

INSTITIÚID ARD-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
1970-71

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

Summary of Annual Report
of the work of the Constituent Schools
for the year 1970-71

School of Celtic Studies

In the report for 1969-70 it was mentioned that no expansion of the staff of the School had been allowed and that it had not been possible to meet the Minister for Education to acquaint him with the facts of the situation. A meeting between the Minister and the Director took place in September 1970 and as a result approval was given for the appointment of an additional full-time research assistant to engage in bibliographical work, and for the appointment of a visiting professor for the Michaelmas term 1971. Approval for the remainder of the staff expansion programme submitted to the Minister in 1968 has not yet been granted.

On November 27, 1970, a public symposium was held to mark the fiftieth anniversary of the death of An tAthair Peadar Ua Laoghaire; it is hoped to publish the papers. A symposium for university staff and research workers was held in March 1971.

Weekly seminars were held by Professors Binchy, Carney, Greene and Ó Cuív. The Statutory Public Lecture - entitled Written and Colloquial Breton - was delivered by M. Louis Paul Nemo in University College, Dublin, on November 12, 1970.

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 workers.

Eight books (including periodicals) were produced by members of the School; three of these were published by the Institute. Members contributed nineteen papers or shorter items to books or periodicals published elsewhere.

School of Theoretical Physics

Professor Lanczos continued his research on the form of the line element in the microscopic and the macroscopic world, and on the Noether type of variational problems. Professor Synge investigated problems over a wide range in relativity, classical dynamics and Hilbert space. Professor McConnell completed a lengthy investigation on the combined use of weight diagrams and Young tableaux for the reduction of representations of the general linear group under certain subgroups. Professor Ó Raifeartaigh extended his previous work on group representations and on the saturation of current algebra with solutions of wave equations. Professor Solomon applied group theory to superfluids, and in particular to the coupling of two superfluids.

The School continued to provide lectures suitable for advanced university students in mathematics and physics. These lectures were given by Professors McConnell, Jánossy and Balazs.

The Statutory Public Lecture entitled The Lorentz-FitzGerald contraction was given by Professor Jánossy in Trinity College, Dublin, on 6 November 1970.

Members of the School attended scientific meetings or gave invited lectures in Aberdeen, Austin (Texas), Cambridge (Mass.), Copenhagen, Daresbury,

Edinburgh, Galway, Glasgow, Helsinki, Kiev, Leeds, London, Nancy, Nice, Newcastle-upon-Tyne, Nottingham, Oxford and Paris.

The distinguished scientists who spent some time at the School included Professors Vaidya (Gujarat), Takahashi (Edmonton), Jánossy (Budapest), Balazs (Stony Brook) and Morawetz (New York).

Thirty seminars and review lectures were given, and one mathematical symposium was held.

Six books were published and three were in the press. Eighteen papers were published in learned journals and nineteen were in the press.

School of Cosmic Physics

Astronomical Section:

Considerable progress was achieved during the year in producing final data for stellar photometry of standard stars in the Magellanic Clouds and of light-curves of cepheid variable stars. Interpretation in terms of the theory of these variables was started. Various side-investigations, including data on interstellar reddening were also carried out.

Work on solar velocity fields continued and an advanced control unit was added to the microdensitometer to enable this work to be pursued further.

The data available on Halley's Comet over twenty-seven centuries were finally assimilated in terms of perturbation to the orbit of the comet and its interpretation in terms of non-gravitational forces.

Cosmic Ray Section:

The main work of the Section has been in the carrying out of balloon-flights of substantial packages of plastic and photographic material for the registration of ultra-heavy cosmic-ray primary particles. A processing plant for the plastic materials has been designed and built. Analysis of material obtained to date continues and has been successful in providing considerable amounts of data on heavy particles.

Work on the processes of cosmic-ray interactions has continued to enable detailed comparisons to be made between experimental results and particle theory. These investigations include the mechanism of ultra-high energy nuclear reactions.

Geophysical Section:

Gravity Surveys, particularly in the Sligo and Lough Foyle areas, were analysed with respect to various unexpected features. A more detailed survey of a fault trough at Kingscourt was carried out, also a limited magnetic survey in N.W. Mayo. Various magnetic sea surveys in the vicinity of Dublin and to the west of Ireland were also completed.

Seismic equipment was improved during the year and extensive trials have been made, as well as various long periods of records as contributions to collaborative work.

Some work on meteorology and palaeomagnetism has continued during the year.

INSTITIÚID ARD-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
for the Financial Year 1970-71

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, 1971.

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 1971.

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, 1971.
- II - Report of the Governing Board of the School of Celtic Studies.
- III - Report of the Governing Board of the School 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 1971.

1. THE COUNCIL OF THE INSTITUTE

Chairman:

Professor M. A. Hogan, B.E., D.Sc., Ph.D., D.I.C.

Ex-Officio Members:

J. J. Hogan, M.A., B.Litt. (Oxon.), President, University College, Dublin; Albert J. McConnell, M.A., M.Sc., Sc.D., Provost, Trinity College, Dublin; Vincent C. Barry, D.Sc., F.R.I.C., President, Royal Irish Academy.

Members appointed by the Governing Boards of Constituent Schools:

Professor Brian Ó Cuív, M.A., D.Litt.; T. K. Whitaker, D.Econ.Sc.; Reverend Professor J. R. McConnell, M.A., D.Sc.; Professor P. Quinlan, B.E., D.Sc., Ph.D.; Professor P. A. Wayman, Ph.D.; Professor E. F. Fahy, 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:

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.; James H. Delargy, M.A.; D.Litt., Litt.D.; Proinsias Mac Cana, M.A., Ph.D.; Edward MacLysaght, M.A., D.Litt.; Ernest Gordon Quin, M.A., F.T.C.D.; Reverend John Ryan, S.J., M.A., D.Litt.; Thomas Kenneth M. Whitaker, D.Econ.Sc.

3. THE GOVERNING BOARD OF THE SCHOOL OF THEORETICAL PHYSICS

Chairman:

Albert J. McConnell, M.A., M.Sc., Sc.D., F.T.C.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.; Reverend James J. McMahon, M.Sc., Ph.D.; Thomas Edwin Nevin, D.Sc.; Patrick Quinlan, B.E., D.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:

Edward Francis Fahy, M.Sc., Ph.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.; Peter Kevin Carroll, M.Sc., Ph.D.;
Cyril F. G. Delaney, M.A., Ph.D., F.T.C.D.; Eric M. Lindsay, M.A.,
M.Sc., Ph.D., F.R.A.S.; Reverend Thomas P. G. McGreevy, M.Sc., Ph.D.;
Patrick J. Nolan, Ph.D., D.Sc.; Cilian Ó Brocháin, M.Sc., Ph.D.;
Neil A. Porter, Ph.D.; Ernest T. S. Walton, M.A., M.Sc., Ph.D.,
D.Sc., F.T.C.D.

5. ADMINISTRATIVE STAFF

Registrar:

Patricia O'Neill.

Senior Clerk:

Maure Devoy.

Accounts Clerk:

Mary A. O'Rourke.

Clerks:

Susan Kealy; Desmond Pender.

6. MEETING WITH HIGHER EDUCATION AUTHORITY

In view of impending legislation the Council of the Institute sought a meeting with the Higher Education Authority. At the meeting, which took place on the 8th December 1970, matters of immediate and of future concern to the Institute were discussed.

II - Annual Report of the Governing Board of the School of Celtic Studies
for the year 1970-71 adopted at its meeting on 29th June 1971.

1. STAFF, SCHOLARS AND EXTERN RESEARCH WORKERS.

Senior Professors:

Brian Ó Cúiv, Director of the School; Daniel A. Binchy;
Myles Dillon; David Greene.

Professor:

James P. Carney.

Assistant Professors:

Louis Paul Nemo (Roparz Hemon - retired 18 November 1970);
Rev. Pádraig Ó Súilleabháin, O.F.M.; Gearóid Mac Niocaill.

Assistant:

Pádraig de Brún.

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:

Fergus Kelly; John Cullen; Tomás Ó Cathasaigh; Patrick Considine
(to 30 September 1970); Cáit Ní Dhomhnaill (to 30 September 1970);
William Gillies (to 30 September 1970); Ronald I. M. Black (appointed
1 October 1970); Mary Herbert (appointed 1 October 1970); Arndt
Wigger (appointed 1 October 1970); John Shaw (appointed 1 October 1970).

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;
Mr. Brynley Roberts; Mrs. Rachel Bromwich; Rev. Fergal Mac Raghnaill,
O.F.M.

The financial provision for the School for the year 1970-71 did not allow for any of the staff expansion proposed in the memorandum submitted to the Minister for Education in 1968. In view of this the Director continued to press for a meeting with the present Minister in order to acquaint him with the view of the Governing Board that the continued postponement of new appointments and uncertainty about the future of

the School would have most serious consequences for the future of Celtic Studies. A meeting between the Minister and the Director took place in September 1970 and as a result approval was given for the appointment of an additional full-time research assistant to engage in bibliographical work. Ministerial approval was also given for the appointment of a visiting professor for the 1971 Michaelmas term. Approval has not so far been received for the remainder of the staff expansion programme.

2. RESEARCH AND EDITING

Professor Brian Ó Cuív initiated the scheme, referred to in section 6, for indexing the contents of the Irish manuscripts in the National Library of Ireland, and he took part in the indexing and directed the work of others. He read proofs of works in course of publication, completed an article on a linguistic topic and some editions of short texts for publication in Éigse, compiled indexes for a reprint edition of T. F. C'Rahilly's Irish Dialects Past and Present, and did further work on linguistic and textual items for publication in the near future. He also did some work on the volume referred to in section 9. See also sections 4, 6, 10 and 11.

Professor Daniel A. Binchy completed the transcription of the extant legal manuscripts for the Corpus Iuris Hibernici, comprising in all 2,579 foolscap pages of which 470 are still with the printers. He was engaged in correcting the proofs of the material already in print. See also sections 4 and 11.

Professor Myles Dillon completed his work on Indo-European origins and prepared the book for press. An article and reviews were written for Celtica IX and copy for the volume was sent to the printer. Proofs were read and returned for revise. A lecture on Irish settlements in Wales was prepared, to be delivered as the O'Donnell Lecture at Oxford in 1971. An article on Celtic Mythology was written for the Encyclopaedia Britannica. See also sections 10 and 11.

Professor David Greene checked and returned for final revise proofs of Duanaire Mhéig Uidhir. Work on Bergin's Irish Bardic Poetry was completed. He began a long-term project on Saltair na Rann; a draft edition and translation of the first 1,000 lines is now available for consultation in the School's library. The following items were prepared for press:- (i) a paper on 'Linguistic Evidence for the dating of Early Welsh Poetry'; (ii) a paper on 'The Irish War Cry' together with some short notes (for publication in Ériu). See also sections 4, 10 and 11.

Professor James Carney worked on Early Irish poetry and The Lambeth Glosses. An article entitled 'Three Old Irish poems in accentual metres' was accepted for publication in Ériu xxii. See also section 11.

M. Louis Paul Nemo continued to work on the Historical Dictionary of Breton, the sixteenth and seventeenth instalments of which were published during the year. Work continued on the preparation of an edition of an Early Modern Breton text of the miracle play The Last Judgment. See also sections 3 and 11.

