

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

1968-69

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

Summary of Annual Report  
of the work of the Constituent Schools  
for the year 1968-69

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School of Celtic Studies

Professor Brian Ó Caív succeeded Professor Myles Dillon as Director of the School in April 1968. In the following months the activities of the School were reviewed and in September 1968 the Governing Board submitted to the Minister for Education a memorandum containing a programme of research and publication for the quinquennium 1969-74, together with proposals concerning the gradual expansion of the staff of the School. Since one of the primary functions of the School is 'the training of advanced students in methods of research' particular importance was attached to the need for increasing the number of research assistants, and it was pointed out that by this means the School would be in a position to contribute to the staffing of Irish or Celtic departments in universities as it did in the past. At the end of the year the Governing Board had still failed to get the approval of the Minister for Education for the appointment of even one additional junior staff member to work on Irish bibliography.

A new contribution to Irish studies at higher educational level was made by the School in organising two symposia, in December 1968 and March 1969, for members of the staffs of Irish departments in universities and teachers' training colleges and research workers in learned institutions.

Arrangements were made for a Summer School of Celtic Studies to be held in July-August 1969, and the Department of Education agreed to provide a number of study grants for award to scholars from abroad.

Weekly seminars were held by Professors Binchy and Ó Caív, and the Statutory Public Lecture - entitled The Linguistic Training of the Mediaeval Irish Poet - was delivered by Professor Ó Caív in University College, Dublin on 13th March 1969.

The full report gives details of the work of research and editing carried out in their various fields by members of the School and by extern research workers.

In the field of publications nine books (including periodicals) were published, four of them being Institute publications. Members of the School contributed thirty-eight papers or shorter items to books or periodicals published elsewhere.

School of Theoretical Physics

Professor Lanczos examined the hypothesis that the field equations of general relativity should be deducible from an action principle which is quadratic in the curvature quantities. Professor Synge worked on the equations of motion in general relativity and investigated statical systems. In the kinematics of particle interaction he defined a new canonical frame of reference based on the diagonalisation of the matrix of quadratic moments of the four 4-momenta of the incoming and outgoing particles. Professor McConnell collaborated with Dr. D. J. Simms of Trinity College, Dublin, in preparing material for a book on algebra, and related the method of Young tableaux with that of weight diagrams for semi-simple Lie algebras. Professor Ó Raifeartaigh worked with Dr. S. J. Chang on infinite component wave equations, and in collaboration with Dr. Chang and Dr. Dashen analyzed the saturation of current algebra with states of isospin  $\frac{1}{2}$  at infinite momentum.

Professor Takahashi generalized his method of field quantization to multi-mass fields and applied the hyperquantization method to quantum electrodynamics and the Rarita-Schwinger field. Professor Israel continued to work on pulsars, event horizons and gravitational collapse in general relativity. Professor Balazs investigated a number of problems in statistical mechanics and quantum theory. The Research Associates, Scholars, and Student investigated a wide range of problems in relativity, quantum theory and the theory of groups.

Twenty-six weekly seminar lectures were given and two symposia were held.

The Statutory Public Lecture was delivered by Professor McConnell in Trinity College, Dublin on 30th January 1969. The staff gave a number of invited lectures in Ireland and abroad, and took part in scientific meetings and conferences.

During the year two books were published outside the Institute by staff members and three were in the press. Twenty-eight papers were published in learned journals and twelve were in the press.

#### School of Cosmic Physics

##### Astronomical Section:

During the year an observational programme of solar research was carried out jointly with Sacramento Peak Observatory. In research on stellar photometry the computer programmes for reduction of iris photometer readings to stellar magnitudes have been developed and modified. The full report deals with this research and also with individual research in other fields including statistical astronomy and further study of the Magellanic Cloud Membership.

Professor Wayman served on the Council of the Royal Astronomical Society throughout the year and was appointed Chairman of the newly-formed National Committee for Astronomy of Ireland.

One book and eight papers were published during the year.

##### Cosmic Ray Section:

The European  $K^-$  Collaboration and other investigations using emulsion techniques were expanded and continued successfully by staff and scholars. The full report gives details of the particular research and work carried out by individual staff members and scholars, and details of conferences and meetings attended. During the year a meeting of the  $K^-$  Collaboration was held in Dublin and was attended by delegates from all the Laboratories involved.

The setting up of the instrumentation of the new plastics laboratory in the School was completed and the research technique of the detection of primary cosmic rays in selected plastic materials was further developed.

The above research resulted in the publication, by members of the staff and scholars, of six papers in learned journals. Eleven further papers were at the press and in preparation.

The Statutory Public Lecture was delivered in University College, Dublin on 27th February 1969, by Professor D. H. Perkins of Oxford University.

##### Geophysical Section:

Gravity and magnetic surveys were continued throughout the country and some results published.

Seismic studies were continued and a portable seismic station was developed.

Measurements of the magnetic polarisation of rock samples were made.

Two books and one paper were published. Another paper was in the press.

INSTITIÚID ÁRD-LÉINN BHAILE ÁTHA CLIATH  
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Annual Report of the work of the Institute and  
its Constituent Schools presented by the Council  
for the Financial Year 1968-69

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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, 1969.

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 the membership of the Governing Boards of the three Constituent Schools on the 31st March 1969.

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, 1969.
- 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.

I - Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31st March 1969.

1. THE COUNCIL OF THE INSTITUTE

Chairman:

Vacant.

Ex-Officio Members:

Mr. J. J. Hogan, M.A., B.Litt. (Oxon.), President, University College, Dublin; Dr. Albert J. McConnell, M.A., M.Sc., Sc.D., Provost, Trinity College, Dublin; Dr. Joseph Raftery, M.A., D.Phil., President, Royal Irish Academy.

Members appointed by the Governing Boards of Constituent Schools:

Professor Brian Ó Cuív, M.A., D.Litt.; Dr. E. MacLysaght, M.A., D.Litt.; Professor Felix E. W. Hackett, M.A., M.Sc., Ph.D.; Reverend Professor J. R. McConnell, M.A., D.Sc.; Professor J. H. J. Poole, M.A., B.A.I., Sc.D.; Professor T. Murphy, D.Sc.

2. THE GOVERNING BOARD OF THE SCHOOL OF CELTIC STUDIES

Chairman:

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

Senior Professors:

Daniel A. Binchy, M.A., Ph.D., B.L.; Myles Dillon, M.A., Ph.D.; David Greene, M.A.; Brian Ó Cuív, M.A., D.Litt.

Appointed Members:

Tomás de Bhaldraithe, M.A., Ph.D., D.Litt.; Edward MacLysaght, M.A., D.Litt.; Ernest Gordon Quin, M.A., F.T.C.D.; Reverend John Ryan, S.J., M.A., D.Litt.; Reverend Francis Shaw, S.J., 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.; Reverend James R. McConnell, M.A., D.Sc.; Lochlainn Ó Raifeartaigh, M.Sc., Ph.D.

Appointed Members:

George R. Keating, M.Sc.; Albert J. McConnell, M.A., M.Sc., Sc.D.; Thomas Edwin Nevin, D.Sc.; Patrick Quinlan, B.E., M.Sc., Ph.D.; Seán Seosamh Tóibín, M.Sc., Ph.D.; Thomas David Spearman, M.A., Ph.D. (Cantab.).

4. THE GOVERNING BOARD OF THE SCHOOL OF COSMIC PHYSICS

Chairman:

John H. J. Poole, M.A., B.A.I., Sc.D.

Senior Professors:

Cormac Ó Ceallaigh, M.Sc., Ph.D.; Thomas Murphy, D.Sc.;  
Patrick Arthur Wayman, Ph.D.

Appointed Members:

Patrick M. A. Bourke, M.Sc.; Cyril F.G. Delaney, M.A., Ph.D.;  
Eric M. Lindsay, M.A., M.Sc., Ph.D.; John J. McHenry, M.A. (Cantab.),  
D.Sc.; Right Reverend Monsignor Patrick J. I. McLaughlin, D.Sc.;  
Patrick J. Nolan, Ph.D., D.Sc.; Cilian Ó Brocháin, M.Sc.; Ernest  
T. S. Walton, M.A., M.Sc., Ph.D., F.T.C.D.

5. ADMINISTRATIVE STAFF

Registrar:

Patricia O'Neill.

Senior Clerk:

Maura Devoy.

Clerks:

Mary A. O'Rourke; Susan Reade; Desmond Pender.

II - Report of the Governing Board of the School of Celtic Studies  
adopted at its meeting on 19th June 1969.

1. STAFF, SCHOLARS AND EXTERN RESEARCH WORKERS.

Senior Professors:

Brian Ó Cuív (appointed Director of the School for three years from 26 April 1968); Daniel A. Binchy; Myles Dillon (Director to 26 April 1968); David Greene.

Professor:

James P. Carney.

Assistant Professors:

Louis Paul Nemo (Roparz Hemon); Rev. Pádraig Ó Súilleabháin, O.F.M.; Gearóid Mac Niocaill.

Assistant:

Pádraig de Brún (appointed 1 October 1968).

Assistants (Part-time):

Mrs. Nessa Doran; Mrs. Anne O'Sullivan.

Research Associates:

Heinrich Wagner; Proinsias Mac Cana.

Technical and Clerical Staff:

Máire Breatnach; Máire Bean Uí Chinnsealaigh.

Scholars:

Donncha Ó hAodha (to 30 September 1968); Pádraig de Brún (to 30 September 1968); Donncha Ó Corráin; Thomas Charles-Edwards; Nicholas J. A. Williams; Mrs. Leslie Owen (appointed 1 July 1968); Fergus Kelly (appointed 1 October 1968).

Extern Research Workers:

Dr. Cecile O'Rahilly; Rev. Anselm Faulkner, O.F.M.; Rev. Cuthbert McGrath, O.F.M.; Dr. Ludwig Bieler; Mr. I. P. Sheldon-Williams; Éamonn Mhac an Fhailigh; Professor J. E. Caerwyn Williams; Mr. Brynley Roberts; Máire Ní Chatháin; Caitlín Ní Maol-Chróin.

