No. 84 June 2012

IAMG Newsletter

Official Newsletter of the International Association for Mathematical Geosciences

Contents

Nominations requested for 2013 IAMG Awards !

The Association invites all members to submit nominations for the **Felix Chayes Prize** and for the **Andrei Borisovich Vistelius Award**

Deadline: January 31, 2013

For details about prerequisites for nominations please see the IAMG web site **http://www.iamg.org/** and click on **Awards**

There is also a list of past recipients and their laudatios on the web site. Please have a look at it before sending your nominations!

The (informal) documents which should accompany a proposal are:

- a short statement summarizing the relevant qualifications of the nominee
- a curriculum vitae of the nominee

Nobody gets an award without a nomination, so please support your colleague when you believe he/she deserves an award by submitting a nomination. Nomations can be submitted by a single person or by a group. The Laudatios written over the last few years and published in Mathematical Geosciences are a good source of inspiration on how to write a nomination. Nominations can be submitted via e-mail or sent to:

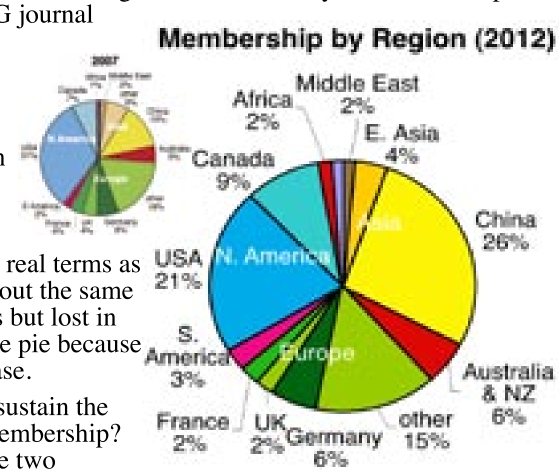
Jef Caers - Chairman, IAMG Awards Committee
Stanford University
Dept. of Energy Resources Engineering
367 Panama St.
Stanford, CA 94305-2220 - USA
E-mail: jcaers@stanford.edu

Nominations for other Awards may also be submitted at any time.

From the Editor

Membership is increasing again! Over the last two years IAMG has added more than 200 members. At 720 members this is the third highest number in IAMG history. Several factors contributed to this development, but largest is the growth of IAMG in China from 13% of the IAMG membership in 2007 to 26% in 2012. That is an increase from 75 to 195 Chinese members. We can thank the efforts of Qiuming Cheng and Frits Agterberg as well the support of Zhao Pengda to establish the Chinese Topical Section IAMG-CN. Another factor is the establishment of five new IAMG Student Chapters thanks to Helmut Schaeben and many local advisors.

Membership also seems to be affected by the global economic climate and the financial health of the geoscience community. This hypothesis is supported by the roughly similar trends between IAMG and AAPG shown on the graph. The main difference between the two associations is smoothness of the AAPG curve which comes with 50 times larger membership. The frequent ups and downs of IAMG are due, in part, to one year, one time memberships entered by local geologists at the annual meetings, and now free 1 year memberships for authors of IAMG journal articles.



Interesting is also the regional shift in membership from 2007 to 2012 (graph 2). The number of US members has gone down from 31% to 21%, and in real terms as well. Europe has about the same number of members but lost in the percentage of the pie because of the overall increase.

What can we do to sustain the growth of IAMG membership? In my view there are two areas: keep promoting student membership and chapters at various universities - students are our future full members! And focus on countries that are underrepresented, such as China was in the past. India might be a good candidate, especially with the IAMG2014 planned for New Delhi.

Harald S. Poelchau

The mission of the IAMG is to promote, worldwide, the advancement of mathematics, statistics and informatics in the Geosciences

International Association for Mathematical Geosciences

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PRESIDENT'S FORUM

The time for the 34th IGC is near, and with it the end of my term as President of IAMG. It was not an easy time, mainly due to the world-wide financial crisis, but also due to personal health problems. Thanks to the great support and good work of all members of the Executive of IAMG, of the Council, of all those who keep the Association running as editors of our journals, the newsletter, the web, as members of the committees, as active participants in all IAMG activities, we have not been seriously hurt by the crisis, and the Association continues running smoothly.

All presidents have tried to leave behind a better Association than they received. I am particularly proud of having started the promotion of mathematical modelling in the geosciences by establishing the Curriculum Quality Committee under the direction of Dr. **Maria-Theresia Schafmeister**. I still consider this initiative a project in the making and hope that future IAMG administrations see the merit of it to continue and advance the program. The idea is to assure that short courses and curricula sponsored by IAMG have a homogeneous, guaranteed minimum level that attracts interested scientists.

I share the opinion that IAMG affairs continue to become more complex and demanding. Ten years ago, the burden on the treasurer reached a limit beyond what was expected to be taken by a volunteer treasurer. The solution was to contract the services of an office support provider. As the reader may know, this office was in Canada and was not exclusively dedicated to IAMG; it serviced several other organizations. By 2010, the 2008–12 Council reached the conclusion that with the deterioration in the service it was not worth renewing the contract. We took the big step of considering having our own office. The solution was to hire **Regina van den Boogaart**. Although she is in Freiberg, Germany, the official address of IAMG is in Houston. Conventional mail comes to a box that we opened there, and the address doesn't have to be changed when a new secretary general comes into office. Regina is doing an excellent job, our association is getting more and more professional and the number of members is now 720, a clearly significant increase from 630 in 2008 (see graph on page 1).

Another significant move to make the administration of IAMG more efficient and less demanding on the members of the Executive Committee (President, Executive Vice-President, Secretary General and Treasurer) has been completion of restructuring of the Council. Recent amendments approved by electronic balloting intend primarily to decentralize the daily decision making and administrative work by offering the president a better supporting team to which to delegate responsibilities. If the General Assembly at the 34th IGC approves the amendments, in the future the president will be allowed to appoint the secretary general and two ordinary vice-presidents. As a transition, vice-presidents in the 2012–16 Council have been elected by the members.

Trying to better coordinate and support IAMG conferences, Council approved the creation of a meetings committee, something hard to believe that IAMG has not had in the more than 40 years of its existence. Fulfilling the expectations, this committee has provided good guidance to organizers of meetings in the past three years and to the Council in accepting demands of support. In addition, the committee was instrumental in accepting bids and seek approval for the IAMG conference that the current Council was responsible to organize. The Spanish Geological Survey (IGME) will host IAMG2013 in Madrid on September 2-6, 2013. The Jawaharlal Nehru University, New Delhi, India will hold IAMG2014 on October 17-20, 2014. Considering that the 35th IGC will take place in Cape Town, South Africa in July/August 2016, and the 34th IGC takes place this year in Brisbane, Australia, IAMG members have the chance to visit four continents in four years. Note that site selection for IAMG2015 will not take place until next year. Any volunteers from the Americas?

On the more routine side of business, our publications continue in good standing although we have to keep an eye on them. With collapse of interest rates, royalties from our publications are more than ever our main source of true income. We depend on them, because on the income from royalties we build our policy concerning student support through the Student Affairs Committee, and our support to our annual meetings. Both are essential to promote our mission and to guarantee the continuity of our activities, including that of our publications. The Editors-in-Chief of our journals continue doing hard work: Dr. **Roussos Dimitrakopoulos** for Mathematical Geosciences, with an ISI impact factor for 2010 of 1.511; and Dr. **Jef Caers** for Computers & Geosciences, with a 5-year impact factor of 1.632. With the appointment by the Council of Dr. **Michael Piasecki** as co-editor of Computers & Geosciences we hope the huge amount of work due to the many submissions will be handled efficiently. While I write these lines we are looking for a new Editor-in-Chief for Natural Resources Research, as Dr. **Keith Long** had to step down suddenly for health reasons. We all wish him a good and quick recovery!

The Student Affairs Committee continues to be a great asset to the Association by inviting new generations to become active in quantitative modelling in the earth sciences. In his eighth year as committee chair, **Helmut Schaeben** continues to be the same enthusiastic driving force. It was quite fitting to hear that he will be the next recipient of our John Cedric Griffiths Teaching Award. Currently there are seven active IAMG student chapters in six countries.

Despite the hard economic times, the Association has been able to keep active the Distinguished Lecture series. **Jack Schuenemeyer** is the current lecturer. At the 34th IGC in August, in addition of Dr. **Helmut Schaeben**, we will have the chance to meet the 2012 William Christian Krumbein Medallist, Dr. **Eric Grunsky**. I want to acknowledge the good work of our Awards Committee and of all our members who sent in nominations. I am proud to announce a new Honorary Member, Dr. **Jean Serra**. The Matheron Lecturer for 2012 is Dr. **Jean-Paul Chilès** and the 2013 Distinguished Lecturer has yet to be decided. My congratulations to all of them for this deserved recognition for their scientific, professional and personal achievements.

The most important step at the end of a term is the election of a new Council and Executive. I am really proud that the election process could be performed through electronic voting without problems, and that the participation reached a height of 48%. The newly elected board can look upon a solid support for their mandate. My thanks to all those who participated, to Dr. **Dan Tetzlaff** and **Regina van den Boogaart** for setting up and taking care of the voting process, to all those who accepted to be candidates, and my best wishes for a good term to the new board.

Vera Pawlowsky-Glahn

Association Business

Election Results

The election closed on March 31, 2012. We received a total of 309 ballots (48% of the membership). One ballot was mailed, 24 were e-mailed, the majority of votes were cast electronically through the website.

The complete results can be found at www.iamgmembers.org/Election-2012-result.php

The amendment to Statutes articles 10 and 11 passed by 81% of the votes.

Results are subject to ratification by the IAMG General Assembly that will meet on Tuesday August 7th, 2012, at 7 PM, at the International Geological Congress in Brisbane, Australia. If approved the voting members of the new Council will be:

President:
Qiuming Cheng
(Canada, China)

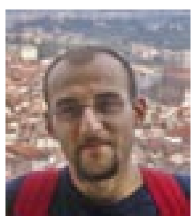
Executive Vice President:
Jennifer McKinley (UK)

Treasurer:
David Collins (USA)

Vice Presidents:

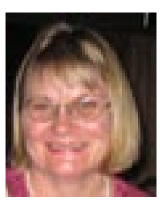
Secretary General:
Frits Agterberg
(Canada)

Julián M. Ortiz
(Chile)



Raimon Tolosana-Delgado
(Spain)

Past President:
Vera Pawlowsky-Glahn
(Spain)



IGC Councilor:
Christien Thiart
(South Africa)

Ordinary Councilors:

Guillaume Caumon
(France)

Yongqing Chen
(China)

June Hill
(Australia)

Gang Liu
(China)

Jean Serra elected IAMG Honorary Member

The IAMG Council has elected **Jean Serra** to be an Honorary Member of the International Association for Mathematical Geosciences. Honorary Life Membership recognizes exceptional work in the field of Mathematical Geosciences on behalf of IAMG that is beyond normal expectations, or outstanding donation to the IAMG of time, skill, or financial resources.