Rev. Pádraig Ó Súilleabháin, O.F.M. corrected and returned to the printer proofs of 73 galleys of notes and vocabulary of Buaidh na Naomhchroiche, checked pp.95-148 of the notes to Dán na mBráthar Mionúr II and read the introduction and text of Fr. Feargal Mac Raghnaill's typescript of Ó hEódhasa's Teagasg Críostuidhe. Preparatory work amounting to 200 pages of typescript on The Annals of the Four Masters began. He excerpted 16 sermons translated from French and worked on the indexing of articles and notes in Ériu 1-xxi dealing with etymology, grammar, syntax etc. The following articles were accepted for publication:- (i) 'Seanmóir ar uimhir bheag na bhFírén' (Éigse); (ii) 'A humorous letter of Mark O'Keeffe's' (The Past); (iii) A note on 'Thomas Fitzsimons and Our Lady's Primer' (Breifne). See also section 11.

Dr. Gearóid Mac Niocaill continued preparation of printer's copy of the translation and annotations of vol.I of the Annals of Ulster.

He checked and saw through the press Una Nic Énrí's edition of the second recension of An Teanga Bhithnua for Celtica IX. A book entitled Ireland before the Vikings has been accepted for publication by Gill and MacMillan. See also sections 5, 10 and 11.

Pádraig de Brún completed the catalogue and indexes of Irish manuscripts in King's Inns Library. This material is now in galley-proofs; some preparatory work was done on the introduction. Until the end of September 1970 he gave twice weekly lessons in modern Irish to Dr. Patrick Considine. Work continued on part I of the anthology of later Irish poetry. Page proofs of a forthcoming publication - Filíocht Sheáin Uí Bhraonáin - were checked. He edited Journal of the Kerry Archaeological and Historical Society No.4. See also section 11.

Mrs. Nessa Doran worked on Fasc.III of A Catalogue of Irish MSS. in the National Library of Ireland and on some of the Irish manuscripts in the King's Inns Library.

Mrs. Anne O'Sullivan continued to collate Professor Binchy's transcripts of law texts with the following manuscripts:- T.C.D. Ms. H 3. 17; H 5. 15; H 3. 18; H 2. 12; H 2. 15B; N.L.I. Ms. G 3; G 11; Brit. Mus. Ms. Eg. 90; Nero A VII; Bodleian, Oxford Ms. Rawl. B 502; Copenhagen MS. 261B. Work on a transcription of the Book of Leinster f.311^a is in progress. An article (in collaboration with Miss Mary Herbert) on the history of Ms. Laud 615, a collection of poems relating to Colum Cille, is in preparation.

Professor Proinsias Mac Cana, as General Editor of the Mediaeval and Modern Welsh Series read first proofs of Mrs. Rachel Bromwich's translation of Sir Ifor Williams's edition of Armes Prydein and saw final proofs of Brynley Roberts's edition of Brut y Brenhinedd through the press.

Mr. Fergus Kelly continued preparation of an edition of Audacht Moraínd. He co-edited Irish Bardic Poetry with Professor Greene. See also section 11.

Mr. William Gillies completed a first-line index to Mackinnon's Catalogue of Gaelic Manuscripts. He wrote a review of Charles Dunn's Highland Settler for Celtica IX. Under the direction of Professor Ó Cuív he worked on an Early Modern Irish text on the Harrowing of Hell which has been provisionally accepted for publication in Celtica X. See also section 11.

Tomás Ó Cathasaigh worked on Irish origin legends and prepared an edition of an Old Irish text with a commentary. He assisted in the work of listing the contents of uncatalogued manuscripts in the National Library. See also section 10.

Miss Mary Herbert worked on the editing of the collection of poems ascribed to Colum Cille in the Ms. Laud 615. In collaboration with Mrs. Anne O'Sullivan a description and history of the above manuscript are being prepared for publication. She assisted in the work of listing the contents of uncatalogued manuscripts in the National Library.

Mr. Ronald Black was engaged in general study in Old and Middle Irish paying particular attention to mythological aspects of the sagas. He studied Classical Irish verse and prose of Scottish provenance and made a number of transcripts of such manuscript material in Dublin and Edinburgh. Preparation began on an edition of Cathal MacMhuirich's poem 'Saoth liom do chor, a Cholla' with a view to publication.

Dr. Arndt Wigger prepared an article entitled 'Towards a Generative Phonology of the Modern Irish Noun' for publication in Linguistics (The Hague). The work deals with the phonology of the noun in Conamara Irish and is based on research done in Hamburg. It is a revised English version of a paper read at the Annual Meeting of the Societas Linguistica Europaea in Prague on 10 October 1970. An article is being prepared for Ériu: 'Irregularity in the morphology of the verb in Conamara Irish', which will deal with the distinction between predictability and unpredictability in the verbal system.

Mr. John Cullen worked on a transformational analysis of a portion of Irish syntax. He concentrated on isolating sentences showing a minimal contrast of the copula versus the substantive verb in the Kilkerrin-Carna dialect. He has also been engaged in some phonological investigation and prepared an essay entitled 'Hiberno English Dentals: A Case of Language Contact' for publication in the Journal of the Dublin College of Speech Therapy.

Cáit Ní Dhomhnaill continued the examination of material from Galway dialects. She typed and checked her transcription of the Conamara tapes.

Dr. Patrick Considine continued to work on his edition of a part of the New Testament section of the Biblical History in Leabhar Breac (pp.146-150).

Mr. John Shaw continued research on his doctoral dissertation concerning Old Irish verbal nouns and their relation to stem-formation and the verbal system in Indo-European.

Dr. Cecile O'Rahilly excerpted from the following texts for the Dictionary of Classical Modern Irish:- (i) an Bheatha Dhiaga (Eg. 120 [1773]); (ii) Incheimniughadh do chum Beatha Chrábhaigh [1840]; (iii) Seanmóir ar an mBás. Preparation began on an edition of Rec.I of Táin Bó Cuailnge. Three short notes were accepted for publication in Éigse. See also section 11.

Rev. Anselm Faulkner, O.F.M. completed the preparation of the text of his edition of An Bheatha Chrábhaigh. Final draft of the notes is in typescript (60 pp.); vocabulary has been revised in final form. Preparation of the text of An Sgáthan Spioradálta is complete. Work is proceeding on the final draft of notes and vocabulary; some of the introduction has been prepared.

Dr. Ludwig Bieler continued to act as General Editor of Scriptores Latini Hiberniae. He completed the proof-reading of his edition of The Four Latin Lives of St. Patrick and the work was passed for press.

He read first proofs of I. P. Sheldon-Williams's edition of Iohannis Scotti Eriugena Periphyseon Liber II. The manuscript of Periphyseon III is at an advanced stage of preparation. Another volume, which is to contain the Latin Lives and the Irish-Latin Rawlinson Life of St. Brigid, has been planned and preparations are under way.

Mr. I. P. Sheldon-Williams read and returned for revise first proofs of his edition of Iohannis Scotti Eriugena Periphyseon Liber II. Preparation continued of Periphyseon Liber III.

Mr. Brynley Roberts read final proofs of his edition of Brut y Brenhinedd for the Mediaeval and Modern Welsh Series and the work was passed for press.

Mrs. Rachel Bromwich read first proofs of her translation of Sir Ifor Williams's edition of Armes Prydein which is to be published in the Mediaeval and Modern Welsh Series.

Rev. Fergal Mac Raghnaill, C.F.M. completed preparation on his edition of Ó hEódhasa's Teagasg Críosduidhe.

3. STATUTORY PUBLIC LECTURE

A Statutory Lecture entitled Written and Colloquial Breton was delivered by M. Louis Paul Nemo in University College, Dublin, on 12 November 1970.

4. SEMINARS

Professor Brian Ó Cúiv continued his weekly seminar on the Irish Grammatical Tracts in April-May 1970. He also continued his weekly class on manuscript reading and textual editing in April-May 1970, and from October 1970 to March 1971.

Professor David Greene held a weekly seminar on Saltair na Rann in the Michaelmas and Hilary terms.

Professor Daniel A. Binchy held a weekly seminar on an Old Irish law-tract during Michaelmas term 1970.

Professor James Carney held a weekly seminar on Early Irish poetry from October 1970 to March 1971.

The seminars continued to attract a large number of scholars from outside the School.

5. SYMPOSIA

On November 27, 1970, a public symposium was held in University College, Earlsfort Terrace, Dublin, to mark the fiftieth anniversary of the death of An tAthair Peadar Ua Laoghaire. Papers were presented by An tAthair Shán Ó Cuív, Máire Mhac an tSaoi, an tOllamh Tomás Ó Concheanainn. Publication of the papers is planned.

On March 25-26, 1971, a symposium was held at No.5 Merrion Square for university and college staffs and research workers. Papers were read as follows:-

Pádraig Ó Riain: Boundaries and their associations in early Irish Society

Breandán Ó Buachalla: Stair an Chónaisc acht coⁿ

Tomás Ó Concheanainn: Murchadh Ó Cuinnlis, scríobhaí

Gearóid Mac Eoin: Ráthachas na nDúl

Noel Hamilton: Notes on tenses in North Donegal

Gearóid Mac Niocaill: Annála agus Mionannála roimh an Dara hAois Déag

6. MANUSCRIPT CATALOGUING

For some years past the School has been engaged in providing catalogues of Irish manuscripts. The draft catalogue of the manuscripts in the Franciscan Library in Killiney was revised and completed by Pádraig de Brún and published in 1969. A catalogue of the collection in the King's Inns Library in Dublin by Pádraig de Brún and Mrs. Nessa Doran was completed in 1971 and is being printed.

Mrs. Doran has continued to work on the catalogue of the Irish manuscripts in the National Library of Ireland. However, since there are still over 900 manuscripts to be catalogued, it was decided that an effort should be made to compile, as an interim measure and as quickly as possible, some basic information on the contents of these manuscripts, while at the same time allowing the detailed cataloguing to proceed. A scheme was drawn up by the Director of the School after consultation with the Director of the National Library. It was proposed that some extern workers, including university post-graduate students, should be recruited on a part-time basis to engage in the task of putting the relevant information on index cards which would then be classified and kept in the School for consultation by scholars. The Governing Board approved the proposal and provision was requested in the financial estimates for 1971-2 to enable the work to be done. In the meantime the School received an offer of financial help for the scheme from Sir John Galvin, and this was readily accepted. The work of indexing was begun in the autumn. Two of the School's scholars and one extern worker, in addition to the Director, took part, and a typist has been engaged in transferring information from the master cards for cross-reference purposes. A hundred manuscripts had been indexed by the end of the year.

7. LEXICOGRAPHICAL AND LINGUISTIC ARCHIVES

Professor O'Rahilly continued to add to the collections for the Early Modern dictionary. It was decided to establish, as an adjunct to the lexicographical collections, a linguistic archive to cover, as far as possible, the full range of the language. This will be a long-term project. As a beginning Rev. Pádraig Ó Súilleabháin, O.F.M. has indexed material from Ériu 1-xxi.

8. CONSULTATION WITH DEPARTMENT OF EDUCATION OFFICIALS

Discussions have taken place with officials of the Department of

Education in relation to parts of the certificate courses in Irish in post-primary schools. The discussions were initiated because the School has in preparation an anthology of Irish verse from the seventeenth century to the nineteenth. The first volume is being edited jointly by Pádraig de Brún of the School and An tOllamh Tomás Ó Concheanainn and An Dochtúir Breandán Ó Buachalla of University College, Dublin, and every effort is being made to ensure that the available manuscript sources will be used to the best advantage. While the anthology is mainly intended for use by university students, it is hoped that, by means of this work undertaken by the School and through the rapport which has been achieved with the Department officials, improved texts of poems will be made available for use in post-primary schools.