During the year 1967-8 plans for bringing work on Irish Bibliography up to date were considered by the Governing Board of the School and approval was sought from the Minister for Education for the appointment of a junior staff member to work in this field. The Board's request was rejected by the Minister in the summer of 1968, but at the same time the School was asked to

submit proposals on the academic staffing of the School. Accordingly in September 1968 the Board submitted to the Minister a memorandum containing a programme of research and publication for the quinquennium 1969-74, and putting forward proposals regarding the gradual expansion of the staff of the School to enable it to carry out the programme. It was pointed out that whereas in 1942-3 the School had six research assistants, it had only one assistant and two part-time assistants in 1968-9. It was proposed that as a first step in redressing the situation provision should be made for two additional assistants and one part-time assistant in 1969-70. By increasing the number of research assistants the School would be in a better position to perform its function of 'the training of advanced students in the methods of research' and it would be in a position to contribute to the staffing of Irish or Celtic departments in universities as it did in the past. Despite the convincing case which was made for the proposed expansion in the staff of the School, approval was withheld by the Minister.

## 2. RESEARCH AND EDITING.

Professor Brian Ó Cuív continued to work on Irish metrics and lexicography and on linguistic developments at various stages between Middle Irish and Modern Irish dialects. He completed the editing of several short texts for publication. He saw two parts of Éigse through the press and had brought a third to proof stage by March 1969. He also passed through its final stages the volume A View of the Irish Language for publication by the Stationery Office in 1969. (See also sections 3, 4, 5, 7 and 8).

Professor Myles Dillon checked and passed for press final proofs of Celtica VIII. He was also engaged in revising articles for Celtica IX. An article was written for the memorial volume to be dedicated to the late Alf Sommerfeld. The Celtic Realms was revised for the Italian and Spanish editions. Excerpting for the Dictionary of Modern Irish was continued. (See also sections 5, 7 and 8).

Professor Daniel A. Binchy continued to transcribe from Irish legal manuscripts for Corpus Iuris Hibernici of which 1,555 pages are now in first proof. He held a weekly class on Irish law-texts for Dr. Gearóid



Mac Niocaill and Mr. Thomas Charles-Edwards. (See also sections 4, 7 and 8).

Professor David Greene re-commenced work on Bergin's Bardic Poetry the typescript of which was destroyed by fire at the premises of the Dublin University Press. He was assisted by Mr. Fergus Kelly who collated the poems with the manuscripts. He has completed an article on the Gaelic Revival which has been accepted for publication in a volume on The Church of Ireland 1870-1970 edited by Father Michael Hurley S.J. Work continued on a booklet on Modern Writing in Irish which has been commissioned by the Cultural Relations Committee and also on a study of The Celtic numerals which is to be published in a volume edited by Professor A. S. C. Ross. Professor Greene, as Editor of Ériu, read proofs of Volume XXI to which he has contributed some articles. (See also sections 5, 7 and 8).

Professor James Carney did some general work on Irish literature and some work on the Lambeth Glosses. He did preliminary work towards an edition of Saltair na Rann. The following articles were accepted for publication in Ériu:- (i) The Ó Cianáin Miscellany; (ii) A Discussion of the Problem of National Library MSS. G 2 and G 3; (iii) an edition of four short prose texts and three medieval poems. (See also sections 7 and 8).

M. Louis Paul Nemo continued to work on the Historical Dictionary of Breton, the fifteenth volume of which is now ready for publication. He is preparing an edition of the miracle-play Ar Varn Diwezhan (The Last Judgement), from a text in Early Modern Breton. (See also section 8).

Rev. Pádraig Ó Súilleabháin, O.F.M. corrected and returned page proofs of the Irish and Latin texts of Buaidh na Naomhchroiche. Preparation of the vocabulary has been completed. Owing to a printer's error in the line numbering all references have to be verified and the necessary adjustments made. He revised the vocabulary of Fr. Cuthbert's edition of Dán na mBráthar Mionúr II before submitting it to the printer. The following articles were accepted for publication in Éigse:- (i) Seanmóir ar an mbás; (ii) Nótaí ar roinnt focal i dTrí bior-ghaoithe an bháis. (See also section 8).

Dr. Gearóid Mac Niocaill worked on annotation of Annals of Ulster and their relationship to other annalistic texts; completed fresh text of Chronicon Scotorum. He prepared for press Miss Una McHenry's edition of

Tenga Bithma. An article entitled 'À propos du vocabulaire social irlandais du bas moyen âge' was accepted for publication in Études Celtiques XII. (See also sections 7 and 8).

Pádraig de Brún read proofs of A Catalogue of Irish MSS. in the Franciscan Library (M. Dillon and C. Mooney, O.F.M.) and did some preparatory work on a catalogue of Irish MSS. in King's Inns Library and on Filíocht Sheáin í Bhraonáin. Work was resumed on the Munster section of an anthology of later Irish poetry and on an edition of the poems of Piaras Feiritéar. He saw Journal of the Kerry Archaeological and Historical Society, No. 2 through the press. The following articles were accepted for publication in Éigse Vol. XXIII:- (i) Ar Shaorbhreathach Mhág Cártaigh; (ii) Ranna Fáin; (iii) Lámhscríbhinní Thorna - Addenda. (See also section 8).

Mrs. Nessa Doran continued to work on the preparation of Fasc. III of A Catalogue of Irish MSS. in the National Library of Ireland. MSS. G 90 - 94, 107, 110, 112 - 114 and Kings Inns 15 were catalogued. (See also section 8).

Mrs. Anne. O'Sullivan was engaged in collating and comparing Dr. Binchy's transcripts and proofs of Irish law texts with the following mss.:- T.C.D.: H.3.17, H.3.18; Oxford: Rawl. B 506, Rawl. B 487 and Rawl. B 502; British Museum: Eg. 88, Earl. 432, Eg. 90. She also worked on the inscriptions on these manuscripts with a view to eventually establishing something of the transmission of the texts. (See also section 8).

Professor Heinrich Wagner read final proofs of volume IV of the Linguistic Atlas and Survey of Irish Dialects. This volume contains (a) The Dialects of Ulster; (b) Manx; (c) specimens of Scottish Gaelic Dialects; (d) Phonetic Texts from East Ulster prepared by Dr. O'Boyle (University of Aberdeen).

Professor Proinsias Mac Cana as General Editor of the Medieval and Modern Welsh Series read the typescript of Mrs. Rachel Bronwich's edition of Armes Prydein which is being prepared for publication in this Series. He read proofs of Brynley Roberts' edition of Brut Y Brenhinedd and suggested to the Editor some emendations which are to be incorporated in the revised

proofs.

Donncha Ó hAodha continued to work, under the direction of Professor Binchy, on the preparation of an edition of the Old Irish Life of St. Bridget.

Donnchadh Ó Corráin continued his study of early Munster history with particular reference to the genealogies and early distribution tracts. He has transcribed much unedited genealogy from Lec., BB., UM and H. 2.7. The following articles were accepted for publication:- 'The later Eoganacht pedigrees' (Journal of the Cork Historical and Archaeological Society); 'Studies in West Munster history: the Ciarraige Luachra' (Journal of the Kerry Archaeological and Historical Society, No. 3); 'Diarmait Mac Murchada' [a lecture in the current Thomas Davis Series The Anglo-Norman Invasion of Ireland ed. F. X. Martin, London and Cornell]. (See also sections 7 and 8).

Mr. Thomas Charles-Edwards has been mainly concerned with work on his thesis for which he has written chapters on the Irish tellach and Welsh dadannudd procedures, on the semi-free classes in Ireland (the fuidir and bothach), on the Welsh laws on sharing the inheritance, and on the Irish kindred and its Celtic origins. An article on the forms edryf, edryd, edfryd and edrydd has been accepted for publication in the Bulletin of the Board of Celtic Studies and one on the terms for the heir-apparent in Irish and Welsh for publication in Celtica.

Mr. Nicholas J. A. Williams continued working on the Irish of Louth-Armagh and discovered more sources; three manuscript note-books by John Hannon of Crossmaglen (1898) among Joseph Lloyd's papers in the National Library; note-books by Éamonn Ó Tuathail and Rev. Coslett Quin in the Folklore Commission. He has reconstructed the accidence of the irregular verbs of the dialect and transcribed them into phonemic notation. He has started to prepare for publication one of Hannon's note-books. This involves converting Hannon's O'Growney notation into IPA and supplying a version in traditional orthography alongside. An edition of the early eighteenth century satire Eachtra Aodha Mhic Oireachtaigh, with introduction, glossary and indices has been accepted for publication in Éigse. He wrote some brief notes on Middle Cornish and in collaboration with Mr. T. Charles-Edwards he wrote an article on the etymology of Welsh diffoddi all of which have been accepted for

publication in the Bulletin of the Board of Celtic Studies. The following articles have been written with a view to publication (i) the etymology of arsuighim 'I tell'; (ii) a specimen of Drogheda Irish in quasi-phonetic notation, from a manuscript in the Royal Irish Academy in the hand of Bernard Tomalty; (iii) phonetic texts from Omeath taken from the note-book of Éamonn Ó Tuathail.

Mrs. Leslie Owen worked on Cogadh Gaedhiel re Gallaibh.

Mr. Fergus Kelly worked on the preparation of an edition of Audacht Moraind (both recensions). He has collated most of the mss. of Professor Green's edition of Bergin's Bardic Poems.

Dr. Cecile O'Rahilly excerpted from the following texts for the Dictionary of Classical Modern Irish:- An Bheatha Dhiadha; Eochair Sgiath an Aifrinn; An Tiomna Nuadh (1602); Carewell's Translation of Knox's Liturgy; Beatha San Froinsias; Annals of Innisfallen (A.D. 1092-1214, 1258-1285); Eachtra Ridire na Leomhan; Bartholomaeus Anglicus I; Gaelic Marco Polo; Three Fragments (O'Donovan); Richardson's Sermons (1711); Bardic Poems of Tadhg Dall; and some shorter texts. She collected material for an article on conjunctions which has been accepted for publication in Celtica IX. (See also section 8).

Rev. Anselm Faulkner, O.F.M. continued to compare the mss. (15) with the basic text of An Sgathán Spioradálta and noted the variant readings. The basic text was compared with the Italian original and 86 pp. of general notes prepared in rough form. Preparation of the vocabulary (40 pp.) has been completed.

