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INSTITUTE FOR MATHEMATICAL SCIENCES
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Tenth Anniversary of Institute for Mathematical Sciences >>>

IMS Director Louis Chen greets NUS President TAN Chorh Chuan

Smiling guests on a happy occasion

Great oaks from little acorns grow. – English proverb

On 24 June 2010, the Institute for Mathematical Sciences (IMS) celebrated its 10th anniversary in one full-day event with formal speeches, musical performance, video presentation and invited lectures, culminating in an informal appreciation dinner.

The day's celebration began at 9.30 am in the Institute's auditorium with a welcome speech by the Director, Louis Chen who, in his usual concise way, reminded the audience of the origin, mission and modus operandi of the Institute. His somewhat unemotional and methodical expression of appreciation belied the agony and joy that he must have gone through in the past 10 years.

In contrast, the speech of Chi-tat Chong was an intensely personal testimony of a long road travelled in pursuit of a tropical mathematical paradise for research activity. He recalled briefly how the idle canteen discussions regularly indulged in with his colleagues more than 20 years ago ignited the engine that inevitably and inexorably set in motion a collective journey to the west and back in search of an ideal model of a research institute. Finally, he suggested, if not exhorted, that we should start "another round of idle canteen talks" that would propel the Institute forward to the next stage of development.

A charmed memento for the Guest of Honor

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While the first two speeches were more locally inspired, the Chairman of the Scientific Advisory Board, Roger Howe gave the audience a historical and paradigmatic perspective of some of the achievements of the local mathematical community. He cited three important examples as evidence of the successful and positive role of the Institute in the mathematical development of Singapore.

In his speech as the guest of honour, the President of NUS, Tan Chorh Chuan showed an empathetic understanding of the mathematical mind and an appreciation of the mathematical spirit of enquiry. Some of the Institute's achievements that he highlighted must have certainly vindicated the faith and support that the University has given to the Institute during the past 10 years.

Musical interlude

The celebratory gathering

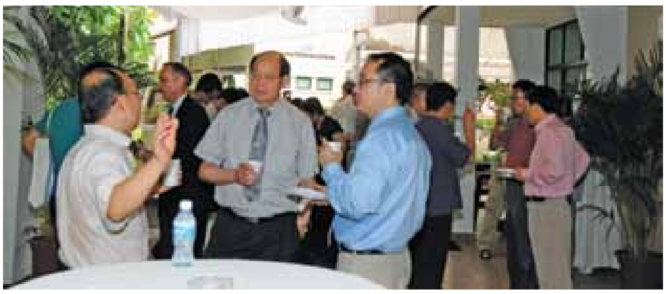
After the speeches were made, the Director presented the President, as has usually been our custom, with a token of appreciation – a copy of the commemoration volume *Creative Minds*, *Charmed Lives* consisting of interviews published in the Institute's newsletter *Imprints*.

As in the official opening of the Institute some 9 years ago, the highly motivated and purposeful atmosphere was

Bouncing ideas for IMS' future?
(From left: Olivier Pironneau, Chi-tat Chong and Hugh Woodin)

transformed for some intangible magical moments by two young budding musicians in a duet on two contrasting instruments, Kelly Loh on the flute and Mifiona Quah on the harp. The first piece, entitled *Remembrance*, brought back nostalgic memories with an eastern touch and was specially composed for the occasion by our own versatile scientist and composer Bernard Tan, himself in the audience. The second piece then brought the audience back to the present with a modern composition *Entr'acte* by the eclectic French composer Jacques Ibert.

The stage was next set for a visual and more impressionable infusion of the messages that the preceding speeches had conveyed. A video presentation prepared by the University's Centre for Instructional Technology gave us an informative glimpse of the cumulative and collective efforts that have contributed to the progress made by the Institute.



More enlightening conversations at IMS

The reception that followed saw the rather modest grounds of the Institute overflowing with guests, visitors, local academics and scientists and graduate students. Some have travelled afar from home base to renew ties with old and new friends. Perhaps the short reception could have been too short for some as they took this opportunity to catch up with each other's diverse interests and activities.

A total of more than 90 people packed the Institute's auditorium with some viewing the proceedings via live

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Guests signing in

telecast shown in the adjoining seminar room. Among the local dignitaries who came were Provost Eng-Chye Tan, Deputy President (Research and Technology) Barry Halliwell, Science Dean Andrew Wee, CHAM Tao Soon (Chairman of SIM University Board of Trustees) and LUI Pao Chuen (Chief Scientific Advisor to Ministry of Foreign Affairs).