9. CO-OPERATION WITH THE DEPARTMENT OF FINANCE

In 1969 Professor Brian Ó Cuív was asked to prepare a volume of documents on the Irish language for publication on behalf of the Department of Finance. Following discussions with the Minister for Finance and officials of the Department, it was agreed that the work of compiling and editing the volume would be undertaken as an activity of the School on behalf of the Department which would be responsible for the eventual publication of the volume. Examination and cataloguing of material in newspapers and other periodicals was begun by Liam Mac Mathúna, M.A. under the direction of Professor Ó Cuív. It is hoped to complete the selection and editing of material in 1971-2.

10. EXTERNAL ACTIVITIES

Professor Brian Ó Cuív took part in conferences of contributors to A New History of Ireland in April and October 1970. In November 1970 he lectured to the Irish Historical Society on 'Keating and his Sources'. He took part in the Place-Names Conference and annual meeting of the Council for Names Study in Great Britain and Ireland in Dublin in March 1971.

Professor Myles Dillon resumed his Fellowship in the Indian Institute of Advanced Study at Simla from September 1970 to January 1971. During that period he delivered the following lectures:-

- Sept. 2 and 3 1970: Two lectures on 'Celts and Indo-Aryans' at the Indian Institute of Advanced Study, Simla.
- Sept. 16 1970: 'Linguistics as a Source for the History of Indian Civilisation' as above.
- Oct. 5 1970: 'Celts and Indo-Aryans' at the Vedic Research Institute, Hoshiarpur.
- Nov. 23 1970: 'Vedic as a Source for the Pre-History of India' at Deccan College, Poona.
- Dec. 15 1970: 'Notes on the Old Irish Verbal System' as above.
- Dec. 21 1970: 'Celt and Hindu' at the University of Poona.
- Jan. 13 1971: 'Celtas et Hindous' at the University of Rome.

Professor David Greene lectured to the conference of the staffs of the Welsh Departments of the University of Wales on 'Linguistic evidence for the dating of Early Welsh poetry', in June 1970. This lecture was repeated by request in Aberystwyth in March 1971. A lecture on 'The development of Irish as a language of culture' was delivered in January 1971 to the Linguistic Seminar of the University of Bonn. In May 1970 he delivered a lecture to the Royal Irish Academy on 'The Irish War Cry'.

Dr. Gearóid Mac Niocaill delivered a series of lectures on early Irish law for LL.M. course in University College, Dublin, at the request of the Dean of the Faculty of Law.

Tomás Ó Cathasaigh lectured on Irish mythology to the Dublin Summer School in July 1970 and in January 1971 he delivered a lecture on the Déisi to the Old Waterford Society.

11. PUBLICATIONS

(a) Books published by the Institute:

Stories from the Acallam. Edited by Myles Dillon.
pp.xxv + 54. Price 75p. Published October 1970.

Irish Bardic Poetry. Texts and translations, together with an introductory lecture by Osborn Bergin. With a foreword by D. A. Binchy. Compiled and edited by David Greene and Fergus Kelly. pp.xi + 320. Price £3.00. Published December 1970.

Críth Gablach. Edited by D. A. Binchy. pp.xx + 109. Price 75p. Revised edition reprinted December 1970.

[A new catalogue of the publications of the School was compiled and was issued in February, 1971.]

(b) Books published outside the Institute:

Brian Ó Cuív:

Éigse XIII, Parts III and IV. Edited by Brian Ó Cuív. Published by the National University.

Seven Centuries of Irish Learning, 1000-1700. (Second edition). Edited by Brian Ó Cuív. Published by the Mercier Press. 1970.

Roparz Hemon:

Historical Dictionary of Breton, Rann XVI. (Kaouenn - Kempenn). Published Etienne, Paris, June 1970. pp.1501-1600.

Historical Dictionary of Breton, Rann XVII. (Kempenn - Klamastrenn). Published Etienne, Paris, December 1970. pp.1601-1700.

Pádraig de Brún:

Journal of Kerry Archaeological and Historical Society No.4, 1971, edited by Pádraig de Brún.

(c) Contributions to periodicals and other publications:

Brian Ó Cuív:

A Poem for Cathal Croibhdhearg Ó Conchubhair. Éigse XIII, 195-202.

Reviews of publications, ibid., 243-5, 327-32.

D. A. Binchy:

Celtic Suretyship, a fossilized Indo-European Institution?
Indo-European and Indo-Europeans (Philadelphia, 1970).

Myles Dillon:

An Saighead. Éigse XIII, 186-7.

James Carney:

The so called Lament of Créidhe. Éigse XIII, 227-42.

Notes on Early Irish Verse. ibid., 291-312.

Pádraig Ó Súilleabháin, O.F.M.:

Seanmóir ar ghnáithchleachtadh an pheacaidh. Éigse XIII, 279-90.

Jeremiah Donovan's translation of the Roman Catechism. The Past VIII, 27-35.

Gearóid Mac Niocaill:

Admissible and inadmissible evidence in early Irish law. Irish Jurist IV, 2 (1969) [recte late 1970], 332-7.

Pádraig de Brún:

Cacine ar Mhac Fíinín Duibh. Éigse XIII, 221-4.

A lament in Irish for John Stafford, coadjutor bishop of Ferns. The Past VIII, 43-51.

Some Irish MSS. with Bréifne associations. Breifne 1969 [1970], 552-61.

Review of North Munster Studies (Ed. E. Rynne. 1967). Studia Hibernica 9 (1969 [1970]), 169-71.

Corrigendum. Clogher Record 1970, 22C.

A sidelight on the 1834 affrey at Ballyeagh. Journal of Kerry Archaeological and Historical Society No.4 (1971), 71-3.

Uacht Shéafraidh Uí Dhonnchadha an Ghleanna. ibid., 166.

William Gillies:

A poem on the downfall of the Gaoidhil. Éigse XIII, 203-10.

Dr. Cecile O'Rahilly:

Words descriptive of Hair in Irish. Éigse XIII, 177-80.

The words aimirtne, aimirtneach. ibid., 324.

12. O'RAHILLY TRUST

The trust has been referred to in the report for 1969-70. In May 1970 the Council of the Institute, on the advice of the Governing Board of the School, appointed Professor D. A. Binchy as an additional trustee. The various formalities connected with the trust were completed early in 1971 and the unpublished writings of the late Professor T. F. O'Rahilly were then deposited in the School of Celtic Studies and examination and cataloguing of them was begun.

13. DONATION

A sum of money was given to the School by Sir John Galvin to finance the first part of the scheme for indexing material in the Irish manuscripts in the National Library of Ireland, referred to in section 6. Were it not for this generous donation the work could not have been undertaken.

III - Report of the Governing Board of the School of Theoretical Physics
adopted at its meeting on 17 June 1971.

1. ACADEMIC STAFF AND SCHOLARS

Professor Emeritus:

Cornelius Lanczos.

Senior Professors:

Rev. James R. McConnell (appointed Director of the School for three years from 9 January 1969); John L. Synge; Lochlainn S. C. Raifeartaigh.

Visiting Professors:

P. C. Vaidya (April-June 1970); Yasushi Takahashi (May-August 1970); Lajos Jánossy (October-November 1970); Nendor Balazs (January 1971); Cathleen Morawetz (February 1971).

Assistant Professor:

Alexander I. Solomon.

Research Associates:

D. Judge, P. S. Florides, Rev. C. P. Ryan (reappointed September 1969 to September 1972); Rev. D. McCrea (appointed June 1969 to September 1972); B. K. P. Scaife (appointed January 1970 to September 1972); P. D. McCormack (appointed September 1970 to September 1972).

Scholars:

E. Massa (left August 1970); W. Montgomery (left September 1970); U. Niederer (left December 1970); R. Ll. Jones (left September 1970); P. Yodzis (appointed October 1970); S. Banerji (appointed October 1970); J. M. Golden (appointed October 1970); S. Dineen (appointed September 1970); M. Conneely (appointed October 1970); T. Yoshimura (appointed October 1970).

Technical Assistant:

Evelyn R. Wills.

2. STUDY AND RESEARCH

Professor Lanczos continued his research on the possibility of the physical world having a genuine (positive definite) Riemannian line element on the microscopic, and yet a Minkowskian (indefinite) line element on the macroscopic, level. Investigation of the (macroscopic) superposition Lagrangian showed that under four-dimensional (positive definite) isotropy the Lagrangian vanishes identically; consequently, only a small deviation from the full isotropy becomes observable, and

this deviation (of 3+1, instead of 4+0 symmetry) gives rise to the Minkowskian + - - - world, in spite of the Riemannian structure of the physical world. Moreover, he found that the "free vector" of Einstein's theory, caused by general covariance (here lost through averaging), is now subjected to the wave equation and the Lorentz condition, and becomes identifiable with the electro-magnetic potential. He is at present preparing this work for publication. Professor Lanczos also studied the Noether type of variational problem, and found that they demand a technique going beyond the Euler-Lagrange formalism. He used a greatly simplified approach to Noether's Theorem, by changing Noether's "infinitesimal parameter" to a free function of t (or in the partial case, of the x_1), and considering it to be an added field variable. He found that the associated Euler-Lagrange equation yields the desired conservation law, without writing down the equations of motion explicitly, although this conservation law is a consequence of those equations. He hopes to publish this work shortly.

In addition to the work represented by the papers listed later in this report as published or in press, Professor Synge carried out some investigations which have not yet been brought into final form. These include the following: (1) A teleological variational principle in which a trajectory is determined by its end-points but not by initial conditions, as is usually the case. (2) Dynamics of null particles in special relativity, with associated Frenet-Serret formulae, modifying recent work by Bonnor. (3) Interaction of charged particles by electromagnetic impulses. (4) Dynamics of systems rigid in the Minkowskian sense. (5) The Schrödinger equation in curved q -space and the question of constraints. (6) Kinematics, angular momentum and Eulerian dynamics in Hilbert space.

Professor McConnell prepared a Communication on weight diagrams, which is now in course of publication. This Communication embodies studies that he has been making of the properties of the weight diagrams of semi-simple Lie algebras of rank two, and of the combined use of weight diagrams and Young tableaux for the reduction under the rotation

group and the exceptional group of certain irreducible representations of the general linear group. He worked with Mr. Jones on graph theory with a view to its application to weight diagrams. He continued to collaborate with Dr. D. J. Simms in the preparation of an algebra for the use of physicists.

Professor Ó Raifeartaigh and Dr. Niederer studied (1) the problem of saturating current algebra with solutions of wave-equations and (2) the connexion between induced and manifestly covariant group representations. Work on the unitary representations of the group $SU(1,1)$ was completed and work on crossing-relations and $\pi\pi$ scattering begun.

During the year Professor Solomon continued work along two lines of interest. Firstly, he concluded an examination of the application of nonlinear realisations of symmetry groups to particle physics, showing an intimate connection between these and a model proposed by Sugawara, as well as the phenomenon of Goldstone bosons. The second area of interest concerned the application of the theory of groups to the problem of superfluidity in the Quantum Many Body Theory. A solution to the basis problem by this means was obtained, and published in the Journal of Mathematical Physics. Work is continuing on the problems arising out of the coupling between two superfluids.

Professor Vaidya studied Einstein-Maxwell equations with special reference to electromagnetic fields which are pervaded by a field of null currents. He obtained a solution of the Einstein-Maxwell equations, which generalizes the well-known Nordström solution to the case where the charged particle is accelerated. He then began a study of Riemannian space-times which admit shearfree, but not hypersurface orthogonal, null convergence.

Professor Takahashi derived some identities convenient for covariant calculations occurring in relativistic quantum field theory. These identities enable one to calculate the commutators of physical quantities and the generators of the Poincaré group without canonical field commutators. Thus the field obeying parastatistics can also be treated equally. He also investigated the effect of the presence of the mass

on the scale transformation, and concluded that even in renormalizable field theory, the notion of broken scale transformation is not compatible with covariance.