Rev. Outhbert McGrath, O.F.M. worked on the Introduction, Vocabulary and Appendices (217 pp.) of Part II of Dán na mBráthar Mionúr. This material was sent to the printer in January 1969. First proofs of the Appendices have been checked by the author.

Dr. Ludwig Bieler continued to act as General Editor of Scriptores Latini Hiberniae. He checked and returned first proofs of his edition of The Four Latin Lives of St. Patrick.

Mr. I. P. Sheldon-Williams checked final proofs of his edition of Johannis Scotti Eriugense Periphyseon (de divisione naturae) which was pub-

lished during the year. Book II of this work has been prepared for press. Work has continued on the translation and notes of volume III and on the preparation of the text of volumes IV and V.

Éamonn Mhac an Fhailigh checked final proofs of his phonemic study, The Irish of Erris, Co. Mayo which was published during the year.

Professor J. E. Caerwyn Williams worked on the preparation of Llywarch Hen and Heledd Cycle which is to be published in the Medieval and Modern Welsh Series. He was also engaged in work on the Gododdin Poem. His edition of The Poems of Taliesin was published during the year.

Mr. Brynley F. Roberts continued work on the Welsh versions of Geoffrey of Monmouth's Historia Regum Britanniae, or Brut y Brehinedd. The volume of selections from the Llanstephan MS. 1 version, to be published in the Medieval and Modern Welsh Series, has reached the proof stage, and the work for a full critical edition is almost complete. A second version, Peniarth MS 44, has been edited and the study of this version is now complete. A full textual study of the Brut Dingestow version has also been prepared. Work is in progress on the so-called Brut Tysilio.

Máire Ní Chatháin continued her editorial work on Betha Muire.

Caitlín Ní Maol-Chróin worked on the Introduction to her edition of Caithréim Cellaig which is to be published in the Mediaeval and Modern Irish Series. Proofs of the two texts, apparatus criticus, glossary and index nominum have been in book form since 1964.

### 3. STATUTORY PUBLIC LECTURE

A Statutory Lecture entitled The Linguistic Training of the Mediaeval Irish Poet was delivered by Professor Brian Ó Cuív in University College, Dublin, on 13th March 1969.

### 4. SEMINARS

Professor Brian Ó Cuív held a weekly seminar from October 1968 to March 1969 - on Buille Shuibhne in the first term and on the Irish Grammatical Tracts on Declension in the second.

Professor D. A. Binchy held a weekly seminar on an Old-Irish legal tract from October 1968 to March 1969.

## 5. SYMPOSIA

A symposium, to which members of the staffs of Irish departments in the universities, teachers' training colleges, and the research workers in Irish in learned institutions were invited, was held on December 19-20 1968. This was the first occasion on which an opportunity was thus provided for the discussion of matters of common interest to Irish scholars and teachers at the higher educational level.

Over forty members, including representatives from all the universities, attended.

The following papers were presented:

Myles Dillon: Stories from Acallam na Senórach.

Dáithí Ó hUaithne: Foirm an fheagra sa Ghaeilge.

Brian Ó Cuív: Díochlaonadh an ainmfhocail sa Nua-Ghaeilge Chlasaicigh.

The following topics were discussed at three special sessions:

- (i) University courses in Irish;
- (ii) Research work and publications;
- (iii) Future co-operation.

A second symposium was held on March 21-2, 1969, to discuss the teaching of Irish at university level.

Special topics were:

An caighdeán Iontrála: principal speaker: An tOllamh Tomás de Bhaldraithe.

Caighdeáin agus Cúrsaí: principal speaker: An tOllamh Risteard Breatnach.

A more general discussion was introduced by An tAthair Pádraig Ó Fiannachta and An tOllamh Tomás Ó Máille.

The symposium was attended by over thirty members.

## 6. SUMMER SCHOOL

In April 1968 the Board decided that a Summer School of Celtic Studies would be held in 1969 and the work of organising the School has been proceeding satisfactorily. The School is to be held from July 14 to August 1 1969 and will include courses in Irish, Welsh, Breton and Mediaeval Irish History.

## 7. EXTERNAL ACTIVITIES

Professor Brian Ó Cuív broadcast from Radio Éireann on March 9, 1969 a Thomas Davis lecture entitled 'Ireland before the Invasion - Learning and Culture'.

Professor Myles Dillon delivered a lecture on 'The Indo-European Heritage of Celt and Hindu' at the University of Glasgow on February 26, 1969. He took part in a colloquium on place-names at the University of Nottingham from 28-31 March 1969.

Professor D. A. Binchy delivered the O'Donnell Lectures (2) on 'Celtic and Anglo-Saxon Kingship' in the University of Oxford on 23 and 24 May, 1968.

Professor David Greene broadcast from Radio Éireann a Thomas Davis lecture on 'The Founding of the Gaelic League'. He read a paper on 'The War Chariot in Early Irish Literature' to a conference on The Iron Age organized by the British Council for Archaeology. Both of these will be published.

Professor James Carney gave a discourse on 'The date and authorship of Saltair na Rann' to the Royal Irish Academy on 30 November 1968.

Dr. Gearóid Mac Niocaill gave a series of lectures on early Irish law at University College, Dublin at the request of the Dean of the Faculty of Law.

Donnchadh Ó Corráin broadcast from Radio Éireann a Thomas Davis lecture entitled 'Diarmait Mac Murchada'.

## 8. PUBLICATIONS

### (a) Books published by the Institute:

Johannis Scotti Eriugena Periphyseon (De Divisione Naturae).  
Edited by I. P. Sheldon-Williams. (Scriptores Latini Hiberniae  
Vol. VII) pp. ix + 269. Published July 1968. Price 50s.

Celtica Vol. VIII. Edited by Myles Dillon.  
pp. 258. Published October 1968. Price 30s.

The Poems of Taliesin. Edited by J. E. Caerwyn Williams.  
pp. lxviii + 176. Published November 1968. Price 12s.6d.

The Irish of Erris, Co. Mayo. By Éamonn Mhac an Fhailigh.  
pp. vii + 259. Published December 1968. Price 30s.

(b) Books published outside the Institute:

Brian Ó Cuív:

Éigse XII, Parts III and IV. Published by the National University of Ireland and edited by Brian Ó Cuív.

David Greene:

Cúirt an Mheán Oíche. Published by Cumann Merriman, Dublin, 1968.

James Carney and David Greene:

Celtic Studies - Essays in memory of Angus Matheson. Published by Routledge and Kegan Paul, London 1968.

Pádraig de Brún:

Journal of Kerry Archaeological and Historical Society No. 2, 1969, edited by Pádraig de Brún.

Roparz Hemon:

Historical Dictionary of Breton, Rann XIV. (Hiz-Izel). Published Etienne, Paris, August 1968. pp. 1301-1400.

(c) Contributions to Periodicals and other publications:

Brian Ó Cuív:

The Gaelic Cultural Movements and the New Nationalism. The Making of 1916. (Published by the Stationary Office, Dublin, 1969). 1-27.

A Colam Cille Dialogue. Éigse XII. 165-72.

Ranna Aoir - 1. ibid. 202.

Ranna Aoir - 2. ibid. 228.

Some Developments in Irish Metrics. ibid 273-90.

Reviews of Publications. ibid. 251-60, 347-8.

A poem attributed to Muireadhach Ó Dálaigh. Celtic Studies - Essays in memory of Angus Matheson. 92-98.

D. A. Binchy:

Mellbretha. Celtica VIII. 144-154.

St. Patrick's 'First Synod'. Studia Hibernica No. 8. 49-59.

Myles Dillon:

Lá dá raibh sé. Celtica VIII. 187-190.

An example of Phonetic and Semantic Mixture. ibid. 191-195.

The Semantic History of Irish Gal 'Valour; Steam'. ibid. 196-201.

David Greene:

A Satire by Cathal Mac Muireadhaigh. Celtic Studies - Essays in memory of Angus Matheson. 51-55.



David Greene (continued):

Some linguistic evidence relating to the British Church. Christianity in Britain 300-700, ed. Barley and Hanson. 75-86.

James Carney:

The Deeper Level in Irish Literature. Capuchin Annual 1969.

Two poems from Acallam na Senórach. Celtic Studies - Essays in memory of Angus Matheson. 22-32.

Rev. Pádraig Ó Súilleabháin, O.F.M.:

Varia. Éigse XII. 261-66.

A letter of Nicholas Slevin, 1817. Clogher Record 1968. 493-99.

Gearóid Mac Niocaill:

Bartholomaei Anglici de proprietatibus rerum liber octavus. Celtica VIII. 201-242.

The 'heir designate' in early medieval Ireland. Irish Jurist III 326-329.

Trí hÓrmharg (with M. Dolley). Éigse XII. 173-176.

The proportional method in dating Irish texts. Studia Celtica III 47-52.

Bibliographical notices of Irish texts. Bulletin Codicologique of Scriptorium XIII.

Pádraig de Brún:

Epitaph Aogáin í Rathaile. Éigse XII. 236.

Cnuasach d'fhilíocht Phádraigín Haicéad. ibid. 291-296.

Tuireamh Laidne ar Dáthí Ó Bruadair. ibid. 327-330.

Two eighteenth-century laments. Clogher Record 1968. 618-625.

An tAthair Brasbie. Journal of Kerry Archaeological and Historical Society No. 2. 38-58.

Charles O'Brien's agricultural survey of Kerry, 1800. ibid. No. 1. 73-100; No. 2. 108-132 (with M. G. Moyles).

Nessa Doran (Nessa Ní Shéaghda):

The word Aesán. Éigse XII. 199-201.

Notes on some scribal terms. Celtic Studies - Essays in memory of Angus Matheson. 92-98.

Review of Clár Lámhscríbhinní Gaeilge Choláiste Ollscoile Chorcaí: Cnuasach Thorna. Studia Hibernica No. 8. 172-173.

Anne O'Sullivan:

Contributions to a Dictionary of the Irish Language, Letter C, Fasc. 1. (with others).

Verses on Honorific Portions. Celtic Studies - Essays in memory of Angus Matheson. 118-123.

Anne O'Sullivan (continued):

A legal fragment (with Wm. O'Sullivan). Celtica VIII. 140-143.

The O'Moore poems in the Book of Leinster. ibid. 182-186.

Donnchadh Ó Corráin:

Studies in West Munster history: the Alltraighe. Journal of Kerry  
Archaeological and Historical Society No. 2. 27-37.

