

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

**ANNUAL REPORT**  
**1986**

10 Burlington Road, Dublin 4

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 year ended  
31 December 1986



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 ended 31 December 1986

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School of Celtic Studies

Professor Proinsias Mac Cana succeeded Professor Brian Ó Cuív as Director of the School from 1 April. There were two Visiting Research Associates in the School during the year, from the University of Toronto and St. Francis Xavier University, Antigonish. Of the eleven scholars six were Irish, three were from the United States, and one each from England and West Germany.

In addition to the annual Tionól and the usual unitary series of seminars on major subjects, this year saw something of an innovation in the presentation of a series of seminars on more limited topics given by several members of the Institute staff and by external scholars.

Steps were taken to improve the reference and research facilities in the School: a room was set aside for the recently acquired microcomputers and ancillary equipment and was used constantly by Scholars and members of the staff, and an extensive collection of microfilms was established which has already proved its worth for those members of the School whose work entails extensive use of manuscript material.

Work continued on the cataloging of manuscripts in the National Library of Ireland and in Trinity College Dublin.

Four new works and six reprints were published and six other works were in course of printing. Members of the staff and Scholars contributed some twenty-five articles to journals.

School of Theoretical Physics

President Hillery visited the School on 3 December. On 1 December Professor J. R. McConnell was awarded the Boyle medal of the Royal Dublin Society.

In addition to the use made by Staff, Scholars, and Research Associates of the School in their primary research activities, much use was made also by visitors, particularly during the summer months, of the School's facilities for research - especially of the opportunities for informal discussions, and of the library resources. Thirty-five research workers from universities or other institutes of research or higher education were admitted as research associates of the School; forty scientists from abroad visited the School during the year.

The Easter and Christmas Symposia were held as in previous years, seminars at DIAS and joint seminars (with UCD, TCD, Maynooth, NIHED) in special subject areas were continued. Six courses were given, nine contributions were made to the Journals' Club, and five lectures were given at Irish universities or NIHEDs. The Statutory Public Lecture was given at TCD by Professor Lewis: his title was "Do Bosons Condense?" A meeting of the Irish Mechanics Group was held, and a Workshop on Brownian Motion and Stochastic Mechanics was held.

The School continued its research. The primary areas of research were theoretical particle physics, classical statistical mechanics, and quantum statistical mechanics; secondary areas were general relativity and gravitation, applied mathematics, and pure mathematics. One book was published, and two sent to the press, forty-seven contributions to scientific journals or proceedings were published.

Members of the School attended twenty conferences abroad, and gave ten seminars and one poster at these. They gave thirty-one lectures and three courses of lectures at universities abroad.

School of Cosmic Physics

Astronomy Section

Observational work from La Palma concerned the phenomenon of jets observed from regions of star formation and associated with young stars. Other work related to circumstellar material included a full assessment of the evidence for mass loss associated with cepheid variable stars and the use of EXOSAT to investigate the nature of the X-ray source in the globular cluster M15.

Work in the electronics laboratory included the testing of the proto-type SLED circuits and the assembly and testing of the engineering model in Germany. Following these tests three sets of the digital electronics for the flight model of the SLED experiment, designed for the USSR Phobos mission were constructed.

Cosmic Ray Section

Following extended delay in progress with the Ultra-Heavy Cosmic Ray Experiment launched aboard LDEF in 1984, work has continued in preparation for a proposed second LDEF international mission under the name Heavy Nucleus Detector. This has included extensive laboratory calibration of polymer material.

The outstanding event of the year was the successful Halley Encounter programme of the European Space Agency when the Giotto spacecraft successfully traversed the environment of Comet Halley. The Section provided the Ground Support Equipment and the data analysis system for the particle detector EPA (Energetic Particle Analyses), which worked successfully throughout the mission and sent back satisfactory data on the particle fluxes across the plasma environment of the comet.

Work on the SLED engineering model was carried out in conjunction with the Astronomy Section. A magnetic monopole search program was continued to the point of providing an upper limit for monopole flux.

Geophysics Section

Seismic detectors, adapted or constructed in the Section workshop, have been used on an extensive variety of projects. Natural seismic activity has been monitored to a limited extent but the main work of the Section has been to exploit the co-operative resources available for the cross-survey of Ireland (COOLE) and the European Geotraverse from N. Italy to Kiel. The latter project, with 70 mobile recording stations, had a large Irish participation (20 stations), and magnetic tapes were brought back to Dublin for analysis with the Data General computer which was substantially extended as regards hardware and software with the assistance of EEC support. A new program, Geotwin, was entered into by contract with the University of Karlsruhe.

A marine and magnetic field survey formed part of the COOLE project and considerable progress was made in the interpretation of these data. The strength of the Decca/Loran chains in Irish waters was investigated. A re-drawn gravity anomaly map was produced.



INSTITIÚID ARD-LÉINN BHAILE/ÁTHA CLIATH  
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Annual Report of the work of the Institute  
and its Constituent Schools presented by  
the Council for the year ended  
31 December 1986

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In accordance with the provisions of Section 29 of the Institute for Advanced Studies Act, 1940 (No. 13 of 1940), the Council of the Institute has the honour to present to the Minister for Education for submission to the Government a report of the work and activities of the Institute and its Constituent Schools for the year ended 31 December 1986.

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 31 December 1986.
- II - Report of the Governing Board of the School of Celtic Studies.
- III - Report of the Governing Board of the School of Theoretical Physics.
- IV - Report of the Governing Board of the School of Cosmic Physics.

1 Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31 December 1986.

1 THE COUNCIL OF THE INSTITUTE

Chairman

T. K. Whitaker, D.Econ.Sc.

Ex-Officio Members

Patrick Masterson, M.A., Ph.D., President, University College, Dublin; W.A. Watts, M.A., Sc.D., Provost, Trinity College, Dublin; T. K. Whitaker, D.Econ.Sc., President, Royal Irish Academy.

Members appointed by the Governing Boards of Constituent Schools

P. Mac Cana, M.A., Ph.D.; T. de Bhaldraithe, M.A., Ph.D., D. Litt.; J. T. Lewis, B.Sc., Ph.D.; A. J. McConnell M.A., M.Sc., Sc.D., F.T.C.D.; T. Murphy, D.Sc.; E. F. Fahy, M.Sc., Ph.D.

2 GOVERNING BOARD OF THE SCHOOL OF CELTIC STUDIES

Chairman

T. de Bhaldraithe, M.A., Ph.D., D.Litt.

Senior Professors

P. Mac Cana, M.A., Ph.D.; B. Ó Cuív, M.A., D.Litt.

Appointed Members

G. Mac Eoin, M.A., Ph.D.; P. Ó Fiannachta, M.A.; T. Ó Floinn, M.A.; M. Ó Murchú, M.A.; S. Ó Tuama, M.A., Ph.D.; G. Stockman, M.A.; Ph.D., Dip. Ed.; G. Victory, B.A., Mus.D.; T. K. Whitaker, D.Econ.Sc.

3 GOVERNING BOARD OF THE SCHOOL OF THEORETICAL PHYSICS

Chairman

A. J. McConnell, M.A., M.Sc., Sc.D., F.T.C.D.

Senior Professors

J.T. Lewis, B.Sc., Ph.D.; J. R. McConnell, M.A., D.Sc.;  
L. O' Raifeartaigh, M.Sc., Ph.D.

Appointed Members

J. Dooge, M.E., M.Sc., C. Eng., F.I.E.I., F.A.S.C.E.,  
D.Agr.Sc.; J. N. Flavin, M.Sc., Ph.D.; M.A. Hayes,  
M.Sc., Ph.D.; P. Quinlan, B.E., D.Sc., Ph.D.;  
T.D. Spearman, M.A., Ph.D. (Cantab.) F.T.C.D.; S.S. Tóibín,  
M.Sc., Ph.D.

4 GOVERNING BOARD OF THE SCHOOL OF COSMIC PHYSICS

Chairman

E.F. Fahy, M.Sc., Ph.D.

Senior Professors

T. Murphy, D.Sc.; P. A. Wayman, Ph.D.; L. O'C. Drury, B.A. Ph.D.

Appointed Members

A. Brock, M.A., Ph.D., F.R.A.S., F.Inst.P.; D.J. Bradley  
Ph.D., F.R.S., F.T.C.D.; P.K. Carroll, M.Sc., Ph.D.;  
M. de Groot, Ph.D.; G.F. Imbusch, Ph.D., D.Sc.;  
D. L. Linehan, B. Sc., B.E.; V.J. McBrierty, B.Sc., M.A.  
Ph.D. (Lond.), Sc.D., C.Phys., F.INST.P., F.T.C.D.;  
N.A. Porter, Ph.D.; E.T.S. Walton M.A., M.Sc., Ph.D.,  
D.Sc., F.T.C.D.; D.L. Weaire, B.A. (Cantab.) Ph.D. (Cantab.).

5 ADMINISTRATIVE STAFF

Registrar

Lt. Col. J. P. Duggan, B.A., H. Dip.Ed., M.Litt., MIL.

Senior Clerk

Maura Devoy, B.A.

Accounts Clerk

Mary A. O'Rourke, B.A.

Clerks

Angela Stubbs; Noreen Granahan; Caitríona Tubridy;  
Desmond Pender; Eibhlín Nic Dhonncha.

11 - Annual Report of the Governing Board of the School of Celtic Studies for the year ending 31 December 1986, adopted at its meeting on 2 September 1987.

1. STAFF AND SCHOLARS

Professors Emeriti:

D. A. Binchy, James Carney.

Senior Professors:

Brian Ó Cuív, (Director to 31 March), Proinsias Mac Cana  
(Director from 1 April)

Professor:

Heinrich Wagner

Assistant Professors:

Pádraig de Brún, Fergus Kelly, Rolf Baumgarten,  
Mícheál Ó Siadhail.

Research Assistant:

Malachy McKenna

Assistant (part-time):

Nessa Doran

Junior Research Assistants:

Aoibheann Nic Dhonnchadha, Pádraig Ó Macháin.

Assistant Librarian/Clerk:

Máire Breatnach

Secretary/Publications Officer:

Máire Uí Chinnseala

Clerical Staff:

Karen Elson (appointed 8 January)



Scholars

Máirín Nic Dhonnchadha, Bette Crigger (to 30 September);  
Lisa Bitel (from 1 January to 30 June); Gerald Manning  
(from 12 March to 31 August); Colmán Etchingham,  
Kevin Walsh; Andrew Breeze, James Galvin, Colin Ireland  
Máire Ní Mhaonaigh, Jürgen Uhlich (from 1 October).

Visiting Research Associates:

Dr. Ann Dooley, Department of Celtic, University of  
Toronto (from January to June); Dr. Marilyn Gerriets,  
St. Francis Xavier University, Antigonish (from 1 October).

In addition to the usual seminars and Tionól, preparations  
were already in hand for the organization of the triennial  
Summer School in June-July 1987. Steps were taken to improve  
the reference and research facilities in the School: a room  
was set aside for the recently acquired micro-computers and  
ancillary equipment and has since been in constant use by  
scholars and members of the staff, and an extensive collection of  
micro-films was established which has already proved its worth  
for those members of the School whose work entails extensive  
use of manuscripts.

2. RESEARCH AND EDITING

Professor James Carney continued his work on Archaic Irish  
verse and supervised the work of Jürgen Uhlich. See also § 9 (c).

Professor Brian Ó Cuív completed the editing of Celtica  
xviii to which he contributed two articles and several reviews  
of publications. He continued the revision of Professor  
Kenneth Jackson's edition of Aislinge Meic Con Glinne. He  
also worked on a new edition of Tromdám Guaire which is being  
prepared in collaboration with Pádraig Ó Macháin. He continued  
research work on literary, linguistic and metrical aspects  
of Irish and on personal names. See also §§ 4, 6, 9 (a), (b), (e).

Professor Proinsias Mac Cana completed the editing of  
Ériu xxxviii. He collaborated with Professor T. Arwyn Watkins  
on an edition of Culhwch ac Olwen and continued work on an  
edition of Fled Bricrenn. He also worked on topics in Irish  
and Welsh literature and syntax. He cooperated with  
Professor T. Arwyn Watkins in revising Graham Thomas's edition  
of A Welsh Bestiary of Love. At the request of Unesco and the  
Department of Education, Professor Mac Cana organized a meeting  
of experts in the Institute 22-24 September, to plan a  
photographic exhibition of Celtic art to be mounted under the

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Report of the Comptroller and Auditor General

I have examined in accordance with approved auditing standards the Accounts set out on Pages 1 to 7 which are in the form approved under the provisions of Acht um Institiúid Ard-Léinn, 1940. I have obtained all the information and explanations which I considered necessary for the purpose of my audit.

In my opinion proper books of account have been kept by an Institiúid and the Accounts, which are in agreement with them, give a true and fair view of the state of its affairs at 31 December 1986, and of its transactions for the year then ended.

P. L. McDONNELL  
Comptroller and Auditor General  
9 September 1987.

auspices of Unesco. The eight experts who participated were from Ireland, West Germany, Hungary, Great Britain and France. He spent three weeks (20 October - 9 November) as Visiting Professor at the Department of Celtic, Harvard University. See also §§ 3, 6, 9 (c), (e).

Professor Heinrich Wagner completed the first draft of a section on personal pronouns for inclusion in his forthcoming book on Comparative Celtic Grammar; he edited and sent to press the material for ZCP 42 for which he revised and extended 'The Celtic Invasions of Ireland and Great Britain' (1985 Statutory Lecture delivered by him) and completed work on additional texts to Oral Literature from Dunquin for inclusion in the same volume. An article entitled 'The Roots of Finno-Ugric Folk Poetry' was accepted for publication in The Heroic Process edd. B. Almqvist, S. Ó Catháin, P. Ó hÉalaí. In January Professor Wagner was appointed Honorary Professor in the subject of Irish by University College of Wales, Aberystwyth. See also §§ 5, 9 (e).

Dr. Pádraig de Brún continued to catalogue Irish manuscripts in TCD (with Aoibheann Nic Dhonnchadha); to work on a guide to locations of manuscripts in Irish and to annotate a list of the Irish Society's Bible Teachers 1818-27. The following articles were accepted for publication: (i) 'The Irish Society's Bible Teachers, 1818-27 iv' (Éigse); (ii) 'Litir ó Thor Londain' (ibid.); (iii) Braithre Leasa Gabhail (Clogher Record); (iv) 'Tralee voters in 1835' Kerry Archaeological and Historical Society Journal. See also §§ 7, 8, 9 (c), (e).

Fergus Kelly completed the preparation of An Introduction to Early Irish Law; supervised Bette Crigger's work on Di Dligiud raith ocus somaíne and Colin Ireland's on Briathra Flainn Fína. As Director of the 1987 Celtic Studies Summer School he spent some time in organising and planning the courses. The following articles were accepted for publication: (i) 'An Old Irish Text on Court Procedure' (Peritia); (ii) Two notes on Old Irish final-verb constructions (Celtica). See also §§ 4, 6, 9 (e).

Rolf Baumgarten finalized work on the Bibliography of Irish Linguistics and Literature 1942-71 which was published in March. He worked on early Irish syntax and on an early recension of In Lebor Gabála. While in Germany in December he examined and described an Irish manuscript containing a later recension, An Leabhar Gabhála, compiled and written by Mícheál Ó Cleirigh, which was in the possession of a grand-niece of Kuno Meyer in Berlin. The manuscript was subsequently purchased by the Royal Irish Academy. An article entitled 'D. A. Binchy: a bibliography' was accepted for publication in Peritia. See also § 9 (b).

Mícheal Ó Siadhail completed work on his book Modern Irish Dialects and acted as extern examiner for a Ph.D. thesis for the Department of English, UCD. See also §§ 4, 9 (e).

Dr. Malachy McKenna continued work on an edition of The Spiritual Rose and completed the preparation of the following articles which were accepted for publication in ZCP: 'On the word for "sinner" in the Würzburg Glosses'; 'Review of A Handbook of Later Spoken Manx' (G. Broderick). See also §§ 4, 9 (e).

Nessa Doran (Nessa Ní Shéaghda) checked the final proofs of Fasc. IX of Catalogue of Irish Manuscripts in the National Library of Ireland which was published in March. Work on Fasc. X proceeded; descriptions of the MSS (G434-G500) were completed and typed in preparation for publication. See also §§ 7, 9(a), (b), (e).

Aoibheann Nic Dhonnchadha continued cataloguing the medical manuscripts in TCD under the supervision of Pádraig de Brún. See also § 7.

Pádraig Ó Macháin completed descriptions of MSS G501-G599 for Fasc. XI of Catalogue of Irish Manuscripts in the National Library of Ireland. He began work towards the formation of a stemma codicum for Tromdámh Guaire; and read proofs of the text of Professor Kenneth H. Jackson's edition of Aislinge Meic Con Glinne and revised the draft of the Vocabulary in preparation for publication. He investigated, with some success, various locations in Co. Waterford for the possible existence of Irish manuscripts. See also §§ 7, 9 (e).



Máirín Ní Dhonnchadha worked on the conveyance of property and rights by charter and other written documents and did some preparatory work on cáin-law for an edition of Cáin Adomnáin. An article entitled 'Inailt "Foster-sister, Fosterling"' was accepted for publication in Celtica. See also §§ 6, 9 (e).

Bette-Jane Crigger continued research on concepts of social identity in early Irish law and completed the textual introduction and preliminary notes for an edition of the clientship tract Di Dligiud raith ocus somaíne. See also §4.

Colmán Etchingham continued work on his doctoral thesis on ecclesiastical lordships in early medieval Ireland which is to be submitted to TCD.

Kevin Walsh edited a modern version of Scéla Mucce Meic Dathó which was accepted for publication in Éigse; he worked on a linguistic analysis of the Annals of Inisfallen. See also § 9 (e).

Lisa Bitel studied early Irish ethnological history in preparation for a Ph.D. thesis on women's monastic enclosures in early Ireland.