Jean Serra obtained the degree of Mining Engineer, in 1962 in Nancy, France, and in 1967 his PhD for work dealing with the estimation of the iron ore body of Lorraine by geostatistics. In cooperation with Georges Matheron, he laid the foundations of a new method, that he called Mathematical Morphology (1964). Its purpose was to describe quantitatively shapes and textures of natural phenomena, at micro and macro scales. In 1967, he founded with G. Matheron, the Centre de Morphologie Mathématique, at School of Mines of Paris, (campus of Fontainebleau), that he led for twenty years as a "Directeur de Récherches". He retired in 2005 and is currently Professor Emeritus at ESIEE. His main book is a two-volume treatise entitled "Image Analysis and Mathematical Morphology" (Ac. Press, 1982, 1988). He has been Vice President for Europe of the International Society for Stereology from 1979 to 1983. He founded the International Society for Mathematical Morphology in 1993, and was elected his first president. His achievements include several patents of devices for image processing, various awards and titles, such as the first AFCET award, in 1988, or the Doctor Honoris Causa of the Autonomous University of Barcelona (Spain) in 1993. In 2006 he was elected member of the Royal Academy of Sciences of Uppsala, Sweden. He recently developed a new theory of segmentation, which is based on set connections (2001-2004), and worked on colour image processing. He is currently developing stochastic models for random spreads, such as forest fires (2005-2006). In 2006 Serra was chosen to be the first lecturer of the newly established IAMG Matheron Lecture Series.

Laudatio for Olena Babak: 2011 Vistelius Award

The Andrei Borisovich Vistelius Research Award is given to a young scientist for promising contributions in research in the application of mathematics in the earth sciences. The recipient should be 35 years or less at the end of the calendar year for which she has been selected for the award. Let me introduce Dr. **Olena Babak** as this year's worthy recipient of the Vistelius award. Olena has indeed made many promising contributions of mathematics to the geosciences and is a young 29 years old. She is extremely qualified and the IAMG Awards Committee has chosen well.

There are few awards for those involved in interdisciplinary research in mathematical geosciences. The coveted Vistelius award is granted every two years and Olena is only the twenty-third recipient. The standards for the Vistelius Award are high;; it takes more than academic credentials, citizenship, hard work, research contributions and an impact on practical applications to merit the Vistelius award. Olena has these and more.

Regarding academic credentials, Olena has a B.Sc. in Mathematics in 2003 and an M.Sc. in Statistics in 2004 from Ivan Franko National University of Lviv, Ukraine. She has a B.Sc. in Mathematics in 2003 and an M.Sc. in industrial engineering in 2005 from the University of Iceland. Finally, she earned a Ph.D. in geostatistics from the University of Alberta in 2008. She received top grades and many awards during her studies – including an IAMG student grant.

Regarding citizenship, Olena is not selfish with her time. She is pleased to answer questions and help colleagues achieve their potential. The last time I met Olena was six weeks ago when she travelled to the University from a different city to contribute to a program that encourages young women to pursue careers in science, engineering and technology. It turns out she has been involved in this program since she was a student and continues her involvement. She has been involved in many forms

of student enrichment from her undergraduate days. Olena is not a one dimensional person focused on her own research.

Regarding hard work, Olena demonstrates an industriousness and dedication to her profession that is impressive and humbling. She manages a demanding career, a young family and continues to take classes. She has two final exams next month for university classes that will contribute to her becoming registered as a professional engineer and geoscientist in Alberta. Moreover, while completing her Ph.D. in Edmonton she taught undergraduate classes in statistics at the University and at an affiliated college. She is not intimidated by the effort required to achieve her goals.

Regarding research contributions, Olena has undertaken a variety of research projects and started publishing in peer-reviewed journals as an undergraduate student. This is certainly the most important aspect of Olena related to the Vistelius award. She has published widely in many journals including IAMG's prestigious journals. Olena's contributions to research are varied, but are mostly aimed at solving difficult geostatistical problems. She brings a depth and breadth of mathematical sophistication to real problems and develops solutions with mathematical rigor and practicality. She has modified the well known kriging equations at a fundamental level, has solved challenges of variance bias in cokriging, has developed multivariate tests and has worked on improved geological modeling of categorical and continuous variables.

Regarding an impact on practical applications, the developments of Olena have been integrated in the best practices of many companies – not just her current employer. Improved geological models have resulted from her research results and improved decisions have been made. The influence of her research will continue to grow as her prolific research results are disseminated.

It takes more than academic credentials, citizenship, hard work, research contributions and an impact on practical applications to merit the Vistelius award. Olena has what it takes. It takes a passion for mathematics and the geosciences. It takes sparks of creativity that can bring together disparate concepts and techniques to solve practical geological modeling problems with flair and skill. It takes dedication and commitment to see the research results through to publication and application. It takes the strength of youth to believe that everything is possible. Congratulations to Olena Babak for the Vistelius Award in 2011.

Clayton V. Deutsch, September 2011

2012 William Christian Krumbein Medal: Eric Grunsky

The Krumbein Medal is the highest award given by the Association and is awarded to senior scientists for career achievement, which includes distinction in application of mathematics or informatics in the earth sciences, service to the IAMG, and support to professions involved in the earth sciences.

Eric Grunsky is a graduate of the University of Toronto (B.Sc., 1973; M.Sc., 1978) and the University of Ottawa (Ph.D., 1988). Eric has been using combined optical and multi-angle radar remotely sensed imagery to refine surface materials mapping as part of the Remote Predictive Mapping Project for mapping Canada's north. As a contributor to the Metals in the Environment Program (MITE), he is evaluating geochemical data from till deposits as part of a program to determine background levels of specific elements in materials with which humans interact. Eric has been working on the development of a statistically based classification scheme of kimberlitic rocks based on geochemistry that distinguishes diamond-bearing from non-diamond-bearing phases. Eric is also using multi-beam radar satellite imagery as a tool to characterize the terrain of the Oak Ridges Moraine and the Mackenzie River Delta. Eric was the recipient of the 2005 Felix Chayes Award for Excellence in Research in Mathematical Petrology. He was IAMG Webmaster for many years and until recently Editor in Chief of *Computers & Geosciences*.

Laudatio for István Dunkl: 2011 Felix Chayes Prize

I am very pleased that **István Dunkl** has received the Felix Chayes Prize for Excellence in Research in Mathematical Petrology.

We met in June 2006, when I moved to take a post-doc position at the Department of Sedimentology and Environmental Geology of the Göttingen University, where he worked. Since the very first moment, I was surprised by his wish to learn from anyone crossing his path. We all ought to have kept the curiosity and enthusiasm of an 8-year old child: he did.

He is not a member of IAMG, never attended one of our conferences, and has seldom published in our journals (I guess, that might have something to do with a bad experience with Computers and Geosciences). He is what I would call, a "self-unaware mathematical geologist", as I am going to briefly explain.

Directly linked to the heritage of Chayes, he works in developing several quantitative techniques for petrographic studies:

- mostly, geochronology (the topic of his talk),
- but also the development of geothermometers,
- multi-mineral indices,
- fission track techniques,
- unstable isotopy, and many more.

I have seen him involved in the scientific process from the field campaign (in Europe, in Oman, in the Tibetan Plateau) to the geological interpretation of results, passing through the lab (he manages his own ICP-MS facility in Göttingen) and the statistical inner subtleties of the methods.

He also regularly publishes software tailored to particular lab tasks, with deep and flexible statistical applications, made simple and transparent for the non-statistician.

As I said, he is barely aware of how important his quantitative work is, maybe because he is active in the geochronology community, where such abilities are not so uncommon as in the faculties of geology taken as a whole. However, his fine awareness of the many pitfalls and traps lying on the road of lab data error propagation and data interpretation make him an outstanding, cautious scientist, never stretching the conclusions his data sets can deliver. And that is a rare quality nowadays.

Finally, he has taught and is also teaching his vast knowledge on nuclear physics, statistical error propagation, geochemistry, geochronology, quantitative tectonics and petrography to 2 generations of geologists from all over Europe, who get the chance to enjoy his dynamic lessons. They get the knowledge, but they also get to learn some critical thinking and that healthy skepticism makes a good scientist

For these reasons, the IAMG is honored to recognize him with the Chayes Prize.

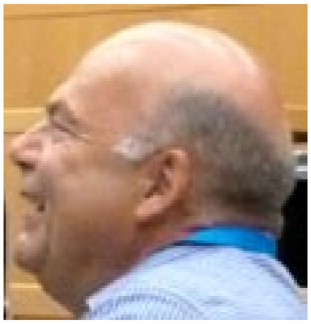
Raimon Tolosana-Delgado, September 2011

2012 Matheron Lecturer: Jean-Paul Chilès

The Matheron Lecture Committee has selected Dr. **Jean-Paul Chilès** to present the Matheron Lecture at the IGC in Brisbane in August of this year.

After spending 22 years as senior research scientist with the Bureau de Recherches Géologiques et Minières (the French Geological Survey) in Orléans (France), Jean-Paul Chilès joined the Centre de Géosciences of Mines Paris (Fontainebleau) to become assistant director of the centre, responsible for the geostatistics team. He is coauthor with Pierre Delfiner of "Geostatistics - Modeling Spatial Uncertainty", Wiley, 1999.

2012 John Cedric Griffiths Teaching Award: Helmut Schaeben



The John Cedric Griffiths Teaching Award is presented to honor outstanding teaching, especially for teaching that involves application of mathematics or informatics to the Earth's nonrenewable natural resources or to sedimentary geology.

Prof. Dr. **Helmut Schaeben** is a mathematician trained in analysis and stochastics. He received his diploma in mathematics in 1976, his Ph.D. in science in 1981, and his habilitation with a "venia legendi" for "Mathematical models for the geological and material sciences" in 1993 from the department of Geosciences of RWTH Aachen University of Technology (Germany) under Prof. Heinrich Siemes. He has been working with geo- and material scientists for more than 25 years.