Report of the Governing Board of the School of Theoretical Physics, adopted at its meeting on 17th June, 1969.

1. ACADEMIC STAFF AND SCHOLARS

Professor Emeritus:

Cornelius Lanczos.

Senior Professors:

John L. Synge, Director of the School to January 1969  
Rev. James R. McConnell; appointed Director of the School January 1969  
Lochlainn S. O'Raifeartaigh; appointed October 1968.

Professors:

Yasushi Takahashi; resigned July 1968  
Lochlainn S. O'Raifeartaigh, to September 1968.

Visiting Professors:

Werner Israel; left July 1968  
Nandor Balazs; left September 1968.

Assistant Professor:

M. Misra; appointed October 1968.

Research Associates:

D. Judge; appointment to 30 September 1969  
P. S. Florides; appointment to 30 September 1969  
Rev. C. P. Ryan; appointment to 30 September 1969.

Scholars:

H. Efinger; left September 1968; M. Misra; to September 1968;  
I. Khan; F. Ando; P. Boyle; left September 1968; A. Singh;  
left September 1968; E. Massa; appointed October 1968;  
W. Montgomery; appointed October 1968; U. Niederer; appointed  
January 1969.

Student:

Rev. D. McCrea; to September 1968.

Technical Assistant:

Evelyn R. Wills.

2. STUDY AND RESEARCH

Professor Lanczos considered the hypothesis that the field equations of general relativity should be deducible from an action principle which is quadratic in the curvature quantities, an hypothesis which has been advocated many times. Using an improved mathematical technique, he was able to bring

the Lagrangian of the quadratic action principle into a form which allowed further conclusions. While nothing new arises if one considers the vacuum metric as a small modification of the Minkowskian line element, the intercalation of a strongly agitated lattice field as basic field permits us to understand the role of electro-magnetism in connection with the free vectorial function  $\varphi_L$ , which in Einstein's theory arises out of the freedom of coordinate transformations, whereas here it becomes identifiable with the electro-magnetic vector potential. This investigation was written up and submitted as a paper to the Journal of Mathematical Physics.

Professor Synge continued to work on equations of motion in general relativity. He published a paper on the application of the same method to statical systems. In the kinematics of particle interactions he defined a new canonical frame of reference based on the diagonalisation of the matrix of quadratic moments of the four 4-moments of the incoming and outgoing particles. This work will be published shortly.

Professor McConnell has been working with Dr. D. J. Simms on the preparation of material for a book on algebra designed for the use of physicists. He has continued the study of semi-simple Lie algebras of rank two, relating the method of weight diagrams with that of Young tableaux. He has examined the reduction of  $SL(4)$  under its subgroup  $C_2$  and constructed invariants for  $C_2$ . These investigations will be published shortly.

Professor O'Raifeartaigh continued his research, with Dr. S. J. Chang, on infinite component wave equations, and the results (that the wave equation considered by Gell-Mann et al. at the Heidelberg conference, definitely has spacelike solutions, and that these were coupled to the time-like solutions by the current, which means that this equation was actually unsuitable for physics) were published in Physical Review. He analyzed, with S. J. Chang and R. Dashen, the general Gell-Mann-Dashen scheme for saturating the current algebra with states of isospin  $\frac{1}{2}$  at infinite momentum, with the same negative results, which were submitted to Physical Review. Since his return to Dublin, Professor O'Raifeartaigh has been working with Dr. Niederer and Dr. Khan on the most general case, that is that in which the isospin is not restricted to be  $\frac{1}{2}$ . This work is still in progress.

Professor Takahashi generalized his method of field quantization to the case where there are particles with various masses (multi-mass fields). According to this method, the negative energy difficulty will not appear, contrary to the quantization based on the canonical formalism. He also applied the hyperquantization method to quantum electrodynamics and the Rarita-Schwinger-field.

Professor Israel continued his work on the following topics: (1) sources of the Kerr metric; (2) dynamics of thin shells in general relativity; (3) differential forms, complex vectorial formalism in general relativity; (4) gravitational collapse; (5) pulsars; (6) (working with Mr. V. de la Cruz) event horizons in very intense gravitational fields, including the problem of existence of regular event horizons in static electrovac space-time.

Professor Balazs investigated a number of problems in statistical mechanics, and in quantum theory, and prepared two of these investigations for publication.

Professor Misra was primarily interested in studying algebraically special fields.

Dr. Ryan continued his work on the theory of weak interactions, especially on the subjects of radiative processes and radiative corrections and of  $K_{L_3}$  decay.

Dr. Florides considered what the source of the Kerr metric may be, and what is the Kerr metric inside the source. He assumed, as is usual, that the two constants  $\underline{m}$  and  $\underline{a}$  appearing in the Kerr metric are of order  $\underline{k}^2$  and  $\underline{k}$ , respectively, where  $\underline{k}$  is a small dimensionless constant. The metric is then expanded in a power series in  $\underline{k}$ . He compared this series with the metric (again in series in  $\underline{k}$ ) of a steadily rotating sphere or shell obtained by the PS method, so far up to the order  $\underline{k}^3$ . To this order he has shown that there exists a coordinate system in which the two series are identical, and he has deduced therefrom that  $\underline{m}$  and  $\underline{a}$  of the Kerr metric are respectively the mass and angular momentum per unit mass of the sphere or shell. Also, since an interior solution for a sphere or a shell has already been found by

the FS method, we now automatically have a Kerr interior solution (up to order  $k^3$ ). Dr. Florides is at present examining the possibility of the fourth and fifth order terms of the metric in the above two solutions being equivalent.

Rev. Dr. McCrea devoted his time during the final months of his stay at King's College, London, to the study of axially symmetric fields with shell-type sources and the focussing of null geodesics emanating from such a source. This type of source was taken as a preliminary to treating the latter question in full generality. Up to the end of the period, the results were still inconclusive.

Dr. Efinger investigated and discussed a relativistic model theory of gravitating Dirac-particles. It was suggested to depart from the principle of general covariance, introducing a finite range for the gravitational field in order to obtain a proper mass-scale unit for elementary particles. This work was submitted for publication.

Dr. Ando's research was in the general area of high energy physics. He studied the finite-energy sum rules from various points of view, and found a new, simple derivation of them. He also studied the possibility of producing the Regge cut in the direct channel partial wave, by means of unitarity based on the Feynman propagator model. He found that the model, if modified with a finite width, could be used to produce a cut. This work will be sent for publication shortly.

Mr. Boyle worked on a method for the solution of Einstein's field equations in general relativity. This method uses Fermi coordinates throughout and proceeds by a series expansion of the metric and energy tensors. It can be used to find the gravitational field of certain stationary systems.

Dr. Niederer's main interest is in elementary particles and group theory. He and Dr. Khan are at present working together with Professor O'Raiifeartaigh on solutions of current algebra at infinite momentum for non-factored isospin.

Dr. Massa studied the cosmological problem in general relativity, in connection with the concept of horizon, and an analysis of Obler's paradox in the Robertson-Walker models. He is writing up these studies in a joint

paper with Professor Luzzatto (Genoa), which will be sent to Nuovo Cimento. He also studied the problem of motion in general relativity, and a possible formulation of Mach's principle. In special relativity he studied the representations of the Lorentz group, as described in the books of Naimark and of Gel'fand, Minlos and Shapiro. The latter work has also been written up and a paper for publication sent to Nuovo Cimento. Dr. Massa also began to study topology (Kelley), Algebra and group theory (Herstein, and Pontryagin) and quantum theory of fields (Bogoliubov and Shirkov).

Dr. Singh's study and research was concerned with the so-called Schwinger terms and the problem of inconsistencies in quantum field theory.

Mr. Montgomery investigated the kinematical properties of the S-matrix, using harmonic analysis on groups.

### 3. SEMINARS AND LECTURES

Review and Seminar lectures were held throughout the year, and as in previous years they 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 lectures were given:

- Professor D. A. Brown (U.C.D.): Molecular orbital theory of organometallic molecules.
- Dr. R. Cutkosky (Cambridge): Theory of analysis of scattering data.
- Professor C. P. G. Delaney (T.C.D): Electrical noise.
- Professor B. Gruber (St. Louis): On multiplicities for the classical group.
- Professor R. Hermann (Santa Cruz): Infinite-dimensional Lie algebras in quantum field theory.
- Professor W. Israel: Model for pulsating radio sources.
- Professor G. L. Kane (Michigan): Conspiracy and moving cut.
- Rev. Professor J. R. McConnell: Radiation damping (2 lectures).
- Rev. Dr. D. McCrea (U.C.D.): General relativistic ray optics.  
Ray optics and gravitational energy.
- Professor T. E. Nevin (U.C.D.): Recent experiments in relation to special relativity.
- Professor L. S. O'Raifeartaigh: Saturation of current algebras at infinite momentum (3 lectures).

- Dr. B. Renner (Cambridge): An extension of current algebra to  $SU_3 \times SU_3$  symmetry breaking.
- Rev. Dr. C. P. Ryan:  $K_{L_3}$  decay (3 lectures).
- Dr. D. J. Sutherland (Glasgow): Theory of  $\eta$ -decay.
- Professor J. L. Synge: Equations of motion in general relativity (2 lectures).
- Dr. P. Winternitz (Prague & Dubna): Group theory and Regge poles for pedestrians.
- Two-dimensional expansions in terms of the homogeneous Lorentz groups (3 lectures).

#### 4. STATUTORY PUBLIC LECTURE

A Statutory Public Lecture, under the auspices of the School, was delivered in Trinity College, Dublin, on 30 January 1969, by Professor McConnell. His subject was "Thinking in Physics throughout the Ages".

#### 5. VISITING PROFESSORS \*

Professor W. Israel (University of Alberta); left July 1968.

Professor N. Balazs (New York State University at Stony Brook); left September 1968.

#### 6. VISITORS TO THE SCHOOL \*

Professor G. L. Kane (Univ. of Michigan) from 6-10 May, 1969;

Professor B. Gruber (Univ. of St. Louis, Mo.) from 27-31 May, 1968.

Dr. J. Dardis (Office of Naval Research) on June 3rd, 1968.

Dr. D. J. Sutherland (Univ. of Glasgow) from 17-20 June, 1968.