Professor Morawetz's work was concerned with scattering theory, including a new theory describing decay and scattering for solutions of the non-linear Klein Gordon equation. She had discussions with Professor Solomon, and also with Professor Ó Raifeartaigh, on a more appropriate mathematical model for nonlinear interactions of particle fields to which the analytic methods of this new theory would be applicable. Stimulated by Professor Lanczos's explanations, she investigated with Professor Solomon the connection of a certain set of integrals to the invariant theory of E. Noether. These particular integrals, obtained in a quite different way, have properties which play a fundamental role in the non-linear scattering theory of particles of zero mass.

Dr. Yodzis pursued the following projects: (1) Research on some general properties of magnetofluids in general relativity; (2) Research on unstable particle states in quantum field theory; (3) Research on exact stationary, axially symmetric solutions of Einstein's field equations; (4) Studies in global differential geometry and differential topology.

Dr. Yoshimura studied the correspondence between composite particles (in terms of propagators, vertex parts, etc.) and Lagrangians, using more general Lagrangians than have heretofore been studied. He considered the objections to the N/D method, and the method of Jouvét et al. Dr. Yoshimura also studied the possibility of non-linear spinor realization of current algebra.

Dr. Golden examined ways of generalising the Veneziano model, so as to allow non-linear trajectories. Also, he studied the problem of imposing crossing symmetry on partial wave amplitudes, with particular reference to pion-pion scattering, and the problem of using constraints to get information about such amplitudes, especially about the resonances which occur.

The Research Associates and Scholars working in Relativity Theory established a study group, which was attended also by interested university students. Lectures were given to the group by Dr. Florides, Dr. McCrea and Dr. Yodzis.

Dr. McCrea, in co-operation with Professor Synge, continued work on the construction of a model universe representing the gravitational field of a rotating sphere. The original intention of treating the case of varying angular velocity was abandoned in favour of a constant angular velocity. The metric in the third approximation is now being calculated, with a view to determining whether further secular effects will manifest themselves in the planetary orbits at this order of approximation.

Dr. Scaife worked on a book on physics of dielectrics, and also collaborated with Dr. T. Ambrose on work on the itinerant oscillator.

Dr. Florides continued his investigations of the possible source of the Kerr metric, and has shown that up to order k^5 ($m \sim k^2$, $a \sim k$, \underline{m} and \underline{a} being the constants appearing in the Kerr metric), a steadily rotating sphere is a possible source of the Kerr metric. He has also found an extension of the (exterior) Kerr metric to the interior of the sphere. Preliminary results show that proper density and principal stresses of such a sphere are physically quite reasonable. Dr. Florides is also considering the possibility of other sources of the Kerr metric.

Dr. McCormack's research centered on the general area of the physics of fluids. In the continuum regime, he studied the interaction of a flame front with a vortex core, and also the boundary layer equations for particle fluid dynamics. In the molecular regime, he studied the phase transitions, in particular between a liquid and its vapour.

Dr. Judge investigated representations of the canonical commutation relations.

Dr. Ryan's study and research was concentrated mainly on three topics; (i) Non-linear realizations of $SU(2) \times SU(2)$ and $SU(3) \times SU(3)$, from the point of view of transformations of the parameter space of the group; (ii) Higher order effects in K-meson decays; (iii) the implications of

light cone expansions of operator products for the high q^2 behaviour of form factors.

3. SEMINARS AND REVIEW 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 Seminars were given:

Professor F. J. Cornish (York): The Kerr-Vaidya metric.

Professor S. F. Edwards (Manchester): The topological entanglement of long polymers.

Professor L. Jánossy (Budapest): A new approach to the theory of relativity (3).

Hydrodynamical model of quantum mechanics.

Dr. D. Judge: Generalized eigenfunction transforms.

Dr. E. Massa: A new approach to the problem of motion in general relativity.

Mr. W. Montgomery: Representations of the Lorentz group.

Professor C. S. Morawetz (New York): Scattering theory, the classical wave operator and reflecting bodies.

Scattering theory, the non-linear Klein-Gordon equation.

Professor J. R. McConnell: Multiplicities in weight diagrams (2).

Dr. U. Niederer: Wave equations and saturation of current algebra.

Professor L. S. Ó Raifeartaigh: Generalized Foldy-Wouthuysen transformations - Mackey-Wigner and covariant representations of groups (2).

Dr. D. O'Sullivan: Cosmic rays, the Moon and heavy nuclei.

Professor N. Papastamatiou (Wisconsin): A model of $SU(3) \times SU(3)$ breaking.

Professor A. I. Solomon: Group theory of superfluidity.

Professor J. L. Synge: Dynamics of bodies rigid in the Minkowskian sense (2).

Professor Y. Takahashi (Alberta): A gauge invariant formulation of massive spin one field (2).

Professor P. C. Vaidya (Gujarat): Radiation of charge in Einstein-Maxwell theory (3).

The following Review Lectures were given:

- Professor N. L. Balazs (Stony Brook): The weight of heat.
Dr. D. J. Judge: Phase and angle variables in quantum mechanics.
Dr. R. P. Riddihough: Time variations of the Earth's magnetic field.
Dr. T. S. Santhanam (Bonn): Dual resonance models.

4. LECTURES FOR UNIVERSITY STUDENTS

The School continued to provide lectures suitable for university students in mathematics and physics. Professor McConnell lectured during Trinity Term on Lie algebras of subgroups of the general linear group with special reference to A_4 , B_4 , C_4 , D_4 , and followed this with a detailed examination of the application of the $SU(3)$ group to the classification and interaction of elementary particles. Professor Jánosy gave a course of lectures in October and November on a New Approach to Electrodynamics. Professor Balazs conducted a course during January on the Free Electron Theory of Metals. This course, which was arranged after consultation with university personnel, was not as well attended by university students as one might have hoped.

5. STATUTORY PUBLIC LECTURE

A Statutory Public Lecture, under the auspices of the School, was delivered in Trinity College, Dublin, on 6 November 1970, by Professor Jánosy. His subject was "The Lorentz-FitzGerald contraction".

6. VISITING PROFESSORS

- P. C. Vaidya (University of Gujarat, Ahmedabad, India) April-June, 1970.
Y. Takahashi (University of Alberta) May-August, 1970.
L. Jánosy (Central Research Inst. Physics, Budapest) October-November, 1970.
N. L. Balazs (New York State University at Stony Brook) January, 1971.
Cathleen Morawetz (New York University) February, 1971.

[For lectures given by Visiting Professors and other visitors see §§3, 4, 5]

7. OTHER VISITORS

Dr. T. S. Santhanam (Bonn) 12-16 October 1970.
Professor N. Papastamatiou (Wisconsin) 19-23 July 1970.
Professor S. F. Edwards (Manchester) 1-2 June 1970.
Professor F. J. Cornish (York) 3 March 1971.
Dr. P. P. Divakaran (Tata Inst., Bombay) 10-11 September 1970.
Professor P. T. Landsberg (Cardiff) 22-26 March 1971.

8. SYMPOSIA

A Mathematical Symposium was held on 21-22 December 1970. The attendance was 51; this included Professors, Lecturers, and Graduate Students from the several Irish universities.

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

Dr. D. J. Simms (T.C.D.): Integrals of motion and Lie group actions.
Professor A. I. Solomon: Non-linear realisations.
Dr. T. Murphy (Essex): Symmetries and observables in quantum and classical dynamics.
Mr. M. Ganly (Edinburgh): A new proof of the complex Hahn-Banach theorem.
Dr. R. J. S. Crossley (York): The calculation of atomic transition probabilities.
Dr. D. P. McCarthy (T.C.D.): Symbolic manipulations by computer.

9. EXTERNAL ACTIVITIES

Professor Lanczos gave the following lectures during the year:
"Mathematics and the physical world" to University College, Dublin, Mathematical Society (1 May 1970); "Emmy Noether and the calculus of variations" to the University of Lancaster (20 October 1970); "Legendre versus Chebyshev polynomials" University of Lancaster (22 October 1970); "Ideas versus formalism" at the Teachers' Conference, Maynooth (24 October 1970); "Research for industry" to University College, Dublin, Mechanical Engineering Society (9 February 1971); "Emmy Noether and the calculus of variations" to the Heriot-Watts University, Edinburgh (15 February 1971), University of Strathclyde, Glasgow (17 February 1971) and to the University

of Aberdeen (19 February 1971); "Physical law and understanding" to University College, Dublin, Scientific Society (4 March 1971).

The degree of D.Sc., honoris causa, was conferred on Professors Lanczos and Synge by the National University of Ireland on 22 April 1970.

Professor Synge attended a Colloquium on Differential Geometry at the University of Leeds, 19-20 May 1970, and lectured on "The world function in general relativity"; he lectured to the Dublin University Mathematical Society on "Hayward's Theorem and other matters" on 25 January 1971.

Professor McConnell attended the International Congress of Mathematicians at Nice in September. He visited NORDITA (Copenhagen), the Research Institute for Theoretical Physics, Helsinki, and the physics departments of Åbo Academy and the University of Turku, Finland. He took part in a meeting of the Committee for the Royal Society European Exchange Programme held at Copenhagen in November. He was re-elected Secretary of the Royal Irish Academy.

Professor Ó Raifeartaigh visited, and lectured at, Massachusetts Institute of Technology, Boston, from 5 April to 15 May 1970, and the NATO Summer School at Istanbul from 10-26 August 1970. He attended the International Conference on Past Decade in Particle Physics, at Austin, Texas in April, and the International High Energy Conference at Kiev in September 1970. He also lectured at Boston University in May, Daresbury High Energy Research Centre in October and Liverpool University in October 1970 and at Canterbury University in March 1971.

Professor Solomon lectured on "Group theory of superfluidity" at the Mathematical Institute, Oxford University, on 3 December 1970.

Drs. Yodzis and Golden attended the Rutherford Conference on High Energy Physics from 4-7 January 1971.

Dr. Dineen gave invited talks at Edinburgh University, Glasgow University and Newcastle-upon-Tyne University from 3-5 February 1971. He spent the month of March 1971 on leave of absence from the Institute as an exchange professor at the University of Nancy, and during this period gave invited talks at the Seminar Lelong, Paris, and at the Université de Nice.

Dr. Florides attended the International Congress of Mathematicians at Nice in September, and with Dr. McCrea attended the Seminar on Relativity at King's College in December 1970.

Dr. McCormack attended the Quantum Theory Conference, Nottingham, 1970.

Professor Jánossy lectured at St. Patrick's College, Maynooth and at University College, Galway, while he was Visiting Professor.

Dr. Ryan gave an invited talk on "Higher order effects in K-meson decays" at Daresbury Nuclear Physics Laboratory, during the Study Week-end there from 29-31 January 1971, and lectured on "Theory of weak interactions" to the Cork and Galway branches of the Institute of Physics on 11 and 12 March, respectively.

10. PUBLICATIONS

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

(1) Books:

Published:

* Talking about relativity. By J. L. Synge. North-Holland Publishing Co., 1970.

* Space through the ages. By C. Lanczos. Academic Press, 1970.

The variational principles of mechanics. By C. Lanczos. 4th edn. (with added chapter on mechanics of continua), Univ. of Toronto Press, 1970.

Tal i Cändlightet (Swedish translation of "Numbers without end"). By C. Lanczos. Gleerups, Lund, 1970.

Albert Einstein and the Cosmic World Order. By C. Lanczos. Translated into Japanese.

In the press:

Volume on relativity to mark the 75th birthday of J. L. Synge. Edited by L. Ó Raifeartaigh. Clarendon Press.

Complex permittivity. Edited by B. K. P. Scaife. English University Press.

