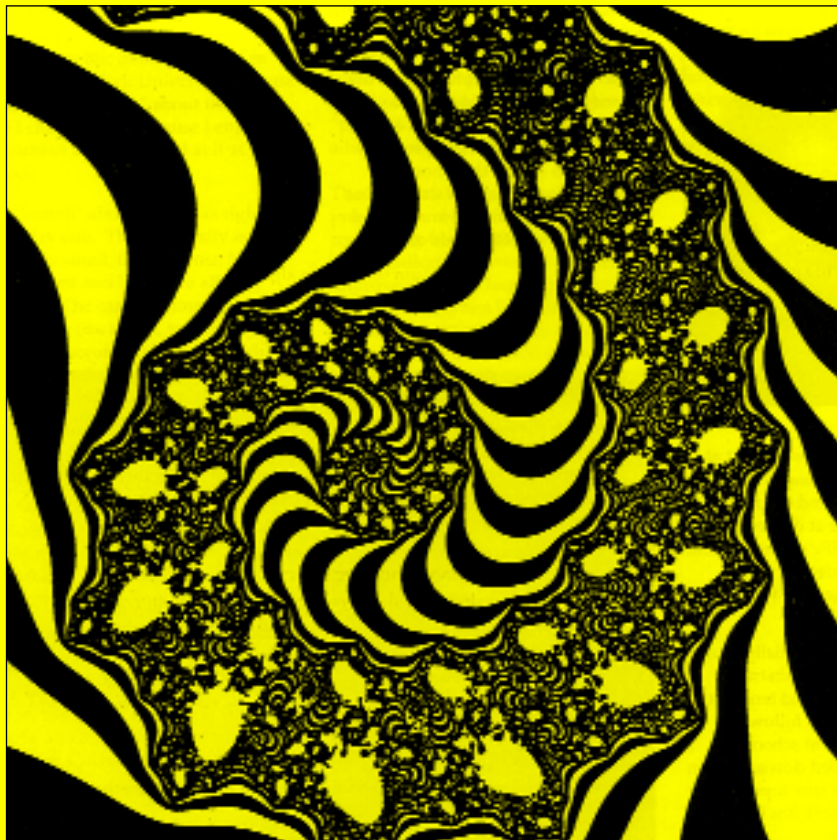


THE PONTIFICAL  
ACADEMY  
OF SCIENCES

PLENARY SESSION ON

# PATHS OF DISCOVERY

5-8 November 2004



Introduction p. 3

Programme p. 4

List of Participants p. 9

Abstracts p. 16

Standing Rules for Meetings p. 19



VATICAN CITY

2004

CASINA PIO IV

V-00120 VATICAN CITY

Tel: 0039 0669883451 Fax: 0039 0669885218

Email: [academy.sciences@acdscience.va](mailto:academy.sciences@acdscience.va)

For further information please visit:

[http://www.vatican.va/roman\\_curia/pontifical\\_academies/acdscien/index.htm](http://www.vatican.va/roman_curia/pontifical_academies/acdscien/index.htm)



Galileo feels in his scientific research the presence of the Creator, who stimulates him, inspires and helps his intuitions, acting in the deepest recesses of his spirit. In connection with the invention of the telescope, he writes at the beginning of *Sidereus Nuncius*, recalling some of his astronomical discoveries: *'Quae omnia ope Perspicilli a me excogitati divina prius illuminante gratia, paucis abhinc diebus reperta, atque observata fuerunt'*. 'All that has been discovered and observed in the last few days thanks to the telescope that I have invented, after having been enlightened by divine grace'. Galileo's confession of divine illumination in the mind of the scientist finds an echo in the text of the conciliar constitution on the Church in the modern world: 'The humble and persevering investigator of the secrets of nature is being led, as it were, by the hand of God in spite of himself'

John Paul II, *Address to the Pontifical Academy of Sciences*, 22 November 1979

## INTRODUCTION

The Council of the Pontifical Academy of Sciences suggests devoting the November 2004 Plenary Session to the following topic: 'Paths of Discovery'. This topic is of interest not only to scientists but also to many other people, including political and economic leaders. The Council is therefore asking for feedback, especially from those members of the Academy who are considering presenting a paper. A tentative title of the proposed paper would be appreciated and any critical or constructive suggestions would be welcome.

Discoveries are at the basis of new knowledge. There is no single recipe leading to discovery; there are a multitude of paths. Some discoveries are made upon verification or falsification of a theory. The discovery can then also give rise to a refinement of the theory, paving the way for further experimental approaches. Quite frequently, a discovery is made while the researcher is looking for something else. His scientific mind and intuition may thereby direct his attention to the unexpected. This source of discovery is generally called *serendipity*. Novel methodology and research strategies can open the doors to many new discoveries, which can then have an impact on individual researchers or, in other cases, on wider research programmes involving many researchers. Think of major scientific endeavours such as CERN depending on a large experimental set-up. However, in this case too progress will depend in part on the activities of individual scientists and their aptitude to design and interpret experiments. The same is true for almost any research, whether it is carried out by a single person or in the context of a larger research programme. More generally, the debate may also address the role played by dogma and widely anchored textbook knowledge in scientific progress, given their frequent influence on the interpretation of observations and experimental data.

The aim of a debate on 'Paths of Discovery' would be to collect a number of case studies largely based on the personal experience of the participants and their scientific environments. However, the debate may also refer to some cases of discovery that have already been documented by the history of science. The resulting documentation is expected to illustrate the range of paths leading to discovery. Such documentation may be useful in political planning for scientific investigations and may represent a welcome contribution to the literature on the principles of the scientific approach.