Dr. P. D. McCormack (Dartmouth Coll., Hanover, New Hampshire) from June 11 - August 16, 1968.

Professor W. Yourgrau (Univ. of Denver) from 22-23 October, 1968.

Dr. P. Winternitz (Prague and Dubna) from 1-27 November, 1968.

Mr. P. C. Wegener (Univ. Coll. of Fort Harte, South Africa) from 11-19 December, 1968.

Professor R. Hermann (Univ. of California, Santa Cruz) from 4-6 March, 1968.

Dr. R. Cutkosky (Univ. of Cambridge) from 12-13 March, 1968.

Dr. B. Renner (Univ. of Cambridge) from 18-25 March, 1968.

\* For lectures given by Visiting Professors and other Visitors to the School, see § 3.



## 7. SYMPOSIA

Mathematical Symposia were held on April 10-11, 1968 and January 2-3, 1969. The attendances were 49 and 48, respectively; this included Professors, Lecturers, and Graduate Students from the several Irish Universities.

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

- April: Dr. T. T. West (T.C.D.): Compact semi-groups.  
Professor M. Kennedy (U.C.D.):  
The role of open sets in point-set topology.  
Professor P. M. Quinlan (U.C.C.):  
The biharmonic equation in a multiply-connected region.  
Dr. J. T. Lewis (Brasenose Coll. Oxford):  
Systems of imprimitivity.  
Professor P. D. Barry (U.C.C.):  
Some regularity theorems in function theory.  
Professor B. H. Murdoch (T.C.D.):  
Green's function on countable groups.
- January: Dr. P. Dolan (Imperial Coll. London):  
Singularities in general relativity.  
Dr. R. J. S. Crossley (York):  
Diagram techniques for angular momentum theory in quantum mechanics.  
Professor T. Kiang (D.I.A.S.):  
Some properties of the random distribution of points on a sphere found by Monte Carlo methods.  
Dr. A. M. Arthurs (York): Some variational principles.  
Dr. G. V. Kelly (U.C.C.):  
Some linear boundary value problems in applied mathematics.  
Dr. F. Holland (U.C.C.): Toeplitz and Hankel operators.

## 8. EXTERNAL ACTIVITIES

Professor Lanczos spent the months February to May, 1968, at Raleigh, North Carolina, at the joint invitation of the Dept. of Mathematics and the Dept. of Physics of the North Carolina State University. He gave a lecture course of three per week, attended primarily by members of the faculty and graduate students, under the title "Space through the ages". This course

dealt with the evolution of geometrical ideas from Pythagoras to Hilbert and Einstein, laying particular emphasis on the evolution of metrical geometry: the Greeks, Descartes, Gauss, Riemann, Einstein, and concluding with a discussion of abstract spaces (function space, Hilbert space, Banach space) and a short survey of projective geometry. The material of the course gave the background of a book entitled *Space through the Ages*, to be published by Academic Press, probably during 1969.

Professor Synge lectured in the University of Liverpool on "Can a massive body be set in rotation by internal stress?", on 9 May, 1968. He lectured on "Space-Time" on 12 February at Queen's University, Belfast, and on 28 February at University College, Dublin.

Professor McConnell was appointed a member of the Steering Committee of the European Physical Society, attending meetings at Prague on 3-4 May, and at CERN on September 12. He became a founding member of the Society on its establishment in Geneva on September 27. He was also appointed a *Miembro Corrispondiente* of the Instituto de Estudios Avanzados of Cordoba, Argentina. He was re-elected Secretary of the Royal Irish Academy on March 15, and retired from the position of Science Secretary.

Professors McConnell and O'Raifeartaigh, Drs. Khan and Ando, and Mr. Montgomery, attended the Oxford Conference on Elementary Particle Physics (Rutherford High Energy Laboratory) in December 1968.

Professor O'Raifeartaigh attended the Washington Meeting of the American Physical Society, and gave a talk at Temple University, Philadelphia, in April 1968. He visited and lectured at the Eighth Nobel Symposium at Aspen<sup>s</sup>gården (near GÖteborg, Sweden) in May, and the Conference on Elementary Particle Physics at Boulder, Colorado, in June. He visited the Argonne National Laboratory for July 1968. In October he gave the first Father Ingram Memorial Lecture to the Irish Association of Mathematics Teachers, in Dublin; he lectured at the Coral Gables (Miami, Florida) Conference on Elementary Particles in January, and at the State University of New York at Stony Brook. In February he lectured at Oxford University, at Imperial College, London, and at Cambridge University, and in March at the University of Birmingham.

Professor Takahashi visited the Nuklearni Institut "J. Stefan", Ljubljana, Yugoslavia, from May 20 to 24, and gave a lecture there on "Can fundamental particles obey statistics other than Bose and Fermi?", and a course of five lectures on "Quantum theory of fields". He also lectured at the University of Zurich on May 27 on "Hyperquantization".

Professor Balazs lectured, on the theory of lasers, at the University of Lund, the Niels Bohr Institute, Copenhagen, and at NORDITA, Copenhagen, the Eidgenössische Technische Hochschule, Zurich, the University of Rome and the University of Cambridge, during April and May, 1968.

Dr. McCrea spent the week May 13-20 at the University of Louvain, on the invitation of Professor Speiser. While there he gave two formal lectures on gravitational radiation - one on the application of the DFS method to this problem, and the other on the asymptotic properties of the radiation field in first approximation.

Dr. Judge went to the University of Alberta, Edmonton, in October 1968 for the academic year 1968-69.

Dr. Ryan visited the École Polytechnique, Paris, in April 1968, and gave a seminar on "Present problems in weak interaction theory". He visited the American University of Beirut from May 20 to June 4, and spent two months as a Visitor at the International Centre for Theoretical Physics, Trieste, from June 21 to August 21. He also attended the Conference on Weak Interactions, at CERN, in January 1969.

Dr. Ando attended the Conference on Current Algebras and Particle Physics held at the University of Karlsruhe, from July 22 to August 2, and also gave an informal talk at Trinity College, Dublin, on November 29, on Finite energy sum rules, duality and crossing symmetry.

Dr. Massa gave three lectures at the University of Genoa in February 1969 on some topics in general relativity. He also gave an informal talk on Mach's principle at Trinity College, Dublin, on December 17.

9. PUBLICATIONS

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

(1) Books:

Published:

- \* Numbers without end. By C. Lanczos. Oliver & Boyd, Edinburgh. 1968. Contemporary Science Paperbacks, no. 22.
- \* Particles and fields. By David Lurié. Interscience Publishers, 1968.

In the press:

- \* An introduction to field quantization. By Y. Takahashi. Pergamon Press.
- Space through the ages. By C. Lanczos. Academic Press.
- Theory of weak interactions in particle physics. By R. H. Marshak and C. Ryan. Wiley.

(2) Communications of the Dublin Institute for Advanced Studies, Series A (Physics):

None published.

(3) Contributions to periodicals and other publications:

Published:

C. Lanczos:

Boundary value problems and the algebraic method. Coll. Internat. Centre Nat. Rech. Sci., no. 165: Programmation en mathématiques numériques, Besancon, 1966. Eds. Centre Nat. Rech. Sci., Paris, 1968, pp. 205-15.

Variational principles. Mathematical methods in solid state and superfluid theory. Scottish Universities' Summer School, 1967, Ed. R. Clark and G. H. Derrick. Oliver & Boyd, Edinburgh, 1969, pp. 1-45.

J. L. Synge:

\* Jets of radiation. Quart. Appl. Math. 26 (1968), 153-65.

\* Special theory of relativity. Nature 219 (1968), 793.

\* Review of "The logic of special relativity" by Prokhovnik, Cambridge Univ. Press, 1967. Proc. Phys. Soc. 2A (1969), 131.

Ireland - The Dublin Institute for Advanced Studies. Nature 218 (1968), 838-40.

Statistical gravitational fields in second approximation. Proc. RIA 67A (1969), 47-66.

L. O'Raifeartaigh:

- \* Analysis of the Gell-Mann-Dashen angular momentum condition for the isospin-factored case. Relativistic symmetries and analyticity. Proceedings of the Eighth Nobel Symposium, Aspenäsgränden, Lerum, Sweden, 1968. Ed. by N. Svartholm. Almqvist and Wiksell, Stockholm / Wiley, New York, 1968, pp. 257-62.
- \* A brief survey of recent algebraic approaches to particle physics. Symmetry principles at high energy. Proceedings of the Fifth Coral Gables Conference, Eds. A. Perlmutter et al., Benjamin, New York, Amsterdam, 1968, pp. 49-85.
- \* Broken symmetry. Group theory and its applications. Ed. E. Loebl. Academic Press, London and New York, 1968, pp. 469-539.

L. O'Raifeartaigh & A. Bohm:

- \* A mass-splitting theorem for general definitions of mass. Phys. Rev. 171 (1968), 1698-1701.

S. J. Chang & L. O'Raifeartaigh:

- \* Coupling of space-like and time-like wave-functions at infinite momentum. Phys. Rev. 171 (1968), 1587-90.

S. J. Chang, J. Kuriyan & L. O'Raifeartaigh:

- \*  $SL(2, C)$  in an infinite momentum basis and calculation of form factors. Phys. Rev. 169 (1968), 1275-77.

S. Komy & L. O'Raifeartaigh:

- \* Some properties of ladder operators. J. Mathl. Phys. 9 (1968), 738-44.

S. J. Chang & L. O'Raifeartaigh:

Unitary representation of  $SL(2, C)$  in an  $E(2)$  basis. J. Mathl. Phys. 10 (1969), 21-29.

Spacelike solutions of infinite component wave functions. Phys. Rev. 170 (1968), 1316-9.

S. J. Chang, R. Dashen & L. O'Raifeartaigh:

Saturation of the isospin-factored current algebra at infinite momentum. Phys. Rev. Lett. 21 (1968), 1026-9.

Y. Takahashi:

- \* Normalization of the Bethe-Salpeter wave function. MATSCIENCE Symposia in Theor. Phys., Vol. 6 (1968), Plenum Press, New York, pp. 97-101.
- \* Non-Lagrange theories and generalized conservation laws. MATSCIENCE Symposia in Theor. Phys., Vol. 6 (1968), Plenum Press, New York, pp. 103-109.