After working on groundwater flow models he pursued texture analysis with Rudy Wenk at UC Berkeley (1982-84). At Bonn University, Germany (1984-89), he was involved in the DFG priority programme on "digital geoscience map compilation" with computer aided geometric modeling of geologic surfaces and solids. At Metz University in France (1989-93), he worked on texture analysis. Since 1996 he holds the chair of "Geoscience Mathematics and Informatics" at Freiberg University of Mining and Technology (Germany).

His favorite topics are: 1) mathematics of the analysis of crystallographic preferred orientation measured by X-ray, neutron, synchrotron or electron diffraction, 2) generalization of two-dimensional geographic information systems to spatio-temporal geoscience information systems including the development of data models and data structures for geoscience data.

He has been involved in cooperative projects with the universities of Metz, Nancy (France), Basel (Switzerland), Hanoi (Vietnam), the International Centre for Diffraction Data, USA, and the Joint Institute of Nuclear Research, Dubna (Russia).

Helmut Schaeben has been chair of IAMG's student affairs committee for 8 years. He is also on the editorial board of Mathematical Geosciences (since 2007). He is a member of „Deutsche Geowissenschaftliche Gesellschaft" and head of its special interest group „Geoscience Informatics", and a member of SIAM and its special interest group "Geosciences".

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Member News

John Harbaugh reports:

Given that I'm essentially retired from active involvement in academic affairs, whatever I may have to contribute to the Newsletter is mostly historical. In this context, I should mention that I have nearly completed my memoirs. While they could be viewed as a catch-all account of an 85-year lifespan, of possible relevance here is that they detail the "*Geomathematics Program*" that flourished at Stanford for more than 35 years and involved nearly 75 participants, including graduate students, post-doctorals, and visitors from more than a dozen countries.

Student Affairs

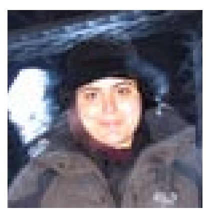
Five Student Grants Awarded

IAMG provides financial support to students in graduate school or post-doctoral positions for research in the fields of mathematical geology, geomathematics, and geoinformatics. Individual Grant amounts may vary and are set by the Student Affairs Committee for each individual case, considering merit of the application and financial need. Guidelines for applications can be found on the website iamg.org under Student Affairs.

Arivazhagan Sundaram, Periyar University, Salem, India, Ph.D.
"Hyperspectral Remote Sensing Study of Sittampundi Anorthosite Complex, India".
Advisor: Prof. S. Anbazhagan

Rebekka Steffen,
University of Calgary, Canada
Diplom (Master's Equivalent)
"Incorporation of faults and lateral density-changes in the crust in glacial- isostatic-adjustment models". Advisors: Patrick Wu (University of Calgary), David W. Eaton (University of Calgary), Björn Lund (Uppsala University)

Zheenbek Kulenbekov, TU BA Freiberg, Germany, BSc/MSc in Physics
"Effect of Radionuclides from Uranium Tailing Dumps on Water System of Lake Issyk-Kul (Kyrgyzstan)". Advisor: Prof. Dr. Broder J. Merkel, TU BA Freiberg, Germany



Sara Attarchi, TU BA Freiberg, Germany, Master of Science Project "Biodiversity and AGB in Loveh forest by remote sensing". Advisor: Dr. Richard Gloaguen, TU BA Freiberg, Germany.

Danial Kaviani, University of Calgary, Canada, Ph.D.
"Interwell connectivity evaluation from well rate fluctuations: a waterflooding management tool".
Advisor: Dr. Jerry Jensen, University of Calgary, Canada

Of the 22 complete applications, 12 were submitted by students at universities where IAMG student chapters are or were active: Sun Yat-sen (1), Twente (1), Stanford (2), Wuhan (2), Freiberg (6).

Applications came from Iran (1), Netherlands (1), India (2: 1 institution), USA (2: 1 institution), Canada (3: 1 institution), China (3: 2 institutions), Pakistan (3: 2 institutions), Germany (7: 2 institutions).

All 5 awardees are members of IAMG, 2 of them are members of the student chapter Freiberg.

Three awardees are PhD students, 2 hold a PhD already and are post docs or "other".

Two grants go to applicants at Calgary University, Canada, 2 to TU Bergakademie Freiberg, Germany, 1 to Periyar University Salem, India.

The subjects of awarded projects are remote sensing (2), water system/ water system management (2), geology (1).

Helmut Schaeben
Chair, Student Affairs Committee

Conference Reports

Wuhan Symposium

The IAMG members from Sun Yat-Sen University took part in the nationalwide mathematical geology meeting.

The tenth Nationwide Mathematical Geology and Geo-Information Academic Symposium was held at the China University of Geosciences in Wuhan from November 25th to November 27th. There were about 170 people attending this meeting from all over the country, including the Chinese Academy of Science, Sun Yat-Sen university, China University of Geosciences, Jilin University and others. Professor **Zhou Yongzhang**, associate professor **Wang Zhenghai**, associate professor **Hou Weisheng**, doctoral student **Zhang Yan** and master's student **Gao Le**, the IAMG members of Sun Yat-Sen university participated in this important meeting, and delivered significant reports in terms of different fields and angles.

The theme of the meeting was Mathematical Geology, Geo-Information and Geologic Environment Evaluation and Disaster Prevention. Many experts and scholars discussed the topics above, such as mineral resources analysis and research, the prediction method of Geological Disasters, GIS and RS Technology, new theories of quantitative geology, nonlinear geology and three-dimensional geological modeling. In addition, some lectures about how to deal with resource scarcity and environment disaster also drew our attention. New achievements of Chinese mathematical geology and Geo-Information were reviewed during the congress. We hope that mathematical geology will have more such contributions in the field of geology.

Gao Le
Sun Yat-Sen University

Chinese National Conference on Integrated Prediction of Mineral Resources in Covered Areas and Geoinformatics

The Chinese National Conference on Integrated Prediction of Mineral Resources in Covered Areas and Geoinformatics (IPMRG) was held successfully in Beijing on December 16-18, 2011. It was chaired by **Qiuming Cheng** and jointly hosted by the State Key Laboratory of Geological Processes and Mineral Resources at China University Geosciences (CUGB, CUG), the Division of Resource Evaluation of China Geological Survey (CGS), IAMG and IAMG-CN. More than 350 experts, scholars and students from nearly 50 units attended this conference which had 14 sessions, 137 oral presentations and 31 poster presentations.

The conference invited six plenary lectures including "Predictive geochemistry in areas of transported overburden mechanisms of anomaly formation" by **Ravi Anand** from Australia; "Modeling gas hydrate resources a statistician's perspective" by John H **(Jack) Schuenemeyer** from US, "Advance of Deep Exploration in China" by **Dong Shuwen** from China Academy of Geological Sciences, "Multifractals and Geostatistics" by **Frits Agterberg** from Canada, "The technical combination of electromagnetic explorations and application examples on important ore deposit types" by **Liu Jianming** from Chinese Academy of Sciences, and "Geochemical exploration through overburden cover" by **Wang Xueqiu** from Institute of Aerogeophysical and Geochemical Survey of China Academy of Geological Sciences. These topics opened various new visions of the research on the mineral resources in covered areas.

In the Workshops for Chinese Program of Integrated Prediction of Mineral Resources in Covered Areas, Qiuming Cheng, the PL of the major program, had updated on the progress of the national program.

79 students from different universities and colleges including 15 members of the IAMG student chapter at CUG and 2 members at SYSU took part in this conference. IAMG Student chapters also organized an exchange activity, which attracted lots of students. Students not only gave oral and poster presentations in several sessions of the conference but also volunteered at the conference, including providing registration for IAMG membership. Some new teachers and students had registered on site to become IAMG members.

Zhijun Chen
Secretary-General,
IAMG-CN

IAMG at AGU 2011

The International Association for Mathematical Geosciences has a tradition of running an exhibition booth at the American Geophysical Union (AGU) Fall Meeting held at the Moscone Convention Center in San Francisco, and December 2011 was no exception. The AGU Fall meeting has long been the worldwide largest meeting in the Earth Sciences, and visitor numbers for the first time exceded 20,000 last December. As soon as I opened the IAMG booth on Tuesday morning (the opening of the exhibits is Tuesday, talks start Monday), colleagues gathered at the booth to talk about projects, exchange news and talk about this and that. The meeting was extremely busy, not only because of the sheer numbers of attendees, but also because of the large number of groups of scientists and disciplines, and because bringing some people to the booth attracts more people to the booth, which creates a certain momentum. Since we have run the booth for several years, we have a great standing with the AGU exhibition organization, which gives our booth an excellent spot on the exhibit floor (for the discounted Academic Showcase rate). This gave us excellent traffic, and we gained more new members than any previous year. Especially younger scientists joined this year. Existing members also like to stop by and talk or renew their membership. While membership is a valuable aspect of the IAMG exhibit, visibility at the AGU meeting may be considered the biggest asset for IAMG. Many people stop by to get information about our journals, as publication is naturally a significant part of any scientist's existence, and subsequently submit papers to IAMG journals. It is vital for IAMG that the Earth Science community notices what IAMG does and has to offer to geophysicists. The AGU Fall Meeting is considered an international meeting by attendees from all over the planet, and one that is not to be missed.

At the booth, IAMG displays our three journals, Mathematical Geosciences, Computers & Geosciences and Natural Resources Research, the newsletter, information on IAMG and any new books or materials members wish to have presented. The AGU meting is also an opportunity to renew our face-to-face relationships with the journal publishers. Much of the publication process is now online, so it is always good to see the people who are behind the scenes. — At our IAMG booth, small chocolates are typically offered – this is a welcome treat to most conference attendees and motivates even overcommitted meeting attendees to stop by for a brief chat and look at our journals. Thanks are due to **Helmut Mayer** for helping with booth setup and dedicating much of his time at the meeting to the IAMG exhibition. This entails hauling the booth materials via truck from Boulder, Colorado, in the middle of winter and carrying booth, furniture and carpeting through the streets of San Francisco to keep the costs for IAMG at bay. — The booth was organized by **Ute Herzfeld**, Research Professor at the Department of Electrical, Computer and Energy Engineering at the University of Colorado Boulder and Senior Research Scientist at CIRES. Only regrets: Our own students could not go to the meeting, because it happened the week before finals!