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

Published:

* No.19. Differential forms in general relativity. By W. Israel. Price £1.05. pp.111 + 100. Published 20 August 1970.

In the press:

No.20. Weight diagrams. By. J. R. McConnell.

(3) Contributions to periodicals and other publications:

Published:

* C. Lanczos:

Judaism and science. 11th Selig Brodetsky Memorial Lecture. Leeds Univ. Press, 1970. 23 p.

J. L. Synge:

* Some reassessments: A review of "Essays in the history of mechanics", by C. Truesdell. Springer, 1968. Science 168 (1970), 354.

* Point-particles and energy tensors in special relativity. Ann. Mat. 84 (1970), 33-60.

* The problem of the thrown string. Math. Gazette 54 (1970), 250-60.

* Motion of a charged particle in a field of plane-wave electromagnetic radiation. Quart. Appl. Math. 28 (1970), 437-40.

Riemannian metric in Gibbsian phase-space. Proc. Roy. Soc. A 319 (1970), 307-17.

Energy levels and Lorentz invariance. Nature 228 (1970), 271-2.

Review of "Differential Geometry" by J. J. Stoker, Wiley, 1969. Quart. Appl. Math. 28 (1970), 299-300.

* L. Ó Raifeartaigh:

Unitary representations of Lie groups in quantum mechanics. Group representations in mathematics and physics, Ed. V. Bargmann, Battelle Seattle 1969 Rencontres. Springer, 1970, pp.144-236.

* I. Khan, U. H. Niederer & L. Ó Raifeartaigh:

On the saturation of non-factored current algebras at infinite momentum with simplified angular condition. Proc. R.I.A. 70A (1970), 47-58.

* P. S. Florides & R. L. Jones:

On stationary systems with spherical symmetry consisting of many gravitating masses. Nuovo Cim. 69B (1970), 41-52.

* F. Ando:

Moving branch points in the angular momentum plane. Phys. Rev. 2 D (1970), 1136-39.

A. I. Solomon:

Nonlinear realizations, the Sugawara Model and Goldstone bosons. Nuovo Cim. Lett. 1 (1970), 337-40.

* Does chiral symmetry imply parity doubled states? Nuovo Cim. 66A (1970), 708-12.

A. I. Solomon:

Group theory of superfluidity. *J. Mathl. Phys.* 12 (1971), 390-4.

J. H. Calderwood & B. K. P. Scaife:

On the motion of space charge in a dielectric medium. *Phil. Trans. Roy. Soc.* 269A (1971), 217-32.

K. V. Kamath, K. R. Mahmud & B. Scaife:

Pressure and temperature dependence of low-frequency relative permittivity of the alkali halides. *Phil. Mag.* 23 (1971), 655-60.

P. D. McCormack:

A theory of surface tension based on the interaction between orbiting molecules. *Surface Science* 23 (1971), 62-75.

* L. J. Judge:

On Zemanian's distributional eigenfunction transforms. *J. Math. Anal. Appl.* 34 (1971), 187-202.

In the press:

J. McConnell:

Review of "Space through the ages", by C. Lanczos, Academic Press, 1970. *Phil. Studies.*

J. L. Synge:

Review of "The common scientist in the 17th century: A study of the Dublin Philosophical Society, 1683-1708", Routledge & Kegan Paul, 1970. *Hermathena.*

The electrodynamic double helix. *J. A. Wheeler Festschrift.*

Fixed points for infinitesimal Poincaré transformations in Minkowskian space-time. *London Math. Soc. Bull.*

A special class of solutions of the Schrödinger equation for a free particle. *Foundations of Physics.*

P. S. Florides & J. L. Synge:

Coordinate conditions in Riemannian space for coordinates based on a subspace. *Proc. Roy. Soc. A.*

P. S. Florides:

Rotating bodies in general relativity. Volume to mark 75th birthday of J. L. Synge. Ed. L. Ó Raifeartaigh. Clarendon Press, Oxford.

P. S. Florides & R. Wingate:

Rotating shells in general relativity. *Proc. Greek Math. Soc.*

P. Yodzis:

Some general relations in relativistic magnetohydrodynamics. *Phys. Rev.*

U. Niederer & L. Ó Raifeartaigh:

Wave-equations and saturation of current algebra for $I=\frac{1}{2}$.
Phys. Rev.

Mackey-Wigner and covariant group representations. Proc.
NATC Summer School, Istanbul, 1970.

J. Golden:

A generalized Veneziano model with nonlinear trajectories.
Nuovo Cim. Lett.

S. Dineen:

Bounding subsets of a Banach space. Math. Anal.

S. Lineen & A. Hirschowitz:

Sur le théorème de Levi-Banachique. C.R. Acad. Sci. Paris.

Y. Takahashi:

Some covariant identities and the generators of the Poincaré
group. Proc. R.I.A.

P. D. McCormack:

Combustible vortex rings. Proc. R.I.A.

Molecular interaction and vortex core size. Appl. Phys. Lett. A.

M. Conneely & S. Ormonde:

Continuum processes in atomic nitrogen. Phys. Rev.

M. Conneely, I. Lipsky & M. Ahmed:

Configuration mixings in two-electron systems. Proc. Seventh
International Conf. on Physics of Electronic and Atomic
Collisions.

C. P. Ryan:

Higher order effects in K-meson decays. Proc. Daresbury Study
Week-end on K-decay, 1971, ed. A. Donnachie & D. G. Sutherland.

IV - Annual Report of the Governing Board of the School of Cosmic Physics
adopted at its meeting on 22nd June 1971.

A. Astronomical Section

1. STAFF AND SCHOLARS

Senior Professor:

P. A. Wayman.

Professor:

T. Kiang.

Research Assistants:

I. Elliott; C. J. Butler (from 1970 November 1).

Experimental Officer:

B. D. Jordan.

Research Associate:

Professor N. A. Porter, U.C.D. (from 1971 March 25).

Technical and Clerical Staff:

Miss A. M. Callanan; Mr. P. Murphy; Mr. D. Fitzsimons (to 1971 February 28); Miss A. Downey.

Scholars:

C. J. Butler (to 1970 October 31); J. K. Brady (to 1970 September 30); M. V. Norris; P. B. Byrne (from 1970 October 1); A. D. Andrews (without stipend).

Professor Wayman continued as Chairman of the Irish National Committee for Astronomy during the year; also as a member of the Board of Governors of Armagh Observatory and a member of the Management Committee of Armagh Planetarium.

C. J. Butler was appointed as Research Assistant on 1970 November 1, being supported for two years by a grant from the National Science Council of Ireland.

2. RESEARCH WORK

Solar Research: . I. Elliott

The effect of strong local magnetic fields on the velocity field of the solar chromosphere is being studied by means of a time-series of

filtergrams. These photographs of the solar surface give information from a narrow (0.2Å) band-pass in the vicinity of strong solar spectrum lines; they were obtained in Sacramento Peak Observatory in 1968. The distribution over the solar surface of the line-of-sight velocities on three levels in the chromosphere is obtained from pairs of filtergrams taken at wavelengths equidistant from the centre of the H α line; simultaneous K-line filtergrams can indicate the distribution of the magnetic field.

Earlier (spectrograph) observations indicated a connection between K-line emission (i.e. local magnetic field strength) and oscillations of characteristic period 15 minutes. The aim now is to investigate this correlation further by a two-dimensional survey. The measurement and reduction of the filtergrams has become possible through the introduction of a scanning device and paper-tape output of the Joyce Loebel micro-densitometer. The calculations can be performed on the 1620 computer with the use of the Symbolic Programming System language.

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

Considerable attention was directed to the problems inherent in establishing the correctness of the magnitude-scales for the stars in the three regions of the Magellanic Clouds that are being surveyed for cepheid variable stars. The work involved a completion of the objective-grating method of testing and the result obtained indicated that the two independent scales set up in the two regions LMC II and SMC were in agreement to an accuracy of 0.1 magnitude in B and V down to magnitude 18.0.

Work on the standard stars in LMC I was also carried out; the photoelectric and photographic values for some 450 stars in the three regions were assembled and prepared for publication.

The work on the cepheid variables has been completed for the regions LMC II and SMC, correction now being made for the separate colour-terms of the individual photographic plates, taking into account the derived colour of the variable ~~at~~ the time of observation.

90 cepheids in LMC II and 73 cepheids in SMC have had light-curves prepared for publication, also 3 long-period variables in LMC II and 2 in SMC, together with one (foreground) RR Lyrae variable and 3 eclipsing variables in LMC II.

With the completion of LMC I, a third region will be available for comparison of cepheids in due course. Each of the three regions has now been adequately calibrated in U, B, V and, partially, in R, and the many photographic plates available for each region permit, for the future, a variety of investigations to be made. Making use of automatic plate-measuring facilities (GALAXY machine, Royal Observatory, Edinburgh) an investigation of Sanduleak's cluster foreground to LMC II has been started jointly with the Astrometry Department of the Royal Greenwich Observatory. Nine plates have been measured over a region $1^{\circ} \times 1^{\circ}$. The proper-motion criterion for membership, derived by Greenwich from long-focus plates, will be combined with photometry of ADH plates at Dunsink Observatory using these measurements. Tests on the "Galaxy" measures, using our standard reduction method, show that the photometry is of adequate accuracy over the main region of the plate, but it is suspected that a "Galaxy" measurement is more sensitive, in terms of magnitude, to slight variations in image-quality than are "Askania" iris-diaphragm measurements.

* The measurements of short-period variables in NGC 1466 have been completed during the year. Plates (B and V) taken at the Radcliffe Observatory, Pretoria, in 1969 have been measured and reduced using Gascoigne's photoelectric sequence. Correction for background fogging has been very important in this investigation and the iris-diaphragm measurements have been found to be much more satisfactory when these corrections are based on individual measurements of fogging near each measured image. Some of the older plates used by Wesselink on the same problem have also been similarly measured. The results have been discussed in terms of light-curves and periods for fifteen stars, five of which were given periods by Wesselink. It was found

that, even though the numbers of observations were small, the period-finding programs developed for cepheid variables were easily and usefully adapted to this somewhat more difficult case of short-period variables. Periods found range from 0.25 to 0.6 days and the B magnitudes lie in the range 18.5 to 19.8 for each variable, with a mean magnitude around 19.1.

Measurements of HV 13055, a suspected symbiotic star in the Large Magellanic Cloud, have been carried out in conjunction with Dr. E. M. Lindsay at Armagh Observatory. The reality of the suspected irregular variations in B over recent years has been confirmed, particular attention being paid to the accuracy of estimates from a variety of observational material, but no similar confirmation could be found in V-light.

Cepheid Variables: C. J. Butler, P. A. Wayman.

Analysis has been carried out on the Period-Luminosity-Colour relations for the cepheid variables of the Magellanic Clouds (SMC and LMC II) together with Gascoigne's published photoelectric data for similar stars. It has been established that where individual cepheids are observed in common, the agreement in magnitude is good.

The attempt is therefore made to represent the Dunsink and Canberra (Gascoigne) data of Period, Luminosity, Colour, etc. by one relationship that shall be chosen such as to give minimum residuals for individual stars. In this way the distance moduli to the Clouds will be best defined, particularly if the same relationship holds for both Clouds. It is found that a very good Period-Luminosity-Colour relationship will hold for the LMC, incorporating only a marginal departure from the partly-theoretical Sandage-Tammann relationship as regards the important colour-coefficient. However, it is difficult to find an equally good relationship which will take in the observations for both Clouds since the colour-coefficient for the SMC stars (P-L-C relation) is decidedly lower. Moreover, a small discrepancy also exists in the SMC between the average data of Dunsink and Canberra, to an extent of ^m 0.1 for the brighter variables; this is possibly due to chance selection.