D. Lurié:

- \* Topics in bound state theory. Lectures in high energy physics, given at American Univ. of Beirut, 1967. Ed. H. H. Aly. Interscience, 1968. pp. 119-225.

N. L. Balazs:

The radiation of a charge under the influence of a constant external force. Proc. RIA 67A (1968), 15-25.

W. Israel:

\* Event horizons in static electrovac space-times. Comm. Math. Phys. 8 (1968), 245-60.

Model for pulsed radio sources. Nature 218 (1968), 755-6.

Pulsar conditions in white dwarf stars. Nature 218, 1235-6.

V. de la Cruz & W. Israel:

\* Spinning shell as a source of the Kerr metric. Phys. Rev. 170 (1968), 1187-92.

M. Misra:

\* Type null vacuum solutions in general relativity. J. Mathl. Phys. 9 (1968), 1052.

F. Cooperstock:

\* The interaction between electromagnetic and gravitational waves. Ann. Phys. 47 (1968), 173-81.

J. Waddell:

\* An empirical determination of the continuum source function in the solar photosphere. Astrophys. J. 152 (1968), 577-92.

I. Khan:

\* The principle of reciprocity and equivalence of monads and their implications. Nuovo Cim. 57B (1968), 321-9.

In the press:

C. Lanczos:

The quadratic action principle of relativity. J. Mathl. Phys.

J. L. Synge:

On the kinematics of particle interaction. Proc. Roy. Soc.

J. R. McConnell:

The general linear group  $GL(4)$  and the Lie group  $C_2$ . Proc. RIA.

Reflections on physical theories. Phil. Stud.

W. Montgomery, L. O'Raiheartaigh & P. Winternitz:

Two variable expansion of relativistic amplitudes and subgroups of  $SU(2,1)$ . Nuclear Phys.

Y. Takahashi:

\* Quantization of higher spin fields. Boulder Summer Inst., Univ. of Colorado, 1967. Univ. of Colorado Press.

Method of hyperquantization. II. Nuclear Phys.

N. L. Balazs:

One dimensional band theory in the WKB approximation.  
Ann. Phys.

On the reduction of images of the Fermi surface. Proc. RIA.

M. Misra:

On the generalized Goldberg-Sachs theorem. Nuovo Cem. Lett.

H. Efinger:

On flat gravitation as a useful model theory. I and II.  
Physica.

An instructive model for the quantization of magnetic  
monopoles. Amer. J. Phys.

IV. Report of the Governing Board of the School of Cosmic Physics adopted at its meeting on 22nd September, 1969.

A. Astronomical Section

1. STAFF AND SCHOLARS

Senior Professor

P. A. Wayman

Professor

T. Kiang

Research Assistant

I. Elliott (on unpaid leave of absence until August 1968).

Experimental Officer

B. D. Jordan

Technical Assistant

D. Fitzsimons (from 1 June 1968).

Junior Technical Assistant

Miss A. Downey (from 1 June 1968).

Clerk

Miss M. Callanan

Technician

R. P. Murphy

Scholars

C. J. Butler; A. D. Andrews (without stipend). From 1 October 1968;  
J. K. Brady; M. V. Norris.

Dr. Elliott returned from Sacramento Peak Observatory in August 1968.

Mr. M. V. Norris (U.C.D.) and Mr. J. K. Brady (U.C.D.) were appointed as Scholars in October 1968 and have been registered as candidates for higher degrees.

Mr. Fitzsimons and Miss Downey were appointed on 1 June, 1968 to two newly-created posts as Technical Assistant and Junior Technical Assistant, respectively.



J. Sutton (U.C.D.), Fr. D. O'Grady S.J., and G. Nadler (San Diego) worked as vacation students during July, August and September, 1968 for a total of eight weeks.

Professor Wayman served on the Council of the Royal Astronomical Society throughout the year, continued as External Examiner in Astronomy at Queen's University, Belfast, and was appointed Chairman of the newly-formed National Committee for Astronomy of Ireland.

## 2. RESEARCH WORK

Solar Research: I. Elliott - Including work carried out at the Sacramento Peak Observatory 1967, July - May 1968.

During 1968 an observational programme for obtaining atmospheric "filtergrams" was carried out jointly with J. M. Beckers, using a tunable H $\alpha$  filter with 0.25Å bandpass. Eight sequences, at seven pre-selected wavelengths, lasting from 20 to 56 minutes, were secured at times of good "seeing". A second birefringent filter was used to take simultaneous solar photographs in the K-line with a bandpass of 0.17Å. This material will be used to study the three-dimensional distribution of light intensity and velocity in the solar chromosphere and its relation to the K-line brightness.

Sequences of chromospheric spectra obtained in 1963 and 1967 were recorded with the automatic microdensitometer at Sacramento Peak and preliminary computing work was done with the SDS Sigma 5 computer there. Fast Fourier techniques are now being developed for use with the Dunsink IBM 1620 and other electronic computers in Dublin.

Photometry of Stars: P. A. Wayman, C. J. Butler, A. D. Andrews, M. V. Norris.

The computer programmes for reduction of iris photometer readings to stellar magnitudes have been developed and modified. By the use of running-means it has been possible to diminish inaccuracies due to the use of polynomial approximations but dealing with the magnitude-dependent colour terms proved impractical using least-squares techniques. The programmes have now been largely standardised and have been used on a variety of observational material. Fortran IV versions have been written of some programmes for use

on the IBM 360 computer at Trinity College, Dublin, and on the ICL 1905 computer at the Dept. of Finance, Stormont.

Reductions were completed for the UBV photographic photometry of 68 Small Magellanic Cloud plates obtained with the ADH telescope at Boyden Observatory in 1965 and 1966. Periods were found for 71 of the Cepheid variables measured. A preliminary period-luminosity relation has been deduced and it is found that a critical examination of small differences from the results of Arp and of Gaposchkin is possible. Work on similar measurement and reduction for 160 variable stars in the Large Magellanic Cloud has been started and periods of about 55 of the variables have so far been obtained. When the UBV plates have been finally reduced for variables in both Clouds it will be possible to make a direct and detailed comparison. Various methods of estimating the reddening have been employed but direct work on the colours of the OB stars in the same regions has not proved as satisfactory as would be required.

The extended photoelectric sequences in the Magellanic Clouds have enabled an investigation to be made of the objective grating technique for extending the magnitude scale beyond the photoelectric limit. Measurements of 6 plates in the LMC showed that the grating should be calibrated over the magnitude range desired. The grating method has also been used (by Andrews) in a discussion of the mean magnitudes and colours of 68 flare stars in the Orion region.

Work on the stellar content of NGC 371 in the Small Magellanic Cloud has been started.

Objective Prism Spectra: C. J. Butler, M. V. Norris.

Objective-prism ADH plates taken through a neo-dymium chloride filter are being used in a preliminary study concerned with the separation of members and non-members of the Magellanic Clouds. The criterion is the radial velocity shift of stellar absorption lines with respect to the NdCl bands. Densitometer tracings of the spectra are measured on a digital reading device. Results have indicated a successful separation of the stars into two velocity groups.

Statistical Astronomy: T. Kiang; J. K. Brady.

The statistical study of the orientation of the orbital planes of double stars has been extended to include edge-on systems. Possible connection with the Gould Belt, hitherto neglected, is given special attention. Besides previously-known methods, a new analysis on the distribution of position angles in different parts of the sky has been applied to the 64,000 systems in the 1963 Index Catalogue of Double Stars, using the ICL 1905 computer of the Royal Greenwich Observatory, where the data are available on magnetic tape.

The study of the random distribution of points on a sphere is nearing completion, awaiting the numerical output of a computing run.

Possible coincidences have been investigated between pulsars and ancient Chinese observations of "guest stars". As far as observed positions are concerned, a number of likely identifications can be made.

Haro Galaxies with Jets: T. Kiang.

Following a contribution on this subject to the Herstmonceux Conference in April, 1968, arrangements were made, through the Large Telescope Users' Panel of the U.K. Science Research Council, to use the 98-inch Isaac Newton Telescope for a total of fifteen half-nights in February and March 1969. Only a few hours of clear skies occurred during the scheduled time and no useful results were obtained because the "seeing" was not sufficiently good during those few hours.

Electronics Laboratory: B. D. Jordan.

Development work on the flying-spot scanner system for a video comparator continued. The construction of the scanning units and various power supplies was completed; also modifications to a commercial EHT supply to enable it to provide power for the flying-spot tube. The focus-alignment and astigmatic-control unit for the flying spot tube was constructed, also a pulse amplifier for supplying blanking pulses to the monitor display. All these units were mounted together to provide a single-channel television display in a bench optical system. The optical and electrical characteristics of the apparatus were found to be capable of producing high-quality

representation of photographic images. Work was started on the design of the two-channel system with a differential video amplifier.

#### Miscellaneous

Various minor items of work were carried out with the 1620 computer, including the production of lighting-up times for the Garda Siochana, following the introduction of Standard Time, a comparison of archaeological orientations (stone circles) with astronomical data, and development of methods of integrating differential equations.

Seven lunar occultations of stars were observed in 1968 and the results reported to H.M. Nautical Almanac Office. Six of these were reported back with residuals, after removal of limb correction, of less than  $0''.3$ , as compared with the standard moon tables.

#### 3. INSTRUMENTS, ETC.

Purchased equipment included a Brandenburg EHT power supply and a Prowest Television Monitor. No change was made in the computer installation. Extension of the basement area has provided four new rooms totalling about 500 sq. ft. for laboratory and darkroom equipment.

#### 4. LECTURES, CONFERENCES, ETC.

Professor Kiang attended the Herstmonceux Conference in 1968 and presented an account of his discovery of faint jets in Haro galaxies.

Professor Wayman attended a meeting on the use of large optical telescopes in Cambridge, England, in August 1968. He also described work on the Cepheid variables in the Magellanic Clouds at Leicester University Astronomy Department and at Cambridge University Observatory, in February 1969.

#### 5. PUBLICATIONS

P. A. Wayman:

A Method of distinguishing Magellanic Cloud Membership.  
IAU Symposium No. 30, 1967, p. 89.

The South Telescope at Dunsink Observatory.  
Irish Astronomical Jour. 8, 274, 1968.