Some of our distinguished friends from overseas included Tony Chan (President of Hong Kong University of Science and Technology), Tim Brown (Vice-Chancellor (Research), La Trobe University, Australia), Takeyuki Hida of Meijo University, Japan, Andrew Barbour of University of Zurich, Olivier Pironneau of Université Paris VI, David Siegmund of Stanford University, Yum-Tong Siu of Harvard University, Michael Waterman of University of South California and Hugh Woodin of University of California, Berkeley.

The day's celebration would have been incomplete without an intellectual offering to stimulate the mind. Three invited talks were given in the Institute's auditorium – one following the reception and the other two in the afternoon after the lunch break. The first talk *Supporting mathematical sciences: An NSF perspective* was given by Tony Chan, the recently appointed President of Hong Kong University of Science and Technology. A friend of many of our NUS academics and a previous organizer of the Institute's program, he shared his rich experience and ideas accumulated during his long and distinguished association with research organizations in the United States.

NUS President TAN Chorh Chuan shares his thoughts on IMS

Insider insights on NSF: Tony Chan

The second talk *The universe of sets* was given by Hugh Woodin of the University of California, Berkeley. Not only is he a frequent visitor to the Institute and an active organizer and participant of the Institutes' activities, but he is also a benefactor and supporter of research in logic in Asia. Thanks to him and his colleague Theodore Slaman, the logic group in NUS led by Chi-tat Chong was recently promised a generous grant from the John Templeton Foundation for research activities in logic in the next three years.

The third talk *Is economics a mathematical science?* was given by Yeneng Sun, himself a former Deputy Director of the Institute and recently appointed Raffles Professor of Social Sciences in NUS, having started his distinguished career in the Department of Mathematics.

The IMS brain trust, members of the Scientific Advisory Board (SAB): (From left: Roger HOWE (SAB Chair), Ser Peow TAN (IMS Deputy Director), Chi-tat CHONG (Management Board Chair), Louis CHEN (IMS Director), LUI Pao Chuen, Olivier PIRONNEAU, Yum-Tong SIU and David SIEGMUND)
Not in photograph: David MUMFORD

The day's celebration was rounded up with an informal appreciation dinner held in the evening in The Pines Club, situated at the fringe of the most modern and cosmopolitan part of Singapore. It was a simple gesture made by the Institute to express its appreciation of the cumulative and collective efforts of its past and present staff. Served without any fanfare and joined in by a number of selected local and overseas guests, the traditional full-course Chinese banquet was both a symbolic and a tangible taste of the fruits of a sapling planted 10 years ago.

Y.K Leong
National University of Singapore

Speech by Chair of Scientific Advisory Board for the IMS Tenth Anniversary Celebrations >>>

Roger Howe, Chair of the Scientific Advisory Board, on mathematical progress

It is a delight to be here today to help celebrate the 10th anniversary of the Institute for Mathematical Sciences. It has been a pleasure for me to be part of the Scientific Advisory Board (SAB), and wonderful for all of us to work with Louis Chen, whose energy and devotion to the goals and activities of IMS have been inspirational. And also, very successful. Under Louis's direction, the IMS has supported many excellent programs that have enhanced local expertise in a wide variety of areas. Louis has been especially careful to recruit programs related to Singapore's strategic technological goals. It is an enviable record. There have been series of programs supporting the country's efforts in biomedical science, imaging science, and hydrodynamics, and a variety of other programs in pure and applied mathematics that reflect and strengthen the research of local mathematical scientists. You don't have to take my word for it; just go read the already 19 volumes of the IMS Lecture Notes Series, published by World Scientific. Here I will use just three for examples: *Gabor and Wavelet Frames, Markov Chain Monte Carlo,* and *Braids*.

I would like to relate these volumes to a model of progress in mathematics. It seems useful to distinguish at least three types of mathematical activity. The most dramatic is the big breakthrough that revolutionizes a field and leads to striking applications. Let's call this a type 1 event. We all love this kind of event, but there are two problems with it:

1) it is relatively rare; and

2) it is almost completely unpredictable.

Sometimes of course, a breakthrough doesn't affect theory and applications equally. Sometimes a theoretical breakthrough has little or no practical ramifications, at least not in the near term, and sometimes a breakthrough just uses off-the-shelf mathematics in a new way. Even these one-sided breakthroughs tend to generate a lot of excitement.

The second kind of activity is the feverish period of dissemination, elaboration and consolidation after the first type of event. Lots of conferences, lots of papers with corollaries, or parallel results in a different context, or applications, or elaborations, or refinements.

The third kind of activity is what happens the rest of the time, which in most fields is most of the time. People are working out programs of investigation. They may be working on still unsolved problems, of older or more recent vintage, or trying to refine further or clarify how ideas in their field fit together, or elaborate concepts to adapt them to more complex situations, or investigating examples, or formalizing results, a kind of axiomatization to distill the key ideas in a particular area. During this kind of activity, it may seem to the outsider that not much is happening.