Ute C. Herzfeld

Upcoming Meetings

GI-Forum 2012: Linking Geovisualization, Society & Learning, Salzburg, Austria, **3 - 6 July 2012**. Contact: office@gi-forum.org; www.gi-forum.org

2012 JOINT STATISTICAL MEETINGS, San Diego, California, **28 July - 2 August 2012.** www.amstat.org/meetings/jsm/2012/

34TH INTERNATIONAL GEOLOGICAL CONGRESS (**IGC**), Brisbane Australia, **5-10 August 2012**. www.34igc.org. Includes IAMG symposia and General Assembly (see www.iamg.org).

ROCK DEFORMATION. Gordon Research Conference. Andover, NH, USA, **19 - 24 Aug. 2012**. fax: 401-783-7644, www.grc.org/programs.aspx?year=2012&program=rockdef

The 32nd International GEOGRAPHICAL Congress, Cologne, Germany, **26 - 30 August 2012**. Theme "Down to Earth". http://www.igc2012.org/

Mathematical Methods in Fluid Dynamics and Simulation of Giant Oil and Gas Reservoirs, Istanbul, Turkey, **3 - 5 Sept. 2012**. www.spe.org/events/lsrs/2012/

ECMOR (European Conference on the Mathematics of Oil Recovery), Biarritz, France, **10-13 Sept. 2012**. www.eage.org/?evp=4430

geoENV2012 - IX Conference on Geostatistics for Environmental Applications, Valencia, Spain, 19-21 September 2012. geoenv2012.upv.es. This conference will also be webcast, but will be limited to 100 internet participants.

International Conference of the GV & SEDIMENT 2012: Of Land and Sea: Processes and Products, Hamburg, Germany, **23 - 28 September 2012**. www.gv-hamburg2012.de

3rd International Conference on Fault and Top Seals, EAGE, Montpellier, France, **1 – 3 October 2012**. www.eage.org/events/

IAG/AIG International Workshop on Objective Geomorphological Representation Models: Breaking through a new geomorphological mapping frontier, Salerno, Italy, **15 - 19 October 2012**. www.geomorph.org/wg/arch/Salerno2012_1circ.pdf

GSA Geological Society of America Annual Meeting "GEOSCIENCES: Investing in the Future", Charlotte, North Carolina, USA, **4 - 7 November 2012**. www.geosociety.org/meetings/2012/

SEG Society of Exploration Geophysicists: Annual Meeting, Las Vegas, Nevada, **4 – 9 Nov 2012**. www.seg.org/events/annual-meeting/

International Symposium on EARTHQUAKE-INDUCED LANDSLIDES (ISEL), Kiryu, Japan, **7 - 9 November 2012**. geotech.ce.gunma-u.ac.jp/~isel/

AGU–American Geophysical Union's 45th annual Fall Meeting, San Francisco, California, **3–7 December 2012**. http://fallmeeting.agu.org/2012/

GEOSYNTHETICS 2013. IFAI. Long Beach, CA, USA, **1 - 4 April 2013**. + 1-651-225-6981, www.geosynthetics2013.com/Technical_program.cfm

AAPG 2013 Annual Convention & Exhibition: Pittsburgh, PA, USA, **19 - 22 May 2013**. www.aapg.org/meetings

75th EAGE Annual Conference & Exhibition incorporating SPE Europec 2013, London, UK, **10 - 13 June 2013**. www.eage.org/events/index.php?eventid=755&Opendivs=s3

SIAM Conference on the Mathematical and Computational Issues in the Geosciences (GS13), Centro Congressi Padova, Padova, Italy, **17-20 June 2013**. www.siam.org/meetings/gs13/

IAMG 2013 Annual Conference, Madrid, Spain, **2 - 6 September 2013.** www.igme.es/internet/iamg2013/

2013 JOINT STATISTICAL MEETINGS, Montreal, Canada, **3-8 August2013**. www.amstat.org/meetings/

59th ISI World Statistics Congress, Hong Kong, S.A.R. China, **25-30 August 2013**. ISI Permanent Office, P.O. Box 24070, 2490 AB The Hague, The Netherlands. Phone: +31–70–3375737, Fax: +31–70–3860025, E-mail: isi @cbs.nl, www.isi2013.hk. Will include invited IAMG session on Prob. & weights of evidence.

GSA Annual Meeting - Celebrating 125th Anniversary, Denver, Colorado, **27 – 30 Oct. 2013.** www.geosociety.org/meetings/2012/

IAMG 2014 Annual Conference, Jawaharlal Nehru University, New Delhi, India. **17-20 October 2014**

34th International Geological Congress

5-10 August 2012, Brisbane, Australia

IAMG will be sponsoring a symposium on Mathematical Geosciences at the 34th IGC. Symposium 5.6 is part of the Information Geoscience Super-symposium (Theme 5). The symposium will cover approximately 3 days of talks and posters. We have over 70 talks, including 18 keynote talks, and approximately 30 posters. There will also be presentations by the recipients of the Krumbein Medal and Griffiths Award, **Eric Grunsky** and **Helmut Schaeben**; and there will be the Matheron Lecture by **Jean-Paul Chilès**. Mathematical Geoscience sessions will cover the following topics:

- Data Analysis in the Geosciences
- Success stories in geocomplexity: Non-linear processes, networks and patterns in geosciences
- Geostatistics for Modelling Complex Geological Systems
- Soft Computing and Intelligent Methods in Mathematical Geology
- Stochastic characterisation of rock masses
- Crystallographic Preferred Orientation and Anisotropy of Rocks
- Geomathematics, Geoinformatics and Remote Sensing
- Quantitative mineral resources estimation
- Geoscience information synthesis for mineral prospectivity mapping
- Numerical modelling of basins and petroleum system modelling
- New Theories and Methods in Resources Exploration

There are also a wide variety of presentations by IAMG members in other symposia in Theme 5 and in other Themes in the congress. For more information please see the program on the IGC website (www.34igc.org) or follow the links on the IAMG home page www.iamg.org (link: IAMG List of Papers in Symposium 5.6).

June Hill
IGC Councillor

IAMG 2015 - (in the Americas ???)

Call for Proposal

to organize the

IAMG 2015 ANNUAL CONFERENCE

The Association is looking for entrepreneurial and enthusiastic individuals or organizations willing to organize the seventeenth IAMG conference during the Summer or Fall of 2015. Guidelines regulating the IAMG conferences are posted at

http://iamg.org/index.php/publisher/articleview/frmArticleID/43

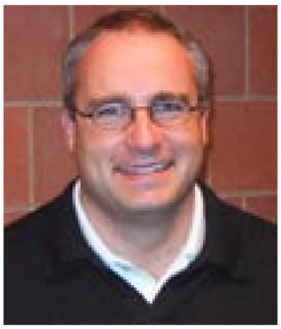
If you have any questions about the system of IAMG conferences or the preparation of the proposal, please do not hesitate to contact the Chair of the Meetings Committee or the IAMG President at president@iamg.org

The deadline for submitting the proposals to the Meetings Committee is **February 15, 2013**.

IAMG Journal Report

Michael Piasecki new co-editor of Computers & Geosciences

At the request of **Jef Caers**, Editor-in-Chief of Computers & Geosciences, Katherine Eve of Elsevier has now agreed to a co-editorship for the journal. The candidate proposed by Jef, **Michael Piasecki**, currently an Associate Editor, will look after the geo-informatics side of papers submitted to C&G. The IAMG Council voted in January that Dr. Piasecki be appointed as Co-editor-in-Chief of C&G starting in July 2012.



Michael Piasecki, who is Associate Professor, Civil & Environmental Engineering has an impressive resume:

Education:

Ph.D. – 1994 University of Michigan, Ann Arbor, MI, Civil Engineering

Diplom – 1991 University of Hannover, Germany, Civil Engineering

Experience:

2011 – present, Assoc. Prof., City College New York, Department of Civil & Environmental Engineering

2004 – 2010, Assoc. Prof. Drexel University Department of Civil, Architectural & Environmental Engineering

1998 – 2004, Assist. Prof. Drexel University Department of Civil, Architectural & Environmental Engineering

1996 – 1998, Assist. Prof. American University of Beirut, Department of Civil Engineering, Beirut, Lebanon

1994 – 1996, Post-Doctoral Fellow, University of Michigan Department of Civil & Environmental Engineering

1991 – 1994, Graduate Assistant, University of Michigan Department of Civil & Environmental Engineering

Research Interests

HydroInformatics: data management and semantic representation of hydrologic knowledge

HydroInformatics: deployment of sensor networks and data streaming from sensor to storage

HydroInformatics: using workflow engines for modeling of hydrologic processes and data curation

Department of Civil Engineering
Faculty, CUNY Environmental Crossroads Initiative
The City College of New York
160 Convent Avenue, NY 10031
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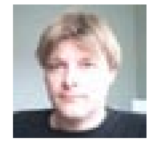
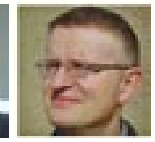
Phone: 212 650 8321
Fax: 212 650 6965
email: mpiasecki [at] ccny.cuny.edu

Best Paper Awards: Computers & Geosciences

In order to fill the gaps left for the last 3 years, the Best Paper Awards Committee under the guidance of Chair **Jef Caers** put in an extra effort to select the winners for the years 2008-2010. Paper selection is performed using the following three criteria: Innovation, Computational complexity, Exposition and Impact. The authors will receive a free 1 year subscription to the journal and a one year free membership in IAMG.

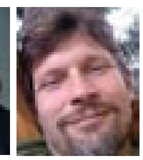
2008 - **Thomas M. Hansen** and **Klaus Mosegaard** (Niels Bohr Institute, København, Denmark): "VISIM: Sequential simulation for linear inverse problems"

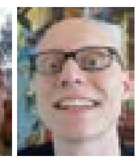




2009 - **Morton J. Canty** (Institute for Chemistry and Dynamics of the Geosphere, Jülich Research Center, Germany): "Boosting a fast neural network for supervised land cover classification"

2010 - **Hans-Jörg Vogel**, **Ulrich Weller** and **Steffen Schlüter** (UFZ—Helmholtz Center for Environmental Research, Halle, Germany): "Quantification of soil structure based on Minkowski functions"





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Editor in Chief of Natural Resources Research

Unfortunately, **Keith Long**, current Editor-in-Chief of NRR, had to resign because of a serious health problem. This means of course that we must find a replacement as soon as possible. Keith was doing an excellent job. We wish him a complete and speedy recovery.