Gerald Manning worked on some additional chapters to his M.Litt. thesis 'The verbal system of Táin Bó Cuailnge - Recension I'. This material deals with (a) the use of the substantive verb and the copula in the text; (b) the status of the H-interpolations in Lebor na hUidre and (c) the manuscript tradition of the text. He began some preliminary work on an edition of the rosc passages in TBC - Recension I and on the poems attributed to Mael Muru of Othain in preparation for a Ph.D. thesis.

Andrew Breeze worked on sources for Céitinn's Trí Biorghaoithe an Bháis with a view to publication in Éigse or Ériu. An article entitled 'Giraldus Cambrensis and Poland' was accepted for publication in the Bulletin of the Board of Celtic Studies xxxiv. The following articles were submitted for publication: (i) 'The head of Brass in Gower, Tudur Aled, and Sir Thomas Browne' (Trivium); (ii) 'The Man in the Tree in Barlaam and Josaphat' (Celtica); (iii) 'The Dance of Death' (Cambridge Medieval Celtic Studies).

James Galvin worked on a thesis entitled 'The article system of Old Irish and Middle Welsh'.

Colin Ireland began research and transcription for an edition of the Bríathra Flainn Fína and Senbríathra Fithail.

Máire Ní Mhaonaigh transcribed and studied the text of Cogadh Gaedhel re Gallaibh from the TCD ms. and worked from a microfilm of the Brussels ms. version. She also worked on a poem concerning Brian Bórainhe Aniar táinic tuitim Bhriain.

Jürgen Uhlich worked on 'The Morphology of compound personal names in Old Irish' for a Ph.D. thesis.

Dr. Ann Dooley of the University of Toronto, worked on various texts including Liber Scintallarum and edited the poem Námha agus Cara dar gCeird which was accepted for publication in Celtica xviii. See also §§ 5, 9 (e).

Dr. Marilyn Gerriets of St. Francis Xavier University, Antigonish, undertook research on the role of king as judge in early Christian Ireland and on the relationship of the king to those *sub censu regali*.

### 3. STATUTORY PUBLIC LECTURE

A Statutory Lecture entitled 'The Early Ulster-Scottish Hero Cycle' was delivered by Professor Proinsias Mac Cana at University College Dublin, on 23 January 1987.

### 4. SEMINARS

Mr. Fergus Kelly's weekly seminar on the Heptads was resumed in January.

Dr. Malachy McKenna held seminars on 21 and 28 January on: 'The linguistic analysis of a dialect text: a methodology' (the text in question is known as The Spiritual Rose and was written by a native of Co. Louth and printed in 1800).

Professor Brian Ó Cuív held a seminar on 'Aspects of Early Modern Irish: Phonology, Grammar and Metrics' in the Hilary and Trinity terms.

Bette-Jane Crigger conducted a seminar (from March to May) on Di Dligiud raith ocus somaíne.

The following weekly seminars were held during the Michaelmas term (from 22 October to 17 December):

- Mícheál Ó Siadhail : Auxiliary Verbs in Modern Irish Dialects.
- Tomás de Bhaldraithe : Foinse Nua Ghaeilge nár saothraíodh - foclóir an Phluincéadaigh (1662)
- Brian Ó Cuív : 'Cóir' and 'Lochtach' in IGT Declension.
- Heinrich Wagner : Word-stress in Manx.
- Anthony Harvey : The Cambridge Juvenius Glosses: evidence for Hiberno-Welsh literary interaction?
- Brian Ó Cuív : Hiatus in Old and Middle Irish.
- Brian Ó Cuív : Hiatus in Classical Irish.
- Domhnall Ó Baoill : Hiatus in Modern spoken Irish (Donegal).
- Malachy McKenna : The system of historically long stressed vowels in a south Ulster dialect text.

##### 5 TIONÓL

The Annual Tionól was held on 21-22 March for University and College staff and research workers. The following papers were read:

- Ann Dooley : Námha agus cara dar gceird: text and discussion
- Heinrich Wagner : Iarfhocal (Epilogue) ar NÍ agus CHA sa Ghaeilge
- Pádraig Breatnach : Macallaí i bhFilíocht na Scol
- Art Hughes : Aspects of the verb in central Donegal
- Fergus Kelly : Uch! Upp! and other onomatopoeic exclamations in old Irish
- Ruairí Ó hUiginn : Tongu do dia toinges mo thúath and related expressions
- Damian McManus : On the authenticity of the manuscript key to the Ogam alphabet
- Tomás Ó Concheanainn : Sliocht Leabhair na Nuachongbhála ar Leabhar Buí Leacáin
- Kim McCone : Werewolves, cyclopes, díberga and fíanna: juvenile delinquents in early Ireland

## 6. EXTERNAL ACTIVITIES

Professor Brian Ó Cuív attended the 18th Annual Conference of the Council for Names Studies in Great Britain and Ireland in Exeter, 4-7 April. He also visited Chatsworth, Derbyshire, on 8-9 April to examine the Book of Lismore copy of Tromdám Guaire.

Professor Proinsias Mac Cana lectured on 'Y Syniad o Undod Cenedl a Gwlad yn Hanes Cymru' ('The notion of the unity of land and people in Welsh history') to Cymdeithas Owain Cyfeiliog, in Wrexham, Wales, on 6 March. Also in March he lectured on 'Placenames and Mythology in Irish Tradition: Places, Pilgrimages and Things' at the Congress of the American Committee for Celtic Studies in Ottawa, and took part in a symposium on 'Paganism and Christianity in early Ireland' at St Michael's College, Toronto. He lectured on 'La Traduction des épopées étrangères en irlandais' during a Table Ronde, 'Traduction et Traducteurs au Moyen Age', organized by the Institut de Recherche et d'Histoire des Textes in Paris, on 26 May, and on 'The Training and qualifications of the early Irish filid' at the Centre for Advanced Welsh and Celtic Studies in Aberystwyth, on 14 June. He held six seminars on Irish literary tradition and learned institutions while visiting Harvard University in October - November. He lectured on 'Myth and Literature in Early Ireland' at a colloquium organized by the Centre d'Études et de Recherches Irlandaises de l'Université de Lille III, on 12 December.

Mr. Fergus Kelly lectured on 'The Brehon Laws' at the Merriman Summer School at Lisdoonvarna on 17 August.

Máirín Ní Dhonnchadha attended the Conference of the Medieval Academy of Ireland in Maynooth in May.

## 7. CATALOGUING OF IRISH MANUSCRIPTS

A Catalogue of Irish Manuscripts in Cambridge Libraries compiled by Pádraig de Brún and Máire Herbert was published during the year.

Work on Irish manuscripts in the National Library of Ireland continued. Fasciculus IX (MSS G374-G433) compiled by Nessa Ní Sheaghda was published during the year. Descriptions of manuscripts G434-G500 for Fasc. X were completed and prepared for press by N. Ní Shéaghda who also described the two



medical manuscripts G505 and G512 for Fasciculus XI. Descriptions of the bulk of the manuscripts (G501-G599) for this Fasciculus were completed by Pádraig Ó Macháin.

Cataloguing of the Irish manuscripts in Trinity College Dublin was continued by Dr. Pádraig de Brún assisted by Aoibheann Nic Dhonnchadha who worked on the medical manuscripts.

#### 8 MICROFORM COLLECTION

A programme for the acquisition of microfilm or microfiche copies of manuscripts in Irish was initiated in 1986, under the supervision of Dr. Pádraig de Brún. Copies have been acquired of manuscripts existing in over eighty locations in Ireland, Britain, Europe, America and Australia. These have been obtained in two ways: (1) by having duplicates made (with the permission of the custodians of the original manuscripts) of negative microfilms in the National Library of Ireland; (2) by direct purchase from the institutions concerned, in cases where the National Library's holdings were inadequate. The first phase of the programme is expected to be completed in 1987, by which time films of about 2,800 of the estimated 4,500 Irish manuscripts in existence will have been acquired (the remainder not yet available on film). The bulk of the collection is in roll form and the films are stored in a controlled environment.

#### 9 PUBLICATIONS

##### (a) Works in course of Printing

The Annals of Ulster - Part II (containing an Introductory note and 3 Indexes compiled by G. Mac Niocaill).

Uraicecht Becc edited by C. McAll

Celtica xviii edited by Brian Ó Cuív

Catalogue of Irish Manuscripts in the National Library of Ireland  
Fasc. IX compiled by Nessa Ní Shéaghda

Uraicecht na Ríar edited by Liam Breatnach

A Welsh Bestiary of Love edited by Graham Thomas

(b) Books published by the Institute

Catalogue of Irish Manuscripts in the National Library of Ireland - Fasc. IX compiled by Nessa Ní Shéaghda.  
pp. iv + 97. £15

Collectors of Irish Manuscripts: Motives and Methods  
Nessa Ní Shéaghda. pp. 30. £1.50

Bibliography of Irish Linguistics and Literature 1942-71  
by Rolf Baumgarten. pp. xxiii + 775. £35

Celtica xviii  
ed. Brian Ó Cuív, pp. 233. £12

(c) Books published outside the Institute

James Carney:

The Playboy and the Yellow Lady. pp. 224  
Poolbeg Press

Proinsias Mac Cana:

Rencontre de Religions: Actes du Colloque de Collège des Irlandais tenu sous les auspices de l'Académie Royale Irlandais (Juin 1981), éd. par Proinsias Mac Cana et Michel Meslin (Les Belles Lettres, Paris, 1986).  
140 pp.

Ériu xxxvii. Edited with E. G. Quin. pp. 196.  
Royal Irish Academy

Pádraig de Brún:

Catalogue of Irish Manuscripts in Cambridge Libraries  
(with M. Herbert), Cambridge University Press.  
pp. xxx + 188.

Some lists of Kerry priests, 1750-1835, reprinted from Kerry Archaeological and Historical Society Journal  
(1985 (1986) ). pp. 83-169.

(d) Reprints of Institute Publications

Pwyll Pendeuic Dyuet ed. R. L. Thomson

Owein ed. R. L. Thomson

Branwen Uerch Lyr ed. Derick S. Thomson

Scéla Mucce Meic Dathó ed. Rudolph Thurneysen

A Historical Phonology of Breton ed. Kenneth H. Jackson

Nua-Dhunaire Cuid 1 edd. Pádraig de Brún, Breandán Ó Buachalla,  
Tomás Ó Concheanainn

(e) Contributions to periodicals and other publications

Brian Ó Cuív

Irish Language and Literature, 1691-1845  
A New History of Ireland IV. (Clarendon Press, Oxford).  
374-423.

Sandhi Phenomena in Irish  
Sandhi Phenomena in the Languages of Europe, ed. Henning  
Andersen (Mouton de Gruyter, Berlin, New York, Amsterdam).  
395-414

Deascán Filíochta.  
Féilscríbhinn Thomáis de Bhaldrathe. Eag. Seosamh Watson  
111-8.

Miscellanea  
Celtica xviii. 105-24

Aspects of Irish Personal Names  
ibid. 151-84.

Reviews of publications  
ibid. 219-26

Varia VII - The two herons of Druim Ceat  
Ériu xxxvii. 194-6.

Proinsias Mac Cana

Eirreadh Nuachair: Nótaí Breise ar an deasghnáth  
Féilscríbhinn Thomáis de Bhaldrathe. Eag. Seosamh Watson  
86-93.

Christianisme et paganisme dans l'Irlande ancienne  
Rencontre de Religions. 57 - 74. See § 9 (c)

Reviews of publications  
Celtica xviii. 214-219

Heinrich Wagner

Zur Etymologie von Keltisch Nodons, Ir. Nuadu, Kymr.  
Nudd/Lludd. Zeitschrift für Celtische Philologie 42, 180-7.

Keltisch und das Problem der indogermanischen Gutturale.  
Festschrift für Ernst Risch. 678-83

Iarfhocal ar NÍ agus CHA sa Ghaeilge  
Féilscríbhinn Thomáis de Bhaldrathe. Eag. Seosamh  
Watson. 1-10

Pádraig de Brún

Barántas ón mbliain 1714  
Éigse xxi. 66-71

The Irish Society's Bible teachers, 1818-27 III  
ibid. 72-149.

Further fragments of the Civil Survey.  
Kerry Archaeological and Historical Journal 18. 78-82.

Some lists of Kerry Priests, 1750-1835.  
ibid. 83-169.

Fergus Kelly

Two Notes on Final-Verb Construction  
Celtica xviii. 1-12

Old Irish creccaire, Sc. Gael. Kreahkir.  
Ériu 37. 185-6.

Mícheál Ó Siadhail

Some modern Irish loanwords describing people  
Celtica xviii. 53-6



Malachy McKenna

Review of An Novelov Ancien ha Devot.  
Celtica xviii. 213

Nessa Ní Sheághda

Moladh an Tobac  
Féilscríbhinn Thomáis de Bhaldráithe.  
Eag. Seosamh Watson. 119-123.

Pádraig Ó Macháin

Additional Readings to some Poems by Tadhg Dall Ó hUiginn.  
Celtica xviii. 69-76.

Ar bhás Chuinn Chéadchathaigh.  
Éigse xxi. 53-65.

Máirín Ní Dhonnchadha

Inailt 'Foster-sister, Fosterling'  
Celtica xviii. 185-91.

Review of Religiones Prerromanas.  
ibid. 210-2.

Kevin Walsh (Caoimhín Breatnach)

Corrigenda to The Annals of Inisfallen.  
Celtica xviii. 193-8

Ann Dooley

Námha agus Cara dar gCeird: A Dán Leathaoire  
Celtica xviii. 125-149.

III - Annual Report of the Governing Board of the School of Theoretical Physics for the year 1986, adopted at its meeting on 15 April 1987.

1. STAFF, EMERITUS PROFESSOR, SCHOLARS, RESEARCH FELLOW, RESEARCH ASSOCIATES, VISITING SCIENTISTS:

Staff:

Senior Professors:

John T. Lewis. Director from 1 January 1975; James R. McConnell; Lochlainn S. O'Raifeartaigh.

Assistant Professor:

A. Wipf, 1 April to 31 December.

Librarian-Executive:

Evelyn R. Wills.

Secretary:

Margaret Matthews.

Emeritus Professor:

John L. Synge.

Scholars:

H. Yoneyama (Japan) left 30 September; A. Wipf (Fed. German Rep.) left 31 March; D. Ó Sé (Ireland) left 31 August; E. Müller (Fed. German Rep.); P. Horváthy (Hungary); M. Vandyck (Belgium); W. Cegła (Poland) from 1 October; G. Raggio (Argentine) from 1 October; N. Gorman (Ireland) from 1 October.

European Science Exchange Fellow (Royal Society of London):

D. Williams (UK) from 1 October

Research Associates: (all appointments to 31 December 1987):

TCD: D. J. Bradley, R. K. Dodd, P. S. Florides, H. C. Morris, A. E. Raftery, B. K. P. Scaife, D. Weaire

UCD: P. A. Hogan, D. J. Judge, J. D. McCrea, J. V. Pulé, W. Sullivan

St. Patrick's College Maynooth: P. McGill, C. Nash, A. O'Farrell, J. Spelman, D. H. Tchrakian; B. Dolan appointed 29 September

UCG: M. J. Conneely, T. N. Sherry

DIT Kevin St.: T. Garavaglia, B. Goldsmith, D. Heffernan, M. Tuite

DIT Bolton St.: P. Houston

NIHED: E. Buffet, D. Heffernan; J. Burzlauff appointed 1 January

NIHEL: J. Kinsella; B. Lenoach appointed 1 January; R. H. Critchley appointed 29 September

Carlow RTC: D. Ó Sé appointed 29 September

An Foras Forbartha: J. M. Golden

Open University: A. I. Solomon

Oxford University: R. C. Flood.

Visiting Scientists:

J. Albery (Berlin) 11-16 Oct; H. Araki (Kyoto) 22 Feb. - 3 Mar.; M. van den Berg (Heriot Watt) 1-11 April and 15-19 Dec; E. Carlen (Princeton) 27 Aug - 1 Sept.; E. Corrigan (Durham) 12-14 May; Dong Ming-De (Beijing) 15 July - 15 Aug; D. E. Evans (Warwick) 27 Feb - 2 Mar; G. W. Ford (Ann Arbor) 23 June - 16 July; P. Forgács (Budapest and Southampton) 28 Ap - 8 May, 10-24 June, 24 Sept - 8 Oct, 15-19 Dec; Y. Fujimoto (Bern) 3-28 Jan and 20 June - 6 July; C. Graham (Simon Fraser) 8 Sept - (one year); M. Hennings (Oxford) 9-11 Feb; C. A. Hurst (Univ. Kent, Canterbury) 18-22 June; G. MacSithigh (Missouri-Rolla) 17-19 Dec; T. Murphy (Los Alamos) 14-16 April; R. Musto (Naples) 16-23 Feb and 8-16 Mar; W. Nahm (Bonn) 21-23 May; R. F. O'Connell (Baton Rouge) 9 June - 18 Aug; D. J. O'Connor (U. Texas at Austin) 28 July - 22 Aug; D. Ó Mathuna (Boston); O. Penrose (Heriot Watt) 29 Sept - 1 Oct; J. Rawnsley (Warwick) 28 Mar - 5 Ap; J. Rayski (Krakow) 23 Sept - 19 Oct; A. Verbeure (Leuven) 29 Sept - 30 Oct; M. Winnink (Groningen) 1 Oct - 4 Nov; M. Yor (Paris VI) 2-27 July.

2. GENERAL

The President, Dr. P. J. Hillery, visited the School on 3 December. He was shown computer work, and recent publications by members of the School.

Professor McConnell was awarded the Boyle Medal of the Royal Dublin Society on 1 December.

3. RESEARCH AND STUDY

Primary areas -

(a) Theoretical Particle Physics

Professor O'Raifeartaigh continued his research on spontaneous symmetry breaking (with J. Burzlaff), color-breaking by monopoles (with P. Horváthy and A. Balachandran), and anomalies in quantum field theory (with R. Musto, A. Wipf, and P. Forgács).

Professor Wipf studied symmetry restoration of Higgs models on the lattice and in the continuum, and index theorems for open manifolds and for manifolds with boundaries.

Dr. Williams completed papers on supersymmetry based on his Ph.D. work, and began a study of Kac-Moody algebras (with Professor O'Raifeartaigh, Dr. Gorman, and Dr. McGill).