WERNER ARBER

Member and Councillor of the Pontifical Academy of Sciences  
Nobel Prize in Physiology or Medicine (1978)

## PROGRAMME

### THURSDAY 4 NOVEMBER 2004

16.00-19.00	<b><i>Council Meeting</i></b>
-------------	-------------------------------

### FRIDAY 5 NOVEMBER 2004

9.00	<b><i>Word of Welcome:</i></b> Prof. Nicola CABIBBO, President of the Academy
9.05	<b><i>The Subject of the Meeting:</i></b> Prof. Werner ARBER, Coordinator of the Meeting
9.15	<b><i>Commemorations of Deceased Academicians</i></b> Sune BERGSTRÖM (15.VIII.04) by Prof. N.M. LE DOUARIN Renato DARDOZZI (3.VI.03) by Prof. N. CABIBBO Nicola DALLAPORTA (23.X.03) by Prof. N. CABIBBO Paul A.J. JANSSEN (11.XI.03) by Prof. C. de Duve Stanisław LOJASIEWICZ (13.XI.02) by Prof. P. GERMAIN Manuel LORA TAMAYO (22.VIII.02) by Prof. A. GARCÍA BELLIDO Thomas R. Odhiambo (27.V.03) by Prof. M.G.K. MENON George PORTER (31.VIII.02) by Prof. R. HIDE Marcel ROCHE (3.V.03) by Prof. C. PAVAN
10.00	<b><i>Self-Presentation of the New Members</i></b> Prof. Suzanne CORY Prof. William D. PHILLIPS Prof. Veerabhadran RAMANATHAN
10.20	<b><i>Presentation of the Pius XI Medal</i></b> awarded to Dr. Laure SAINT-RAYMOND
10.30	<b><i>Coffee Break</i></b>
11.00	<b><i>Possible Papal Audience and Photograph with the Holy Father</i></b>
13.00	<b><i>Lunch at the Academy</i></b>
15.00	<b><i>Session One</i></b> <b><i>Chairperson:</i></b> Prof. <b><i>Speaker:</i></b> ◆ Prof. J. MITTELSTRASS: <i>Different Types of Discovery – Lessons from the History of Science</i>
15.15	<b><i>Discussion</i></b>

15.30	<b>Speaker:</b> ◆ Prof. G.V. COYNE: <i>Discovery in the New Cosmology of Copernicus, Kepler and Galileo</i>
15.45	<b>Discussion</b>
16.00	<b>General Discussion</b>
16.45	<b>Session Two</b> <b>Chairperson:</b> Prof. <b>Speaker:</b> ◆ Prof. P.J. LÉNA: <i>The Case of the Extrasolar Planets</i>
17.15	<b>Discussion</b>
17.30	<b>Speaker:</b> ◆ Prof. R. MURADIAN: <i>Going from Quarks to Galaxies: Two Findings</i>
17.45	<b>Discussion</b>
18.00	<b>Coffee Break</b>
18.30	<b>Speaker:</b> ◆ Prof. C. RUBBIA: <i>(Title to be submitted)</i>
18.45	<b>Discussion</b>
19.00	<b>Speaker:</b> ◆ Prof. S.L. JAKI: <i>On a Discovery about Godel's Incompleteness Theorem</i>
19.15	<b>Discussion</b>
19.30	<b>General Discussion</b>
20.00	<b>Dinner at Domus Sanctae Marthae</b>

**SATURDAY 6 NOVEMBER 2004**

9.00	<p><b>Session Three</b>  <b>Chairperson:</b> Prof.  <b>Speaker:</b>                  ♦ Prof. M. MOSHINSKY: <i>Diffraction in Time (Tentative Title)</i></p>
9.15	<b>Discussion</b>
9.30	<p><b>Speaker:</b>                  ♦ Prof. C. COHEN-TANNOUJJI: <i>Optical Methods – A Simple Way to Interrogate and to Manipulate Atoms</i></p>
9.45	<b>Discussion</b>
10.00	<p><b>Speaker:</b>                  ♦ Prof. M.G.K. MENON: <i>The Role of Innovation, Interdisciplinarity and Phenomenology as Components of Creativity in Opening New Windows</i></p>
10.30	<b>Discussion</b>
10.45	<p><b>Speaker:</b>                  ♦ Prof. M.J. REES: <i>From Confusion towards Consensus in Cosmology</i></p>
11.00	<b>Discussion</b>
11.15	<b>Coffee Break</b>
11.30	<p><b>Session Four</b>  <b>Chairperson:</b> Prof.  <b>Speaker:</b>                  ♦ Prof. W.E. THIRRING: <i>Instabilities of Gravitation Dominated Systems</i></p>
12.00	<b>Discussion</b>
12.15	<p><b>Speaker:</b>                  ♦ Prof. A. ZICHICHI: <i>A Personal Experience of Unexpected Discoveries</i></p>
12.45	<b>Discussion</b>
13.00	<b>Lunch at the Academy</b>
15.00	<p><b>Speaker:</b>                  ♦ Prof. M. HELLER: <i>Discovering the World Structure as a Goal of Physics</i></p>
15.30	<b>Discussion</b>
15.45	<b>General Discussion</b>
16.00	<p><b>Session Five</b>  <b>Chairperson:</b> Prof.  <b>Speaker:</b>                  ♦ Prof. J.-M. MALDAMÉ: <i>Comment la réflexion sur l'inspiration de la Bible éclaire l'invention en matière de science</i></p>
16.15	<b>Discussion</b>
16.30	<p><b>Speaker:</b>                  ♦ Prof. M. SELA: <i>Paths of Discovery of a Therapeutic Vaccine</i></p>