Policymakers and funders of course love the first kind of event. Everybody does. It is obvious that we can now do things better than in the past, or at least understand something much better; and if the breakthrough has an applied aspect, someone (probably not mathematicians!) will save or make a lot of money. Policymakers tend also to feel pretty favorable about the second kind of activity, because the excitement is still there, and they can still remember the difference between before and after the event. These events are natural candidates for IMS programs.

The true test of policymakers is in supporting the third kind of activity. In this activity, which I believe characterizes most of mathematics most of the time, it may seem that mathematicians are wasting their time, becoming overly refined, not keeping their eyes on the main prize. But I submit that this is in fact the most important kind of mathematical activity. It is out of the ferment of exploration, or turning over ideas, subjecting them to critiques and "what if"s, mixing them together and seeing what happens, that the big breakthroughs come. In particular, this type of work is also suitable for IMS programs. I would like to use some IMS Lecture Notes to illustrate this claim, by briefly sketching how complex the history was that led to a few type 1 events.

Volume 10: Gabor and Wavelet Frames

In imaging science, a major revolution came in the 1980s, with the advent of wavelet methods, a superb example of a type 1 event. Wavelets have become an essential part of the toolkit of signal processors, including being incorporated in the JPEG standards. Wavelets have figured strongly in the image processing activities at IMS, and have been a central topic of research of several members of the NUS Department of Mathematics.

What led to the wavelet revolution? The complete history is very complex, but here I simply want to emphasize its long pedigree. Fourier analysis has been a heavily used tool in mathematics and physics since the late 18th century, and the first serious studies of the major linear partial differential equations of physics: the wave equation, the heat equation,

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and Laplace's equation. Desire to understand what the Fourier Transform does led to intense study. Speaking very loosely, it was learned that Fourier Transform takes spatial information and converts it into frequency information. The standard, spatial representation of a function does not exhibit very plainly its frequency behavior, and vice versa.

The advent of quantum mechanics forced the realization that we cannot arbitrarily specify both the spatial behavior and the frequency behavior of a function. This is the celebrated Heisenberg Uncertainty Principle. Also with the advent of quantum mechanics, we got what mathematicians call the Heisenberg group, since it is the group-theoretic embodiment of the Heisenberg Canonical Commutation Relations. The Heisenberg group embodies both the spatial and frequency aspects of a function at the same time, at the price of being non-commutative.

When these ideas had been sufficiently digested, it occurred to some people to ask if there could be ways to represent functions that are partially localized in both position and in frequency, and also have good properties with respect to scaling. One of the early attempts to create bases of such functions was made by D. Gabor, but it was only in the 1980s, after several decades of development of ideas from the Calderon- Zygmund school of harmonic analysis that Gabor's ideas were combined systematically with considerations based on scaling, giving rise to the bases known as *wavelets*, and associated multi-resolution analysis. This brief sketch will suggest how much history and patient investigation lay behind the dramatic advent of wavelets.

Volume 19: Braids

Another type 1 event of the 1980s was the discovery by Vaughan Jones of a connection between von Neumann algebras and knot theory. Each of these areas had a long history, with knot theory going back to the 19th century, and von Neumann algebras having their roots in von Neumann's papers on operator algebras in the 1930s. They had been completely separate areas, but in his thesis, Jones found some algebraic structures that eventually led him to a connection with knots. This led to a tidal wave of new results in knot theory, including applications to DNA. (It has been discovered that nature has designed enzymes whose job is to perform basic operations of knot combinatorics!)

A more classical approach to knot theory, developed by Artin, is through the study of braids. A few years ago, a surprising discovery (a type 1 event in pure math) by members of the Mathematics Department at NUS linked braids to some of the classic questions in topology, especially the homotopy groups of spheres. IMS sponsored a program to highlight this new discovery, and followed it up with a broader program to integrate the new discoveries into the already existing fabric of algebraic topology.

Volume 7: Markov Chain Monte Carlo

Finally, let me mention the volume on Markov Chain Monte Carlo (MCMC) methods. Markov chains were invented by Andrei Markov in the early 20th century, apparently motivated by theoretical probability questions. They are a simple model of probabilistic dynamics. They envision a collection of possible states, and a fixed rule governing the chance of moving from one state to another. They have a clean and elegant theory, and are sometimes the subject of a tidy section in a chapter on eigenvalues and eigenvectors in a textbook on linear algebra. However, over the years, many people have applied them to many kinds of phenomena. For example, random walks are Markov chains.