Dr. Yoneyama studied symmetry restoration at finite temperature, and began a study of string theory.

Dr. Horváthy studied topological aspects of gauge theory, in particular the non-Abelian Bohm-Aharonov effect, and the (in-)stability of non-Abelian monopoles.

Dr. Gorman completed his Ph.D. and did further related research on methods of analytic continuation, and their applicability in extending approximate results derived from certain quantum mechanical models.

Dr. Burzlaff continued his study of topologically non-trivial solutions, and found such solutions in generalized Yang-Mills-Higgs theory in 4 dimensions (in collaboration with Dr. Tchrakian), and in more than 4 dimensions (in collaboration with Dr. Ó Sé and Dr. Tchrakian). Dr. Tchrakian continued the search for exact solutions of generalized Yang-Mills systems and generalized Einstein systems, and also studied the dynamical properties of these systems in the context of their vacuum structures in quantum field theory.



Dr. Tuite continued his study of finite-temperature field theory (FTFT), in particular its real-time formulation; he investigated the application of FTFT techniques in gauge theories, especially for symmetry restoration, and for dynamical symmetry-breaking. He began a study of topics of current interest in string theory.

(b) Classical Statistical Mechanics

(i) Brownian Motion and Relaxation Phenomena

Professor McConnell continued his research on nuclear magnetic relaxation. He studied dielectric relaxation in solids, the Mie-Born-Schrödinger nonlinear electromagnetic theory, and properties of molecular liquids. He completed the preparation of his book on the theory of nuclear magnetic relaxation in liquids for the Cambridge University Press. He also completed an article in Italian on dielectric properties in solids for the Dizionario delle Scienze Fisiche.

(ii) Phase Transitions in Lattice Systems

Dr. Cegła studied phase transitions in statistical mechanics.

(c) Quantum Statistical Mechanics

Dr Raggio studied large-deviation methods in the statistical mechanics of quantum spin systems, and the thermodynamics of the Dicke-Moser model.

(i) Asymptotic Evolution of Open Systems

Dr Müller studied basic differential recursion in the averaging method for the asymptotic evolution of an open system replaced by a purely algebraic recursion, using a newly defined multicommutator.

(ii) Boson Condensation

Professor Lewis continued his investigation of boson condensation in interacting systems using the principle of large deviations (with Dr. Pulè and Dr. van den Berg).

Dr. Müller studied the use of Debye potentials for the interaction of matter and electromagnetic, in particular the derivation of a covariant formulation for the coupling of Dirac field and electromagnetic field. He completed work on the thermodynamic limit of the free boson gas for fixed mean energy density, and began preparations of computations using REDUCE.

(iii) Quantum Stochastic Processes

Professor Lewis continued his research on the quantum Langevin equation (with Prof. Ford and Prof. R. F. O'Connell).

Secondary areas -

(e) General Relativity and Gravitation

Dr. Vandyck completed his study of the relativistic Robinson-Trautman line-elements. The spaces with small Gaussian curvature have been shown to evolve in time analogously to an ordinary heat wave, and the wire-singularities were investigated. He continued his study of classical supergravity, with the aim of comparing its predictions with those of general relativity and gauge theories, and began a development of a new formalism to define supersymmetric space-time symmetry.

Dr. McCrea's work was mainly concerned with generalizing from the Poincaré gauge theory to a metric-affine theory of gravitation, in collaboration with F. Hehl and E. Mielke (Cologne). They investigated the consequences of setting up a Lagrangian formalism in a metric-affine spacetime, where the connection was no longer metric-compatible. They studied the geometry of metric spacetimes, and the field equations and Noether identities for a general form of the Lagrangian.

(f) Applied Mathematics

Dr. Raggio investigated Bell's inequality in the  $C^*$ -algebraic framework, and the partial-ordering of states in  $C^*$ -algebras.

Dr. Cegła studied the application of large deviations in quantum spin systems.

Professor Graham, in collaboration with Dr. Golden, continued research on boundary value problems in elasticity and viscoelasticity, contact problems, crack problems, and applications to fracture.

Dr. Lenoach continued his work on waves in random media and on inverse problems.

(g) Pure Mathematics

Professor Synge studied a generalization of the Torricelli point of a triangle to the case of a simplex in  $n$ -dimensional Euclidean space, proving existence and uniqueness.

Dr. Goldsmith studied the applications of combinatorial principles from logic to problems in Abelian groups/modules and endomorphism algebras.

Research Reports

Research work during the year was written up in the first instance in research reports. Two lists of titles of these reports (preprints) were prepared and circulated to a mailing list of approximately 300 research institutes and university departments throughout the world. As far as available, copies of the preprints were supplied to research workers in response to requests. Many of the reports appeared later as publications, or were in press at the end of the year (See Section 11).

- DIAS-STP-86-01: T. GARAVAGLIA: Finite temperature quantum electrical network theory.
- 02: J. McCONNELL: Proprietà dielettriche nei solidi.
- 03: J. McCONNELL: Correlation and nuclear magnetic relaxation times.
- 04: P. A. HORVÁTHY: The Wu-Yang factor and the non-Abelian Aharonov-Bohm experiment.
- 05: F. W. HEHL & J. D. McCREA: Bianchi identities and the automatic conservation of energy-momentum and angular momentum in general relativistic field theories.
- 06: J. L. SYNGE: The nine-point circle in the Minkowskian plane.
- 07: J. L. SYNGE: Euclid and Minkowski juxtaposed.
- 08: R. MUSTO, L. O'RAIFEARTAIGH, & A. WIPF: The  $U(1)$ -anomaly, the non-compact index theorem, and the (Supersymmetric) BA-Effect.

- 09: P. A. HORVÁTHY & J. H. RAWNSLEY: On the stability of monopoles.
- 10: G. M. O'BRIEN & D. H. TCHRAKIAN: Localised instantons in four dimensions.
- 11: M. van den BERG, J. T. LEWIS, & J. V. PULÈ: The large-deviation principle and some models of an interacting boson gas.
- 12: J. T. LEWIS: Why do bosons condense?
- 13: M. van den BERG, J. T. LEWIS, & J. V. PULÈ: The existence of the pressure for a model of an interacting boson gas.
- 14: T. GARAVAGLIA: Spontaneous symmetry breaking in the composite vector boson model.
- 15: M. van den BERG, J. T. LEWIS & M. LUNN: On the general theory of Bose-Einstein condensation and the state of the free boson gas.
- 16: J. L. BIRMAN & A. I. SOLOMON: Spectrum generating algebras in condensed matter physics.
- 17: A. I. SOLOMON & J. L. BIRMAN: Mechanism for generation of triplet superconductivity.
- 19: A. I. SOLOMON & J. L. BIRMAN: Many fermion Green functions and dynamical algebra.
- 20: J. BURZLAFF, D. Ó SÉ & D. H. TCHRAKIAN: A finite-action solution to generalized Yang-Mills-Higgs theory.
- 21: G. W. FORD, J. T. LEWIS, & R. F. O'CONNELL: Thermodynamic perturbation theory for an atom interacting with blackbody radiation.
- 22: D. Ó SÉ, D. H. TCHRAKIAN, & T. SHERRY: Nonself-dual monopole solutions for  $SU(n)$  Yang-Mills-Higgs systems.



- 23: M. VANDYCK: On the motion of test-particles in a plane wave of supergravity.
- 24: L. O'RAIFEARTAIGH: The supersymmetry of the Dirac-Yang-Mills operator and some applications.
- 25: J. McCONNELL: Schrodinger's non-linear optics.
- 28: Y. FUJIMOTO, A. WIPF, & H. YONEYAMA: Symmetry restoration of Higgs models at finite temperature.
- 29: Y. FUJIMOTO, A. WIPF, & H. YONEYAMA: Finite temperature  $\lambda\phi^q$  theory in 2 and 3 dimensions and symmetry restoration.
- 30: P. HORVÁTHY: Monopole geography.
- 31: L. FEHÉR & P. HORVÁTHY: Dynamical symmetry of monopole scattering.
- 32: A. W. WIPF: The U(1)-anomaly, phase shifts and the  $\eta$ -invariant.
- 33: P. HORVÁTHY & L. O'RAIFEARTAIGH: Monopole instability I: negative modes.
- 34: D. WILLIAMS: Explicit construction of the massive supersymmetry multiplets in space-time.
- 35: D. Ó SÉ & D. H. TCHRAKIAN: Conformal properties of the BPST instantons of the generalised Yang-Mills system.
- 37: T. GARAVAGLIA: Predictions from the quark-parton model and source theory for deep-inelastic scattering with polarized particles.
- 38: J. KATRIEL, A. I. SOLOMON, G. d'ARIANO & M. RASETTI: Multiboson Holstein-Primakoff squeezed states for SU(2) and SU(1,1).
- 39: J. KATRIEL, M. RASETTI, & A. I. SOLOMON: Squeezed and coherent states of fractional photons.

- 40: J. KATRIEL, M. RASETTI, & A. I. SOLOMON: Generalized Holstein-Primakoff squeezed states for  $SU(n)$ .
- 41: A. I. SOLOMON & J. L. BIRMAN: An  $SU(8)$  model for the unification of superconductivity, charge and spin density wave.
- 42: J. BURZLAFF: Time-dependent vortices and monopoles.
- 43: J. McCONNELL: From nonlinear optics to nuclear magnetics.
- 44: P. FORGÁCS, L. O'RAIFEARTAIGH, & A. WIPF: Scattering theory,  $U(1)$ -anomaly and index theorems for compact and non-compact manifolds.
- 45: J. McCONNELL: Nuclear magnetic relaxation by intramolecular dipolar coupling.
- 46: D. WILLIAMS: Unitary irreducible representation of Lie supergroups.
- 47: M. VANDYCK: On the problem of space-time symmetries in the theory of supergravity.
- 48: E. MÜLLER: Bose-Einstein condensation in dependence of the mean energy effect.
- 49: J. McINERNEY & D. HEFFERNAN: Optical bistability in semiconductor injection lasers.
- 50: D. HEFFERNAN, P. PHELAN, J. O'GORMAN, & J. McINERNEY: Instabilities in external cavity injection lasers due to resonant self-pulsing.
- 51: J. L. SYNGE: An unperiodic concentrated sonic pulse.
- 52: G. W. FORD, J. T. LEWIS, & R. F. O'CONNELL: On the thermodynamics of quantum-electrodynamic frequency shifts.

- 53: M. VANDYCK: On the time evolution of some Robinson-Trautman solutions.  
Part 2.

4. SEMINARS, REVIEW LECTURES, SERIES, COURSES.

Seminar and review lectures, series, and courses, in specialised areas of physics and/or mathematics were given at DIAS-STP throughout the year, by members or visitors; as in previous years these were attended by members of staff and students from the universities and other third level and research institutes in the Dublin Area, and by members of the scientific schools of DIAS. And seminars or lectures were given at the Journals' Club, and at other Irish venues.

(a) Seminar and review lectures given at DIAS-STP:

Prof. H. ARAKI (Kyoto): (1) Introductory seminar on  $C^*$ -algebras and phase-transitions in lattice models.

(2) The ground-states of the XY-model.

(3) The 2-dimensional Ising model.

Dr. A. BOSSAZIT (Electricité de France): Group theory and boundary value problems.

Prof. E. CARLEN (Princeton): (1) Nelson's stochastic mechanics.

(2) Bounds of heat kernels.

Dr. W. CEGŁA

(1) Localisation of photon.

(2) Review of Ya. G. Sinai's Course on the Theory of Probability.

Dr. E. CORRIGAN (Durham): (1) Contemporary string theory.

(2) Twists and symmetry breaking.

- Dr. P. FORGÁCS (Budapest and Southampton): Developments in higher-dimensional (KK) theories and their reduction.
- Dr. Y. FUJIMOTO (Bern): (1) Introduction to a new real time finite temperature quantum field theory - Thermo field dynamics.  
(2) Introduction to thermo field dynamics II.
- Dr. T. GARAVAGLIA: Finite temperature quantum electrical network theory.
- Dr. P. GODDARD (DAMTP, Cambridge): Infinite dimensional algebras.
- Prof. K. HAYASHI (Kitasato): Interpretations of geophysical and Eotvos anomalies.
- Dr. M. HENNINGS (Oxford): Some properties of normal quantization.
- Prof. C. A. HURST (Adelaide & Canterbury): A Pfaffian approach to lattice models.
- Dr. S. McMURRY (TCD): A wave equation for the photon.
- Prof. W. NAHM (Bonn): Gauge theory of strings.
- Prof. J. SERRIN (Minnesota): A general variational identity.



(b) Series and courses given at DIAS-STP:

Prof. O. PENROSE (Heriot Watt): Quantum Monte-Carlo method and a model of a ferromagnetic fluid.

Prof. A. VERBEURE (Leuven): The Goldstone modes for spin-density waves.

Prof. M. WINNINK (Groningen): (1) Finite-element calculation of phase-diagrams of alloys.

(2) Survey of variational characterizations of equilibrium states in statistical mechanics.

Dr. A. WIPF: String theories (4 seminars).

Dr. E. MÜLLER: Use of Debye potentials in the Dirac equation (4 seminars).

The Probability Seminar organized by Professor Lewis and Dr. Sullivan was continued from the previous year. The main topic was large deviations, and the following lectures were given:

Prof. J. T. LEWIS: An introduction to large deviations (2 lectures).

Large deviations and phase transitions.

Dr. W. SULLIVAN: Large deviations for lattice systems (2 lectures).

Large deviations for continuous-time Markov chains.

(c) Contributions to the Journals' Club (Joint TCD-UCD-Maynooth-DIAS Meeting, held in TCD):

J. BURZLAFF: The generation puzzle.

B. DOLAN: Homogeneous space with torsion - alternative compactification for superstrings.

T. GARAVAGLIA: Reports on Winter 1985 Rutherford Meeting (Thermofields and the theory of black holes / CP violations).

A. WIPF: The  $U(1)$  anomaly, phase shifts and the  $\eta$ -invariant chiral anomalies and index theorems.

D. TCHRAKIAN: Compactified generalized Yang-Mills systems.

C. NASH: (1) A complex anomaly.  
(2) Global anomalies.

H. YONEYAMA: Constrained effective potential.

M. VANDYCK: Motions of test-particles in some waves of supergravity.

(d) Other lectures or seminars given in Ireland by members of DIAS-STP:

L. O'RAIFEARTAIGH: Supersymmetric quantum mechanics, at UCD, on 17 April.

Supersymmetry and the Dirac operator, at UCD, on 29 May.

M. VANDYCK: The MACSYMA language: Overview and Applications, at Summer School on Computational Mathematics, held at NIHEL, 3 July.

E. MÜLLER: Bose-Einstein condensation of free photons, at NIHED, on 5 March.

H. YONEYAMA: Monte Carlo simulations in quantum field theories, at the Dublin Physics Summer School, July.

## 5. ACTIVITIES OUTSIDE IRELAND

Professor McCONNELL attended a Meeting on 12 May, at the University of Paris VI, of the Organizing Committee of the Fourth European Molecular Liquids Group (EMLG) Conference; he visited the Dept. of Physics of the University of Pavia on 24 June, for consultations; and he attended Meetings of Committees of the EMLG at Cambridge from 22-24 September. He attended the Conference on "Rotational Dynamics of Small and Macromolecules in Liquids" at the ZIP, Bielefeld, 21-23 April, the Conference on "Collision Induced Phenomena and Microdynamics of Liquids", in Florence, 18-21 June, the NOVA SPES International Symposium on "New Hope for Security and Cooperation in Europe", in Vienna, 19-20 September, and the 4th EMLG Conference, on "Non-rigid Molecular Liquids", in Cambridge 22-25 September.

Professor O'RAIFEARTAIGH paid short visits in April to Argonne Nat. Lab., Fermi-Lab., the University of Illinois (Urbana), Notre Dame, and MIT. He attended the Conference on Symmetries in Physics, at the University of Southern Illinois, at Easter, and the Conference on Differential Geometrical Methods in Math. Physics, at the Univ. of Clausthal, 28 July - 1 Aug. From September to December (inclusive) he was on sabbatical leave at Syracuse Univ., and paid short visits to Rochester Univ. (in October), City College NY (in November), and MIT (in December).

Professor LEWIS attended a Conference at Helsinki, 8-12 January, the Conf. on Large Deviations and their Applications, Oxford, 23-28 March, the One-Day Conf. in Statistical Mechanics, King's Coll. London, 6 June, and the Congres IAMP, Luminy (Marseille), 17-24 July. He visited Heriot-Watt Univ. 22-25 April and 22-26 September, Univ. Warwick 21-24 October, and Univ. Groningen 6-12 November, for discussions.

Professor WIPF attended the 22nd Winter School on Fields and Geometry, at Karpacz (Poland), 17 February - 3 March, and the Conf. on Non-Perturbative Methods in Quantum Field Theory, Siófok (Hungary) 1-7 September.

Dr. RAGGIO attended the Workshop on Operator Algebras in Mathematical Physics, Univ. of Warwick, 23-28 March, and visited the Kath. Univ. Leuven from 2-5 June.

Dr. YONEYAMA visited Univ. Kaiserslautern 29-31 January, and Univ. Bern 1-9 February for collaboration with Dr. Fujimoto, and to give a seminar; he visited Univ. Kyushu in August.

Dr. HORVÁTHY visited Univ. Bologna 5-10 January, and Univ. Naples 10-20 January. He visited Marseille 1-23 February, and attended the Mathematical Physics Conference at Marseille, 16-26 July. He attended the

15th Inter. Conf. on Diff. Geomet. Methods in Math. Phys., Clausthal, 28 July - 1 August, and the Conf. on Non-Perturbative Methods in Quantum Field Theory, Siofok (Hungary) 1-7 September. He visited Univ. Warwick on 16 October, and Univ. Liverpool on 25 October. He went to Marseille on leave of absence from 30 November for 6 months.

Dr. GORMAN went to Univ. Languedoc, Montpellier, from 11 November - 7 December, for research and discussions.