16.45	<b>Discussion</b>
17.00	<b>Coffee Break</b>
17.15	<b>Speaker:</b> ◆ Prof. A. SZCZEKLIK: <i>Aspirin and Eicosanoid Pathways: The Discoveries that Changed Contemporary Medicine</i>
17.45	<b>Discussion</b>
18.00	<b>Session Six</b> <b>Chairperson:</b> Prof. <b>Speaker:</b> ◆ Prof. A.M. BATTRO: <i>Microdiscoveries: A Case Study of Creative Paths and Academic Networks in Science</i>
18.30	<b>Discussion</b>
18.45	<b>Speaker:</b> ◆ Prof. W.J. SINGER: <i>The Discovery of Synchronous Oscillations in the Brain: The Role of Chance and Fortunate Coincidences</i>
19.00	<b>Discussion</b>
19.15	<b>Speaker:</b> ◆ Prof. R.J. WHITE: <i>Discovering Pathways to Brain Cooling</i>
19.30	<b>Discussion</b>
19.45	<b>General Discussion</b>
20.00	<b>Dinner at Domus Sanctae Marthae</b>

**SUNDAY 7 NOVEMBER 2004**

<b>Trip to Montecassino Abbey</b> <b>60th Anniversary of the Abbey's Destruction and Reconstruction</b>	
7.00	<b>Bus leaves Domus Sanctae Marthae</b>
10.15	<b>Arrival in Montecassino and Greeting by Abbot Monsignor Bernardo D'Onorio</b>
10.30	<b>Abbey Mass with Gregorian Chants, celebrated by His Eminence Cardinal Joseph Ratzinger</b>
11.30	<b>Guided Visit to the Abbey</b>
12.30	<b>Social Lunch at the Abbey</b>
15.00	<b>Bus leaves for Domus Sanctae Marthae</b>

**MONDAY 8 NOVEMBER 2004**

9.00	<p><b>Session Seven</b>  <b>Chairperson:</b> Prof.  <b>Speaker:</b>          ◆ Prof. W. ARBER: <i>The Impact of Microbial Genetics on the Development of Genomics and Biotechnology</i></p>
9.30	<b>Discussion</b>
9.45	<p><b>Speaker:</b>          ◆ Prof. C. PAVAN: <i>Endosymbiotic Bacteria Associated with Plant Seeds and Birds' Eggs</i></p>
10.00	<b>Discussion</b>
10.15	<p><b>Speaker:</b>          ◆ Prof. R. VICUÑA: <i>Microbial Biodiversity: A New Voyage of Discovery</i></p>
10.45	<b>Discussion</b>
11.00	<b>Coffee Break</b>
11.30	<p><b>Session Eight</b>  <b>Chairperson:</b> Prof.  <b>Speaker:</b>          ◆ Prof. R. HIDE: <i>Geomagnetism, 'Vacillation', Atmospheric Predictability and 'Deterministic Chaos'</i></p>
11.45	<b>Discussion</b>
12.00	<p><b>Speaker:</b>          ◆ Prof. B.M. COLOMBO: <i>Paths to Discovery: Personal Experiences in a Social Science</i></p>
12.15	<b>Discussion</b>
12.45	<p><b>Speaker:</b>          ◆ Prof. P.J. CRUTZEN: <i>The 'Anthropocene', the Present Era Influenced by Human Activity</i></p>
13.00	<b>Discussion</b>
13.15	<b>Lunch at the Academy</b>
15.00	<p><b>Speaker:</b>          ◆ Prof. M.J. MOLINA: <i>(Title to be submitted)</i></p>
15.15	<b>Discussion</b>
15.30	<b>General Discussion</b>
16.00	<b>Closed Session for Academicians</b>
19.00	<b>Dinner at Domus Sanctae Marthae</b>



## LIST OF PARTICIPANTS

### *Academicians*

**CABIBBO Prof. Nicola** (President)  
Università degli Studi di Roma 'La Sapienza'  
Dipartimento di Fisica  
Piazzale Aldo Moro, 5  
I-00185 Roma (Italy)  
Tel: +39 064453858 – Fax: +39 064453829  
email: nicola.cabibbo@roma1.infn.it

**COTTIER Card. Georges Marie Martin, O.P.**  
Palazzo Apostolico  
V-00120 Città del Vaticano  
Tel: +39 0669885675; 0669885227 – Fax: +39 0669885993  
email: teologo@petrus.va

**MARTINI Card. Carlo Maria, S.J.**  
Santuario di Galloro  
Via Appia, 54  
I-00040 Galloro, RM (Italy)  
Tel: +39 069339191  
email: carlomar.martini@virgilio.it

**RATZINGER Card. Joseph**  
Congregazione per la Dottrina della Fede  
Palazzo del S. Uffizio  
V-00120 Città del Vaticano  
Tel: +39 0669883296 – Fax: +39 0669884532  
email: prefect@cfaith.va

**SÁNCHEZ SORONDO H.E. Msgr. Marcelo** (Chancellor)  
Pontificia Accademia delle Scienze  
Casina Pio IV  
V-00120 Città del Vaticano  
Tel: +39 0669883451 – Fax: +39 0669885218  
email: academy.sciences@acdscience.va

**ARBER Prof. Werner**  
University of Basel, Biozentrum  
Department of Microbiology  
Klingelbergstrasse 70  
CH-4056 Basel (Switzerland)  
Tel: +41 61 2672130 – Fax: +41 61 2672118  
email: werner.arber@unibas.ch