In the meantime, **Jerry Jensen**, former EiC of NRR, has agreed to step in as acting EiC for a maximum of 6 months (finishing the 2012 issues), while a replacement EiC is found.

Graeme Bonham-Carter and the Publications Committee are now searching for candidates and will publish the following advertisement:

Editor-in-Chief, Natural Resources Research

Natural Resources Research (NRR) is a journal published by Springer and sponsored by the International Association for Mathematical Geosciences (IAMG). Currently, the journal has 4 issues per year, and is now in its 21st year of publication. Information about the journal, including the membership of the editorial board, can be seen at the IAMG web page (www.iamg.org) under Publications, or on the Springer page (http://www.springer.com/earth+sciences+and+geography/geology/journal/11053).

Applications for this position should be sent to Dr Graeme Bonham-Carter (Graeme.bc1@gmail.com), Chair, Publications Committee (IAMG) including a CV and list of publications.

Current Journal Statistics

Mathematical Geosciences:

ISI-impact factor for 2010: 1.511

approx. ave. daily downloads March-May: 80

Rejection rate: 55%

Turnaround time: 75 days (average; submission to first review)

Computers & Geosciences:

2010 Impact Factor: 1.416

5-Year Impact Factor: 1.632

Natural Resources Research:

approx. ave. daily downloads March-May: 200

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A Modified Weights-of-Evidence Method for Regional Mineral Resource Estimation — Frits Agterberg

Descriptive and Predictive Growth Curves in Energy System Analysis — Mikael Höök, Junchen Li, Noriaki Oba and Simon Snowden

Goodnews Bay Platinum Resource Estimation Using Least Squares Support Vector Regression with Selection of Input Space Dimension and Hyperparameters — Snehamoy Chatterjee and Sukumar Bandopadhyay

Choosing Between Two Kind of Sampling Patterns Using Geostatistical Simulation: Regularly Spaced or at High Uncertainty Locations? — Vanessa Cerqueira Koppe, João Felipe Coimbra Leite Costa, Rodrigo de Lemos Peroni and Jair Carlos Koppe

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Mineral Prospectivity Prediction from High-Dimensional Geoscientific Data Using a Similarity-Based Density Estimation Model — Andrew A. Skabar

Statistical Analyses of La, Ce, Nd, Y, Nb, Ti, P, and Zr in Bedrocks and Their Significance in Geochemical Exploration at the Um Garayat Gold Mine Area, Eastern Desert, Egypt — Ahmed M. El-Makky

Geochemical Fingerprinting of Coltan Ores by Machine Learning on Uneven Datasets — Christian Savu-Krohn, Gerd Rantitsch, Peter Auer, Frank Melcher and Torsten Graupner

Environmental Flow Requirements in Tungabhadra River, Karnataka, India — B. K. Harish Kumara and S. Srikantaswamy

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Determination of Realistic and Statistical Value of the Information Gathered from Exploratory Drilling — Saeed Soltani and Ardeshir Hezarkhani

Haynesville Shale Well Performance and Development Potential — Mark J. Kaiser and Yunke Yu

Geological Modeling of Gold Deposit Based on Grade Domaining Using Plurigaussian Simulation Technique — Tayfun Y. Yunsel and Adem Ersoy

Combining AHP with GIS for Predictive Cu Porphyry Potential Mapping: A Case Study in Ahar Area (NW, Iran) — Kaveh Pazand, Ardeshir Hezarkhani, Mohammad Ataei and Yousef Ghanbari

Graphical Planning Envelopes for Estimating the Surface Footprint of CO2 Plumes during CO2 Injection into Saline Aquifers — Christopher J. Brown

Unconventional Energy Resources: 2011 Review — American Association of Petroleum Geologists

An Analysis of the Published Mineral Resource Estimates of the Haji-Gak Iron Deposit, Afghanistan — David M. Sutphin, Karine M. Renaud and Lawrence J. Drew

Petrochemical and Mineralogical Constraints on the Source and Processes of Uranium Mineralisation in the Granitoids of Zing-Monkin Area, Adamawa Massif, NE Nigeria — I. V. Haruna, D. M. Orazulike, A. B. Ofulume and Y. D. Mamman

Discrimination Analysis of Earthquakes and Man-Made Events Using ARMA Coefficients Determination by Artificial Neural Networks — Mostafa Allameh Zadeh

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Mineralogical and Thermoluminescence Characterizations of the River Sediments from Tamilnadu, India — G. Suresh, V. Ramasamy and V. Ponnusamy

Comment on "A Conditional Dependence Adjusted Weights of Evidence Model" by Minfeng Deng in Natural Resources Research 18(2009), 249–258 — Helmut Schaeben and K. Gerald van den Boogaart

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Growth Rates of Global Energy Systems and Future Outlooks — Mikael Höök, Junchen Li, Kersti Johansson and Simon Snowden

Peak Minerals: Theoretical Foundations and Practical Application — Daniel May, Timothy Prior, Dana Cordell and Damien Giurco

Hydrochemical Characteristics and Sodification of Groundwater in the Shirin Sou, Hamedan, Western Iran — Mohsen Jalali

Pyrolysis of Municipal Solid Waste for Syngas Production by Microwave Irradiation — Vidyadhar V. Gedam and Iyyaswami Regupathi

Tee-SVX: Enhanced Oil Flow Rate in Solvent Vapor Extraction Process — Fanhua Zeng, Kelvin D. Knorr and Xinfeng Jia

Stream Sediments Geochemical Exploration in the Northwestern Part of Wadi Allaqi Area, South Eastern Desert, Egypt — Ahmed M. El-Makky and Kadry N. Sediek

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How We Lose Ground When Earth Scientists Become Territorial: Defining "Soil" — Matthys A. Dippenaar

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Role of Stranded Gas from Central Asia and Russia in Meeting Europe's Future Import Demand for Gas — Emil D. Attanasi and Philip A. Freeman

Implementation of the Iterative Proportion Fitting Algorithm for Geostatistical Facies Modeling — Yupeng Li and Clayton V. Deutsch

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A Severance Tax Revenue Forecast Model for Louisiana — Mark J. Kaiser and Yunke Yu

Aluminum Consumption and Economic Growth: Evidence from Rich Countries — Vishal Chandr Jaunky

Evaluation of Syenite as Feldspar Source: Piranshahr Pluton, NW of Iran — S. A. Mazhari, B. Hajalilou and F. Bea

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Validation Techniques for Geological Patterns Simulations Based on Variogram and Multiple-Point Statistics — S. De Iaco and S. Maggio

BOOK REVIEW V. Pisarenko and M. Rodkin: Heavy-Tailed Distributions in Disaster Analysis, Springer, New York, 2010. ISBN 978-90-481-9170-3 — Joan L. Latchman

ASSOCIATION ANNOUNCEMENT Dr. Lawrence Drew - International Association for Mathematical Geosciences Krumbein Medalist 2010

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Approximate Derivative Computations for the Gradient-Based Optimization Methods in the Local Gradual Deformation for History Matching — Didier Yu Ding

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A Simple Floc-Growth Function for Natural Flocs in Estuaries — Daniel Mikes

BOOK REVIEW Roger S. Bivand, Edzer J. Pebesma, Virgilio Gomez-Rubio: Applied Spatial Data Analysis with R, Springer, New York, 2008. 378 pp. ISBN 978-0-387-78170-9 — Didier Renard

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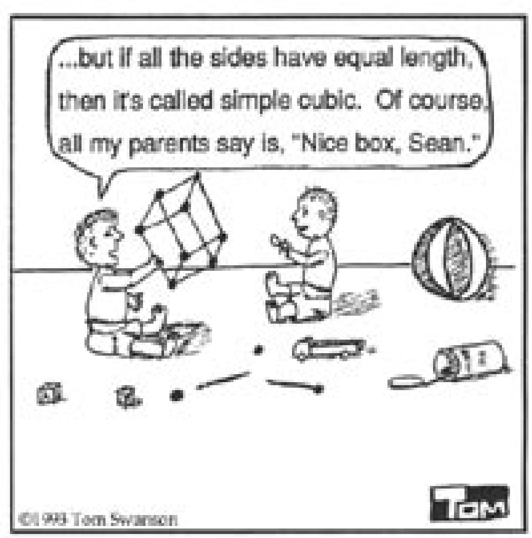


New Books

Mathematical Geoscience

Series: Interdisciplinary Applied Mathematics, Vol. 36

Andrew Fowler (MACSI Dept. of Mathematics & Statistics, Univ. of Limerick)

1st Edition., 2011, XIX, 883 p. 211 illus., 6 in color.

ISBN 978-0-85729-699-3 Springer $89.95

Mathematical Geoscience is an expository textbook which aims to provide a comprehensive overview of a number of different subjects within the Earth and environmental sciences. Uniquely, it treats its subjects from the perspective of mathematical modelling with a level of sophistication that is appropriate to their proper investigation.

This book introduces a whole range of important geoscientific topics in one single volume and serves as an entry point for a rapidly expanding area of genuine interdisciplinary research. By addressing the interplay between mathematics and the real world, this book will appeal to graduate students, lecturers and researchers in the fields of applied mathematics, the environmental sciences and engineering.

Spherical Functions of Mathematical Geosciences

A Scalar, Vectorial, and Tensorial Setup

Series: Advances in Geophysical and Environmental Mechanics and Mathematics

Willi Freeden, Michael Schreiner (University of Kaiserslautern)

2009, XVI, 602 p. 82 illus., 5 in color.

ISBN 978-3-540-85111-0 Springer $109.00

This book collects all material developed by the Geomathematics Group, TU Kaiserslautern, during the few last years to set up a theory of spherical functions of mathematical (geo-)physics. First shown is the natural transition from the scalar to the vectorial and tensorial theory of spherical harmonics given in coordinate-free representation. Second, the canonical transition from spherical harmonics via zonal (kernel) functions to the Dirac kernel is presented in close orientation to an uncertainty principle classifying the space/frequency behavior for purposes of constructive approximation and data analysis. Modeling and simulating phenomena and processes of the Earth system.