S. M. P. McKenna:

Astronomy in Ireland from 1780.  
Vistas in Astronomy, 2, 283, 1968.

T. Kiang and W. C. Saslaw:

The Distribution in Space of Clusters of Galaxies.  
Mon. Not. R.A.S. 143, 129, 1969.

T. Kiang:

Reduced Counts of Galaxies along Galactic Co-Ordinates.  
Dunsink Observatory Publications Vol. 1, No. 5, 1968.

I. Elliott:

Power Spectra of H $\alpha$  Doppler Shifts.  
Solar Physics, 6, 28, 1969.

The Solar Balmer Lines.  
Thesis, University of Dublin, 1967. (University Microfilms,  
(Ann Arbor) 68-17, 557).

C. J. Butler and P. A. Wayman:

Use of an Objective Grating with Iris Diaphragm Photometry.  
The Observatory, 89, 109, 1969.

The IBM 1620 Computer at Dunsink Observatory.  
Irish Astr. Journ. 2, 1, 1969.

B. Cosmic Ray Section.

1. STAFF AND SCHOLARS

Senior Professor:

C. O Ceallaigh.

Professor:

K. Imaeda.

Assistant Professor:

M. Kazuno.

Research Assistants:

Dr. A. Thompson; Dr. D. O'Sullivan.

Technical and Clerical Staff:

Miss A. Madden; Dr. J. Daly; Miss N. Leahy (to 22 November, 1968);  
Miss A. Smyth (to 29 November, 1968); Miss D. Molloy; Miss E. Byrne;  
Miss G. Doyle; Miss L. Rogers (to 29 November, 1968); Mrs. J. Seguin  
(from 2 December, 1968 to 3 January 1969); Miss M. Ryan (from 9  
December, 1968); Miss E. Kee (from 7 January 1969); Miss P. Batt  
(from 10 February, 1969).

Scholars:

T. Cantwell; P. Fleming; A. Curran (from 1 October, 1968).

2. RESEARCH WORK

European  $K^-$  Collaboration: T. Cantwell (with others).

A nuclear emulsion stack was exposed to  $5 \times 10^6$  stopping  $K^-$  mesons at the Brookhaven accelerator in January 1968. The development of the stack was carried out at CERN. The scanning of the material, which commenced in April 1968, is still in progress.

The main priority of the experiment is to determine the binding energies of mesic hypernuclei of mass numbers greater than or equal to five, and to study the excited states of hypernuclei which have a primary star configuration of the type:  $\pi + 1 + \text{HF} (\pi - R \text{ or } \pi + 3, 4)$ . It is hoped to increase the present world statistics for these events by a factor of six. It is also planned to extend the excited state analysis as suggested in the Nathalie stack and to study final state interactions.

Due to the greatly increased statistics, it will be possible to obtain more accurate values of the masses of the  $\Sigma^{\pm}$  hyperons and, if observational biases can be overcome, to measure their lifetimes as well. The binding energy determination of  ${}^3_{\Lambda}\text{H}$  will be continued in this work as well as the  $Q^-$  ratio of  ${}^{\Lambda}\text{B} - {}^{\Lambda}\text{C} - {}^{\Lambda}\text{N}$  hypernuclei. It is also hoped to investigate in some detail the problems concerning the Range-Energy relation and the binding energy difference between  ${}^4_{\Lambda}\text{H}$  and  ${}^4_{\Lambda}\text{He}$ .

C. O Ceallaigh, A. Thompson and D. O'Sullivan.

A second batch of plastic material was flown successfully at a height of  $3 \text{ gm/cm}^2$  at Fort Churchill, Canada, in August 1968 and has been examined during the year. In order to obviate the effects of 'fading' of the tracks due to annealing of the plastic, a modified etching procedure using ethanol + water at  $23^{\circ}\text{C}$  was tried. It was found, however, that the identification of nuclear species in the plastics had a marked dependence on the dip angle of the tracks. Consequently, a further batch was etched for 160 hours at  $40^{\circ}\text{C}$ , instead of the original 8 Hours at  $70^{\circ}\text{C}$  which had led to difficulties due to annealing.

Various theoretical models have been used to explain the observed variation of cone-length as a function of residual range. One such assumption was that the rate of etching at any point along the track depends on the primary or restricted ionization of the charged particle at that point. Using the well-known Bethe-Bloch expression in conjunction with various plausible assumptions as to how the etching-rate varied with ionization, a family of curves was drawn expressing cone-length as a function of residual range, one for each nuclear species. The position of particles of given  $Z$  and  $A$  was anchored to the observed cone-lengths using  ${}^{16}_{\text{O}}_8$  and  ${}^{20}_{\text{Ne}}_{10}$  ions from the Yale Heavy Ion Accelerator. A sample of some 500 stopping cosmic-ray primary particles has been analysed using the curves referred to, taking into account in addition, the position of the well-known iron peak in that spectrum. Good separation of the various constituents of the primary cosmic ray spectrum was achieved, but the predicted slopes of the cone-length-residual range curves showed various departures from the experimental points.

Accordingly, it is planned to consider the effect of using various other expressions for the ionization, notably those of Katz and Kobetich in order to see if the fit can be improved.

It is also planned to institute a close collaboration with Professor P. H. Fowler at Bristol who has put forward evidence, using the nuclear emulsion technique, for the existence of transuranic elements in the primary cosmic ray spectrum. The main aim of such a collaboration would be to compare the charge-spectra predicted by the independent techniques of plastic detectors and nuclear photographic emulsion.

K. Imaeda.

The study of the "fireball-isobar" model of meson multiple production has been carried out using a statistical-thermodynamical theory of a hadron gas. The theory has succeeded in predicting the existence and the stability of fireballs observed in cosmic-ray jets. It has been shown that whenever the temperature of hadron gas exceeds the critical temperature, - the "boiling point of hadrons" (Hagedorn), - a hadron gas starts to condense forming hadron liquid drops or fireballs. The above ideas have been used to interpret the observed characteristics of cosmic-ray jets.

K. Imaeda and P. Fleming.

(a) The azimuthal angle distribution of the secondary particles of cosmic-ray jets has been studied. Applying a new formula which relates the azimuth asymmetry to the transverse velocity of a fireball or an isobar emitted in a jet, the transverse momenta of fireballs and isobars have been estimated using an auto-correlation function calculated from the angles of the secondary particles. The upper limit of the transverse momentum of fireballs was estimated to be  $\sim 3.0 \text{ GeV}/c$ .

(b) Nucleus-nucleus collisions have been studied. The study has advantages over that of nucleon-nucleon collisions in respects of statistics of small bias and that of mono-energetic primaries which are very infrequently observed in cosmic-ray experiments. The reason for this is that it is a nucleus-nucleus collision and may be considered as a superposition of many nucleon-nucleon collisions in certain aspects.



It has been shown that the number of the isobar decay products increases very slowly with the primary energy but the number of fireball mesons increases much faster than that expected from the nucleon-nucleon collisions at the primary energy  $10^{12}$  eV per nucleon.

K. Imaeda, M. Kazuno, A. Curran, P. Fleming.

Data from about 700 cosmic ray jets with energy from  $5 \times 10^{10}$  eV to  $10^{14}$  eV produced in nuclear emulsion has been collected both from published papers throughout the world and from the Dublin part of ICEF (International Collaboration Flight) stack. The values of various quantities characteristic of the jets have <sup>been</sup> estimated by A. Curran using the 360 T.C.D. computer. To establish an empirical law of multiple particle production at very high energy, the characteristic features of jets such as the multiplicity distribution, the energy distribution of the primaries, the angular distribution of secondaries and the four-momentum distribution have been studied.

M. Kazuno.

(a) Further investigation on the characteristic difference between  $\pi$ -N and N-N interactions at cosmic ray energy region has been carried out. Besides the appreciable difference in physical quantities between them, the difference of primary energy dependence of isobar-pionization link is observed. It was demonstrated by the cutoff method, that the link between Isobar system and Pionization system of  $\pi$ -N interactions seems very weak while the contrary appears to hold for N-N interactions.

(b) A kinematical analysis was made on particles emitted in the group comprising the largest angles in lab. system. A concept, generally accepted, that a particle emitted in the group of largest angles is a recoil target particle was excluded. Taking into consideration the formation and decay of target isobars, the average mass of target isobars has been computed from the experimental data. For interactions of  $< 10^{12}$  eV the average mass of target isobar does not exceed 2000 MeV, while for those of  $> 10^{12}$  eV, the average mass is expected to be 5200 MeV.

A. Curran.

Data from over 500 high energy cosmic ray reactions was prepared in

computer form for statistical analysis. IBM 360 programs were written to obtain information, not previously accessible on certain characteristics of ultra high energy nuclear reactions. The predictions of the fireball model were compared with experimental observations. A first attempt was made, using a large computer, to resolve the controversial question of azimuthal anisotropy in interactions at extreme high energies.

### 3. WORKSHOP

Mr. Daly has completed the fitting of the three Leitz Ortholux microscopes in the plastics laboratory with magnetic transducers. These devices generate from motion along the Z-coordinates (position in depth in the plastics), a signal which actuates a digital voltmeter. The device is virtually free from the lack of linearity which has been a troublesome feature of the dial gauges previously used. The precision of measurement of depth appears to be of the order 0.1  $\mu$ m. The devices have been calibrated over the working range of the instruments by an improved interferometer constructed by Mr. Daly in terms of the mercury line of wave-length 0.5461  $\mu$ m. The usual maintenance work on the scanning microscopes was carried out throughout the year.

### 4. CONFERENCES AND COMMITTEES

The following International Conferences and Collaboration Meetings have been attended by members of the Section:

Conference on Chemical Composition of Cosmic Rays, Cambridge, 16-19 July, 1968 (D. O'Sullivan and A. Thompson).

Symposium to mark the 20th Anniversary of Return to Italy of Professor G. P. S. Occhialini, 9-10 October, 1968 (C. O. Ceallaigh).

International Conference on High Energy Nuclear Physics, Vienna, 27 August-6 September, 1968 (A. Thompson).

K<sup>-</sup> Collaboration Meeting, Brussels, 30 September-4 October, 1968 (A. Thompson and T. Cantwell).

$K^-$  Collaboration Meeting, London, 23-29 March, 1969 (T. Cantwell).