**BATTRO Prof. Antonio M.**

Battro & Denham, Consultores  
Billinghurst 2574 Piso 1A  
C1425DTZ Buenos Aires (Argentina)  
Tel: +54 2322 462202 – Fax: +54 11 48013725  
email: abattro@byd.com.ar – abattro@ross.org

**BERTI Prof. Enrico**

Università degli Studi di Padova  
Dipartimento di Filosofia  
Piazza Capitaniato, 3  
I-35139 Padova (Italy)  
Tel: +39 0498274753 – Fax: +39 0498274701  
email: enrico.berti@unipd.it

**COHEN-TANNOUJJI Prof. Claude**

Collège de France – École Normale Supérieure  
Département de Physique – Laboratoire Kastler Brossel  
24, rue Lhomond  
F-75231 Paris Cedex 05 (France)  
Tel: +33 1 47077783 – Fax: +33 1 44323434  
email: cct@lkb.ens.fr

**COLOMBO Prof. Bernardo Maria**

Università degli Studi di Padova  
Dipartimento di Scienze Statistiche  
Via C. Battisti, 241  
I-35121 Padova (Italy)  
Tel: +39 0498274144 – Fax: +39 0498274170  
email: colber@stat.unipd.it

**CORY Prof. Suzanne**

The Walter and Eliza Hall Institute of Medical Research  
1G Royal Parade  
Parkville  
Victoria 3050 (Australia)  
Tel: +61 3 93452551 – Fax: +61 3 93452508  
email: cory@wehi.edu.au

**COYNE Prof. George V., S.J.**

Specola Vaticana  
V-00120 Città del Vaticano  
Tel: +39 0669885266 – Fax: +39 0669884671  
email: gcoyne@as.arizona.edu; gcoyne@specola.va

**CRUTZEN Prof. Paul Josef**

Max-Planck-Institute for Chemistry, Department of Atmospheric Chemistry  
P.O. Box 3060  
D-55020 Mainz (Federal Republic of Germany)  
Tel: +49 6131 305458 – Fax: +49 6131 305511  
email: air@mpch-mainz.mpg.de

**GARCÍA BELLIDO Prof. Antonio**

Universidad Autónoma de Madrid  
Centro de Biología Molecular 'Severo Ochoa'  
Laboratorio de Genética del Desarrollo  
Cantoblanco  
28049 Madrid (Spain)  
Tel: +34 91 3974129 – Fax: +34 91 3978632  
email: agbellido@cbm.uam.es

**GERMAIN Prof. Paul Marie**

Académie des Sciences  
23, quai de Conti  
F-75006 Paris (France)  
Tel: +33 1 44414352 – Fax: +33 1 44414363  
email: pmgermain@aol.com

**HELLER Prof. Michael**

Pontifical Academy of Theology  
Faculty of Philosophy  
ul. Franciszkańska, 1  
PL-31-004 Kraków (Poland)  
Tel: +48 12 4229804 – Fax: +48 12 4218416  
email: mheller@wsd.tarnow.pl

**HIDE Prof. Raymond**

Department of Mathematics  
Imperial College  
180 Queen's Gate  
London SW 7 2BZ (United Kingdom)  
*Mailing address:*  
17, Clinton Avenue  
East Molesey, Surrey KT8 0HS (United Kingdom)  
Tel: +44 20 88733366  
email: r.hide@cwctv.net

**JAKI Prof. Stanley L., O.S.B.**

Seton Hall University  
South Orange, NJ, 07079 (USA)  
*Mailing address:*  
P.O. Box 167  
Princeton, NJ 08542 (USA)  
Tel: +1 609 8963979 – Fax: +1 609 8969307  
email: sljaki@netcarrier.com – website: www.sljaki.com

**KEILIS-BOROK Prof. Vladimir Isaakovich**

University of California, Los Angeles  
Institute of Geophysics and Planetary Physics  
3845 Slichter Hall, Box 951567  
Los Angeles, CA 90095-1567 (USA)  
Tel: +1 310 8253939  
email: vkb@ess.ucla.edu  
Int. Institute of Earthquake Prediction Theory and Mathematical Geophysics  
Warshavskoye sh. 79, Kor 2  
Moscow 113556 (Russia)  
Tel: +7 095 1107795 – Fax: +7 095 3107032; 9567095  
email: vkborok@mitp.ru

**LE DOUARIN CHAUVAC Prof. Nicole Marthe**

Académie des Sciences  
23, quai de Conti  
F-75006 Paris (France)  
Tel: +33 1 44414383  
email: sec-perpetuel2@academie-sciences.fr  
C.N.R.S. – Collège de France  
Institut d'Embriologie Cellulaire et Moléculaire – UPR 9064  
49bis, avenue de la Belle Gabrielle  
F-94736 Nogent-sur-Marne Cedex (France)  
Tel: +33 1 45141515 – 45141507 – Fax: +33 1 48734377

**LÉNA Prof. Pierre Jean**

Université Paris VII Denis Diderot – Observatoire de Paris  
Département de Recherche Spatiale  
Unité de recherche associée au CNRS # 8632  
Place Jules-Janssen  
F-92195 Meudon (France)  
Tel: +33 1 45077951 or 7835 – Fax: +33 1 45077102  
email: pierre.lena@obspm.fr