Dr. MÜLLER visited Univ. Milan, and Univ. Zürich in May-June, for research and discussions. He visited the Univ. Ryensburg on 30 June, the Tech. Univ. Aachen on 1 July, and the Univ. Tübingen on 3 July.

Dr. WILLIAMS attended the Rutherford High Energy Lab.'s Annual Winter Meeting on 16-17 December.

Dr. BURZLAPP visited the Univ. of Kaiserslautern 20-22 January, 14-15 April, and 8-19 December, and Univ. Cambridge 12-14 February, and he attended the 15th Inter. Conf. on Differential Geometrical Methods in Math. Phys., Univ. of Clausthal, 28 July - 1 Aug.

Dr. TCHRAKIAN visited CPT-Luminy (Marseille) in July, to work with R. Coquereaux and to give seminars; and he attended the IAMP Conference at Luminy; he visited Univ. Kaiserslautern in August to work with H. J. W. Müller-Kirsten, and to give seminars.

Dr. GOLDSMITH visited Univ. Essen in February, for research, and Univ. Padova in May as an Invited Speaker.

Dr. McCREA visited Ben Gurion Univ. (Beersheba), and Univ. Tel Aviv, 16-23 March, and he attended the 11th International Conf., on General Relativity and Gravitation, at Stockholm, 6-12 July.

Dr. LENOACH attended the Conf. on Applied Modelling & Simulation, at Vancouver, 2-6 June, and visited the Univ. of Alberta 7-22 June.



Seminars, Lectures, Poster, and Courses given Abroad:

Professor McCONNELL:

Lecture: Relaxation of rigid and non-rigid molecules,  
ZIP Conference.

Professor LEWIS:

Lectures: Boson Condensation and Large Deviations,  
King's Coll., London

Dynamical Systems and Quantum Optics,  
Marseille Conf.

Large Deviations in Statistical Mechanics,  
Heriot-Watt.

Professor O'RAIFEARTAIGH:

Lecture Course on Anomalies in Field Theory, Syracuse,  
Nov.-Dec.

Lectures on Anomalies and Supersymmetry of Dirac  
Operator, at all the other centres he visited (see  
above), and at the Conferences at Southern Illinois and  
Clausthal.

Professor WIPF:

Lectures: SUSY and Anomalies, Karpacz.

The U(1) anomaly, phase-shifts, and the  $\eta$ -  
invariant, Siofok.

Dr. RAGGIO:

Lecture: Bounds for the free-energy of quantum spin  
system S, Leuven.

Dr. MÜLLER:

Lecture: Bose-Einstein Condensation of Free Photons,  
Ryensburg, Aachen, and Tübingen.

Dr. YONEYAMA:

Lecture: Constraint effective potential, at  
Kaiserslautern and Bern.

Dr. HORVÁTHY:

Lectures: Monopole Geography, Warwick.  
Monopole Instability, Liverpool.  
The non-Abelian Bohm-Aharonov Effect, Naples  
Topological Aspects of Monopoles, Naples  
The problem of 'global color' in gauge theory  
Naples.  
Quantum ambiguities, Marseille, February  
Plenary Session Lecture: Monopole Geography, Siofok.  
8-hour course: Geometric Quantization and Feynman Path  
Integrals, Bologna:  
Poster: Monopole Instability, Marseille.

Dr. TCHRAKIAN:

Lecture: Generalized Yang-Mills and Gravitational  
Systems on Higher Dimensions: Luminy, and  
Kaiserslautern.

Dr. BURZLAFF:

Lectures: Successful Models for the Inflationary  
Universe, Kaiserslautern, January  
Global Existence of Time-dependent Vortices  
and Monopoles, Cambridge  
Helium-3, Kaiserslautern, April  
Disconnected Non-maximal Stability Groups  
and Horizontal Symmetry, Kaiserslautern,  
December  
Time-dependent Vortices and Monopoles,  
Clausthal Conference  
Series of Lectures: Applications of Group Theory,  
Kaiserslautern, December.

Professor GOLDSMITH:

Lectures: Coslender Groups, Essen.

Essentially Indecomposable Modules in  $V=L$ ,  
Padova.

Mixed modules in  $V=L$ , Padova.

Dr. McCREA:

Lectures: Bianchi and Noether Identities in Relativistic Field Theories, Beersheba, and Tel Aviv.

Poincaré Gauge Theory of Gravitation, at Stockholm Conf.

#### 6. STATUTORY PUBLIC LECTURE

A Statutory Public Lecture under the auspices of the School was delivered by Professor LEWIS on 10 December in Trinity College Dublin. The title was 'Do Bosons Condense?'

#### 7. SYMPOSIA

Two Mathematical Symposia were held during the year, 3-4 April, and 18-19 December. The attendance (33 in April, 58 in December) included professors, lecturers, and graduate students from the Irish universities and other third-level and research institutes, and from institutes abroad, and members of the scientific Schools of DIAS.

Lectures were given as follows:

APRIL:

Review Lectures:

Prof. J. FLAVIN (UCG): Inequalities in potential theory and elasticity theory.

Dr. J. RAWNSLEY (Warwick): Stability of harmonic maps.

Lectures:

- Dr. G. MURPHY (UCC): Diagonalization, extensions and K-theory.
- Dr. M. VANDYCK: Waves in supergravity.
- Dr. B. LENOACH (NIHED): Inverse problems.
- Dr. P. MCGILL: Trapped Brownian motion and an elliptic function identity.

Short talks:

- Dr. J. BURNS (Maynooth): Conjugate cut loci in compact symmetric spaces.
- Mr. P. DOWLEY (Waterford RTC): An empirical method of discriminating between the principal formalisms of quantum mechanics.
- Dr. M. O'CALLAGHAN (UCC): Orthotropic plate vibrations using the edge-function method.
- Prof. P. M. QUINLAN (UCC): The edge-function method for fracture mechanics.
- Dr. T. SHERRY: Perturbative expansion of the Zeta-function.
- Dr. J. J. GRANNELL (UCC): Coupling of boundary and domain methods in finite-element analysis.

DECEMBER:

Review Lectures:

- Prof. R. ARON (Kent State & UCD): Homomorphisms and continuity.
- Prof. G. MacSITHIGH (Missouri-Rolla): Constrained variational problems.



Lectures:

- Prof. T. LAFPEY (UCD): Products of skew-symmetric matrices.
- Dr. R. A. RYAN (UCG): The Banach space  $c_0$ .
- Dr. D. WALSH (Maynooth): Hankel operators.
- Dr. M. van den BERG (Heriot-Watt): Gaussian bounds for the heat kernel.

Short Talks:

- Dr. C. THOMPSON (Southampton): Infinite products in Banach algebras.
- Dr. D. HURLEY (UCG): Lyapunov exponents.
- Prof. M. HAYES (UCD): On the central circular sections of Lamé's stress ellipsoid.
- Dr. D. BIRMINGHAM (Imperial Coll.): A BRST-invariant string state.
- Dr. B. McCANN (UCG): Fitting classes.
- Dr. N. Ó MURCHADHA (UCC): Conformal scalar curvature on asymptotically flat manifolds.

8. IRISH MECHANICS GROUP / DIAS-STP MEETING:

A Meeting on 'Developments in Mechanics' organised by the Irish Mechanics Group in collaboration with DIAS-STP was held at DIAS on 17 December; the attendance was 17. Lectures were given as follows:

- Prof. E. T. HANRAHAN (UCD): A new stress-strain-time theory for real materials.
- Prof. J. FLAVIN (UCG): Some upper estimates in axisymmetric linear elasticity.
- Mr. T. P. MOLONEY (NIHEL): Soliton interactions (for KdV).
- Prof. G. MacSITHIGH (Missouri-Rolla): Bifurcation in finite elasticity.

Prof. J. DUNWOODY (QUB): Deformation at the interface of two adjoined finitely pre-stressed hyperelastic half-spaces.

Mr. D. REYNOLDS (NIHED): An example of bifurcation in viscoelasticity.

Prof. P. M. QUINLAN (UCC): Current research project on edge functions in reduced order modelling and elastodynamics.

Prof. A. NORRIS (Rutgers): Gaussian wave packets.

Prof. M. A. HAYES (UCD): Maximum orthogonal shear.

9. WORKSHOP ON 'BROWNIAN MOTION AND STOCHASTIC MECHANICS:

A Workshop on 'Brownian motion and stochastic mechanics' was held at DIAS-STP from 7-11 July; the attendance was 14. Lectures were given as follows:

Dr. M van den BERG (Heriot-Watt): Heat equation in polygons and other regions in  $R^2$ .

Dr. P. BIANE (Paris VI): About  $\int_0^t ds/B_s$ , where B is BM(1).

Prof. E. B. DAVIES (King's Coll. London): Gaussian upper bounds on heat kernels and others.

Prof. K. D. ELWORTHY (Warwick): Spectrum of Laplacian and generalized Bochner theorem.

Prof. R. HUDSON (Nottingham): Quantum stochastic calculus.

Prof. T. JEULIN (Paris VI): Enlargement of filtrations and "old" results on Brownian local times.

Prof. J. F. Le GALL (Paris VI): Intersection properties of Brownian paths and limit theorems for the Wiener sausage.

Prof. J. T. LEWIS: The large deviation principle for triangular arrays of geometrically distributed random variables.

Prof. T. LYONS (Edinburgh): Tail-fields for diffusions.

Dr. N. MANDOUVALOS (King's Coll. London): Spectral theory of hyperbolic manifolds and some results on heat kernels.

Dr. P. MCGILL: Some explicit Wiener-Hopf calculations.

Dr. W. SULLIVAN: Random walks on  $Z^d$  and Schrödinger operators.

Prof. J. B. WALSH (U Brit. Columbia): A theorem or conjecture on Levy's Markov property.

Prof. M. YOR (Paris VI): Recent studies of multiple points of Brownian motion.

## 10. VISITORS

For lectures given by Visitors, see Sections 4, 7, 8, & 9. As in previous years, visitors from abroad came to the School for short or long periods, for discussions with School members, to give seminars, and to avail of the School's library resources for their research work.

Short visits (up to one week) were made by

- J. ALBERTY (Berlin), 11-16 Oct
- D. ANDERSON (UC San Diego), 19 June
- A. BOSSAZIT (Electricité de France), 5 Sept
- E. CARLEN (Princeton), 27 Aug - 1 Sept
- E. CORRIGAN (Durham), 12-14 May
- D. E. EVANS (Warwick), 27 Feb - 2 Mar
- P. GODDARD (DAMTP, Cambridge), 24 June
- K. HAYASHI (Kitasato), 16 July
- M. HENNINGS (Oxford), 9-11 Feb
- C. A. HURST (Adelaide & Southampton) 18-22 June
- G. MacSITHIGH (Missouri-Rolla), 17-19 Dec
- T. MURPHY (Los Alamos), 14-16 April
- W. NAHM (Bonn), 21-23 May
- O. PENROSE (Heriot-Watt), 29 Sept - 1 Oct.
- J. SERRIN (Minnesota), 22-25 May
- A. VERBEURE (Louvain), 29 Sept - 3 Oct



Longer visits were made by

- H. ARAKI (Kyoto) 22 Feb - 3 Mar  
M. van den BERG (Heriot-Watt), 1-11 April, 15-19 Dec  
DONG MING-DE (Beijing Inst. TP), 15 July-15 Aug  
G. W. FORD (Ann Arbor), 23 June - 16 July  
P. FORGÁCS (Budapest & Southampton), 28 April - 8 May,  
10-24 June, 24 Sept- 8 Oct, & 15-19 Dec.  
Y. FUJIMOTO (Bern), 3-28 Jan, 20 June - 6 July  
C. GRAHAM (Simon Fraser) 8 Sept - (academic year)  
R. MUSTO (Naples), 16-23 Feb, 8-16 Mar  
R. F. O'CONNELL (Baton Rouge), 9 June - 18 Aug  
D. J. O'CONNOR (U Texas at Austin), 28 July - 22 Aug  
D. Ó MATHUNA (Boston)  
J. RAWNSLEY (Warwick), 28 Mar - 5 April  
J. RAYSKI (Krakow), 23 Sept - 19 Oct  
M. WINNINK (Groningen), 1 Oct - 4 Nov  
M. YOR (Paris 6), 2-27 July

Visits to the School in connection with the Workshop on Brownian Motion and Stochastic Processes (Sect. 9) were made by M. van den Berg (Heriot-Watt), P. Biane, T. Jeulin, J. F. Le Gall (all Paris 6), E. B. Davies & N. Mandouvalos (King's Coll Lond), K. D. Elworthy (Warwick), R. Hudson (Nottingham), T. Lyons (Edinburgh), J. B. Walsh (Brit. Columbia).

11. PUBLICATIONS

Note: Items marked with an asterisk have been recorded as in press in previous reports.

(1) Book:

Published:

\*L. O'Raiheartaigh. Group structure of gauge theories. Cambridge University Press 1 May 1986

In the press:

J. McConnell. The theory of nuclear magnetic relaxation in liquids. Cambridge Univ. Press.

J. M. Golden & G. A. C. Graham: Boundary value problems in linear viscoelasticity. Springer.

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

None published.

(3) Contributions to periodical and other publications:

J. McConnell:

\*Theory of nuclear magnetic relaxation by dipolar interaction. Physica 135A (1986), 38-62.

Correlation and nuclear magnetic relaxation times. Physica 138A (1986), 367-381.

Relaxation of rigid and non-rigid molecules in liquids. Report no. 20/1986. Res. Gp. on Complex Liquids, Centre for Interdisc. Res. (21F), U. Bielefeld.

J. T. Lewis:

Brownian motion on a submanifold of a Euclidean space. Bull. Lond. Math. Soc. 18 (1986), 616-620

D. E. Evans & J. T. Lewis:

\*On a C\*-algebra approach to phase transition in the two-dimensional Ising model. II. Commun. math. Phys. 102 (1986), 521-535.

G. W. Ford, J. T. Lewis, & R. F. O'Connell:

Stark shifts due to black-body radiation. J. Phys. B: At. & Mol. Phys. 19 (1986), L41-L46.

Thermodynamic perturbation theory for an atom with blackbody radiation. Phys. Rev. 34A (1986), 2001-2006.

G. W. Ford & J. T. Lewis:

\*Quantum stochastic processes. Probability, statistical mechanics, and number theory, Adv. in Math. Supplemental Stud. v.9, pp.169-1194, Acad. Pr. 1986.

M. van den Berg, J. T. Lewis, & M. Lunn:

\*On the general theory of Bose-Einstein condensation and the state of the free boson gas. Helvetica phys. Acta 59 (1986), 1289-1310.

M. van den Berg, J. T. Lewis, & J. V. Pulè:

A general theory of Bose-Einstein condensation. Helvetica phys. Acta 59 (1986), 1271-1288.

E. Buffet & J. V. Pulè:

Hard bosons in one dimension. Ann. Inst. H. Poincaré, Phys. th. 44 (1986), 327-340.

L. O'RaiFeartaigh:

The supersymmetry of the Dirac-Yang-Mills operator and some applications. Symmetries in Science II, Eds. B. Gruber & R. Lenczewski, Plenum 1986, pp. 591-600.

D. Kaymakçalan, L. Michel, K. C. Wali, W. D. McGlinn, & L. O'RaiFeartaigh:

\*Absolute minima of a  $SO(10)$  invariant Higgs potential. Nuclear Phys. 267B (1986), 203-230.

L. O'RaiFeartaigh, A. Wipf, & H. Yoneyama:

\*The constraint effective potential. Nuclear Phys. 271B (1986), 653-680.

R. Musto, L. O'Raifeartaigh, & A. Wipf:

The  $U(1)$ -anomaly, the non-compact index theorem,  
and the (supersymmetric) BA-effect. Phys.  
Lett. 175B(1986), 433-438.

A. W. Wipf:

\*Tunnel determinants. Nuclear Phys. 269B (1986),  
24-44.

J. Burzlaff:

\*Statics and dynamics of classical Yang-Mills-Higgs  
systems: Some recent developments. 4th Symp.  
Theor. Phys., Seoul 1985, Selected Topics in Par-  
ticle Physics, ed. H. S. Song, Seoul: Kyohak  
Yunkusa, 1986, p.109.

J. Burzlaff & L. O'Raifeartaigh:

\*Disconnected non-maximal stability groups and  
horizontal symmetry. Proc. 14th Internat. Coll.  
Group Theor. Methods in Physics, Seoul 1985, ed.  
Y. M. Cho, World Sci. 1986, p. 455.

J. Burzlaff & N. Ó Murchadha:

\*Global existence of time-dependent Yang-Mills-  
Higgs monopoles. Commun. math. Phys. 105 (1986),  
85-98.

J. Burzlaff & D. H. Tchrakian:

\*Finite-action solutions of higher-order Yang-Mills  
theory in four dimensions. Il Nuovo Cim. 92A  
(1986), 107-115.

G. M. O'Brien & D. H. Tchrakian:

\*Stress tensor for GYM in 4p dimensions and vi-  
ability of GYM-Higgs in four dimensions. LMP  
11 (1986), 133-140.

D. H. Tchrakian:

Comment on "Torsion and chiral fermions in  
Kaluza-Klein theories". Phys. Rev. 34D (1986),  
3930-3931.



A. Chakrabarti & D. H. Tchrakian:

\*A compactification of, and instantons in, 4p-dimensional gravity. Phys. Lett. 168B (1986), 187-191.

D. Ó Sé, T. N. Sherry, & D. H. Tchrakian:

\*Surface integrals in lower dimensions from higher-order Chern classes and a class of solutions in three dimensions. J. math. Phys. 27 (1986), 325-339.

Non-self-dual monopole solutions for SU(n) Yang-Mills-Higgs systems. J. Phys. A: Math. Gen. 19 (1986), L853-L859.

H. Yoneyama:

\*The Martinelli-Parisi systematic expansion in lattice gauge theory - Z(2) model on a cubic lattice. J. Phys. A: Math. Gen. 19 (1986), 1235-1243.

\*Migdal renormalization group approach to deconfinement phase transition. Z. Phys. 30C (1986), 267-278.