Compositional Data Analysis Theory and Applications

1. Edition - September 2011
€83.90
400 Pages, Hardcover
ISBN-10: 0-470-71135-3
ISBN-13: 978-0-470-71135-4 - John Wiley & Sons

Vera Pawlowsky-Glahn, University of Girona, Spain (editor)

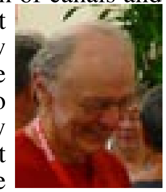
Antonella Buccianti, University of Florence, Italy (editor)

It is difficult to imagine that the statistical analysis of compositional data has been a major issue of concern for more than 100 years. It is even more difficult to realize that so many statisticians and users of statistics are unaware of the particular problems affecting compositional data, as well as their solutions.

This book presents the state-of-the-art in compositional data analysis and features a collection of papers covering theory, applications to various fields of science and software. Areas covered range from geology to biology, environmental sciences, forensic sciences, medicine and hydrology.

Distinguished Lecture Tour Report

I have just returned from 12 very busy days in The Netherlands and Germany as part of my IAMG Distinguished Lecturer tour. In The Netherlands my first presentation was on shale gas modeling to geoscientists at TNO, a Dutch company involved in energy and innovation. TNO is located in Utrecht, a beautiful town of canals and history, located 30 miles east of Amsterdam. My next talk was at ITC, an international graduate school, now a part of the University of Twente in Enschede, The Netherlands. Next I returned to Amsterdam for a trip to Dresden to spend a day with old friends who graciously drove us to Freiberg. There I taught a three-day short course on R with earth science applications to 15 graduate students from 12 different countries at the University of Freiberg. It is always enjoyable to see new sights but the real benefit of being an IAMG Distinguished Lecturer is the opportunity to talk to graduate students from all over the world. My IAMG student chapter host at ITC was **Sanaz Salati** and at Freiberg it was **Veraldo Liesenberg**. Both were wonderfully efficient, thoughtful and a joy to be with. I came away with a new appreciation of the importance of student chapters and I hope that all members of IAMG will give their strong support to foster them.



Jack Schuenemeyer

IAMG-CN website updated

We are happy to announce that we revised the website of the Topical Section of the International Association of Mathematical Geosciences for Chinese members (IAMG-CN), www.iamg.org.cn which is a non-profit academic organization by the overseas Chinese IAMG members established in June 2009 under the IAMG. IAMG-CN enjoys promoting Chinese national mathematical geosciences revitalization and prosperity in the challenging environment.

IAMG-CN website is combining most versatile features with flexible layout to design a state-of-the-art multimedia site through a series of new promotions. It has bilingual navigation and a clear site map which describes the hierarchy and offers richer columns as following: about, membership, news, meetings, eduction, contact. The logo of IAMG-CN is also redesigned so as to be easy to remember and prominent by the fusion of IAMG logo elements, Chinese culture element and sense of times.

You are welcome to visit our website. If you spot any issues with the website, or have suggestions, we would appreciate if you could let us know. Help is appreciated as always!

Zhijun Chen
Secretary-General
IAMG-CN

Rereading Materials (from 52 years ago)

The Unreasonable Effectiveness of Mathematics in the Natural Sciences

by Eugene Wigner

Mathematics, rightly viewed, possesses not only truth, but supreme beauty, a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than Man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry. --Bertrand Russell, Study of Mathematics

THERE IS A story about two friends, who were classmates in high school, talking about their jobs. One of them became a statistician and was working on population trends. He showed a reprint to his former classmate. The reprint started, as usual, with the Gaussian distribution and the statistician explained to his former classmate the meaning of the symbols for the actual population, for the average population, and so on. His classmate was a bit incredulous and was not quite sure whether the statistician was pulling his leg. "How can you know that?" was his query. "And what is this symbol here?" "Oh," said the statistician, "this is pi." "What is that?" "The ratio of the circumference of the circle to its diameter." "Well, now you are pushing your joke too far," said the classmate, "surely the population has nothing to do with the circumference of the circle."

Naturally, we are inclined to smile about the simplicity of the classmate's approach. Nevertheless, when I heard this story, I had to admit to an eerie feeling because, surely, the reaction of the classmate betrayed only plain common sense. I was even more confused when, not many days later, someone came to me and expressed his bewilderment [1] with the fact that we make a rather narrow selection when choosing the data on which we test our theories. "How do we know that, if we made a theory which focuses its attention on phenomena we disregard and disregards some of the phenomena now commanding our attention, that we could not build another theory which has little in common with the present one but which, nevertheless, explains just as many phenomena as the present theory?" It has to be admitted that we have no definite evidence that there is no such theory.

The preceding two stories illustrate the two main points which are the subjects of the present discourse. The first point is that mathematical concepts turn up in entirely unexpected connections. Moreover, they often permit an unexpectedly close and accurate description of the phenomena in these connections. Secondly, just because of this circumstance, and because we do not understand the reasons of their usefulness, we cannot know whether a theory formulated in terms of mathematical concepts is uniquely appropriate. We are in a position similar to that of a man who was provided with a bunch of keys and who, having to open several doors in succession, always hit on the right key on the first or second trial. He became skeptical concerning the uniqueness of the coordination between keys and doors.

Most of what will be said on these questions will not be new; it has probably occurred to most scientists in one form or another. My principal aim is to illuminate it from several sides. The first point is that the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it. Second, it is just this uncanny usefulness of mathematical concepts that raises the question of the uniqueness of our physical theories. In order to establish the first point, that mathematics plays an unreasonably important role in physics, it will be useful to say a few words on the question, "What is mathematics?", then, "What is physics?", then, how mathematics enters physical theories, and last, why the success of mathematics in its role in physics appears so baffling. Much less will be said on the second point: the uniqueness of the theories of physics. A proper answer to this question would require elaborate experimental and theoretical work which has not been undertaken to date.

WHAT IS MATHEMATICS?

Somebody once said that philosophy is the misuse of a terminology which was invented just for this purpose.[2] In the same vein, I would say that mathematics is the science of skillful operations with concepts and rules invented just for this purpose. The principal emphasis is on the invention of concepts. Mathematics would soon run out of interesting theorems if these had to be formulated in terms of the concepts which already appear in the axioms. Furthermore, whereas it is unquestionably true that the concepts of elementary mathematics and particularly elementary geometry were formulated to describe entities which are directly suggested by the actual world, the same does not seem to be true of the more advanced concepts, in particular the concepts which play such an important role in physics. Thus, the rules for operations with pairs of numbers are obviously designed to give the same results as the operations with fractions which we first learned without reference to "pairs of numbers." The rules for the operations with sequences, that is, with irrational numbers, still belong to the category of rules which were determined so as to reproduce rules for the operations with quantities which were already known to us. Most more advanced mathematical concepts, such as complex numbers, algebras, linear operators, Borel sets (and this list could be continued almost indefinitely) were so devised that they are apt subjects on which the mathematician can demonstrate his ingenuity and sense of formal beauty. In fact, the definition of these concepts, with a realization that interesting and ingenious considerations could be applied to them, is the first demonstration of the ingeniousness of the mathematician who defines them. The depth of thought which goes into the formulation of the mathematical concepts is later justified by the skill with which these concepts are used. The great mathematician fully, almost ruthlessly, exploits the domain of permissible reasoning and skirts the impermissible. That his recklessness does not lead him into a morass of contradictions is a miracle in itself: certainly it is hard to believe that our reasoning power was brought, by Darwin's process of natural selection, to the perfection which it seems to possess. However, this is not our present subject. The principal point which will have to be recalled later is that the mathematician could formulate only a handful of interesting theorems without defining concepts beyond those contained in the axioms and that the concepts outside those contained in the axioms are defined with a view of permitting ingenious logical operations which appeal to our aesthetic sense both as operations and also in their results of great generality and simplicity. [3] The complex numbers provide a particularly striking example for the foregoing. Certainly, nothing in our experience suggests the introduction of these quantities. Indeed, if a mathematician is asked to justify his interest in complex numbers, he will point, with some indignation, to the many beautiful theorems in the theory of equations, of power series, and of analytic functions in general, which owe their origin to the introduction of complex numbers. The mathematician is not willing to give up his interest in these most beautiful accomplishments of his genius. [4]

WHAT IS PHYSICS?

The physicist is interested in discovering the laws of inanimate nature. In order to understand this statement, it is necessary to analyze the concept, "law of nature."

The world around us is of baffling complexity and the most obvious fact about it is that we cannot predict the future. Although the joke attributes only to the optimist the view that the future is uncertain, the optimist is right in this case: the future is unpredictable. It is, as Schrodinger has remarked, a miracle that in spite of the baffling complexity of the world, certain regularities in the events could be discovered. One such regularity, discovered by Galileo, is that two rocks, dropped at the same time from the same height, reach the ground at the same time. The laws of nature are concerned with such regularities. Galileo's regularity is a prototype of a large class of regularities. It is a surprising regularity for three reasons.

The first reason that it is surprising is that it is true not only in Pisa, and in Galileo's time, it is true everywhere on the Earth, was always true, and will always be true. This property of the regularity is a recognized invariance property and, as I had occasion to point out some time ago, without invariance principles similar to those implied in the preceding generalization of Galileo's observation, physics would not be possible. The second surprising feature is that the regularity which we are discussing is independent of so many conditions which could have an effect on it. It is valid no matter whether it rains or not, whether the experiment is carried out in a room or from the Leaning Tower, no matter whether the person who drops the rocks is a man or a woman. It is valid even if the two rocks are dropped, simultaneously and from the same height, by two different people. There are, obviously, innumerable other conditions which are all immaterial from the point of view of the validity of Galileo's regularity. The irrelevancy of so many circumstances which could play a role in the phenomenon observed has also been called an invariance. However, this invariance is of a different character from the preceding one since it cannot be formulated as a general principle. The exploration of the conditions which do, and which do not, influence a phenomenon is part of the early experimental exploration of a field. It is the skill and ingenuity of the experimenter which show him phenomena which depend on a relatively narrow set of relatively easily realizable and reproducible conditions.[5] In the present case, Galileo's restriction of his observations to relatively heavy bodies was the most important step in this regard. Again, it is true that if there were no phenomena which are independent of all but a manageably small set of conditions, physics would be impossible.

The preceding two points, though highly significant from the point of view of the philosopher, are not the ones which surprised Galileo most, nor do they contain a specific law of nature. The law of nature is contained in the statement that the length of time which it takes for a heavy object to fall from a given height is independent of the size, material, and shape of the body which drops. In the framework of Newton's second "law," this amounts to the statement that the gravitational force which acts on the falling body is proportional to its mass but independent of the size, material, and shape of the body which falls.