**LEVI-MONTALCINI Prof. Rita**

Institute of Neurobiology, CNR  
Viale Marx, 15  
I-00137 Roma (Italy)  
Tel: +39 0686090510 – Fax: +39 0686090269  
email: r.levimontalcini@in.rm.cnr.it

**MALDAMÉ Prof. Jean-Michel, O.P.**

Institut Catholique de Toulouse  
31, rue de la Fonderie  
F-31068 Toulouse Cedex (France)  
Tel: +33 561368100 – Fax: +33 561258275  
email: jean-michel.maldame@dominicains.com

**MENON Prof. Mambillikalathil Govind Kumar**

K-5 (Rear), Hauz Khas Enclave  
New Delhi 110016 (India)  
Tel: +91 11 26511454 – Fax: +91 11 26510825  
email: mgkmenon@ren02.nic.in

**MITTELSTRASS Prof. Jürgen**

Universität Konstanz  
Fachbereich Philophie und Zentrum Philosophie  
und Wissenschaftstheorie  
D-78457 Konstanz (Federal Republic of Germany)  
Tel: +49 7531 882498 – Fax: +49 7531 882502  
email: juergen.mittelstrass@uni-konstanz.de

**MOLINA Prof. Mario José**

Massachusetts Institute of Technology  
Department of Earth, Atmospheric and Planetary Sciences  
77 Massachusetts Avenue  
Cambridge, MA 02139-4307 (USA)  
Tel: +1 617 2535081 – Fax: +1 617 2586525  
email: mmolina@mit.edu – ltmolina@mit.edu

**MOSHINSKY Prof. Marcos**

Universidad Nacional Autónoma de México  
Instituto de Física  
Apdo. Postal 20-364, Delegación Alvaro Obregon  
01000 México, D.F. (México)  
Tel: +52 55 56225023 – Fax: +52 55 56161535  
email: moshi@fisica.unam.mx

**MURADIAN Prof. Rudolf**

Byurakan Astrophysical Observatory  
AM-378433 Byurakan (Armenia)  
*Mailing address:*  
Universidade Estadual de Santa Cruz  
Departamento de Ciências Exatas e Tecnológicas  
Rodovia Ilhéus/Itabuna, km 16  
45650-000 Ilhéus, Bahia (Brazil)  
Tel: +55 73 6322739 (Res.)  
email: rudolfmuradian@hotmail.com; rudolfmuradian@namag.com

**PAVAN Prof. Crodowaldo**

Universidade de São Paulo, USP  
Instituto de Ciências Biomédicas, Lab. de Microbiologia  
São Paulo, S.P. 05389-970 (Brazil)  
Tel: +55 11 38187346 – Fax: +55 11 38130845  
email: crodowaldo@hotmail.com

**PHILLIPS Prof. William Daniel**

National Institute of Standards and Technology  
Physics Laboratory – Atomic Physics Division  
100 Bureau Drive, Stop 8424  
Bldg. 216, Rm. B137  
Gaithersburg, MD 20899 (USA)  
Tel: +1 301 975 6554 – Fax: +1 301 975 8272  
email: william.phillips@nist.gov

**RAMANATHAN Prof. Veerabhadran (Ram)**

University of California, San Diego  
Scripps Institution of Oceanography  
Center for Atmospheric Sciences  
9500 Gilman Drive, MC 0221  
LA JOLLA, CA 92093-0221 (USA)  
Tel.: +1 858 5348815 – Fax: +1 858 8225607  
email: vramanathan@ucsd.edu

**RAVEN Prof. Peter Hamilton**

Missouri Botanical Garden  
P.O. Box 299  
St. Louis, MO 63166-0299 (USA)  
Tel: +1 314 5775111 – Fax: +1 314 5779595  
email: praven@nas.edu

**REES Prof. Martin John**

University of Cambridge  
Institute of Astronomy  
Madingley Road  
Cambridge CB3 0HA (United Kingdom)  
Tel: +44 1223 337548 – Fax: +44 1223 337523  
email: mjr@ast.cam.ac.uk

**RUBBIA Prof. Carlo**

Ente per le Nuove Tecnologie, l'Energia e l'Ambiente (ENEA)  
Lungotevere Thaon di Revel, 76  
I-00196 Roma (Italy)  
Tel: +39 063227554 – Fax: +39 0636272313  
European Organization for Particle Physics (CERN)  
CH-1211 Geneva 23 (Switzerland)  
Tel: +41 22 7676338; 7672282 – Fax: +41 22 7677555; 7677960  
email: carlo.rubbia@cern.ch

**SELA Prof. Michael**

The Weizmann Institute of Science  
Department of Immunology  
P.O. Box 26, Rehovot 76100 (Israel)  
Tel: +972 8 9466969; 9344022 – Fax: +972 8 9469713  
email: lisela@weizmann.weizmann.ac.il – michael.sela@weizmann.ac.il

**SINGER Prof. Wolf Joachim**

Max-Planck-Institute for Brain Research  
Department Neurophysiology  
Deutschordenstrasse 46  
D-60528 Frankfurt am Main (Federal Republic of Germany)  
Tel: +49 69 96769218 – Fax: +49 69 96769327  
email: singer@mpih-frankfurt.mpg.de

**SZCZEKLIK Prof. Andrzej**

Jagiellonian University School of Medicine  
Department of Medicine  
ul. Skawińska 8  
PL-31-066 Kraków (Poland)  
Tel: +48 12 4305169 – Fax: +48 12 4305203  
email: mmszczek@cyf-kr.edu.pl