Y. Fujimoto, K. Ideura, Y. Nakano, & H. Yoneyama:

\*The finite temperature renormalization group equation in  $\lambda\phi^4$  theory. Phys. Lett. 167B (1986), 406-410.

S. Caracciolo & H. Yoneyama:

\*Optimization of the potential shifting in the Martinelli-Parisi expansion of the Z(2) gauge theory on a cubic lattice. J. Phys. A: Math. Gen. 19 (1986), 1229-1234.

E. Müller:

\*Bose-Einstein condensation of free photons in thermal equilibrium. Physica 139A (1986), 165-174.

P. Horváthy & C. Nash:

\*A geometric view on topologically massive gauge theories. Phys. Rev. 33D (1986), 1822-1824.

P. A. Horváth:

\*Non-Abelian Aharonov-Bohm effect. Phys. Rev. 33D  
(1986), 407-414.

P. Horváth & J. Rawnsley:

\*The problem of "global color" in gauge theories.  
J. math. Phys. 27 (1986), 982-990.

T. Garavaglia:

Spontaneous symmetry breaking on a composite-  
vector-boson model. Phys. Rev. 34D (1986),  
3236-3239.

D. M. Heffernan:

Transient resonant spiking in degenerate four wave  
mixing in saturable absorbers. Optik 72 (1986),  
69-70.

P. Phelan, J. O'Gorman, J. McInerney, D. Heffernan:

Instabilities in external cavity injection lasers  
due to resonant self-pulsing. Appl. Phys. Lett.  
49 (1986), 1502-1504.

F. W. Hehl & J. D. McCrea:

\*Bianchi identities and the automatic conservation  
of energy-momentum and angular momentum in  
general-relativistic field theories. Found.  
Phys. 16 (1986), 267-293.

W. G. Sullivan:

$L^2$  convergence of certain random walks on  $Z^4$  and  
related diffusions. Proc. Conf. on Stochastic  
spatial processes, Heidelberg 1984. Springer  
LNM 1212, 1986, pp.249-257.

B. Goldsmith:

\*Essentially indecomposable modules over a  
complete discrete valuation ring. Rend. Sem.  
Mat. Univ. Padova 70 (1983), 21-29.

B. Goldsmith:

On endomorphisms and automorphisms of some torsion-free modules, in Proc. Oberwolfach Conf. on Abelian Groups. Gordon & Breach, 1986.

Realizing rings as endomorphism rings - the impact of logic. Bull. Irish Math. Soc. 17 (1986), 20-28.

B. Franzen & B. Goldsmith:

On endomorphism algebras of mixed modules. J. Lond. Math. Soc. (2) 31 (1985), 468-472.

B. Lenoach:

Non-stationary reliability models in applied modelling and simulation, Acta Press (Anaheim, CA), 1986, pp. 7-13.

G. C. W. Sabin & G. A. C. Graham:

Causality and the Laplace transform. Canad. Math. Soc. Appl. Math. Notes 11 (1986), 33-40.

J. L. Synge:

Backward energy-flux for spherically symmetric scalar waves. Quart. appl. Math. 44 (1986), 361-365.

Euclid and Minkowski juxtaposed. C. R. Math. Rep. Acad. Sci. Canada 8 (1986), 171-175.

The nine-point circle in the Minkowskian plane. C. R. Math. Rep. Acad. Sci. Canada 8 (1986), 176-180.

In the press:

J. McConnell:

Schrödinger's nonlinear optics. Schrödinger Centenary Celebrations of a Polymath., Ed. C. W. Kilmister Camb. Univ. Pr.

From nonlinear optics to nuclear magnetics. Occas. Papers in Irish Sci. & Tech. RDS.

Proprietà dielettriche nei solidi. Invited contribution for Il Dizionario delle Scienze Fisiche.

Relaxation of rigid and non-rigid molecular liquids. Rotational Dynamics of Small and Macromolecules in Liquids. Eds. Th. Dorfmueller & R. Pecora, Springer LNP.

J. T. Lewis:

Do bosons condense? Schrödinger Centenary Celebrations of a Polymath., Ed. C. W. Kilmister. Camb. Univ. Press.

G. W. Ford, J.T. Lewis, & R. F. O'Connell:

On the thermodynamics of quantum electrodynamic frequency shifts J. Phys. B: At. Mol. Phys.

M. van den Berg:

On the asymptotics of the heat equation and some best possible bounds on traces associated with the Dirichlet equation. J. funct. Anal.

D. Ó Sé & D. H. Tchrakian:

Conformal properties of the BPST instantons of the generalised Yang-Mills system. LMP.

J. Burzlaff, D. Ó Sé, and D. H. Tchrakian:

A finite-action solution to generalized Yang-Mills-Higgs theory. LMP.

G. M. O'Brien & D. H. Tchrakian:

A dimensional reduction of the GYM-Dirac system in  $4p$ -dimensions ( $p=2$ ). Il Nuovo Cim. A.

Localised instantons in four dimensions. Phys. Rev. D.

P. A. Horváthy & J. Rawsley:

Monopole invariants. J. Phys. A: Math. Gen.

L. Fehér & P. Horváthy:

Dynamical symmetry of monopole scattering. Phys. Lett. B.

M. Vandyck:

On the motion of test-particles in a plane wave of supergravity. Class. Q. Gravity.



On the time evolution of some Robinson-Trautman solutions. II. Class. Q. Gravity.

J. McInerney & D. Heffernan:

Optical bistability in semiconductor injection lasers. IEE Proc. J - Optoelectronics.

J. Katriel, M. Rasetti, & A. I. Solomon:

Generalised Holstein-Primakoff squeezed states for  $SU(n)$ . Phys. Rev. D.

J. M. Golden & G. A. C. Graham:

The transient quasi-static plane viscoelastic moving load problem. Internat. J. Engg. Sci.

The steady-state plane normal viscoelastic contact problem. Internat. J. Engg. Sci.

The three-dimensional steady state viscoelastic indentation problem. Internat. J. Engg. Sci.

B. Goldsmith & R. Godel:

Essentially indecomposable modules which are almost few. Quart. J. Math. (Oxford).

Mixed modules in  $L$ . Rocky Mountain J. Math.

R. Dimitric & B. Goldsmith:

On Coslender modules. Glasnik Math.

J. D. McCrea:

Poincaré gauge theory of gravitation: foundations, exact solutions, and computer algebra. Proc. 14th Internat. Conf. Differential Geometric Methods in Math. Phys., Salamanca 1985, eds. P. L. Garcia & A. Perez-Rendon, Springer LNM.

E. Schrufer, F. W. Hehl, & J. D. McCrea:

Exterior calculus on the computer: the REDUCE package EXCALC applied to general relativity and to the Poincaré gauge theory. GRG.

B. Lenoach:

Wave propagation in a random layered medium. J. Phys. A.

J. L. Synge:

An unperiodic concentrated sonic pulse. Quart.  
appl. Math.

#### LIBRARY

Approximately 220 new titles were added to the library stock during the year; approximately 200 current periodicals were taken, of which almost half were received by gift or under exchange arrangements. The RIA 'permanent loan' scheme was continued, as were other forms of cooperation with research libraries at home and abroad.

Offprints and preprints were received from many scientific institutes and university departments at home and abroad, either directly or in response to requests.

In addition to the regular exchanges, gifts of books or journals were received from Professor J. McConnell, Professor Synge, Dr. Müller, Dr. Ó Sé, Professor H. W. Peng, Dr. O. Glaser, Dr. R. Kuik, Dr. J. Rawnsley, the Acad. Rep. Soc. of Roumania, Fermilab, ICTP, Inst. Nuclear Study of Tokyo, KEK, Slovak Acad. Sci., Univ. Cath. Louvain, and the Univ. of Warsaw.

The President, Dr P. J. Hillery, visited the Library on 3 December.

IV - Annual Report of the Governing Board of the School  
of Cosmic Physics adopted at its meeting on 1 May 1987.

A ASTRONOMY SECTION

1 STAFF, SCHOLARS AND EMERITUS PROFESSOR

Senior Professor :

P. A. Wayman

Professor :

T. Kiang

Research Assistant :

I. Elliott

Experimental Officer :

B.D. Jordan

Research Associates :

P.B. Byrne (Armagh), B. McBreen (UCD), R.M. Redfern (UCG)

Visiting Scientist :

T.P. Ray

Technical and Clerical Staff :

A.M. Callanan, W.H. Dumbleton, M. Smyth

Scholar :

P. J. Callanan

Emeritus Professor :

H. A. Brück

Mr. H.P. Deasy held a Studentship at the Copernicus Astronomy Centre, Warsaw from 1 March to 31 December, following award of a UNESCO Copernicus Fellowship. Mr. Deasy was awarded the Ph.D. degree in the University of Dublin, Trinity College, in October.

Mr. A.J. Keane (UCG) and Mr. T. Beard (Imperial College, London) worked as vacation students during July and August.

Members of the Section served on committees in Ireland as in the Report for 1985. In addition Professor Wayman was invited to attend meetings of the Large Telescope Committee of the Spanish Canary Islands Observatories International Scientific Council as Irish representative.

## 2 RESEARCH WORK

### Pulsation Studies, Cepheid Variables :

H.P. Deasy, P.A. Wayman.

In the completion of his Ph.D. thesis, Mr. Deasy reviewed the evidence that mass loss from cepheids is occurring. From the presence of (IRAS) infrared excess and from measurements of absorption lines in ultra-violet (IUE), the levels that were found lie between  $10^{-10}$  and  $10^{-8}$  solar masses per year in a few individual cases. Such low levels do not resolve the problem of 'evolutionary' cepheid masses being out of agreement with 'pulsation' estimates. Hydrodynamical models were also investigated with a view to using Y.A. Fadeyev's non-linear code applied to pulsation-related mass loss in classical cepheid variable stars. In conjunction with D.J. Mullan (Newark, N.J.) programmes for submission to the Space Telescope Science Institute were prepared in respect of cepheid mass-loss. Also, the nebulosity associated with RS Puppis was studied in order to relate this variable star with mass loss; a paper incorporating this work has been submitted for publication.



Asteroid Dynamics : T. Kiang

Theoretical investigation of asteroid orbital stability was continued. It is now apparent (i) that the application of Helleman's method of finding periodic orbits of asteroids may not be superior to the traditional method by "trial-and-error"; (ii) that the basic fourth-order differential equation for  $\Delta\Gamma$  may be reduced to one of third order depending on whether or not the variation in the Hamiltonian function can be regarded as time independent; (iii) that, for a third-order or a fourth-order equation, the solution must be unstable in the mathematical sense and the e-folding time for  $\Delta\Gamma$  is less than the age of the solar system.

In these investigations Prof. Dong Ming-di, visiting scientist in the School of Theoretical Physics contributed useful discussion on Hill's Equation.

Relativistic Astrophysics : T. Kiang, with S.P. Xiang  
and J.L. Zhang (Hefei, China)

In a visit to Hefei, work with Chinese colleagues concerned the question of validity of partial derivatives. It was agreed that the calculation of apparent velocity of a moving source around a Kerr black hole should be re-done using corrected formulae which alter considerably the predicted behaviour.

Ap Stars : I. Elliott

Recent observations by T.J. Kreidl and by L. Huang of the Ap star 21 Comae support the null result for short-period variability obtained by I. Elliott and P.J. Callanan in 1985. A critical appraisal of the existing evidence for rapid oscillations of 21 Comae was carried out and it was apparent that the results obtained by Musielok in 1982 were affected by the method of curve-fitting adopted.

Proposals were formulated to use CCD detectors to search for short-lived variability in Ap stars within star clusters and a test programme was submitted for service observing with the Jacobus Kapteyn telescope.

Blue Compact Galaxies : B. McBreen (UCD),  
P. Grimley (UCD), and T.P. Ray.

In July T.P. Ray and P.L. Grimley obtained CCD images of blue compact galaxies with the Jacobus Kapteyn telescope on La Palma, continuing earlier work with the UCD-DIAS CCD camera. Good photometric information was obtained and well-defined morphological features were recorded on images with B.V.R. and I filters on 12 galaxies. It has been possible to use Starlink software on the UCD Aargs image-display system and many of the objects show signs of being the merger of two galaxies. This is particularly so for MKN 314, IZn 176 and IZn 56. Further observations are proposed for 1987 to distinguish merging processes as against possible jet production during galaxy formation.

Jets from Young Stars : T.P. Ray, P.A. Wayman,  
B. McBreen (UCD)

There is evidence that most, if not all, young stellar objects (YSOs) undergo energetic mass loss before evolving into main-sequence stars. Using observations made with the 2.5 -m Isaac Newton telescope on La Palma, in September 1985 with the RCA Charge-coupled device camera, under excellent conditions, details have been obtained of many features of visible 'jets' supposedly associated with bipolar outflows from young stellar objects. The programme on some nine objects, principally YSO's and HH (Herbig-Haro) objects, revealed a variety of new jets and an account of, particularly, NGC 7129, GGD 34, HH105, RNO43, HH3 and HH5 has been published. The visible jet associated with RNO43 has a length of 1.4 parsec making it the longest known jet from a young star.

Time was allotted to T.P. Ray and R. Mundt (Heidelberg) in November with the 3.5-m telescope at Calar Alto. Due to a technical problem no observations were obtained then but very good results were obtained in December by R. Mundt.

X-ray sources : P.C. Callanan, R.M. Redfern (UCG)

Using, in collaboration with the X-ray group at the Cambridge University Institute of Astronomy, data received from EXOSAT X-ray astronomy satellite of the European Space Agency, a total of 70 hours of observation have been obtained on the X-ray source in the globular cluster M15 and the 'bursting' source 1704-32. For the M15 source, a time-analysis of the data has been completed and the spectral data have been modelled using standard blackbody and bremsstrahlung components. Following possible discovery of the optical counterpart, the optical flux in UBV has been modelled on the basis that a star is being heated by X-rays from a collapsed companion. Observations with the Isaac Newton Group telescopes on La Palma in August were made in conjunction with P.A. Charles (Oxford) and T. Naylor (Oxford) and an orbital period of 8.5 hours was deduced. It has also been investigated whether an accretion disk corona could exist in the M15 source and in a short published paper this possibility is shown to explain many of the optical and X-ray properties of M15 as well as of other low-mass X-ray binaries. Work has been started on a quantitative model for the optical output.

The EXOSAT and optical data available on flare stars has been investigated and in the case of the flare star Gliese 644 there is some evidence for the occurrence of a double X-ray flare.

Hipparcos Double Stars : P.A. Wayman, with A.N. Argue  
(Cambridge)

In an extended programme to secure photometric and positional data for important double stars which are to be used in the astrometric programme of the Hipparcos satellite (ESA launch, 1988), P.A. Wayman and A.N. Argue observed some 400 double stars with the RGO CCD camera on the Jacobus Kapteyn telescope in April and preliminary reduction of the data was carried out in Cambridge by M. Irwin.

'Normalized Units' : T. Kiang

The general characteristics of 'normalized units' (where units are chosen such that one or more physical constants have the value unity) have been abstracted from specific examples (e.g. the Astronomical Unit in astronomy, the 'geometric units' of General Relativity,

the Hubble units in cosmology, the e.s.u. and e.m.u. of classical electromagnetism, and Planck's 'natural units'). These principles have been shown always to result in the removal of the symbols representing physical constants when normalization of units takes place, and conversion ratios always being *added* to equations when mixed units are used. The confusion regarding physical meaning of symbols when normalized units are adopted *as well as* mixed units can be considerable. An account of this work has been submitted for publication.

Cataclysmic Variables : H.P. Deasy

Working at the Copernicus Astronomy Centre, Warsaw, H.P. Deasy, in association with Professor J. Smak (Warsaw), aimed at modelling hydrogen and helium emission lines from accretion disks of interacting binary stars, with emphasis on cataclysmic variables. It was possible to produce a realistic Balmer decrement with proper assumed helium abundance, which was previously a difficulty. A computer code first developed by M. Alitzur (Tel Aviv) was used.

3 OBSERVATORY DEL ROQUE DE LOS MUCHACHOS

The Jacobus Kapteyn 1-m telescope (JKT) was in use throughout the year with one period of commissioning work. The control computer has been upgraded and a 20-MByte disk installed for temporary data storage.

During 1986 Irish observers undertook observing time for five periods as follows:

14-20 January : B. McBreen, N. Smith, L. Metcalfe - JKT  
22-28 April : P. A. Wayman JKT  
10-16 July : P.L. Grimley, T.P. Ray - JKT  
1-3 August : R.M. Redfern, P.C. Callanan - JKT, with associated INT programme by P.A. Charles  
2-8 September : P. Grimley, N. Smith - JKT



The first allocation was unprofitable due to adverse weather. The fifth allocation involved use of the star photometer with LSI computer built by the UCD Physics Department, which had been tested in the January visit, and it gave satisfactory records of "Rapid flux changes and periodicities in Blazars". The other three allocations receive mention in Section 2 above.

The Observatories Scientific Council established a Large Telescope subcommittee to consider the case for a future 'large telescope' in the Canary Islands complementing the Very Large Telescope project of the European Southern Observatory in Chile (La Silla).

#### 4 HISTORICAL ASTRONOMY P. A. Wayman

The remaining four chapters of the history of Dunsink Observatory over 200 years were completed during the year. S. McKenna-Lawlor (Maynooth) contributed material relevant to the period 1958-63 when M.A. Ellison was Senior Professor. W. Stuart of Leixlip assisted with the chapter concerning the clocks and the time service of Dunsink Observatory, which was provided to the Dublin Port and Docks Board and other users from 1874 to 1937. P. A. Wayman investigated the electrical requirements of the control system and incorporated a detailed account of the system, not previously available. Publication up to galley proof stage was reached by the end of the year.

#### 5 ELECTRONICS LABORATORY : B.D. Jordan, M. Smyth

The work of the laboratory during the year concerned development of the SLED experiment equipment in conjunction with the Cosmic Ray Section, with the Physics Department, Maynooth, and with the Max Planck Institut f. Aeronomie in Lindau, W. Germany.

The first versions of the wire-wrap laboratory model of the digital electronics, the preliminary software, and the check-out equipment were completed in February. Tests in Budapest with the data processing unit were carried out and various changes made. The design was finalized in May and the designs of the ROM chips and printed circuit boards were produced commercially. The first engineering model was tested at Lindau in July and found to be acceptable after several modifications.