The preceding discussion is intended to remind us, first, that it is not at all natural that "laws of nature" exist, much less that man is able to discover them.[6] The present writer had occasion, some time ago, to call attention to the succession of layers of "laws of nature," each layer containing more general and more encompassing laws than the previous one and its discovery constituting a deeper penetration into the structure of the universe than the layers recognized before. However, the point which is most significant in the present context is that all these laws of nature contain, in even their remotest consequences, only a small part of our knowledge of the inanimate world. All the laws of nature are conditional statements which permit a prediction of some future events on the basis of the knowledge of the present, except that some aspects of the present state of the world, in practice the overwhelming majority of the determinants of the present state of the world, are irrelevant from the point of view of the prediction. The irrelevancy is meant in the sense of the second point in the discussion of Galileo's theorem.[7] As regards the present state of the world, such as the existence of the earth on which we live and on which Galileo's experiments were performed, the existence of the sun and of all our surroundings, the laws of nature are entirely silent. It is in consonance with this, first, that the laws of nature can be used to predict future events only under exceptional circumstances when all the relevant determinants of the present state of the world are known. It is also in consonance with this that the construction of machines, the functioning of which he can foresee, constitutes the most spectacular accomplishment of the physicist. In these machines, the physicist creates a situation in which all the relevant coordinates are known so that the behavior of the machine can be predicted. Radars and nuclear reactors are examples of such machines.

The principal purpose of the preceding discussion is to point out that the laws of nature are all conditional statements and they relate only to a very small part of our knowledge of the world. Thus, classical mechanics, which is the best known prototype of a physical theory, gives the second derivatives of the positional coordinates of all bodies, on the basis of the knowledge of the positions, etc., of these bodies. It gives no information on the existence, the present positions, or velocities of these bodies. It should be mentioned, for the sake of accuracy, that we discovered about thirty years ago that even the conditional statements cannot be entirely precise: that the conditional statements are probability laws which enable us only to place intelligent bets on future properties of the inanimate world, based on the knowledge of the present state. They do not allow us to make categorical statements, not even categorical statements conditional on the present state of the world. The probabilistic nature of the "laws of nature" manifests itself in the case of machines also, and can be verified, at least in the case of nuclear reactors, if one runs them at very low power. However, the additional limitation of the scope of the laws of nature which follows from their probabilistic nature will play no role in the rest of the discussion.

THE ROLE OF MATHEMATICS IN PHYSICAL THEORIES

Having refreshed our minds as to the essence of mathematics and physics, we should be in a better position to review the role of mathematics in physical theories.

Naturally, we do use mathematics in everyday physics to evaluate the results of the laws of nature, to apply the conditional statements to the particular conditions which happen to prevail or happen to interest us. In order that this be possible, the laws of nature must already be formulated in mathematical language. However, the role of evaluating the consequences of already established theories is not the most important role of mathematics in physics. Mathematics, or, rather, applied mathematics, is not so much the master of the situation in this function: it is merely serving as a tool.

Mathematics does play, however, also a more sovereign role in physics. This was already implied in the statement, made when discussing the role of applied mathematics, that the laws of nature must have been formulated in the language of mathematics to be an object for the use of applied mathematics. The statement that the laws of nature are written in the language of mathematics was properly made three hundred years ago;[8] it is now more true than ever before. In order to show the importance which mathematical concepts possess in the formulation of the laws of physics, let us recall, as an example, the axioms of quantum mechanics as formulated, explicitly, by the great physicist, Dirac. There are two basic concepts in quantum mechanics: states and observables. The states are vectors in Hilbert space, the observables self-adjoint operators on these vectors. The possible values of the observations are the characteristic values of the operators, but we had better stop here lest we engage in a listing of the mathematical concepts developed in the theory of linear operators.

It is true, of course, that physics chooses certain mathematical concepts for the formulation of the laws of nature, and surely only a fraction of all mathematical concepts is used in physics. It is true also that the concepts which were chosen were not selected arbitrarily from a listing of mathematical terms but were developed, in many if not most cases, independently by the physicist and recognized then as having been conceived before by the mathematician. It is not true, however, as is so often stated, that this had to happen because mathematics uses the simplest possible concepts and these were bound to occur in any formalism. As we saw before, the concepts of mathematics are not chosen for their conceptual simplicity, even sequences of pairs of numbers are far from being the simplest concepts, but for their amenability to clever manipulations and to striking, brilliant arguments. Let us not forget that the Hilbert space of quantum mechanics is the complex Hilbert space, with a Hermitean scalar product. Surely to the unpreoccupied mind, complex numbers are far from natural or simple and they cannot be suggested by physical observations. Furthermore, the use of complex numbers is in this case not a calculational trick of applied mathematics but comes close to being a necessity in the formulation of the laws of quantum mechanics. Finally, it now begins to appear that not only complex numbers but so-called analytic functions are destined to play a decisive role in the formulation of quantum theory. I am referring to the rapidly developing theory of dispersion relations.

It is difficult to avoid the impression that a miracle confronts us here, quite comparable in its striking nature to the miracle that the human mind can string a thousand arguments together without getting itself into contradictions, or to the two miracles of the existence of laws of nature and of the human mind's capacity to divine them. The observation which comes closest to an explanation for the mathematical concepts' cropping up in physics which I know is Einstein's statement that the only physical theories which we are willing to accept are the beautiful ones. It stands to argue that the concepts of mathematics, which invite the exercise of so much wit, have the quality of beauty. However, Einstein's observation can at best explain properties of theories which we are willing to believe and has no reference to the intrinsic accuracy of the theory. We shall, therefore, turn to this latter question.

IS THE SUCCESS OF PHYSICAL THEORIES TRULY SURPRISING?

A possible explanation of the physicist's use of mathematics to formulate his laws of nature is that he is a somewhat irresponsible person. As a result, when he finds a connection between two quantities which resembles a connection well-known from mathematics, he will jump at the conclusion that the connection is that discussed in mathematics simply because he does not know of any other similar connection. It is not the intention of the present discussion to refute the charge that the physicist is a somewhat irresponsible person. Perhaps he is. However, it is important to point out that the mathematical formulation of the physicist's often crude experience leads in an uncanny number of cases to an amazingly accurate description of a large class of phenomena. This shows that the mathematical language has more to commend it than being the only language which we can speak; it shows that it is, in a very real sense, the correct language. Let us consider a few examples.

The first example is the oft-quoted one of planetary motion. The laws of falling bodies became rather well established as a result of experiments carried out principally in Italy. These experiments could not be very accurate in the sense in which we understand accuracy today partly because of the effect of air resistance and partly because of the impossibility, at that time, to measure short time intervals. Nevertheless, it is not surprising that, as a result of their studies, the Italian natural scientists acquired a familiarity with the ways in which objects travel through the atmosphere. It was Newton who then brought the law of freely falling objects into relation with the motion of the moon, noted that the parabola of the thrown rock's path on the earth and the circle of the moon's path in the sky are particular cases of the same mathematical object of an ellipse, and postulated the universal law of gravitation on the basis of a single, and at that time very approximate, numerical coincidence. Philosophically, the law of gravitation as formulated by Newton was repugnant to his time and to himself. Empirically, it was based on very scanty observations. The mathematical language in which it was formulated contained the concept of a second derivative and those of us who have tried to draw an osculating circle to a curve know that the second derivative is not a very immediate concept. The law of gravity which Newton reluctantly established and which he could verify with an accuracy of about 4% has proved to be accurate to less than a ten thousandth of a per cent and became so closely associated with the idea of absolute accuracy that only recently did physicists become again bold enough to inquire into the limitations of its accuracy.[9] Certainly, the example of Newton's law, quoted over and over again, must be mentioned first as a monumental example of a law, formulated in terms which appear simple to the mathematician, which has proved accurate beyond all reasonable expectations. Let us just recapitulate our thesis on this example: first, the law, particularly since a second derivative appears in it, is simple only to the mathematician, not to common sense or to non-mathematically-minded freshmen; second, it is a conditional law of very limited scope. It explains nothing about the earth which attracts Galileo's rocks, or about the circular form of the moon's orbit, or about the planets of the sun. The explanation of these initial conditions is left to the geologist and the astronomer, and they have a hard time with them.

The second example is that of ordinary, elementary quantum mechanics. This originated when Max Born noticed that some rules of computation, given by Heisenberg, were formally identical with the rules of computation with matrices, established a long time before by mathematicians. Born, Jordan, and Heisenberg then proposed to replace by matrices the position and momentum variables of the equations of classical mechanics. They applied the rules of matrix mechanics to a few highly idealized problems and the results were quite satisfactory. However, there was, at that time, no rational evidence that their matrix mechanics would prove correct under more realistic conditions. Indeed, they say "if the mechanics as here proposed should already be correct in its essential traits." As a matter of fact, the first application of their mechanics to a realistic problem, that of the hydrogen atom, was given several months later, by Pauli. This application gave results in agreement with experience. This was satisfactory but still understandable because Heisenberg's rules of calculation were abstracted from problems which included the old theory of the hydrogen atom. The miracle occurred only when matrix mechanics, or a mathematically equivalent theory, was applied to problems for which Heisenberg's calculating rules were meaningless. Heisenberg's rules presupposed that the classical equations of motion had solutions with certain periodicity properties; and the equations of motion of the two electrons of the helium atom, or of the even greater number of electrons of heavier atoms, simply do not have these properties, so that Heisenberg's rules cannot be applied to these cases. Nevertheless, the calculation of the lowest energy level of helium, as carried out a few months ago by Kinoshita at Cornell and by Bazley at the Bureau of Standards, agrees with the experimental data within the accuracy of the observations, which is one part in ten million. Surely in this case we "got something out" of the equations that we did not put in.