A meeting of the  $K^-$  Collaboration was held in Dublin, 14-17 May, 1968, and was attended by delegates from all Laboratories involved.

Visits to Laboratories:

D. O'Sullivan worked in connection with the Dublin-Schenectady Collaboration at the Research and Development Center of the General Electric Company during the period 29 August-15 November, 1968. C. O Ceallaigh visited the H. H. Wille Physical Laboratories, University of Bristol on 31 January, 1969, for the purpose of arranging a collaboration with Professor P. H. Fowler F.R.S., on the spectrum of heavy and ultra-heavy cosmic ray primary particles. T. Cantwell worked at University College London for the period 6-12 January, 1969, in connection with the  $K^-$  Collaboration.

Physics III Meetings at CERN, Geneva were attended by Professor O Ceallaigh on the following dates: 24 April, 16 October, 1968, and 29 January, 1969.

5. PUBLICATIONS

A. Thompson (and others):

The Production of Hypernuclei by the absorptions of  $\Sigma^-$  Hyperons at Rest in Emulsion Nuclei. Bulletin de l'Institut de Physique de l'Universite Libre de Bruxelles, no. 39 (1969).

C. O Ceallaigh, D. O'Sullivan and A. Thompson (and P. B. Price, R. L. Fleischer and D. D. Peterson, General Electric R & D Center, New York):

High Resolution Study of Low-Energy Heavy Cosmic Rays with Lexan Track Detectors. General Electric R & D Center Report no. 68-C-232 (1968) and Phys. Rev. Lett. 21, 630 (1968).

C. O Ceallaigh, D. O'Sullivan and A. Thompson (and P. B. Price, R. L. Fleischer and D. D. Peterson):

Plastic Track Detectors for Identifying Cosmic Rays. Canadian Journal of Physics 46, S1149 (1968).

D. O'Sullivan (and others):

The  $\pi^+$  Mesonic Decays of Light Hypernuclei. Nuclear Physics B9, 1 (1969).

E. Imaeda:

An Interpretation of Cosmic-Ray Jets. Canadian Journal of Physics 46, S722 (1968).

M. Kazuno:

Isobar Process and Landau Process in Cosmic-Ray Jets.  
Nuovo Cimento 56A, 1 (1968).

In the Press:

A. Thompson and T. Cantwell (and others):

Production of Hypernuclei from the Interactions of 10.1 GeV/c  $K^-$  Mesons with Emulsion Nuclei. Nuovo Cimento.

A. Thompson (and others):

Hypernucleus and Cryptofragment Production from the Interactions of  $E^-$  Hyperons at rest with Emulsion Nuclei.  
Acta Physica Polonica.

K. Imaeda and P. Fleming:

Azimuth Angle Distribution of the Secondary Particles of Cosmic-Ray Jets. Nuovo Cimento.

M. Kazuno:

Characteristic Difference of  $\pi$ -N and N-N Interactions at Cosmic-Ray Energy Region. Nuovo Cimento.

In Preparation:

C. O Ceallaigh, D. O'Sullivan and A. Thompson (and P. B. Price, R. L. Fleischer and D. D. Peterson, General Electric R. & D. Center, New York):

Composition of Cosmic Rays of Atomic Number 13 to 30.  
To be delivered at the 11th International Conference on Cosmic Rays, Budapest, Hungary, August 1969.

D. O'Sullivan (and others):

The Non-Mesonic Decay of Helium Hypernuclei.

On the Lifetime of the  ${}^3_{\Lambda}H$  Hypernucleus.

P. Fleming and K. Imaeda:

Multiple Particle Production in Collisions of Heavy Cosmic-Ray Nuclei with Light Nuclei in Emulsion. To be delivered at the 11th International Conference on Cosmic Rays, Budapest, Hungary, August 1969.

A. Curran, P. Fleming, K. Imaeda and M. Kazuno:

A Study of the Characteristic Features of Cosmic-Ray Jets of Energy from  $5 \times 10^{10}$  eV to  $10^{14}$  eV in Emulsion. To be delivered at 11th International Conference on Cosmic Rays, Budapest, Hungary, August 1969.

K. Imaeda:

Statistical Thermodynamics of Hadron Gas and the Interpretation of Multiple Particle Production.

M. Kazuno:

Kinematics and Dynamic of Secondary Particles emitted at largest angle in Cosmic-Ray Jets.

C. Geophysical Section.

1. STAFF AND SCHOLARS

Senior Professor:

T. Murphy.

Professor:

Vacant.

Research Assistants:

R. F. Riddihough; D. G. G. Young.

Senior Technical Assistant:

F. J. Morley.

Technical and Clerical Staff:

Miss A. Byrne; Miss E. Byrne (to 30 May, 1968); Mrs. J. Gosling (from 1 July, 1968); Miss E. Ryan (from 1 October, 1968); K. Bolster; J. Fay.

Scholars:

I. Dixon; C. P. English; A. W. B. Jacob (to 31 December, 1968); P. Morris; K. W. Robinson.

2. RESEARCH WORK

(a) Gravity and magnetic fieldwork:

Drs. Riddihough and Young continued gravity and magnetic surveys of Co. Donegal completing the magnetic coverage of the Slieve League peninsula. Their study of the diapiric granite at Ardara was thus brought to a close and the data have been collected for publication. They found, as they expected, that the magnetic anomaly corresponding to the granite is of annular form, a positive anomaly surrounding a central flat area. Elsewhere the general magnetic survey detected a magnetic structure beneath the exposed Dalradian.

The gravity anomaly deduced from the survey shows a domination of the various granite masses which give negative anomalies. Elsewhere the magnetic and gravity anomalies are complementary in that the gravity field confirmed the magnetic picture of the sub-Dalradian basement structure. Apart from the granite masses the gravity picture cannot be simply related to the surface geology.

A detailed gravity survey was carried out (Murphy, Young, English and Robinson) in conjunction with a mineral prospecting company - Anglo United Development Corporation - near Rathangan, Co. Offaly. The object was to detect, if present, any decomposition of the underlying but hidden limestone which was about to be explored by drilling. No unusual effects were detected and confirmation of our speculations is awaited.

Messrs. English and Robinson, working in partnership carried out gravity and magnetic surveys in two separate areas. One, in the south, consisted of a trial survey across the frontal belt between the Old Red Sandstone and the Carboniferous formations. The magnetic results showed very small variations while the gravity effects are rather complicated, particularly by the presence of extensive decomposition of certain strata in the lower Carboniferous, so that a considerable amount of additional work would be necessary before the structure can be elucidated. The other area was contiguous to the one investigated by English in previous years but unfortunately because of a defect developing in the gravimeter the work was curtailed and had to be postponed. The results to date are most encouraging.

Mr. Robinson carried out a detailed magnetic survey of Lambay Island and the adjacent mainland. The field as measured is quite complicated but it is yielding to analysis.

(b) Magnetism:

Dr. Riddihough continued his study of the magnetic diurnal variations into greater depth and prepared the results for publication. These confirm the preliminary results of last year showing that the diurnal variation follows a repeating geographical pattern of time and amplitude which contrasts considerably with a dependence upon local time hitherto assumed. They exhibit features not unlike those predicted theoretically by Roden for the effect of an ocean edge.

Cambridge University, who had been carrying out a similar investigation of shorter period magnetic variations, approached us with a view to extending their investigations to Ireland. Collaboration was arranged whereby we operated four fluxgate magnetometers at a series of meteorological stations

here. The data are being analysed by Fourier Analysis at Cambridge.

Following from his study of the diurnal variation Dr. Riddihough drew up, for internal use, a series of notes for the instruction of field parties on magnetic surveys. Because of outside interest these notes were redrafted and published as a Bulletin. Based on these Mr. Robinson drew up a scheme using the coordinate digitizer and computer so that field data and variometer records from Valentia Observatory can be processed expeditiously.

(c) Meteorology:

Routine observations of the meteorological elements were continued throughout the year and the autographic records tabulated.

The solarimeters were calibrated with the assistance of the Meteorological Service at Valentia Observatory and continuous solarimeter recordings commenced which give a more accurate estimate of the insolation.

(d) Seismology:

Mr. Jacob completed his studies and presented his findings in a thesis for the degree of Ph.D. These can be summarised as follows:-

- 1) The average crustal thickness along the Valentia-Eskdalemuir line is between 25 and 30 km.
- 2) Confirmation of a low velocity layer for S waves in the mantle at a depth of approximately 50 km.
- 3) Anisotropy between SV and SH of about 5% seems to be present in the depth range 10-50 km.
- 4) No anisotropy was found in the Upper Mantle low velocity layer.
- 5) The phase velocity obtained from the array processing indicates that there is a velocity gradient in the upper part of the crust and a velocity step from about 6.0 to 6.4 km/s at about 12 km deep.

The latter findings are already in the press.

A portable seismic recording station has been developed using readily available tape recorders. Preliminary tests have shown that they are much easier to handle and very suitable for the purposes in mind. Delay in the supply of supplementary equipment has prevented any experiments being carried out.

(e) Palaeomagnetism:

Mr. Morris has extended his study of the carboniferous limestone areas and has tested most of the rock types occurring in the southern half of the

country. He has found that magnetisation of rocks is widespread except in the Carboniferous where, apart from the Volcanics, it is confined to the lower strata.

Volcanic rocks are being treated separately and a large number has been accumulated.

The magnetometer was rebuilt and its sensitivity increased by a factor of ten. Improvements are still being carried out and additional equipment to further increase the sensitivity is on order.

Demagnetising equipment was set up and Mr. Morris visited universities in England discussing the aspects of this work.

### 3. CONFERENCES

Professor Murphy attended the 30th Meeting of the European Society of Exploration Geophysicists held at Salzburg in June 1968, and the planning conference for the Continental Margin Experiment at Birmingham in November 1968.

### 4. PUBLICATIONS

T. J. Morley:

Wind in Dublin City. Bulletin 24.

R. P. Riddihough:

Magnetic surveys off the north coast of Ireland. Proc. R.I.A. 66B, 3, 27-41.

Notes on the reading and reduction of ground total field magnetic data with particular reference to Ireland. Bulletin 25.

In the press:

A. W. B. Jacob:

Seismic Array processing. Geophys. Journ.

M. A. Hogan

CHAIRMAN

19 December, 1969.