A new instrument housing was designed for the flight models at Lindau and improvements to the analog electronics were carried out at Maynooth. Three sets of flight model boards and components were constructed in the clean room of the Microelectronics Laboratory of Trinity College, made available by Prof. Whelan.

6 COMPUTER INSTALLATION ; I. Elliott, B.D. Jordan

After tests by Bord Telecom on the leased line to UCD, amplifiers were fitted to overcome the unacceptable attenuation. New modems were fitted and the line became reliable at 4800 Baud in March. Lightning caused damage in June and July. The Starlink Software Collection installed on the UCD VAX was updated to Revision 230 in February.

The possibility of developing new devices such as the INMOS Transputer for real-time image-processing in conjunction with the Physics Department, University College, Galway, and the Instituto de Astrofisica de Canarias (Tenerife) has been investigated. A proposal was prepared by R.M. Redfern (UCG) for submission to the EEC Stimulation Programme, with P. Alvarez (Tenerife) and P. A. Wayman as co-proposers. Initial development is under way in Galway, with a view to installation within the GHRIL (Groundbased high-resolution imaging laboratory) of the 4.2-m William Herschel Telescope in 1987-88.

7 LECTURES, CONFERENCES, ETC.

I. Elliott gave a course of sixteen lectures on Introductory Astrophysics to Junior and Senior Sophister students in Trinity College during the Michaelmas term. P. A. Wayman gave a course on Topics in Astronomy and Astrophysics to Junior and Senior Sophister students in Mathematical Physics in the Michaelmas Term.

Contributions to the Irish Astronomical Science Group meetings were, in Belfast (4th April):

- P.A. Wayman, 'IRAS observations of Cepheids'
  - P.B. Byrne, 'Model for a stellar active region'
- and in Galway (26 September) :

T. P. Ray, 'The remarkable nebula of PV Cep'

P. A. Wayman, 'The Dunsink time service clock control from 1874'

R. M. Redfern 'Real-time image sharpening'

Professor W.I. Axford (Max Planck Institute, Lindau) gave a Statutory Public Lecture "Spacecraft Observations of Halley's Comet" in Trinity College, Dublin, on 15th April.

T. Kiang visited the People's Republic of China during August and September, giving lectures at the Centre for Astrophysics, University of Science & Technology of China, Hefei, Anhui Province, 1-6 September. He also attended IAU Symposium No. 124, 'Observational Cosmology in Beijing, 25-30 August.

P. A. Wayman attended the Halley Encounter Invitation at the European Space Operational Centre, Darmstadt on 13th March, and IAU Symposium No. 122 'Circumstellar Matter' at Heidelberg, 23-27 June. He was Chairman of a private meeting arranged by Dr. P. Moore in London on 6 June to discuss the proposal to move the Royal Greenwich Observatory from Herstmonceux Castle.

I. Elliott attended meetings of the La Palma Users Group on 5 Feb, 23 June and 21 Nov., a meeting on Astronomical Data Networks, Strasbourg, 29-30 May, IAU Symposium No. 123, 'Advances in Helio- and Astero-Seismology' in Aarhus, Denmark, 7-11 July, and an educational conference 'GIREP 1986' in Copenhagen, 18-23 August. He contributed to a seminar on Interactive Video at NIHE, Dublin in March.

T.P. Ray attended IAU Symposium No.122 "Circumstellar Matter" Heidelberg, in June and the IAU Regional Astronomy Meeting in Leicester in September.

#### 8 VISITORS

The President of Ireland, Dr. Patrick Hillery, paid an official visit to Dunsink Observatory on 3rd December 1986 as part of his visit to the Dublin Institute for Advanced Studies. At Dunsink he presented to the Institute for display items he had received during overseas visits, namely a reproduction of a Spanish Astrolabe originating at the Royal Inauguration of the Canary Islands Observatories in 1985 and a model of the Giotto spacecraft that was presented by the European Space Agency during a visit of Heads of State to Darmstadt in 1986.

Fourteen Public Open Nights were held during the year and visitors included the joint meeting of the Royal Meteorological Society and the Irish Meteorological Society on 10 July and from the Irish Horological Institute on 4th October.

#### 9 PUBLICATIONS

Published jointly with Armagh Observatory, the Irish Astronomical Journal produced one issue during the year, the Dunsink Observatory Bicentenary Issue, Vol. 17, No. 3, pp. 240.

With Translation Editor T. Kiang, Chinese Astronomy and Astrophysics was issued as Vol. 10, Nos 1-4, pp. 356 during the year.

The following papers were published:

J.H. You, F.H. Cheng, F.Z. Cheng and T. Kiang:

"Cerenkov Line Radiation", Phys. Rev.A., 34:  
3015-3021, 1986.

T.P. Ray :

"CCD Observations of Jets from Young Stars",  
Astron. Astrophys., 171: 145, 1987.

H.P. Deasy and C.J. Butler :

Evidence for Mass Loss from IRAS observations  
of classical cepheids", Nature, 320: 726-728, 1986.

P.J. Callanan, A.C. Fabian, A.F. Tennant, P.M. Redfern  
and R.A. Shafer :

EXOSAT Observations of the X-ray source in M15",  
Mon.Not. R.Astr.Soc., 224: 781-789, 1987.

A.C. Fabian (Cambridge), P.W. Guilbert and P.J. Callanan,

"Accretion disc corone and the X-ray source in M15",  
Mon.Not.R.Astr.Soc., 225: 29P-31P, 1987.

D.J. Mullan :

"Narrow absorption components in the spectra of OB  
stars", Astr.Astrophys., 165; 157-162, 1986.



I. Elliott :

"A specification for an interactive video tutor",  
Proc. GIREP Conference, ESA SP-253, pp. 403-406, 1986.

I. Elliott :

"The Irish Academic Network", Bull. Inform. C.D.  
Strasbourg, No. 31, pp 63-64, 1986.

T.P. Ray, Proc. of the Conference on Jets from Stars  
and Galaxies, Can. Journ. Physics., 61, Aiv. 1986.

P.A. Wayman and D.J. Mullan, Obituary of E.J. Opik,  
Quart.Journ. R.Astr.Soc., 27: 508-514, 1986.

Irish Astronomical Journal :

The following articles, reviews, etc. appeared in the  
March 1986 and September 1986 issues of the journal,  
including work of Research Associates : Vol. 18,  
Nos 3 & 4, 1986:

p. 167 P.A. Wayman : The Andrews Professors of  
Astronomy and Dunsink Observatory  
1785-1985.

p. 187 P. A. Wayman: A Visit to Canada in 1884  
by Sir Robert Ball.

p. 216 P.B. Byrne : Flares and Coronal Heating

p. 286 H.P. Deasy and P.A. Wayman : Mass-loss  
Estimates for Cepheid Variables

p. 294 P.B. Byrne : HDE 319139

p. 378. P.A. Wayman : Rev. John Brinkley and Sir James South

p. 383 I. Elliott : Some Photometry of Ap Stars

p. 401 P.B. Byrne and P. Panagi : Spots on II Peg.

p. 469 P.A. Wayman and H.P. Deasy : IRAS observations  
of Cepheid Variable stars.

- p.507 P.A. Wayman : Dunsink Observatory in 1985.  
p.516 I. Elliott : The Association for Astronomy Education  
p.517 I. Elliott : Progress towards L E S T  
p.524 T.P. Ray : The New Astronomy (Review)  
p.525 T.P. Ray : Astrophysical Jets, Turin Workshop 1982  
(Review)

The thesis "Evidence for Mass Loss in Cepheid Variable Stars" was completed by H.P. Deasy for the requirements of the Ph.D. Degree in the University of Dublin.

#### 10 MISCELLANEOUS

Buildings and Grounds The North porch of the main building was renovated during the year and a new window provided. Work in the grounds included some tree-felling and replanting including ceremonial planting of a copper beech tree by President Hillery on 3rd December.

B COSMIC RAY SECTION

1 STAFF, SCHOLARS AND EMERITUS PROFESSOR

Senior Professor

L. O'C. Drury (from 1 June)

Professor:

A. Thompson (from 1 October)

Assistant Professors:

D. O'Sullivan, A. Thompson (to 30 September)

Research Assistant:

Vacant

Experimental Officer:

J. Daly

Scholars:

C. Domingo, P. Duffy (from 1 October)

Technical and Clerical Staff:

G. Broderick, E. Clifton, E. Flood, A. Grace-Casey,  
S. Ledwidge, H. Sullivan.

Emeritus Professor:

C. O' Ceallaigh

P.A. Wayman (Senior Professor, Astronomy Section) continued as acting head of section for the first five months of the year. A. Thompson served as secretary of the National Committee for Physics and as a member of the Royal Irish Academy Committee for Space Research during the year. A. Thompson and D. O'Sullivan continued as members of the NASA HNC Science Steering Committee and as members of the Giotto Science Working Team.

D. O'Sullivan continued as a member of the editorial board of Nuclear Tracks and Radiation Measurements. A. Thompson completed a four year term of office as Ireland's representative on the Council of the European Physical Society.

## 2 RESEARCH WORK

### 2.1 Experimental Space Physics

#### 2.1.1 The Ultra Heavy Cosmic Ray Experiment (LDEF Mission)

A. Thompson, D. O'Sullivan, J. Daly and C. Domingo with V. Domingo (ESTEC) and K.-P. Wenzel (ESTEC)

The NASA Long Duration Exposure Facility (LDEF) carrying the DIAS-ESTEC Ultra Heavy Cosmic Ray Experiment (UHCRE) hardware, remained in Earth orbit during the year. Following the space shuttle "Challenger" disaster on 28 January 1986, the shuttle fleet was grounded, pending modification of the solid rocket boosters. Eventually, in October 1986, NASA produced a new shuttle manifest which included LDEF retrieval, although many other payloads were cancelled. Retrieval is now planned for Mission 51 (Space Shuttle Atlantis) which is scheduled for launch on 15 November 1990. The extension of the exposure duration from approximately one year to more than six years will enable a greatly enhanced scientific yield to be obtained. In particular, it is anticipated that about 1200 cosmic ray nuclei with  $Z > 65$  will be recorded, including  $16 \pm 8$  actinides. Thus, the UHCRE may represent the only possibility of obtaining a significant sample of actinides for the next decade or so.

In July 1986, the NASA Langley Research Center completed a new thermal analysis of the LDEF, including the UHCRE hardware, for a 6.5 year period in orbit. This analysis incorporated new information on, inter alia, silvered teflon degradation, available due to the Solar Max Repair Mission, which was performed after LDEF deployment. The new analysis indicates a thermal profile for the extended exposure which is actually more favourable to the UHCRE than the pre-flight estimates for the originally planned exposure of approximately one year.



A program of detector response studies, related to the UHCRE exposure, continued during the year (see below).

2.1.2. The Heavy Nucleus Collector Experiment

D. O'Sullivan and A. Thompson with J.H. Adams (NRL)  
J.F. Ormes (GSFC), P.B. Price (Berkeley), G. Tarlé (Michigan),  
C.J. Waddington (Minnesota) and J.P. Wefel (Louisiana).

In response to the changed circumstances resulting from the Challenger space shuttle disaster, in particular the cancellation of Strategic Defence Initiative interest in a second LDEF mission (LDEF re-flight), the Heavy Nucleus Collector (HNC) Science Steering Committee decided to recommend radical modifications which would minimise launch delay while avoiding any compromise of HNC status as a NASA approved experiment.

Briefly, agreement was reached on a new approach which involves dispensing with the re-flown LDEF and substituting a modular or folding "spacecraft" which is assembled in orbit and which is dedicated entirely to the HNC experiment. Thus by occupying a much smaller proportion of the shuttle payload bay, by being lighter and by being decoupled from other interests, the probability of a short term flight opportunity would be greatly increased. After consideration of various proposals from several NASA centers it was decided to opt for a folding dual disc configuration, derived from a Goddard Space Flight Center design, with double sided horizontal viewing and gravity gradient stabilisation. This configuration will involve 16 double-sided experiment trays in a six year mission at 28.5 degrees orbital inclination. The new approach necessitates redesign and rebuilding of some of the experiment hardware. The NASA Office of Space Science and Applications (OSSA), Astrophysics Division, has agreed to the provision of the extra finance necessary to implement these extensive changes. However, the HNC experiment does not, at present (31 December 1986) have a launch schedule.

### 2.1.3 The Energetic Particle Analyser Experiment (Giotto Mission)

A. Thompson and D. O'Sullivan with S. McKenna-Lawlor (SPCM), E. Kirsch (MPAe) and K.-P Wenzel (ESTEC).

Construction of the Giotto Science Center and Giotto PR/Media Center at ESOC (the European Space Operations Center, Darmstadt) was completed during January, enabling the Energetic Particle Analyser (EPA) experiment ground support equipment (EGSE) to be established and tested in its final configuration for the Giotto spacecraft's encounter with Comet Halley (one set of EPA EGSE in the Giotto EGSE Center ; a second set, with back up units, in the Giotto Science Center). Using archived data, two Giotto Halley Encounter simulations were carried out, at the end of January, for all ten Giotto experiments simultaneously.

The EPA instrument, which had been switched off since 20 December 1985 (see Annual Report for 1985), was switched on again during a Giotto telemetry pass on 2-3 February 1986, and successfully tested in all real-time operation modes. During February, two full-scale Giotto Halley Encounter rehearsals took place and several major solar events were observed by EPA. Some further, last minute, improvements in the EPA EGSE real-time analysis software were carried out by the end of February.

Final decisions for the Encounter period were made at a series of Giotto SWT meetings, EPA team meetings, and ESOC operations briefing/debriefing meetings in early March. The final Encounter rehearsal was held on 10-11 March and the final operations briefing was completed at 17:00 UT on 13 March. Continuous (24 hour) Giotto telemetry contact was maintained for the period 10-15 March. The Halley Encounter climax, the closest approach (CA), occurred a few minutes after midnight on 13/14 March (00:03:02 UT on 14 March 1986) at 600 km from the cometary nucleus. The telemetry distance to Earth was about  $1.5 \times 10^8$  km and the relative fly-by velocity about 68 km/sec. Spacecraft nutation induced by cometary dust impact (maximum 1.8 degrees) resulted in temporary loss of telemetry at CA. Dust impact also disabled several experiments and damaged a number of Giotto sub-systems.

However, EPA continued to operate without any problems until the experiments were switched-off on 15 March at 03:00 UT approximately. During the Encounter period, a total of about 7 megabytes of energetic particle data from EPA and a further 48 megabytes of EPA associated data were recorded. The initial EPA results and graphics from the Encounter period up to 8:00 UT on 14 March were presented at the Giotto Halley Encounter Press Conference in ESOC at approximately 14:00 UT on 14 March. Giotto Encounter material was screened by 56 television companies from 37 countries.

The first energetic cometary ions to be detected by EPA were observed at approximately 18:00 UT on 12 March, when Giotto was about  $7.5 \times 10^6$  km before CA, and particle fluxes were still strongly enhanced when EPA was switched off at about  $6.75 \times 10^6$  km beyond CA. The inward crossing of the bow shock occurred at 19:40 UT on 13 March, at a distance of approximately  $1.1 \times 10^6$  km from CA. Overall, a very complex energetic ion and electron environment, which appeared to be structured in distinct regions, was observed. Energies, intensities and directions fluctuated considerably over short time intervals, but a major result was the detection, over extended intervals, of significant fluxes of ions with energies in the MeV region. Conventional acceleration mechanisms, such as the solar wind pick-up process, are inadequate to explain such high energies.

After the Encounter period the Giotto spacecraft was commanded into an Earth return orbit. All Giotto onboard systems were switched off on 2 April, leaving the spacecraft in hibernation. Giotto will return to the vicinity of Earth in July 1990, providing the option of re-targeting for a second mission to another comet.

The first journal publication of initial EPA results was in a special Comet Halley edition of Nature which appeared on the same day (15 March 1986) as a major Giotto post-Encounter press conference and presentation of results at the European Space Agency headquarters in Paris. Work on the EPA Encounter-phase data and Cruise-phase data continued during the rest of the year. The two sets of EPA microcomputer-based EGSE were

shipped to DIAS after Encounter and have proved to be very effective, on "replay" mode, for preliminary analysis, as envisaged when the software was configured.

#### 2.1.4 The Solar Low Energy Detector Experiment (Phobos Mission)

B. Jordan, D. O'Sullivan and A. Thompson with  
S. McKenna-Lawlor (SPCM), M. Martin (SPCM), E. Keppler(MPAe)  
E. Kirsch (MPAe) and A.K. Richter (MPAe).

A wire-wrap model of the Solar Low Energy Detector (SLED) instrument and preliminary onboard software were completed in January and brought to KFKI, Budapest, in February for preliminary tests. Interfacing of this model with the ESTER data processing unit (DPU) was carried out satisfactorily although some potential hardware and software problems were identified. The SLED design was finalised in May and contracts were awarded to ACL, Limerick, for printed circuit boards and to Flattery Engineering, Dublin, for instrument housing. Read Only memory chips, with software, were prepared by Trim Electronics, Co. Meath.

The SLED engineering model was completed in July and underwent thermal-vacuum and vibration tests at MPAe, Lindau. Some mechanical and thermal problems became apparent and an unacceptable noise level was observed in the analogue electronics. However, despite these difficulties, the engineering model was integrated with the ESTER Complex in KFKI and was shipped to IKI, Moscow, for long term testing.

Construction of the two SLED flight models was started in September and some modifications were made to the original design following the experience gained from the earlier tests. A contract for flight model instrument housing was awarded to Presco Tool and Die Co., Dublin, and some alterations were made to the printed circuit board design along with some minor software changes. Some of the printed circuit boards for the digital electronics were assembled in the clean room of the Microelectronics Laboratory at TCD. An improved version of the cbeck-out equipment was also produced at this stage.

The first SLED flight model was completed by mid-December and preliminary tests proved satisfactory. Construction of the second flight model continued to the end of the year. Thermal-vacuum tests and vibration tests were scheduled for



both instruments in January/February 1987 at MPae and ESTEC, before shipment to KFKI for integration with the two ESTER Complex flight models.