These factors make a final adopted P-L-C relation elusive.

Interstellar Reddening: C. J. Butler

The magnitudes and colours of photoelectric standards in the Magellanic Clouds have been analysed in terms of stellar population. Photometric spectral classification has been made for early type stars and the interstellar reddening derived. The measured V-R colours make it possible to estimate the ratio of reddening E_{V-R}/E_{B-V} . All three regions show a higher value for this ratio than is normal within the Galaxy, indicating an unusual composition for the interstellar medium.

Planetary System: T. Kiang

The work on Halley's Comet was concluded during the year. Cowell and Crommelin's calculation of the planetary perturbations was fully repeated with a number of refinements. Perturbations were calculated, in three dimensions, by all the major planets and to the second order with respect to the motion of Jupiter. Each of the 28 revolutions took 7 hours' computing time on the 1620 computer. The parameter of time of perihelion passage was determined from a detailed re-examination of Chinese records. The perturbations and the orbital elements for 29 returns and the results of the Chinese data have been prepared for publication. The average perturbation in ω was found to be nearly 1° per revolution, much larger than the value of $0^\circ.15$ adopted previously. Precise data for the return of A.D. 837 are made use of for the first time. Other results include the evaluation of a deceleration due to non-gravitational force (change in period of +4.1 days per revolution) and the conversion of the apparently linear Chinese "foot" to true angular units (1 "foot" = $1^\circ.5$).

From permanently-numbered asteroids with $m_0 < 15$, it has been found that the thickness of the system of asteroids increases monotonically outwards. The 50% point in the density distribution perpendicular to the ecliptic increases from 0.12 A.U. at 2.2 A.U. (from the Sun) to 0.38 A.U. at 3.5 A.U. The same trend is confirmed by the sample of faint asteroids in the Palomar-Leiden survey, after the

latitude cut-off in the survey has been allowed for. A paper giving these results has been prepared.

3. INSTRUMENTS, ETC.

Electronics Laboratory: B. D. Jordan

Development of the signal processing units and the video switching network for the Video Comparator was completed. The mechanical system for plate alignment has been designed for construction in the workshops and further tests on the video system have been carried out.

A high-performance analogue to digital converter for digitizing the diaphragm reading on the Askania Iris photometer has been constructed and fully tested. The associated serializer, etc. for producing punched tape is being constructed.

Considerable work was done during the year on the construction of a twin-channel photometer head for use with the ADH telescope. The head amplifiers use a varactor bridge configuration. Recording instruments were prepared and, in order to facilitate recording slow transients on magnetic tape using a domestic tape recorder, two F.M. modulators and demodulators were built. The purpose of this equipment is to record optical phenomena over a field of 1° , approximately, with a comparison channel, the time-constants being of the order of 0.5 secs.

Computer and Associated Equipment: I. Elliott

The Joyce Loebel microdensitometer was converted to automatic scanning and punched paper tape output by the makers. 5-micron steps in X and Y are assigned from pre-set controls on the console. Tests were carried out to evaluate reproducibility, etc.

The benchmark tests to evaluate the possible benefits from replacement of the IBM 1620 computer were completed during the year and the results analysed.

Miscellaneous:

A two-channel photometer head for use with the 60-inch telescope at the Boyden Observatory (Cassegrain focus) has been constructed by a

commercial firm under a contract placed by the Royal Greenwich Observatory for several similar instruments.

4. LECTURES, CONFERENCES, ETC.

The Statutory Public Lecture for the School was presented by Dr. D. W. Sciama, Fellow of All Souls' College, Oxford, on 1971 March 24th, with the title "Recent Work on the Origin of the Universe".

The Fourteenth General Assembly of the International Astronomical Union was held in Brighton, England, in August 1970. The Assembly was attended by Professor P. A. Wayman, as National Representative, Professor T. Kiang, Dr. I. Elliott, Dr. C. J. Butler, and Mr. M. V. Norris. Professor Wayman served as Secretary to the Finance Committee of the General Assembly and as Secretary to the Magellanic Cloud Sub-Committee of Commission 28. Contributions to the meetings of Commissions 28 (Galaxies), 33 (Galactic Structure) and 27 (Variable Stars) were made by various members of the Section.

B. D. Jordan attended the Conference on Automation in Optical Astrophysics at Edinburgh in 1970 August. I. Elliott attended the I.A.U. Symposium on Solar Magnetic Fields in Paris in 1970 September, and T. Kiang attended the Colloquium on Asteroids at Tucson, Arizona, in 1971 March.

Meetings of the Boyden Observatory Council, attended by Professor P. A. Wayman, were held in Brighton in August, 1970, and in Bloemfontein in March, 1971.

5. VISITORS

Visitors to Dunsink Observatory during the year included Uachtarán na hÉireann (May 29), the School of Theoretical Physics (May 11), T. S. Jacobsen (June 22), the Annual Meeting of the Irish Astronomical Society (Sept. 19), L. Jánossy (Nov. 3), the U.C.D. Collaborative Radio Symposium (Nov. 5), Dublin University Experimental Science Association (Nov. 26), l'Association des Français and the Ambassador of France (Dec. 2), and R. H. Stoy (Dec. 30).

6. PUBLICATIONS

The following papers have been prepared for publication during the year:

- T. Kiang: "The Past Orbit of Halley's Comet".
- T. Kiang: "The z-Distribution of Asteroids".
- C. J. Butler: "Reduction of Iris-Diaphragm Measurements to Magnitude.
- C. J. Butler: "Photometric Standards in the Magellanic Clouds.
- P. A. Wayman: "The Phenomenon of the Ice Ages - a review of some contributions by E. J. Opik".
- E. M. Lindsay
and
P. A. Wayman: "Further Observation of HV 13055".

In addition, the following "Notes on the History of Dunsink Observatory" have been prepared for publication in the Irish Astronomical Journal:

- I. Henry Ussher at Dunsink, 1783-1790.
- II. The Visitation Book of Dunsink, 1791-1924.
- III. The Arnold Clocks at Dunsink.

B. Cosmic Ray Section.

1. STAFF AND SCHOLARS

Senior Professor:

C. Ó Ceallaigh.

Professor:

K. Imaeda.

Assistant Professor:

M. Kazuno.

Research Assistants:

Dr. A. Thompson; Dr. L. C'Sullivan; Dr. Y. V. Rao.

Experimental Officer:

Mr. J. Daly.

Technical and Clerical Staff:

Miss M. Dalton; Miss D. Molloy; Miss E. Byrne; Miss M. Ryan;
Miss E. Kee; Miss H. O'Donnell.

Scholars:

T. Cantwell; A. Curran; P. Fleming (to 1 January 1970).

2. RESEARCH WORK

European K⁻ Collaboration: T. Cantwell (with others)

The work, as outlined in the 1969-70 Annual Report, is now being brought to a close. The scanning has been completed and most of the data has been measured and analysed. The interpretation of the results and the writing of the drafts of the various papers is now in progress.

A value of $(1.41 \begin{smallmatrix} +0.09 \\ -0.08 \end{smallmatrix}) \times 10^{-10}$ sec. has been obtained for the lifetime of the Σ^- hyperon is in good agreement with the more recent determinations using the Hydrogen Bubble Chamber technique. Values of the decay branching ratio of the Σ^+ hyperon and the ratio of Σ^- to Σ^+ hyperon production have been obtained. An estimate has been made of the mean orbital capture time of Σ^- hyperons in emulsion. This is the first time that such an estimate for Σ^- hyperons has been obtained for using any detecting medium.

In this experiment, three further examples of the decay ${}^6_{\Lambda}\text{He} \rightarrow \pi^{-} {}^8\text{Li}$ have been found. These observations establish the existence of such a hypernuclear species. Previously, only one example has been reported in the literature.

D. O'Sullivan (during leave of absence at University of California, Berkeley 1.10.69 - 30.9.70).

Dr. O'Sullivan was granted leave of absence for the period October 1969 to September 1970 to take up a position as visiting lecturer and research physicist at the University of California at Berkeley. He lectured on electromagnetic theory to final year students and took part in a series of seminars on astrophysics for graduate students. During the year, he assisted Professor P. B. Price, Professor of Cosmology at Berkeley, in initiating a programme of research in cosmic rays using dielectric detectors and Lunar samples from the Apollo 11 and 12 missions. Three major research programmes were undertaken and completed during his stay.

Work on Lunar materials (with P. B. Price).

The history of solar and galactic radiation as well as the rate of erosion of the lunar surface were studied by using lunar rocks brought back on the Apollo missions. Studies of the galactic cosmic ray iron group nuclei in the interior of these rocks indicated that they had been exposed on the lunar surface for $\sim 10^7$ years. From observations on the steep gradient of cosmic ray nuclei in the outer few millimetres of the rocks it was possible to determine the average energy spectrum of production in solar flares over the past 10^7 years, and to set some limits on the rate at which the lunar surface has been eroded by micro-meteorite bombardment. A comparison of recent data from satellite experiments on solar flare spectra coupled with a study of lunar rocks showed that the average rigidity of nuclei ejected during these solar disturbances over the last 10^7 years was greater than that observed at present. The lunar erosion rate determined ($\sim 10^{-7}$ cm./year) agreed well with the value found by Shoemaker et al. in a study of the geology of lunar craters.

Study of the Charge-Spectrum of Heavy and Very Heavy Nuclei in Cosmic Radiation.

(a) D. O'Sullivan (with Berkeley and Bristol Groups)

Detectors flown in balloons over (i) Sioux Falls, S. Dakota in September 1969, and (ii) Palestine, Texas were used to study the charge spectrum of very heavy nuclei ($Z > 30$) in the primary cosmic rays. The former was undertaken with a view to collecting and identifying a sample of stopping heavy nuclei and constitutes the first information on this combined charge and energy region which had not been investigated hitherto. The latter experiment was confined to relativistic nuclei in consequence of the high geomagnetic cut-off for charged particles entering over Texas. These experiments were carried out jointly by the Berkeley group and Professor P. Fowler's Group at Bristol University. The results provided strong evidence of the existence of heavy nuclei extending into the radioactive region beyond $Z = 83$. Together with the data accumulated at relativistic energies in earlier flights, the results give some indication of an r-process abundance peak at $N = 126$, thus favouring supernovae as the possible source of these extremely heavy nuclei. They also supported the conclusion that heavy cosmic rays have a lifetime of less than 10^7 years.

(b) C. Ó Ceallaigh, A. Thompson, Y. V. Rao and D. O'Sullivan (from 1.10.70) assisted by J. Daly, Miss D. Molloy, Miss Mary Ryan and Miss Emer Kee.

The collaboration between the D.I.A.S. Group and Professor P. H. Fowler's Group at the University of Bristol has continued throughout the year. The chief objective has been the design, construction, exposure and recovery of a track-detecting ensemble for ultra-heavy cosmic-ray primary particles of very large collecting area sent aloft to altitudes $\sim 125,000$ feet by means of giant helium-filled balloons.

The trays of detecting materials consist of alternate layers of nuclear photographic and 'lexan' polycarbonate sheets separated by absorbers of brass sheet of carefully chosen thickness. The total thickness of each array was 7.6 grams/cm^2 . Since the mean free path for interaction of very heavy nuclei is about five times greater in brass than in polycarbonate the relative thickness and disposition of

the successive layers in the stack was arranged to favour the probability of stopping very heavy nuclei while minimising the probability of distortion of the mass spectrum by fragmentation. The assembly of the modules was carried out by a combined Bristol-Dublin team during summer 1970.