**THIRRING Prof. Walter E.**

Universität Wien  
Institut für Theoretische Physik  
Boltzmannngasse 5  
A-1090 Vienna (Austria)  
Tel: +43 1 427751516 – Fax: +43 1 42779515  
email: walter.thirring@univie.ac.at – karin.picek@univie.ac.at

**TUPPY Prof. Hans**

University of Vienna, Institute of Medical Biochemistry  
Dr. Bohr-Gasse 9/3. Stock  
A-1030 Vienna (Austria)  
Tel: +43 1 427761670 – Fax: +43 1 42779616

**VICUÑA Prof. Rafael**

Pontificia Universidad Católica de Chile  
Facultad de Ciencias Biológicas  
Departamento de Genética Molecular y Microbiología  
Casilla 114-D, Santiago (Chile)  
Tel: +56 2 6862663 – Fax: +56 2 2225515  
email: rvicuna@bio.puc.cl

**WHITE Prof. Robert Joseph**

Case Western Reserve University Medical School  
MetroHealth Medical Center  
Division of Neurological Surgery and Brain Research Laboratory  
2500 MetroHealth Drive  
Cleveland, OH 44109-1998 (USA)  
Tel: +1 216 7784383 – Fax: +1 216 7785616  
email: patedkav@aol.com – whiteringwhites@aol.com

**ZICHICHI Prof. Antonino**

'Ettore Majorana' Foundation and Centre for Scientific Culture  
Via Guarnotta, 26  
I-91016 Erice (Italy)  
Tel: +39 0923869133 – Fax: +39 0923869226  
email: fiorella@ccsem.infn.it

*Pius XI Medal*

**SAINT-RAYMOND Dr. Laure**

Laboratoire Jacques-Louis Lions  
Université Paris VI Pierre et Marie Curie  
4 place Jussieu  
75 Paris Cedex 05 (France)  
Tel: +33 1 44 27 37 72 – Fax: +33 1 44 27 72 00  
email: saintray@ann.jussieu.fr

## ABSTRACTS

### MICRODISCOVERIES: A CASE STUDY OF CREATIVE PATHS AND ACADEMIC NETWORKS IN SCIENCE

ANTONIO M. BATTRO

My thesis is that several cognitive processes engaged in any ‘microdiscovery’ are common to every scientific task up to major discoveries or breakthroughs, like the double helix. I analyze the paths of discovery of the ‘fractal character of saccadic eye movements’ as a case study where I have recorded in detail many of the different steps of the new idea from the point of view of the cognitive sciences. In particular, I discuss the importance of ‘analogies’ in my research, the role of ‘chance’ encounters with relevant information, meetings with people and findings of experimental data. Finally, I analyze the concepts of innovation, confrontation, modelisation and parsimony in scientific discoveries.

*Reference:* <http://www.byd.com.ar/fractalstory.htm>



### DISCOVERING THE WORLD STRUCTURE AS A GOAL OF PHYSICS

MICHAEL HELLER

The structuralist view on mathematics, claiming that mathematics is ‘about structures and their morphology’, is well founded in both mathematical practice and metatheoretical investigation, although it is difficult to formulate in a rigorous manner. Assuming the structuralist view on mathematics, we look for its consequences for interpreting physical theories.

Empirical successes of physical theories support their realistic interpretation, but discontinuities in the world image, often caused by replacing a successful physical theory by another even more successful theory, support their anti-realistic interpretation. However, if we remember that the mathematical structure of the old theory can be obtained, as a limiting case, from the mathematical structure of the new theory, we recover a continuity at the level of structures (even if there is no continuity at the level of respective world images). This supports the view that physical theories are ‘about the structure of the world’ or, more precisely, that the method of physics catches only the world structure. From the philosophical point of view, two possibilities can be envisaged: either (1) structures discovered by physical theories are structures of something, i.e., there is a ‘structured stuff’, but this stuff is transparent for the physical method (epistemic structuralism), or (2) such a stuff does not exist (ontic structuralism). To decide between these two possibilities one should go beyond the analysis of the physical method and appeal to metaphysical or logical reasons.

In the case, when one physical theory admits more than one mathematical formulation (which is not infrequent situation in physics), we should assume that these formulations are but various representations of an abstract structure, and that it is this abstract structure that reflects or approximates the Structure of the World.



## GEOMAGNETISM, 'VACILLATION', ATMOSPHERIC PREDICTABILITY AND 'DETERMINISTIC CHAOS'

RAYMOND HIDE

'Discoveries' – as the organisers of this symposium on 'paths of discovery' emphasise – 'are the basis of all new knowledge. [----] Some stem from the direct verification or 'falsification' of theory, but in many cases serendipity plays a key rôle. Then a discovery is made whilst something else is being sought but the scientific mind and intuition of the researcher become directed towards the unexpected'.

Serendipity certainly featured in some of the main events outlined in this contribution to the symposium. They started in 1947 when P.M.S. Blackett, a cosmic ray physicist then at the University of Manchester, proposed a testable new theory of the Earth's magnetism [1], which over the next few years he and colleagues succeeded in 'falsifying' by observation and experiment. The events ended in 1963 when E.N. Lorenz, a dynamical meteorologist at the Massachusetts Institute of Technology (MIT), published an account of his work on deterministic non-periodic fluid flow, motivated by his interest in the predictability of weather patterns. Lorenz's paper [2] was later recognised by scientists in other disciplines and by mathematicians as a seminal contribution to what subsequently became known as 'chaos theory'. This now influences ideas and methodologies in many branches of science and technology.