## 2.2 Nuclear Tracks

### 2.2.1 Magnetic Monopole Search

D. O'Sullivan and A. Thompson

Following the revival of interest in magnetic monopoles in the mid nineteen seventies a large array of Lexan polycarbonate was deployed at ground level by the Cosmic Ray Section in 1976. Stacks comprised of six sheets of the polymer and amounting to a total collecting area of  $\approx 93 \text{ m}^2$  were placed in the attic of Dunsink Observatory and in No. 5 Merrion Square. The objective of the experiment was to detect Dirac type monopoles which were hypothesised to possess a magnetic charge  $g = ng_0$ , quantised in discrete multiples of  $g_0 = e/2\alpha$  where  $e$  is the electronic charge and  $\alpha$  is the fine structure constant. Estimates of the ionisation produced by such particles indicated that for  $n = 1$  the sensitivity of Lexan was sufficient to record the passage of a monopole for values of  $\beta \geq 0.3$ , and for  $n > 1$  a monopole would register over the region  $0 < \beta < 1$ . Between mid-1985 and mid-1986 the upper sheet of each stack was removed, etched and scanned. To date no candidate has been observed, setting an upper limit on the flux of magnetic monopoles with  $n \geq 1$  of  $3.6 \times 10^{-11}/\text{m}^2 \text{ sec}$  at ground level.

### 2.2.2. Nuclear Track Detector Response Studies (Part 1)

A. Thompson, D. O'Sullivan, C. Domingo and J. Daly

Experimental studies of the track response of polymers to energetic heavy nuclei continued during the year. Two central issues in these studies were the polymer temperature during particle registration and the time-temperature history of stored latent tracks after registration. Apart from its inherent value for elucidating track formation mechanisms, such work is necessary for interpreting the data from long duration exposure of arrays of solid state nuclear track detectors in Earth orbit. In particular, in view of the extension of the LDEF mission (see above), this work is crucial for optimising the spectral resolution of the data return from the Ultra Heavy Cosmic Ray Experiment.

During March, six solid state nuclear track detector stacks (two Cronar polyester, one Rodyne-P polycarbonate and three Lexan polycarbonate) were assembled and prepared for a new series of exposures to beams of ultra heavy ions at the Lawrence Berkeley Bevalac. The detector elements employed were flight spares from both the Heavy Nucleus Collector Experiment and the Ultra Heavy Cosmic Ray Experiment. During April, the exposures were successfully implemented using beams of lanthanum, gold and uranium nuclei with energies of 0.75, 1.02 and 0.93 GeV/N respectively. One set of exposures was made with detector elements at  $-78^{\circ}\text{C}$ , the remainder were made at  $+18^{\circ}\text{C}$ . A total of 30 independent exposures were carried out, the stopping power of the stacks being sufficient to bring the ion beams to rest in each case. After return to Dublin, multiple batches of exposed detector elements were stored in controlled environments at temperatures of  $-70$ ,  $-18$ ,  $3$ ,  $25$ ,  $37$ , and  $45^{\circ}\text{C}$ .

The exposures had two major objectives; (a) the investigation of the registration temperature effect (RTE) in polyester and an extension of the DIAS work on the RTE in polycarbonate, (b) the first stage of a comprehensive study of latent track intensification (LTI) and fading (LTF) in polycarbonate and polyester, based on dedicated exposures and re-exposures. This work requires individual treatment for about  $2 \times 10^3$  detector elements. A programme was set up to monitor and implement the many time dependent steps of etching, measurement and analysis through the remainder of the year and beyond. Processing of the first batch of detector elements began in May. The plan continued during the year and the programme was on schedule at the end of the year.

### 2.2.3 Nuclear Track Detector Response Studies (Part 2)

D. O'Sullivan, A. Thompson and C. Domingo with  
C. Baixeras (UAB), F. Fernández (UAB) and A. Vidal-Quadras  
(UAB).

A new programme of collaboration with the Universidad Autónoma de Barcelona began early in the year. Using pre-existing irradiated detector elements (i.e. non-dedicated exposures) the variation of signal strength with latent track storage time at  $-25^{\circ}\text{C}$  and at  $+3^{\circ}\text{C}$  was investigated. The detector polymer was Tuffak polycarbonate and the ion beams employed (LBL Bevalac exposures, August 1984) were xenon (873 MeV/N), holmium (850MeV/N), gold (998 MeV/N)

and uranium (945 MeV/N). Etching, measurement and analysis continued till the end of the year and covered latent track storage times from about 30 days to about 800 days.

The results, to date, are consistent with a temperature dependent, conventional, significant short term (< 30 days) latent track intensification and inconsistent with a significant long term (> 100 days) intensification.

### 2.3. Particle Acceleration Theory

L. O'C Drury and P. Duffy with H.J. Voelk and W. Markiewicz (MPIK, Heidelberg)

The question of whether the conventional diffusive shock acceleration mechanism could operate at perpendicular or highly oblique shocks was considered. It was concluded that if the scattering is sufficiently strong to keep the particle distributions close to isotropy, then the mechanism does operate and the same spectrum is obtained as in the conventional theory for parallel shocks. The time scales will be shorter than in the parallel case, but this will not lead to higher maximum energies because of the increased importance of geometric losses. The result is interesting in that it demonstrates the universality of the diffusive acceleration mechanism; it has also resulted in the discovery of a significant technical simplification in the theory of oblique shocks.

The implications of the reaction effects expected from particle acceleration for the dynamical evolution of supernova remnants were studied as part of a continuing collaboration with the theory group at the Max-Planck-Institut fuer Kernphysik in Heidelberg, Germany. The approach adopted has been to construct systems of coupled ordinary differential equations which model the development of the remnant and incorporate the physical processes thought to be important. These systems can be easily solved numerically and the solutions investigated for sensitivity to the model assumptions.

The relative importance of systematic and stochastic terms in classical Fermi acceleration is being investigated.

### 3 FACILITIES

The experimental equipment for nuclear track detector processing, scanning and measurement, was maintained and used throughout the year.

After an investigation of various personal computer systems it was decided to purchase an Atari 1040 STF for detailed evaluation as a text processor and general purpose desk-top workstation. A reorganisation of the library was initiated.

### 4 LECTURES, CONFERENCES, WORKING VISITS ETC.

L. Drury delivered a lecture on 'Computer algebra' to the Dublin Physics Summer School, a review talk to the Astronomical Science Group of Ireland meeting in Galway on 'Particle acceleration processes for Cosmic Rays' and a popular talk to the Irish Astronomical Association in Belfast on 'Cosmic Rays and Astronomy'. D. O'Sullivan presented a talk on Giotto Results to the Astronomical Science Group of Ireland (4 April) and gave a lecture on Space Research at the RDS Science Week (17 July). J.M. Clear (ESTEC) gave a seminar in the Cosmic Ray Section (6 October) entitled 'Recent results in gamma ray astronomy'.

International conferences and workshops were attended as follows:-

The 26th COSPAR General Assembly, Toulouse, France (1-12 July) A. Thompson and D.O'Sullivan.

The IACG Topical Workshop on Comet Halley, MPAe, Germany (22-25 October) L. Drury, A. Thompson, D.O'Sullivan.

The 20th ESLAB Symposium on the Exploration of Halley's Comet, Heidelberg (27-31 October) L. Drury, A. Thompson, D.O'Sullivan.

The ASGI meeting at QUB (4 Apr) was attended by A. Thompson and D.O'Sullivan. The meeting at UCG (26 Sep) was attended by L. Drury, A. Thompson, D. O'Sullivan and C. Domingo.



Working visits were made to the following centres in furtherance of the research programmes of the section:

KFKI, Budapest (9-11 January) A. Thompson.  
ESOC, Darmstadt (29 January - 3 February) D. O'Sullivan  
ESOC, Darmstadt (10-15 February) A. Thompson, D.O'Sullivan  
LaRC, Virginia, USA (26 February - 2 March) A. Thompson,  
D. O' Sullivan  
ESOC, Darmstadt (7-17 March) A. Thompson, D.O'Sullivan  
MPAe, Germany (1-3 April) D. O'Sullivan  
LBL Bevalac, Berkeley, USA (5-16 April) C. Domingo  
ESA HQ, Paris (14-16 May) A. Thompson, D.O'Sullivan  
MPIK, Heidelberg (10 October - 6 November) L. Drury

During February, Mr. P. Zetsche (Institut für Datenverarbeitungsanlagen, Braunschweig) visited the section for two weeks and worked on modifications of the EPA EGSE level 3 software. Dr. E. Kirsch (MPAe, Germany) spent a period of one week at the section during December, studying EPA data from the Cruise Phase of the Giotto Mission. Other visitors during the year included Professor W.I. Axford (Director, MPAe, Germany), Dr. M. Fujii (Institute of Space and Astronautical Science, Tokyo), Professor A. Vidal-Quadras (Universidad Autónoma de Barcelona), Professor J.A.M. McDonnell (Unit for Space Sciences, University of Kent, Canterbury) and Dr. J.M. Clear (Space Science Department, ESTEC, Holland).

#### 5 PUBLICATIONS

S. McKenna-Lawlor, A. Thompson, D.O'Sullivan, E. Kirsch, D. Melrose and K.-P. Wenzel

The Giotto Energetic Particle Experiment. European Space Agency Special Publication SP-1077, 53-65 (1986).

D. O'Sullivan, A. Thompson and P.H. Fowler

The Abundance of Actinide Elements in the Galactic Cosmic Radiation. Nuclear Tracks and Radiation Measurements, 11, 95-98 (1986).

S. McKenna-Lawlor, E. Kirsch, D.O'Sullivan, A. Thompson and K.-P. Wenzel.

Energetic Ions in the Environment of Comet Halley.  
Nature, 321, 347-349 (1986).

S. McKenna-Lawlor, E. Kirsch, A. Thompson and D.O'Sullivan

Energetic particles in the Comet Halley Environment.  
Adv. Sp Res., 5, 211-220 (1986).

E. Kirsch, S. McKenna-Lawlor, A. Thompson D. O'Sullivan and F. M. Neubauer.

Energetic Electron Fluxes ( $E > 180$  keV) observed by the Giotto Experiment EPA during Encounter with Comet Halley. Proc. 20th ESLAB Symposium on the exploration of Halley's Comet, Heidelberg, October 1986, ESA SP-250, 1, 291-295 (1986).

D. O'Sullivan, A. Thompson, E. Kirsch, S. McKenna-Lawlor, K.-P. Wenzel.

The Giotto Mission to Comet Halley. Preliminary results from the Energetic Particle Analyser (EPA) experiment. Irish Astronomical Journal, 17, 462-468 (1986).

P.W. Daly, E. Kirsch, S. McKenna-Lawlor, D. O'Sullivan, A. Thompson, T.R. Sanderson and K.-P. Wenzel.

Comparison of Energetic Ion Measurements at Comets Giacobini-Zinner and Halley. Proc. 20th ESLAB Symposium on the Exploration of Halley's Comet, Heidelberg, October 1986, ESA SP-250, 3, 179-183 (1986).

D. O'Sullivan, A. Thompson, S. McKenna-Lawlor, E. Kirsch, K.-P. Wenzel and F.M. Neubauer

Energetic Particles and Magnetic Field Measurements at Comet Halley. Proc. 20th ESLAB Symposium on the Exploration of Halley's Comet, Heidelberg, October 1986, ESA SP-250, 3, 185-188 (1986).

L. O'C. Drury and S.A.E.G. Falle

On the stability of shocks modified by particle acceleration. Mon. Not. R. Astr. Soc., 223, 353-376 (1986).

The following publications, listed in the 1985 Annual Report, have been updated and republished during 1986, as follows:

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

The Ionisation Dependence of the Registration Temperature Effect in Solid State Nuclear Track Detectors. Nuclear Tracks and Radiation Measurements, 12, 391-394 (1986).

D. O'Sullivan. A. Thompson and C. Domingo

The Response of Tuffak Polycarbonate to High Energy Xenon, Holmium, Gold and Uranium Nuclei. Nuclear Tracks and Radiation Measurements, 12, 399-401 (1986).

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

The Influence of Etching Conditions on the Resolving Power of Lexan Polycarbonate for Ultra Heavy Ions. Nuclear Tracks and Radiation Measurements, 12, 395-398 (1986).

C GEOPHYSICS SECTION

1 STAFF AND SCHOLARS

Senior Professor:

T. Murphy

Professor:

A.W.B. Jacob

Research Assistant:

P.W. Readman

Experimental Officer:

T.A. Blake

Research Associate:

N.P. Murphy

Scholars:

C.P. Lowe

C. Bean

Technical and Clerical Staff:

K. Bolster, A. Byrne, C. Horan, G. Wallace, V. Ward.

Vacation Student:

L. Hanlon (June 23 - August 15).



2 RESEARCH WORK

(a) Gravity

The fieldwork was continued in counties Cavan, Leitrim and Longford and the data processed for publication of sheet 13 of the 1:126 720 scale map.

(b) Geodesy

In collaboration with members of the Department of Forestry and Hempenstall Surveys the distance from Dunsink to Skreen Church Tower trigonometrical stations was measured in three links using a laser distance meter. The results were satisfactory and agreed within a few parts per million with those deduced from satellite observations.

Preliminary observations by F. Prendergast of the College of Technology were taken for azimuth determinations.

(c) Meteorology

Routine observations of the meteorological elements were continued throughout the year, autographic records tabulated and results published. The normals for temperature, rainfall and sunshine for the station computed for the thirty years 1951-1980 were prepared for publication. There is a steady demand from scientific and commercial interests in the results.

(d) Palaeomagnetism

Detailed rock magnetic experiments, including isothermal and anhysteretic remanence experiments on Post-Glacial lake sediments from Denmark were performed at the Geophysics Department, University of Edinburgh. The results confirmed that the main magnetic mineral in the sediments was fine grained, probably pseudo-single domain size, magnetite, as expected from the results of the alternating field demagnetisation of the natural remanence. A small fraction of the isothermal remanence is not saturated until fields of greater than about 0.4 - 0.6 T and this may mean that another magnetic mineral also contributes to the induced remanences, although not to the natural remanence.

e) Workshop

The DIAS seismic stations were further developed for the European Geotraverse experiment. All the stations now record on small cassette recorders and the flutter compensation and time channels have also been modified. Better programmable switching is now available and many of the stations can now be programmed up to one week ahead. 21 stations were ready for the experiment. This gave one spare station over the 20 we had promised. Our original playback equipment was part of a multipurpose system which could not be taken out into the field. To keep the equipment working well during the experiment it was necessary to have a portable playback system. A very light and compact demodulator/amplifier set was thus also built in this period. When this was combined with a cassette tape-deck and a small pen-recorder the result was a very modifiable pay-back system which was itself very reliable and operated without any problems throughout the experiment. This will give the capacity to more easily make checks in the field when the stations are working far from base.

f) Seismic Network

The seismic network suffered in 1986 from a lack of resources and manpower to keep it operating as well as we would like. Within these limitations the processing of data continued with data being supplied, normally by telex, to the international agencies and the groups with which we exchange data.

Seismic activity has continued in the neighbourhood of the large 1984 event. The most notable seismic event within Ireland was the small earthquake at 0332 GMT on 29th November 1986 in South Co. Wexford. The magnitude was  $M_L = 1.7$  and it was felt over an area about 20 km across. The highest intensities were near Newbawn but the indications are that it was relatively deep, probably at least 10 km below the surface. Small events were also reported from North Donegal in May.

g) Explosion Seismology

(i) CELTIC CROSS

In the summer of 1986 a seismic programme was carried out using a shot-point in central Ireland. Four profiles radiated from the shot-point and served to improve the coverage in the middle of the 1982 line (ICSSP) and one of the COOLE lines (line 1 on the map in the 1985 Annual Report). About 30 recorders from DIAS and the University of Karlsruhe were used in an experiment that lasted five days.

(ii) EUROPEAN GEOTRAVERSE

In the autumn of 1986 the Geophysics Section took part in the central section of the European Geotraverse (roughly from Genoa in Northern Italy to Kiel on the southern shores of the Baltic). Funded by an EEC contract, groups from DIAS, the UK, and France brought nearly 70 stations (20 of them Irish) to work on the 1300 km profile in a combined experiment which involved teams from Denmark, Finland, Germany, Italy, Spain, Sweden and Switzerland as well. In addition to the main profile, fans and subsidiary profiles were recorded in northern Italy to get three dimensional information for the most complex part of the traverse. The profile is shown in Fig. 1.

Two weeks before the field work started one DIAS staff member, Chris Bean, travelled to Karlsruhe to assist in the final preparations at headquarters. The preparation and provision of maps, time-tables, instructions etc. to over 100 field recording and shot-firing parties was a mammoth job and had to be very carefully carried out. A main centre for this work was in Karlsruhe and they needed all the assistance that could be provided. On the 9th of September B. Jacob and G. Wallace left Ireland on a ferry from Rosslare to Le Havre. They brought the 21 DIAS stations, playback and test equipment, and other field gear to be used by the DIAS field operators. Five more DIAS staff, T. Blake, C. Lowe, T. Murphy, P. Readman, V. Ward followed by air on the 13th of September and joined the three others in Karlsruhe. It was found to be cheaper to fly the extra people and hire two vehicles in Germany. Karlsruhe hired a large number of cars, got a good rate and passed on the benefits of their order to DIAS. For the experiment, 5 DIAS people were paired with 5 Karlsruhe staff and they operated a mixed group of German



Fig.1

Map of Central Europe showing approximate position of European Geotraverse and locations of shotpoints (A to L).



MARS and Irish stations. A lot of the profile was in German speaking areas and having one German member in each party helped to minimise language problems in the field. Two of the other DIAS operators worked together and used the DIAS van. The electronics engineer, G. Wallace, joined the HQ staff and formed an emergency repair team with one of the Karlsruhe engineers. Many of the tapes used by the DIAS stations during the EGT were purchased on bulk order by Karlsruhe who bought the tapes for most of the participants as these were cheaper than any which could have been obtained in Ireland. This also meant that preliminary tape-labelling could be carried out by the HQ before distribution of tapes and instructions at the beginning of the field work.