It was decided to expose the material in two separate flights each carrying ~ 10 square metres of material divided among 30 modules, the weight of each module being 55 lbs. The flights were scheduled to take place at Minneapolis, Minnesota, in September 1970 at an intermediate geomagnetic latitude to ensure a sufficient sample of stopping particles and the flight arrangements were placed by contract by the National Center for Atmospheric Research (NCAR) in the hands of Winzen Research Incorporated. A similar contract for the Manned Spacecraft Center, Houston, Texas, involving one launching, had first priority. As described in the Report by C. Ó Ceallaigh placed before the Board of the School of Cosmic Physics, there exist two periods in the late spring and the early autumn when the winds in the stratosphere change from E - going to W - going. These 'windows' last for about a fortnight, and during those periods the velocities of the upper winds are at a minimum. Clearly, it is essential for a long exposure-time coupled with easy recovery, that the quiet period be chosen for launching. The full history of the expedition is contained in the memorandum, and need not be repeated here. To summarise, the first attempt at launching the M.S.C. flight was a failure. The second was a partial failure, because, although successfully launched, the balloon was carried 1,000 miles out into the Pacific Ocean because of malfunction of the electronic systems commanding the descent of the balloon and the release of the parachute carrying the load. However, during the slow descent the balloon came into an E - going air stream. After a flight of 13 days it came to rest at Regina, Saskatchewan knocking down an electric power line and blacking-out a large area surrounding the point of impact.

Since Winzen Incorporated possessed but one set of command apparatus, it was not possible to launch the Bristol-Dublin flights until the balloon and ancillary equipment had been recovered. However, in a last-minute

attempt to get our flights off the ground, NCAR arranged for the missing equipment together with a tracking air-craft to be flown up from Texas. By that time, however, the weather conditions, both aloft and on the ground, had deteriorated. A final attempt at launching was made but at the critical moment, the surface winds changed direction and increased in speed so that the attempt was abandoned. Faced with the prospect of worsening conditions, the expedition was abandoned and the material was stored in anticipation of a launch at the Spring turn-about.

Since the difficulties of the Bristol-Dublin Collaboration had arisen, in large measure, because of the history of the M.S.C. flight, an arrangement was made to release a share of the lexan polycarbonate on the understanding that some material from the projected Spring launchings would be given to the M.S.C. and Berkeley Groups. That material was crated at Berkeley by Professor Ó Ceallaigh and Miss D. Molloy and brought to Dublin together with material from the previous Sioux Falls flights, as passenger luggage, fortunately without extra charge!

In the meantime, a processing plant designed and built by Mr. J. Daly had been built at Dublin and an agreement was made with the University of Bristol to finance 50% of the cost of building a much larger plant at Bristol in which D.I.A.S. has a half-share. This arrangement should prove to be most advantageous for future work and was made necessary in consequence of the conditions of gross overcrowding which exist at present at No.5 Merrion Square. It is appropriate to record the fact that the processing plant and ancillary equipment designed by Mr. Daly has exceeded all expectations in performance.

The material from the M.S.C. flight, although defective because of the relatively long time spent at low altitude, has proved to be very useful for pilot studies to establish optimum conditions for etching large sheets. In addition, some 14 events which appear to be very heavy primary particles, some of which came to rest in the stack, have been found in the D.I.A.S. share of the material and are being studied at present. Since the total number of such particles the existence of

which has been established is small, these examples, together with those found at Bristol, constitute a significant addition to the present world-sample.

While the problems posed by the absence of processing facilities have now been removed, a most serious bottle-neck, namely that of computing facilities, still exists. The obsolete I.B.M. 1620 computer which was acquired from Trinity College, Dublin and installed at Dunsink Observatory is now inadequate to meet the current demand. It is essential, therefore, for the execution of the work both of the Cosmic Ray Section and the rest of the School, that a modern faster computer installation be acquired with the minimum delay.

In March 1970, the Cosmic Ray Section was honoured by an invitation to take part in a collaboration experiment by a group at CERN, Geneva. The proposed experiment has a direct connection with our current programme, and involved a study of the feasibility of using Lexan polycarbonate detectors to investigate the possibility of producing very heavy nuclear fragments of relatively high-energy interactions of 30 GeV protons from the CERN proton synchrotron with heavy target materials such as tungsten. There is some evidence, based on nuclear chemistry experiments, that such interactions could lead to the production of stable transuranic elements. It is proposed to use techniques of direct charge estimation, using lexan polycarbonate detectors developed by the Dublin - Schenectady Group, to obtain more direct evidence for the existence and production of such elements. Preliminary experimental work has been carried out and gives encouragement for further investigation.

M. Kazuno

- (1) Further investigation on the mass of baryon isobars in cosmic ray interactions has been carried out resulting in a formula for evaluating average mass of baryon isobars using experimental data. The experimental values are compared with Hagedorn's theoretical predictions. In the lower

energy region ($\sim 10^{12}$ eV), the agreement between the experimental values and the prediction is rather good. However, at extremely high energy region ($\sim 10^{16}$ eV), the theoretical prediction gave large values as compared with the present experimental results.

(2) The production mechanism of very low energy pions (< 100 MeV in the l.s.) present in cosmic ray jets has been studied. It is concluded that those pions could not be produced via a pionization process but rather by an isobar process. From measurements of their emission angles, momenta and the primary energies various properties such as transverse momentum, inelasticity of collision have been evaluated. The results, suggest that the contribution of multi-body decay modes of isobars is significant. The fractional energy of primary carried by single pions in the c.m.s. on average is 0.26 per interaction.

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

K. Imaeda:

A further study of the statistical thermodynamics of hadron gas has been carried out. Special attention is given to the predicted existence of heavy hadron liquid drops which is surmised to be a more favoured form of existence than lighter hadrons in very high energy nuclear interactions when the primary energy exceeds 1,000 GeV. To provide a basis for comparison with experiment, the mechanism of formation and disintegration of hadron liquid drops into secondary particles has been investigated theoretically. Experimental data from cosmic ray jets have been analysed with a view to providing evidence for the existence of such heavy hadrons.

K. Imaeda and P. Fleming:

Improved expressions for predicting the position and dispersion of the $\log \tan \theta$ distribution of the secondary particles from high energy nucleus-nucleus collisions have been derived, with special reference to knock-on protons and alpha-particles and have been compared with observations on jets produced by heavy cosmic ray nuclei in emulsion.

A. J. Curran:

Investigations of the mechanism of ultra-high energy nuclear reactions were continued using additional data obtained from laboratories in Durham and Bristol. Papers giving interim results have been prepared and are listed under Publications. Two papers were presented at the High Energy Conference at Durham in 1970: "Search for a Fireball effect" and "The Dispersion-Energy relation for ultra-high energy reaction", the latter being in collaboration with Dr. Kazuno.

Work continued on the Ph.D. thesis 'Computer models of high-energy interactions' which is almost complete and will be submitted shortly.

3. WORKSHOP AND TECHNICAL DEVELOPMENT - J. Daly

Apart from routine maintenance of equipment the following projects have been completed.

A large Sodium hydroxide etching plant has been designed, built and tested. The temperature control mechanism has functioned in a very gratifying manner. Observed temperature variations were found to be within the range $\pm 0.02^{\circ}\text{C}$ which more than satisfied the degree of stability demanded by satisfactory etching of lexan polycarbonate. The etching bath has been equipped with perspex holding racks capable of accepting up to 40 sheets of size 18" x 12".

An additional measuring unit consisting of a Leitz Ortholux microscope with z - motion coupled to a Rank-Taylor-Hobson magnetic displacement transducer and digital volt meter has been set up. After adjustment, the accuracy of the displacement readings was tested by means of an optical interferometer and was found to be within 0.2% over a range of 2.5 mm.

During the Spring of 1970, a period of a fortnight was spent at the H. H. Wills Physical Laboratory, Bristol, in order to establish a production line for the trays designed to contain the stacks of detecting material for the projected balloon flights at Minneapolis, Minnesota. All materials were cut and shaped and a large number of mechanical sections were assembled.

4. NATIONAL SCIENCE COUNCIL RESEARCH GRANT

A proposal from Professor C. Ó Ceallaigh for a grant to cover a portion of the costs of the Bristol-Dublin Collaboration on Ultra-Heavy Cosmic Ray Primary Particles was accepted by the National Science Council. A grant of £3,400 per annum was made for a period, expected to be three years, commencing 1 October 1970. It was apportioned as follows - Salary of Dr. Y. V. Rao - Consumable materials for etching plastic detectors - Travelling expenses of Y. V. Rao. Professor Ó Ceallaigh was nominated principal investigator.

5. CONFERENCES, MEETINGS, ETC.

The following meetings and international conferences were attended by members of the Section:

7th International Colloquium of Corpuscular Photography and Solid State Detectors - July 1970. (C. Ó Ceallaigh, A. Thompson and Y. V. Rao).

Conference on High Energy Physics, University of Durham, September 1970. (K. Imaeda, M. Kazuno and A. Curran).

Conference on the Origin and Evolution of the Planets - held at the California Institute of Technology, Pasadena, March 1970. (D. O'Sullivan).

Lunar Science Conference (Manned Space Flight Center, Houston, Texas), September 1970. (D. O'Sullivan).

K⁻ Collaboration Meetings, E. Berlin, April 1970; U.C.D., September 1970; Brussels, February 1971. (T. Cantwell).

T. Cantwell also attended a working period at University College, London, September 1970, in furtherance of the K⁻ Collaboration.

J. Daly spent a period of approximately 14 days in May 1970 at Bristol in order to give assistance in establishing a production-line for the assembly of the modules for the projected Minneapolis Flights of the Bristol-Dublin Collaboration on Ultra-Heavy Cosmic Ray Primary Particles.

In July 1970 a party spent a week at the H. H. Wills Physical Laboratories, Bristol, to complete the assembly of the above modules. (C. Ó Ceallaigh, A. Thompson, Misses D. R. Molloy, M. Ryan and E. Kee).

A two-month period August-October 1970 was spent at Minneapolis, Minnesota, U.S.A. by a team from Dublin to assist in the launching and recovery of Minneapolis Flights. (C. Ó Ceallaigh, A. Thompson, Y. V. Rao and Miss D. R. Molloy).

Following the Minneapolis Expedition, C. Ó Ceallaigh, A. Thompson, Y. V. Rao and Miss D. R. Molloy visited the Physics Department, Berkeley, California for discussions with Professor P. B. Price and his collaborators. They also visited the Physics Department of the University of San Francisco for discussions with Professor E. V. Benton and his Group.

C. Ó Ceallaigh and Miss D. R. Molloy crated and transported the Bristol-Dublin share of the M.S.C. Flight and, on the return journey, visited the Physics Department of Washington University, St. Louis, for technical discussions with Professor R. M. Walker's Group from whom they collected the Dublin share of the lexan polycarbonate sheets from the Sioux Falls Flights of 1969.

In October 1970 a discussion meeting of the Bristol-Dublin Collaboration was attended by A. Thompson, D. C'Sullivan and Y. V. Rao.

In March 1971 A. Thompson spent a period of 3 days at CERN, Geneva, for preliminary discussions with Dr. A. J. Herz and Dr. Zielinski on the CERN-Dublin Experiment on Ultra-Heavy Nuclei. He also met Dr. A. J. Herz in London on 25th March 1971 for further discussions.

6. PUBLICATIONS

(a) Published:

T. Cantwell (with others of the K^- Collaboration):

Production of Hypernuclei from the Interactions of 10.1 GeV/c K^- Mesons with Emulsion Nuclei. *Nuovo Cimento, Series X*, Vol.61A, 525 (1969).