Linking these studies were quantitative laboratory experiments in which I discovered in spinning fluids subject to steady (thermal) forcing several nonlinear régimes of flow of varying degrees of complexity in their spatial and temporal characteristics, including (multiply-) periodic ('vacillation') and highly aperiodic ('chaotic') régimes. Undertaken from 1950 to 1953 at the University of Cambridge (and later repeated and their findings confirmed by D. Fultz and his colleagues at the University of Chicago), the experiments were motivated in the first instance by my interest in geomagnetism and motions in the metallic core of the Earth. But they were to attract the attention of meteorologists engaged in research on large-scale atmospheric motions and influence Lorenz's mathematical work on atmospheric predictability and nonlinear dynamical systems.



## MY SCIENTIFIC LIFE

MARCOS MOSHINSKY

My interest in science started rather late in my life as in my primary and early high school I was just an average student. Though my parents had a great admiration for knowledge they emigrated from Russia to Mexico in 1927 and were too busy making a living to be able to dedicate much time to continue their education beyond high school. Arriving though at the third year of Secundaria (equivalent to the end of Junior High) I had a professor of mathematics who required an entrance examination and to my astonishment I got the highest grade of the class. This of course interested me in the field and I finished the course way ahead of the other students.

The following years of high school in Mexico required a definition of the interest of the student in subject matters with the view that they could enter the appropriate courses in college with some basic preparation. I chose mathematics and physics and was thinking of engineering as my future profession. It turned out that on finishing High School I had some psychosomatic illness that the doctors were not able to diagnose but suggested that I stop study-

ing for a year to diminish the mental strain. Thus I spent a year (1939) in New York as a worker in a knitting factory (on Broadway and 12th street) using part of the time to improve my English. On my return to Mexico, on the eve of the Second World War, I learned that the National University of Mexico (UNAM) had established in 1938 a Faculty of Sciences among whose fields were mathematics and physics. I entered the Faculty in the fields mentioned in 1940 and, still in my second year, I received an appointment as an assistant researcher at the Institute of Physics of UNAM, which was also founded in 1938.

My main job at the time was to attend a cosmic ray counter as that was the field of the Director of the Institute a former student of Dr. Manuel Sandoval Vallarta one of the pioneers in cosmic ray research. My work did not interfere with my studies and in 1944 I received the equivalent of my Bachelors degree.

At the time three distinguished American mathematicians spent long periods in Mexico as most of their students were in the armed forces during the Second World War. They were George Birkhoff, Norbert Wiener and Solomon Lefschetz. It was the latter, working in Princeton University, that suggested that I do my graduate studies in his University with Eugene Wigner then already an outstanding physicist and later a Nobel Prize Winner. He helped me get admitted in late 1945 and also obtain a fellowship, and I got my Ph.D. in 1949.

In those years Princeton was the Meca of Theoretical Physics not only because of professors like Wigner, Wheeler, Bargman etc., but also by the fact that in 1947, Robert Oppenheimer became the Director of the Institute of Advanced Study a mile away from the University and brought with him some of the best younger physicists and mathematician of the time. Thus my stay in Princeton was very fruitful and on my return to Mexico I was able to help the development of Theoretical Physics at UNAM.

During my stay in Princeton it became very clear to me that the future standing of nations in the international context would not be given so much by their industries or their arms, as by the knowledge and use of science by its inhabitants. On my return to Mexico I wanted my country to be aware, of this situation and increase the scientific knowledge of its population as well as the use of the same.

Thus during more than 40 years I gave an undergraduate and a graduate course at my University (UNAM), the first one usually on quantum mechanics that I considered the basic one in modern physics, and the second usually related to the research I was carrying out at the moment. In that period I directed close to 30 thesis for Bachelor Degree in Physics, 15 for Ph.D. in the same subject and, as I became more well known internationally, more than 15 foreign postdocs came to Mexico for a year or more to collaborate on research with me.

My physics publications include more than 275 articles in refereed international journals and five books as well as many papers in newspapers mainly on the impact of science and education on society.

My permanent association was always with UNAM though I have traveled widely to many other institutions for periods from a year to a few weeks. I never felt that working in Mexico was a hindrance to my scientific work. In fact it was beneficial as I did not have the pressure to work on subjects that were the rage in advanced countries, but could concentrate on the ones that by myself decided were important.

In fact a few of the subjects that I considered worthwhile became popular after I had written a paper on them such as the role of symmetries of canonical transformations in quantum mechanics; the simplifications of nuclear structure calculations with the help of harmonic oscillator transformation brackets; the relativistic many body problem; the Dirac oscillator, etc. My advice to a young physicist and, also to a young scientist in any field, is not the one of Einstein to work in light-house far from the pressures and distractions of the main institutions of learning, but rather choose a university or research group that is just beginning to be able to contribute to its transformation into a first rate establishment.

## STANDING RULES FOR MEETINGS

1. The Academy invites a number of illustrious scholars who have especially studied a given question and have arrived at different conclusions to meet in Rome at its headquarters, the 'Casina Pio IV', situated in the Vatican City, so as to make a joint examination of all the data on the question.

2. The chief aim of these discussions is to endeavour to reach a common view on the subject of the meeting, but when this is not possible to formulate precisely the reasons for this inability. The scholars invited to these meetings undertake in advance to concentrate their efforts on this.

3. A critical examination of these reasons should lead either to agreement on a partial or provisional solution or else to the conclusion that, on the basis of the information presently available, it is impossible to establish unity on the question concerned. In the latter event the scholars involved will be called upon:

- a) to define the reasons why agreement appears to be impossible for the present;
- b) to specify the kind of research work it would be desirable to undertake in order to solve the problem.