The same is true of the qualitative characteristics of the "complex spectra," that is, the spectra of heavier atoms. I wish to recall a conversation with Jordan, who told me, when the qualitative features of the spectra were derived, that a disagreement of the rules derived from quantum mechanical theory and the rules established by empirical research would have provided the last opportunity to make a change in the framework of matrix mechanics. In other words, Jordan felt that we would have been, at least temporarily, helpless had an unexpected disagreement occurred in the theory of the helium atom. This was, at that time, developed by Kellner and by Hilleraas. The mathematical formalism was too dear and unchangeable so that, had the miracle of helium which was mentioned before not occurred, a true crisis would have arisen. Surely, physics would have overcome that crisis in one way or another. It is true, on the other hand, that physics as we know it today would not be possible without a constant recurrence of miracles similar to the one of the helium atom, which is perhaps the most striking miracle that has occurred in the course of the development of elementary quantum mechanics, but by far not the only one. In fact, the number of analogous miracles is limited, in our view, only by our willingness to go after more similar ones. Quantum mechanics had, nevertheless, many almost equally striking successes which gave us the firm conviction that it is, what we call, correct.

The last example is that of quantum electrodynamics, or the theory of the Lamb shift. Whereas Newton's theory of gravitation still had obvious connections with experience, experience entered the formulation of matrix mechanics only in the refined or sublimated form of Heisenberg's prescriptions. The quantum theory of the Lamb shift, as conceived by Bethe and established by Schwinger, is a purely mathematical theory and the only direct contribution of experiment was to show the existence of a measurable effect. The agreement with calculation is better than one part in a thousand.

The preceding three examples, which could be multiplied almost indefinitely, should illustrate the appropriateness and accuracy of the mathematical formulation of the laws of nature in terms of concepts chosen for their manipulability, the "laws of nature" being of almost fantastic accuracy but of strictly limited scope. I propose to refer to the observation which these examples illustrate as the empirical law of epistemology. Together with the laws of invariance of physical theories, it is an indispensable foundation of these theories. Without the laws of invariance the physical theories could have been given no foundation of fact; if the empirical law of epistemology were not correct, we would lack the encouragement and reassurance which are emotional necessities, without which the "laws of nature" could not have been successfully explored. Dr. R. G. Sachs, with whom I discussed the empirical law of epistemology, called it an article of faith of the theoretical physicist, and it is surely that. However, what he called our article of faith can be well supported by actual examples, many examples in addition to the three which have been mentioned.

THE UNIQUENESS OF THE THEORIES OF PHYSICS

The empirical nature of the preceding observation seems to me to be self-evident. It surely is not a "necessity of thought" and it should not be necessary, in order to prove this, to point to the fact that it applies only to a very small part of our knowledge of the inanimate world. It is absurd to believe that the existence of mathematically simple expressions for the second derivative of the position is self-evident, when no similar expressions for the position itself or for the velocity exist. It is therefore surprising how readily the wonderful gift contained in the empirical law of epistemology was taken for granted. The ability of the human mind to form a string of 1000 conclusions and still remain "right," which was mentioned before, is a similar gift.

Every empirical law has the disquieting quality that one does not know its limitations. We have seen that there are regularities in the events in the world around us which can be formulated in terms of mathematical concepts with an uncanny accuracy. There are, on the other hand, aspects of the world concerning which we do not believe in the existence of any accurate regularities. We call these initial conditions. The question which presents itself is whether the different regularities, that is, the various laws of nature which will be discovered, will fuse into a single consistent unit, or at least asymptotically approach such a fusion. Alternatively, it is possible that there always will be some laws of nature which have nothing in common with each other. At present, this is true, for instance, of the laws of heredity and of physics. It is even possible that some of the laws of nature will be in conflict with each other in their implications, but each convincing enough in its own domain so that we may not be willing to abandon any of them. We may resign ourselves to such a state of affairs or our interest in clearing up the conflict between the various theories may fade out. We may lose interest in the "ultimate truth," that is, in a picture which is a consistent fusion into a single unit of the little pictures, formed on the various aspects of nature.

It may be useful to illustrate the alternatives by an example. We now have, in physics, two theories of great power and interest: the theory of quantum phenomena and the theory of relativity. These two theories have their roots in mutually exclusive groups of phenomena. Relativity theory applies to macroscopic bodies, such as stars. The event of coincidence, that is, in ultimate analysis of collision, is the primitive event in the theory of relativity and defines a point in space-time, or at least would define a point if the colliding panicles were infinitely small. Quantum theory has its roots in the microscopic world and, from its point of view, the event of coincidence, or of collision, even if it takes place between particles of no spatial extent, is not primitive and not at all sharply isolated in space-time. The two theories operate with different mathematical concepts, the four dimensional Riemann space and the infinite dimensional Hilbert space, respectively. So far, the two theories could not be united, that is, no mathematical formulation exists to which both of these theories are approximations. All physicists believe that a union of the two theories is inherently possible and that we shall find it. Nevertheless, it is possible also to imagine that no union of the two theories can be found. This example illustrates the two possibilities, of union and of conflict, mentioned before, both of which are conceivable.

In order to obtain an indication as to which alternative to expect ultimately, we can pretend to be a little more ignorant than we are and place ourselves at a lower level of knowledge than we actually possess. If we can find a fusion of our theories on this lower level of intelligence, we can confidently expect that we will find a fusion of our theories also at our real level of intelligence. On the other hand, if we would arrive at mutually contradictory theories at a somewhat lower level of knowledge, the possibility of the permanence of conflicting theories cannot be excluded for ourselves either. The level of knowledge and ingenuity is a continuous variable and it is unlikely that a relatively small variation of this continuous variable changes the attainable picture of the world from inconsistent to consistent.[10] Considered from this point of view, the fact that some of the theories which we know to be false give such amazingly accurate results is an adverse factor. Had we somewhat less knowledge, the group of phenomena which these "false" theories explain would appear to us to be large enough to "prove" these theories. However, these theories are considered to be "false" by us just for the reason that they are, in ultimate analysis, incompatible with more encompassing pictures and, if sufficiently many such false theories are discovered, they are bound to prove also to be in conflict with each other. Similarly, it is possible that the theories, which we consider to be "proved" by a number of numerical agreements which appears to be large enough for us, are false because they are in conflict with a possible more encompassing theory which is beyond our means of discovery. If this were true, we would have to expect conflicts between our theories as soon as their number grows beyond a certain point and as soon as they cover a sufficiently large number of groups of phenomena. In contrast to the article of faith of the theoretical physicist mentioned before, this is the nightmare of the theorist.

Let us consider a few examples of "false" theories which give, in view of their falseness, alarmingly accurate descriptions of groups of phenomena. With some goodwill, one can dismiss some of the evidence which these examples provide. The success of Bohr's early and pioneering ideas on the atom was always a rather narrow one and the same applies to Ptolemy's epicycles. Our present vantage point gives an accurate description of all phenomena which these more primitive theories can describe. The same is not true any longer of the so-called free-electron theory, which gives a marvelously accurate picture of many, if not most, properties of metals, semiconductors, and insulators. In particular, it explains the fact, never properly understood on the basis of the "real theory," that insulators show a specific resistance to electricity which may be 1026 times greater than that of metals. In fact, there is no experimental evidence to show that the resistance is not infinite under the conditions under which the free-electron theory would lead us to expect an infinite resistance. Nevertheless, we are convinced that the free-electron theory is a crude approximation which should be replaced, in the description of all phenomena concerning solids, by a more accurate picture.

If viewed from our real vantage point, the situation presented by the free-electron theory is irritating but is not likely to forebode any inconsistencies which are unsurmountable for us. The free-electron theory raises doubts as to how much we should trust numerical agreement between theory and experiment as evidence for the correctness of the theory. We are used to such doubts.

A much more difficult and confusing situation would arise if we could, some day, establish a theory of the phenomena of consciousness, or of biology, which would be as coherent and convincing as our present theories of the inanimate world. Mendel's laws of inheritance and the subsequent work on genes may well form the beginning of such a theory as far as biology is concerned. Furthermore, it is quite possible that an abstract argument can be found which shows that there is a conflict between such a theory and the accepted principles of physics. The argument could be of such abstract nature that it might not be possible to resolve the conflict, in favor of one or of the other theory, by an experiment. Such a situation would put a heavy strain on our faith in our theories and on our belief in the reality of the concepts which we form. It would give us a deep sense of frustration in our search for what I called "the ultimate truth." The reason that such a situation is conceivable is that, fundamentally, we do not know why our theories work so well. Hence, their accuracy may not prove their truth and consistency. Indeed, it is this writer's belief that something rather akin to the situation which was described above exists if the present laws of heredity and of physics are confronted.

Let me end on a more cheerful note. The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning.

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1 F. Werner when he was a student in Princeton.

2 W. Dubislav's Die Philosophie der Mathematik in der Gegenwart (Berlin: Junker and Dunnhaupt Verlag, 1932), p. 1.

3 M. Polanyi, in his Personal Knowledge (Chicago: University of Chicago Press, 1958), says: "All these difficulties are but consequences of our refusal to see that mathematics cannot be defined without acknowledging its most obvious feature: namely, that it is interesting" (p 188).

4 The reader may be interested, in this connection, in Hilbert's rather testy remarks about intuitionism which "seeks to break up and to disfigure mathematics," Abh. Math. Sem., Univ. Hamburg, 157 (1922), or Gesammelte Werke (Berlin: Springer, 1935), p. 188.

5 See, in this connection, the graphic essay of M. Deutsch, Daedalus 87, 86 (1958). A. Shimony has called my attention to a similar passage in C. S. Peirce's Essays in the Philosophy of Science (New York: The Liberal Arts Press, 1957), p. 237.

6 E. Schrodinger, in his What Is Life? (Cambridge: Cambridge University Press, 1945), p. 31, says that this second miracle may well be beyond human understanding.

7 The writer feels sure that it is unnecessary to mention that Galileo's theorem, as given in the text, does not exhaust the content of Galileo's observations in connection with the laws of freely falling bodies.

8 It is attributed to Galileo.

9 See, for instance, R. H. Dicke, Am. Sci., 25 (1959).

10 This passage was written after a great deal of hesitation. The writer is convinced that it is useful, in epistemological discussions, to abandon the idealization that the level of human intelligence has a singular position on an absolute scale. In some cases it may even be useful to consider the attainment which is possible at the level of the intelligence of some other species. However, the writer also realizes that his thinking along the lines indicated in the text was too brief and not subject to sufficient critical appraisal to be reliable.

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IAMG 2013 15th CONFERENCE MADRID — Mathematics of Planet Earth 2013

ANNOUNCEMENT


Well for groundwater research. 1001 meters deep. Alcalá de Henares, Madrid (Spain). 1927-1928. Detail of stained glass in the Instituto Geológico y Minero

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May 1, 2013:	Revised extended abstracts returned to authors
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