Hyperon Mass Measurements in Emulsion. *Proceedings of International Conference on Hypernuclear Physics, Argonne National Laboratory, U.S.A. May 5-7, 1969, p.222.*

K. Imaeda:

Statistical Thermodynamics of Hadron Gas and Liquid Drops. *Lett. Al Nuovo Cimento* 1, 290 (1971).

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

A study of the characteristic features of cosmic-ray jets of energy from 5×10^{10} eV to 10^{14} eV in emulsion. *Acta Physica Academiae Scientiarum Hungaricae* 29, 125 (1970).

M. Kazuno:

Baryon Resonances in Cosmic Ray Interactions. *Lett. Nuovo Cimento* 1, 517 (1971).

P. B. Price and D. C'Sullivan:

"Lunar Erosion Rate and Solar Flare Paleontology". *Proceedings of the Apollo 11 Lunar Science Conference, Vol.3, pp.2351-2359, published by Pergamon Press, June 1970.*

D. C'Sullivan, P. B. Price, E. K. Shirk, P. H. Fowler, J. M. Kidd, E. Kobetich and R. Thorne:

High Resolution Measurements of Slowing Cosmic Rays from Iron to Uranium. *Phys. Rev. Lett.* 26, 463 (1971).

D. C'Sullivan, E. Kobetich, E. K. Shirk, P. B. Price:

Resolution of high energy extremely heavy cosmic rays in plastic detectors. *Phys. Lett. B, Vol.34B, No.1 Jan. 1971.*

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

Composition of Cosmic Rays of Atomic Number 12 to 30. *Proceedings of the 11th International Conference on Cosmic Rays, Acta Physica Academiae Scientiarum Hungaricae* 29, Suppl.1, 417 (1970).

A. Thompson (and others of the K^- Collaboration):

Hypernucleus and Cryptofragment Production from the Interactions of Σ^- Hyperons. *Acta Physica Polonica* (1970).

(b) In the press:

K. Imaeda, M. Kazuno, P. Fleming:

Elastic scattering of target protons in nucleon-nucleus collisions. *Nuovo Cimento.*

T. Cantwell (with others of the K^- Collaboration):

Some properties of charged Σ hyperons. Part I. On the Existence of the Hypernucleus $\Lambda^8\text{He}$.

(c) In preparation:

M. Kazuno:

Characteristics of slow pions in Cosmic-ray jets.

K. Imaeda:

Statistical thermodynamics of hadron gas II.

K. Imaeda and P. Fleming:

Nuclear interactions by high-energy cosmic ray nuclei in emulsion.

T. Cantwell (with others of the K⁻ Collaboration):

Some properties of charged Σ hyperons. Part II.

The binding energies of light Hypernuclei.

Further evidence for the existence of Particle-Unstable states of $\frac{12}{\Lambda} \text{C}^n$.

7. LECTURES, COLLOQUIA, ETC.

K. Imaeda:

Faster-than-light particles. 24th November 1970.

Survey of experiments on ultra-high energy nuclear interactions. 8th December 1970.

Statistical thermodynamics of hadron gas and multiple meson production. 15th December 1970.

Conference - K. Imaeda, M. Kazuno and P. Fleming:

Elastic scattering of target protons in nucleon-nucleus collisions in nuclear emulsion at energy region 50 GeV to 10^{14} GeV. Conference on High Energy Physics, 23rd September 1970 at Durham University.

D. O'Sullivan:

Lecture entitled "Cosmic Rays and Lunar Studies" was delivered at Stanford University on September 23rd, 1970. A lecture on the same topic was also delivered at the School of Theoretical Physics, Dublin Institute for Advanced Studies on June 27th 1971.

C. Geophysical Section

1. STAFF AND SCHOLARS

Senior Professor:

T. Murphy.

Professor:

Vacant

Research Assistants:

R. P. Riddihough (to 31 May 1970); D. G. G. Young.

Senior Technical Assistant:

T. J. Morley.

Research Associates:

Rev. G. McGreevy (Maynooth College); P. Morris (Trinity College, from 1 October 1970); K. W. Robinson (Geological Survey, from 1 October, 1970).

Technical and Clerical Staff:

Miss A. Byrne; Miss E. Ryan; K. Bolster; J. Fay; T. Woods (from July 6 to August 28, 1970).

Scholars:

D. Howard (from October 20, 1970); P. Morris (to October 31, 1970); K. W. Robinson (to August 31, 1970).

2. RESEARCH WORK

(a) Gravity and magnetic fieldwork:

In last year's report it was mentioned that when Professor Murphy and Dr. Young carried out gravity readings in the Sligo district linking areas already covered to the North (by Dr. Young) and to the southwest (by Mr. English) they discovered certain discrepancies which they attributed to instrumental difficulties encountered by Mr. English. Further investigation showed that the discrepancies were serious and the whole suspicious area was remeasured. It was found that during the earlier work large random errors occurred spasmodically, but to date no explanation can be given for these. Other areas in Ireland were also rechecked but no similar discrepancies have been discovered.

This gravity work around Sligo confirms the abrupt change in character at a NW - SE line through Coolaney already reported. A further striking feature was found consisting of a belt of high anomaly running in a line NE - SW from near Manorhamilton through Ballymote which connects to the ridge already found near Charlestown. The magnetic work of Mr. English shows a distinct parallelism and the two together indicate that they have a common cause namely a narrow belt of intrusive material of possible Ordovician age. Its linearity is probably associated with large faults postulated to occur in this area but never properly defined. It is hoped that these results will now stimulate more active geological investigations.

Arising from the previous work some unusual gravity readings taken near Ballysodare, Co. Sligo attracted attention and work with aerial photographs suggested that they were caused by a large "sink-hole" in the Carboniferous strata. More gravity measurements were taken on a detailed levelled traverse and confirmed the suggestion that a large cavity now filled with light sediments to a depth of at least 100 m occurs. A ground survey of the district revealed more basinal features with steeply dipping rock walls but no obvious solutional phenomena indicating a recent origin and hence different to "sink-hole" investigated at Bogganstown, Co. Meath reported last year. The possibility that the features could date from the ice-age has aroused great interest particularly as the largest "sink-hole" near Ballysodare is below sea level. Time was not available for investigation by coring which was planned.

The gravity investigations around Lough Foyle were analysed and in co-operation with Dr. P. Brück of the Geological Survey who carried out the geological work the results were compiled and are now in the press.

Because of the unexpected results of the Lough Foyle work the fault trough at Kingscourt immediately presented itself as ripe for further work and Dr. Young carried out a more detailed survey than the earlier work. This confirms that many unusual and geologically unexpected features are present. There must exist deep light sediments in areas

mapped as Carboniferous sediments so that either the mapping is at fault as at Lough Foyle or the geological thickness estimates are wrong. This work was not completed.

Mr. Howard commenced his investigations centred on the Maine Valley, Co. Kerry. The gravity survey of the area published in our Bulletins showed strong gradients of a sign opposite to the indications of the densities of the surface rocks and more recent geological work has selected this district as an important one as the westernmost limit of geotectonic activity of Armorican times. He extended the detailed gravity readings and took magnetic measurements. His analysis is continuing.

Dr. Young carried out a limited magnetic survey in N.W. Mayo in continuation of Mr. English's work and has continued his analysis of the Co. Donegal gravity survey.

Copies of the records of magnetic and gravity surveys taken off the north-west coast were kindly supplied to us by the Hydrographic Office of the British Navy. These have been worked up by Riddihough and Young in conjunction with their work in that part and the results published.

The complete records of two seasons magnetic work taken west of Ireland covering the Porcupine Bank and Sea Bight carried out by the Department of Physical Oceanography, University of Wales have been given to us for analysis. The preliminary work has been carried out but the final analysis awaits further work to be carried out in 1971.

A small magnetic survey was carried out at sea near Dublin in collaboration with University College, Aberystwyth; under Mr. Robinson using our magnetometers.

(b) Magnetism

Dr. Riddihough completed his studies of the diurnal variation and the effects on the accuracy of magnetic surveys caused by the lack of knowledge of the variation in the area of the surveys. His results have been compiled into two parts, one of which is published; the

other is in the press.

Since his departure this work has been suspended.

(c) Meteorology

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

The solar radiation tabulations have been suspended due to the breakdown of one of the recorders.

The meteorological observations made at Trinity College since 1904 have had to be discontinued due to the encroachment of recent building near the site. The deleterious effects on the meteorological observations were noticeable for some time and in agreement with the Meteorological Service the station was closed on January 31, 1971. The observations taken at the School's station at Leinster Lawn overlap those of Trinity College by twenty-three years so that there is no break in continuity of meteorological recordings for Dublin City.

(d) Seismology

In last year's report certain difficulties encountered with the portable seismic recorders were noted and these have now been investigated. The worst features, traced to the amplifiers, have been improved and it has become obvious that the testing of the equipment could only be carried out under field conditions. To this end a small vault directly connected to rock was built in the grounds of Dunsink Observatory and, with the permission of Professor Wayman, arrangements were made to carry out the testing and actual observing in the Observatory buildings.

In November 1970 with improved equipment and facilities three observing stations were set up at Malin Head on Inishowen, outside Ballysodare, Co. Sligo and at Dunsink to record explosions in the sea west of Scotland and the North Channel in co-operation with Universities in Scotland and England. The overall arrangements were carried out by the Seismological Unit, Edinburgh under Dr. B. Jacob. Our records gave quite good results but these were marred by certain phenomena which have been attributed to the seismometers. This effect is being investigated. The final analysis will be made by the Seismological Unit.

A start has been made on recording quarry blasts and on the further improvement of the recorders.

(e) Palaeomagnetism

Mr. Morris completed his investigations and on submission of his thesis entitled "Palaeomagnetic Studies of the Carboniferous system in Ireland" was awarded the degree of Ph.D. by Dublin University and has incorporated some of his results in two papers (see Publications). He has continued his studies, following the cessation of his scholarship, in the Physical Laboratories of Trinity College under a research grant from the National Science Council and has become a Research Associate of the Institute.

3. CONFERENCES AND MEETINGS

The following have been attended by members of the Section:

European Association of Exploration Geophysicists, Edinburgh, May 20-22, 1970. (Murphy).

International Gravity Commission, Paris, September 7-12, 1970. (Murphy).

European Seismological Commission, Luxembourg, September 21-29, 1970. (Murphy).

Northern Universities Geophysical Meeting, Edinburgh, December 10, 1970, (Murphy and Young); March 4, 1971, (Murphy).

Geological Society of London, February 17, 1971. (Young).

First European Earth and Planetary Physics Colloquium, Reading, March 30 - April 2, 1971. (Murphy and Young).

4. PUBLICATIONS

(a) Published:

P. Morris:

Three new high sensitivity spinner magnetometers for use in Palaeomagnetism. Jour. Phys. E 3, 819-21.

An air suspended tumbler for A.C. demagnetisation of rocks. Jour. Phys. E 3, 921-22.

R. P. Riddihough:

An analysis of daily magnetic variation in Ireland. Comm. D.I.A.S. Ser.D, 28.

R. P. Riddihough and D. G. G. Young:

Gravity and magnetic surveys of Inishowen and adjoining sea areas off the north-west coast of Ireland. Proc. Geol. Soc. Lond. 1970, No.1664, 215-220.

(b) In the press:

T. Murphy, D. G. G. Young and P. Brück:

The post-Dalradian strata along the north-west coast of Lough Foyle, Inishowen, County Donegal. Proc. R.I.A.

R. P. Riddihough:

Diurnal corrections to magnetic surveys - an assessment of errors. Geophys. Pros.

D. G. G. Young (with M. H. P. Bott):

Gravity measurement in the North Irish Sea. Q. Jour. Geol. Soc. Lond.

W. B. Stanford
CHAIRMAN.

13th March, 1972.