ordnance Survey - for analysis of the tide gauge records and geodetical matters arising from a proposed Irish Survey by "Lateration".

(b) The South East Ireland Syndicate - in the interpretation of Geophysical investigations carried out by Huntingdonborne Geophysics Ltd. and their own prospecting team.

(c) The Northgate Exploration Co., Toronto - by supply information towards planning detailed geophysical exploration.

EDWARD J. CONWAY

CHAIRMAN

21 December 1960