There were very few problems with the stations during the experiment. Most of those that did occur surfaced early on and were easily corrected. There were some problems with weak radio time signals at some of the sites in valleys among the high mountains encountered in Italy and Switzerland. All the DIAS stations had receivers for both DCF (77.5 KHz, FRG) and (60 KHz, GB) and it was almost always possible to get an acceptable time-signal from one or the other. A reliable internal time reference is obviously desirable in these circumstances and it is intended to incorporate an internal clock into the DIAS stations. As they are small it may then be feasible to bury them completely and make them even more unobtrusive. During the experiment, one of the stations was stolen so it was fortunate that we brought one more than the promised 20. It was also fortunate that the most expensive item, the seismometer, was not disturbed. Its escape may have been due to the fact that it was buried. This increases interest in the idea that stations might be buried completely.

All the DIAS recorded tapes were taken back to Dublin after the experiment finished in early October. When the source details became available, 4-minute segments of each were transferred to simulated Geostore library tapes. These had an apparent speed-up factor of ten with respect to the Geostore time-code. This then allowed us to use the standard Geostore digitising system in the BGS Seismology Unit in Edinburgh to digitise the DIAS data at approximately 500 samples per second. B. Jacob and K. Bolster did this work in early December. When the digital data was brought back to Dublin, C. Horan began the demultiplexing and resampling process to generate a set of digital records at a uniform sampling rate of 400 sps. This will make it easier to merge the data with MARS records from other groups involved in the project.

This contract enabled the Irish/British/French group to make a very large and significant contribution to the highly successful seismic profile along the Central part of the European Geotraverse. The scale of our impact in the proceedings may be judged by the fact that of the 150 stations which operated along the whole line from the Mediterranean to the Baltic, the group provided almost 70 (70 more stations worked only in Northern Italy in the first part of the experiment). If we had not been able to take part the scientific returns would have been much poorer, the detail less, and the output from the shot points would have been used to less advantage. The pattern of the experiment would have been significantly different.

h) Geotwin

EEC Stimulation Programme Contract with University of Karlsruhe to develop seismic inversion techniques.

This work began on the 1st of January 1986 and is scheduled to last for about three years. Two reports have been written covering the activities of the first year.

There has been steady progress in both Institutes during the year with visits by C. Bean, T. Blake and B. Jacob to Karlsruhe and return visits by five of the Karlsruhe staff. There has been an exchange of computer programmes and experience has been gained in running and getting to know what is available.

The work can be broadly grouped under four different headings in both the Geophysics Section (DIAS) and the Geophysikalisches Institut of University of Karlsruhe (GEOK).

(i) Signal Enhancement

Program development at GEOK and DIAS has concentrated on signal enhancement. Later arrivals on a seismogram inevitably suffer from poor signal-to-noise ratios. S and converted phases - particularly important in our programme - therefore need treatment both before and during interpretation.

Various approaches to this problem have been investigated. These include differentiation by spectral difference, polarization analysis, and non-linear stacking.

(ii) Synthetic seismograms and Ray Tracing

Reflectivity program. R. Kind visited DIAS in November, bringing with him the newest version of the reflectivity program (Fuchs and Mueller, 1971) which he has developed and improved in the years since then. The program was installed on the DIAS MV2000 computer and plans to use it in studies of lithospheric and upper mantle structure were discussed.

The newest version of the reflectivity program has many new options which make the use of the program easier, and it also permits different structures at source and receiver sites. The program was set up for a Micro-Vax computer and it needed some modifications to run on the Eclipse computer of the Dublin Institute.

Following a suggestion by B. Jacob, the observation and modelling of steep angle reflections from deep discontinuities in the coda of strong local earthquakes was discussed. This is another possible source of information about lithospheric structure. Such reflections can be modelled with the reflectivity program. The computation of complete theoretical seismograms, including the effect of the free surface, is very important, since all kinds of conversions and multiples contribute to the coda. It was agreed to conduct test computations to identify such steep angle reflections in theoretical seismograms, and in parallel, to try to identify such reflections in the records of earthquakes from Wales (T. Blake) and in GRF records of Swabian Jura events (R. Kind). Kind and Vinnik have been using phase enhancement techniques on teleseismic converted phases and R. Kind suggested that the approach might be tried on refraction on profiles. C. Bean has also been studying surface multiple phases using the reflectivity program. This reached the limits of what it was possible to do on the SI30 and the new program on the MV2000 will greatly assist the work.

Ray tracing programs.

C. Bean spent a considerable amount of time transferring programs from the S130 to the MV2000 in DIAS, and in implementing the ray-tracing program from GEOK on the MV2000. The ray-tracing program, which also generates synthetic seismograms based on ray theory, is now running at DIAS.

The ray method is also a useful tool for investigating the effects of anisotropy and inhomogeneity on the propagation of high frequency elastic waves (Gajewski, 1985). A computer coda, based on the ray method, has been developed by D. Gajewski (GEOK) to compute synthetic seismograms for three dimensional laterally inhomogeneous media, composed of isotropic and anisotropic inhomogeneous layers. General anisotropy may be included. Rays and travel times are evaluated by numerical integration of the corresponding ray tracing equations. If a sufficiently dense system of ray termination points covers a region on the surface of the model, synthetic seismograms can be computed for receivers along arbitrary profiles, fans, and arrays.

(iii) Modelling

Data sets from many different sources have been used for modelling tests. These include data from South Germany, Jordan and the COOLE programme (onshore and offshore Ireland). The last is particularly important as the application of our methods to Irish data is a central feature of the contract. Since 1982 the amount of seismic refraction data has increased enormously.

iv) Marine Surveys

During the COOLE project a detailed gravity and magnetic field survey was performed in two grid patterns, as described in the 1985 Annual Report, over a total of more than 10000 km<sup>2</sup>, off the coasts of West Cork, Kerry and Clare. Considerable progress was made in the reduction and interpretation of this very large data set. The largest effort went into the derivation of the positions and true speed of the ship from the various navigational methods on board the R.S. VALDIVIA: these were DECCA, LORAN-C and Satellite Navigation (MAGNAVOX) as well as optical sightings and radar bearings where possible.



There are problems with Decca in this section of Irish waters, particularly off the coast of Kerry, and in this region satellite navigation was the most reliable and accurate method of position. Interpolation between the satellite "fixes" was performed with the aid of Loran-C, which was found to give surprisingly consistent results. For the northern grid Decca gave consistent and accurate results.

The marine gravity data were combined with the DIAS land gravity data for the S.W. region and the whole data gridded and smoothed to produce a computer-drawn Bouguer Anomaly map for the area.

The gravity field indicates the continuity of the low BOUGUER anomaly area of Kerry thought to be caused by a granitic body.

A start was also made on the reduction of the magnetic data but this is not yet complete.

The work was performed in collaboration with the Geophysics Institute of Hamburg University.

The magnetic field measurements confirm the preliminary survey reported in 1977 and the disturbance to the field south of the Blaskets is attributed to basaltic rocks of Silurian age as the continuation of those on the island of Inishvickillane.

### 3 COMPUTER

Because of the large volume of work involved in the seismic analysis the computer facilities had to be extended and a DATA GENERAL MV2000 was added. The transfer from one computer to the other was undertaken by T. Blake and this with the upgrading of programs and scientific libraries from FORTRAN 5 to FORTRAN 77 has taken several months. Significant amounts of data have been transferred. It is intended that the two computers share some graphical output facilities, in particular, a large CALCOMP plotter. A smaller plotter is intended for use on the MV2000 only. The sharing has caused some unexpected problems and a good deal of program redevelopment has been necessary.

4 OTHER ACTIVITIES

a) Conferences

A.W.B. Jacob, T. Murphy and P.W. Readman attended the 10th United Kingdom Geophysical Assembly in Glasgow, April 7-9.

A.W.B. Jacob attended a meeting of the Royal Society Working Group on Explosion Seismology in Glasgow, April 9.

C. Bean, A.W.B. Jacob and T. Murphy attended the 2nd International Symposium on Deep Seismic Reflection Profiling of the Continental Lithosphere in Cambridge, July 15-18.

A.W.B. Jacob attended two E.E.C. meetings in Brussels re a preliminary earthquake programme being set up in which DIAS will be participating.

P.W. Readman attended the United Kingdom Geophysical Assembly at Glasgow and afterwards visited the Geophysics Department, University of Edinburgh.

P.W. Readman visited the Geophysics Institute, University of Hamburg between 23 June - 3 September, 1986. This visit was mainly funded by the DAAD (Deutscher Akademischer Austauschdienst). He also revisited Hamburg between 4 October - 9 October (i.e. after EGT).

(b) Seminar

Drs. N. Anstey and D. Naylor gave a seminar on Seismic Exploration on June 11.

5 PUBLICATIONS

C.P. Lowe:

"The Coole Project (Celtic Onshore-Offshore Lithospheric Experiment), Proc. L. Beltra 1985 Workshop (NBST), 82-91, 1986.

N. Murphy:

"Upper Crustal Seismic Structure in Eastern Ireland".  
In press, Irish Journal of Earth Sciences.

DIAS

Monthly Meteorological Bulletin for Dublin City.

P.W. Readman edited a special volume of Physics of the Earth and Planetary Interiors on "Palaeomagnetism, Age Dating and Sedimentology of Young Sediments", Vol. 44, no. 1 (1986) 1 - 72.

6. REPORTS

First Report for EEC Scientific Co-operation Contract  
No. ST2J-0080-1-IRL (CD) (GEOTWIN).  
A.W.B. Jacob and C. Prodehl.

Second Report for GEOTWIN.  
A.W.B. Jacob and C. Prodehl.

First Report for EEC Scientific Co-operation Contract,  
No. ST2J-0201-3-IRL(CD) (EGT).  
M.A. Khan, A.W.B. Jacob, A. Hirn.

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

FINANCIAL STATEMENTS FOR YEAR ENDED 31 DECEMBER 1986

<u>CONTENTS</u>	Pages
Accounting Principles and Policies	1-2
Income and Expenditure	3
Balance Sheet	4
Detailed Income & Expenditure Account	5
Notes to the Accounts	6-7



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

1986

**Accounting Principles and Policies**

GENERAL

The Institute was established under the Institute for Advanced Studies Act, 1940

Its functions include the provision of facilities for the furtherance of advanced studies and the conduct of research in specialised branches of knowledge.

It is comprised of three schools - Celtic Studies, Theoretical Physics and Cosmic Physics.

Basis of the accounts

The accounting treatment of fixed assets has been altered in 1986. These assets are displayed on the Balance Sheet for the first time. Comparative figures have been adjusted accordingly. The outturn for each school and the cost of Administration are shown in Statement 1.

Accounting Policies

1. Oireachtas Grants:

Income shown in the Accounts as Oireachtas Grants is the actual cash received in the period of the Account and includes £44,000 for increases in remuneration.

2. Fixed Assets:

Fixed Assets comprise the furniture and equipment of the Institute and are shown at cost less accumulated depreciation.

The rate of depreciation is 10%.

Premises occupied by the Institute are leased from the Office of Public Works.

3. Capital Reserve:

The capital reserve comprises income allocated for the purchase of fixed assets. It is written down in line with the depreciation of the related assets.

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

4. Library:

Expenditure on library books and materials is charged to the Income and Expenditure Account. The current value of such books and materials is estimated at £368,000.

5. Publications:

Expenditure on publications is written off in the year in which it is incurred. The estimated value of such publications on hand at 31 December, 1986 was £660,000.

6. Superannuation:

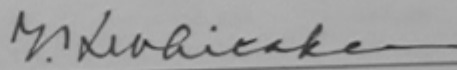
Salaries are charged net of pension contributions. Expenditure arising under the Institute's superannuation schemes is met out of Oireachtas Grants in the year of payment. No provision has been made in these accounts for future superannuation commitments.

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

Income and Expenditure Account  
for the year ended 31 December 1986

<u>1985</u>		<u>1986</u>
£		£
	<u>INCOME</u>	
1,613,000	Oireachtas Grants	1,773,000
43,912	Sales of Publications	46,292
---	School of Cosmic Physics: Fees for Services	30,555
57,260	Miscellaneous	51,128
<hr/>		<hr/>
1,714,172		1,900,975
98,279	Less allocated for capital purposes	94,128
<hr/>		<hr/>
1,615,893		1,806,847
	<u>EXPENDITURE</u>	
325,397	School of Celtic Studies	402,366
239,293	School of Theoretical Physics	261,599
604,666	School of Cosmic Physics	702,669
445,890	Administration	484,784
<hr/>		<hr/>
1,615,246		1,851,418
647	<u>SURPLUS (DEFICIT) for year</u>	(44,571)

The Accounting Policies, Notes 1 to 8 and Statement 1  
form part of these accounts.



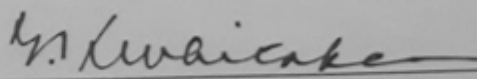
CHAIRMAN - COUNCIL OF THE INSTITUTE

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

Balance Sheet at 31 December 1986

<u>1985</u>				<u>1986</u>
£	£		£	£
261,254		Fixed Assets (Note 5)		297,580
		Current Assets:		
	351,804	Cash on hands and at Bank	287,816	
407,234	55,430	Debtors and prepayments	111,133	398,949
668,488		Total Assets		696,529
		Current Liabilities:		
	(39,759)	Creditors and Accruals (Note 2)	(73,567)	
(56,463)	(16,704)	Funds (Note 1)	(19,182)	(92,749)
612,025		Net Assets		603,780
612,025		Financed by:-		603,780
		Surplus Income and Expenditure Account		306,200
350,771		Capital Reserve (Note 6)		297,580
261,254				603,780
612,025				603,780
612,025				603,780

The Accounting Policies, Notes 1 to 8 and Statement 1 form part of these accounts.



CHAIRMAN - COUNCIL OF THE INSTITUTE



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

Detailed Income and Expenditure Account  
for the year ended 31 December 1986

Statement I

INCOME

	School of Celtic Studies	School of Theoretical Physics	School of Cosmic Physics	Administration	Total
	£	£	£	£	£
Grants	394,900	267,200	691,900	419,000	1,773,000
Sales of Publications	46,233	49	10	-	46,292
Fees	-	-	30,555	-	30,555
Miscellaneous	50	-	3,921	47,157	51,128
	<u>441,183</u>	<u>267,249</u>	<u>726,386</u>	<u>466,157</u>	<u>1,900,975</u>
Less allocated for capital purposes	23,530	13,146	55,745	1,707	94,128
	<u>417,653</u>	<u>254,103</u>	<u>670,641</u>	<u>464,450</u>	<u>1,806,847</u>

EXPENDITURE

Salaries, Wages and Superannuation (Note 8)	295,059	164,507	477,412	232,336	1,169,314
Scholarships	18,127	31,639	17,491	-	67,257
Honoraria	-	-	100	-	100
Library	15,082	33,341	20,930	-	69,353
Microfilms	12,937	-	-	-	12,937
Publications	51,359	1,978	4,081	913	58,331
General Administration (Note 3)	-	-	-	234,407	234,407
Travel and Survey Expenses	2,997	6,393	43,874	1,090	54,354
Symposia and Seminar Expenses	184	4,650	-	-	4,834
Consumable Equipment	-	-	41,341	-	41,341
Special Commitments and Projects	-	-	70,423	-	70,423
General Expenses	6,621	19,091	27,017	16,038	68,767
	<u>402,366</u>	<u>261,599</u>	<u>702,669</u>	<u>484,784</u>	<u>1,851,418</u>
<u>SURPLUS (DEFICIT)</u>	15,287	(7,496)	(32,028)	(20,334)	(44,571)
Balance at 1 January 1986	118,860	32,871	66,033	133,007	350,771
Balance at 31 December 1986	134,147	25,375	34,005	112,673	306,200

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

NOTES TO THE ACCOUNTS

1.	<u>Funds:</u>	£
	These comprise: Vernam Hull Bequest	18,151
	Carmody Fund	1,031

The funds are held on deposit.

2. Creditors and Accruals:

Included in this heading is £15,120 contract research monies unexpended at 31 December 1986.

3.	<u>General Administration Expenses:</u>	£
	Rent, Rates & Insurance	71,753
	Premises Maintenance	81,855
	Postage & Telephones	43,029
	Fuel, Light & Power	33,014
	Sundry Supplies	4,756
		234,407

4. Seismic and Space Research Programmes:

Contributions receiveable by the School of Cosmic Physics were as follows:-

<u>Project</u>	<u>Contributor</u>	<u>Amount</u>
		£
SLED (Solar Low Energy Detector Experiment)	NBST	15,000
Seismic Survey at Carnsore	ESB	300
GEOTWIN Project	EEC	42,742
EGT (Geotraverse)	EEC	27,994
		86,036

The above contributions have been accounted for as follows:-

Included in income	29,405
Offset against expenditure	41,511
Unexpended	15,120
	86,036

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

NOTES TO THE ACCOUNTS (contd.)

	£
5. <u>Fixed Assets</u> (Furniture & Equipment):	
Cost at 1 January, 1986	517,595
Additions	94,128
	611,723
Cost at 31 December, 1986	611,723
Accumulated Depreciation at 1 January, 1986	256,341
Depreciation in year	57,802
	314,143
Accumulated Depreciation at 31 December, 1986	314,143
Net book value at 31 December, 1986	297,580
Net book value at 31 December, 1985	261,254

6. Capital Reserve:

Balance at 1 January, 1986	261,254
Income capitalised in year	94,128
	355,382
Depreciation	57,802
Balance at 31 December, 1986	297,580

7. Leasing:

(a) Operating Leases:

The premises occupied by the Institute are leased from the Office of Public Works. The commitment on foot of such leases in respect of 1987 is £39,800. All except £260 of this commitment is on foot of leases of property from year-to-year.

(b) Finance Leases:

There were no appreciable finance leases in existence at 31 December, 1986.

8. Superannuation:

The total superannuation payments in the year amounted to £121,410. The salaries and superannuation charge in the accounts is net of contributions totalling £8,791.