4. The invitation will be addressed by the Academy to only a small number of representatives of each branch of learning: these will be selected from scholars who are not connected with the Academy. These representatives will be joined during the discussions by members of the Academy who are experts in the same discipline. This invitation, moreover, will apply only to the study of one precise question by each branch of learning.

5. The debates will be strictly private and will take the form of papers and talks in the presence only of a few members of the Pontifical Academy of Sciences who have special knowledge of the subject under discussion.

6. The conclusions arrived at will be published in the form of a 'Statement' (to which may be added individual notes) mentioning:

- a) the points on which agreement was reached;
- b) the points on which it was impossible to reach agreement;
- c) the reasons why it was not possible to reach agreement;
- d) suggestions about the research work that appears most appropriate in order to arrive at a solution of the difficulties.

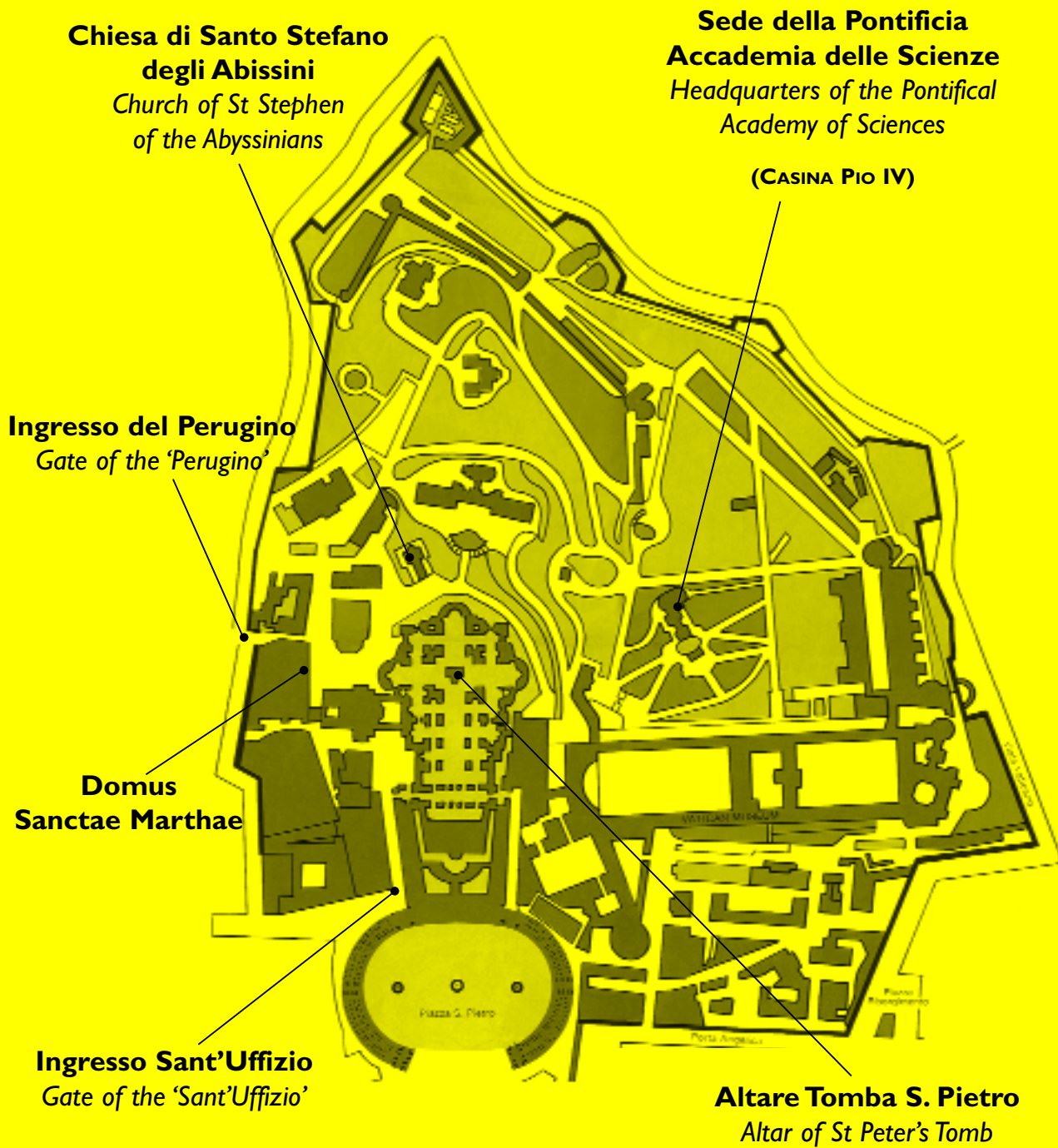
7. The 'Statement' arrived at will be immediately printed and transmitted by the Pontifical Academy of Sciences to all the centres of learning which might be interested in it.

PONTIFICIA ACADEMIA SCIENTIARVM

PLENARY SESSION ON

**PATHS OF DISCOVERY**

5-8 November 2004



**Chiesa di Santo Stefano degli Abissini**  
*Church of St Stephen of the Abyssinians*

**Sede della Pontificia Accademia delle Scienze**  
*Headquarters of the Pontifical Academy of Sciences*

(CASINA PIO IV)

**Ingresso del Perugino**  
*Gate of the 'Perugino'*

**Domus Sanctae Marthae**

**Ingresso Sant'Uffizio**  
*Gate of the 'Sant'Uffizio'*

**Altare Tomba S. Pietro**  
*Altar of St Peter's Tomb*