MCMC is part of this roll call of applications, and has itself become a major type of application. MCMC is really not a type 1 event in the strict sense. Rather it is a long, rolling development, in which a particular approach to some hard problems has been found to be applicable in more and more areas. Yet the cumulative effect is like a revolution. Thus we have the article of P. Diaconis in the April, 2009 Bulletin of the American Mathematical Society, with title *The Markov chain Monte Carlo revolution*.

MCMC started in a 1953 paper by Metropolis, Rosenbluth and Rosenbluth, Teller and Teller. The basic idea, now frequently called simply the Metropolis algorithm, or Metropolis–Hastings algorithm, is to create a Markov Chain to sample approximately a probability distribution which is not easily computable directly. This was a new idea for using Markov chains. Over time, this idea itself has found many variations and new applications, most recently in biostatistics and mathematical finance.

Perhaps the epitome of an applied breakthrough is the rise of Google. Their fabulously successful Internet search engine is also based on a Markov chain, made from all the nodes in the internet! In the last ten years, Google has gone from non–existent to one of the biggest companies on the world in terms of market capitalization. I still cannot quite get my head around the possibility that one can perform a Markov chain on several billion variables, and come out with anything meaningful. Google doesn't prove any theorems, but it shows by example that its methods work, millions of times every day, Few examples show better the power of pure mathematics when used in an opportune way. Let me highlight the fact that Markov chains had been sitting around for a long time, and had been used in a variety of ways that are not so far removed from their use by Google. First their invention, but also the ways they had been applied, reduced the potential barrier to their application to the internet.

These examples underline the importance of maintaining a level of mathematical expertise, so that such technologies can be understood and used adaptively. The IMS has clearly been a positive force in bringing understanding of such new developments to Singapore, and raising the capacity of its mathematical community to adapt to and utilize the new ideas, wherever they arise.

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International Conference in Memory of Kai Lai Chung >>>

K.L. Chung Memorial Conference: Celebrating the Life and Work of a Giant

From 13 to 16 June 2010, the international conference "From Markov Processes to Brownian Motion and Beyond" was held at Peking University in Beijing, China. This conference honored the memory of Professor Kai Lai Chung, one of the leading probabilists of the second half of the twentieth century, who passed away on 1 June 2009 at the age of 91.

Professor Zhiming Ma of the Chinese Academy of Sciences and chair of the Organizing Committee opened the conference by offering a warm welcome to the more than 150 participants. Two former students of Professor Chung, Professors Elton Hsu and Ruth Williams, then gave some introductory remarks on behalf of the organizing committee and a short review of Professor Chung's life and work, respectively.

The conference program featured invited talks ranging over a broad spectrum of topics in probability and related fields. These presentations were given by

Martin Barlow	(University of British Columbia),
Richard Bas	(University of Connecticut),
Krzysztof Burdzy	(University of Washington),
Louis Chen	(National University of Singapore),
Mufa Chen	(Beijing Normal University),
Zhen-Qing Chen	(University of Washington),
Erhan Cinlar	(Princeton University),
Michael Cranston	(University of California, Irvine),
Jim Dai	(Georgia Institute of Technology),
Jean-Francois Le Gall	(Université Paris-Sud),
Elton Hsu	(Northwestern University),
Ming Liao	(Auburn University),
Zhi-Ming Ma	(Chinese Academy of Sciences),
Shige Peng	(Shandong University),
Yuval Peres	(Microsoft Research),
Edwin Perkins	(University of British Columbia),
Mark Pinsky	(Northwestern University),
Yanxia Ren	(Peking University),
S. R. S. Varadhan	(New York University),
John Walsh	(University of British Columbia),
Ruth Williams	(University of California, San Diego),
Jia-An Yan	(Chinese Academy of Sciences) and
Jiangang Ying	(Fudan University).

Many of the speakers included personal remarks on how they had known Professor Chung and benefited from his influence. Several speakers recalled highly memorable encounters with Professor Chung. A common theme in these remarks was his strong personality, his enthusiasm for mathematics, his meticulous attention to detail, his interest in engaging new researchers and his abundant supply of stimulating questions and problems delivered variously in person, by letter, phone and fax. Some speakers who had

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In closing, I would like to say a little about the future of IMS. In its first ten years, IMS has amply demonstrated its value for supporting the mathematical infrastructure of Singapore. I believe I speak for all my colleagues on the SAB, when I marvel at the effectiveness with which Louis Chen has spent the dollars he has been allocated. But I also believe that we have all wished those dollars could have been more. In particular, we have wished that the government had a mechanism for funding IMS, rather than having it be funded as an internal activity of NUS. We are grateful to NUS for taking on that burden, and salute the vision of both Deputy President for Research and Technology Barry Halliwell and Provost Eng-Chye Tan in providing ongoing funding for IMS. But in fact, IMS is, and should be thought of as, a national resource. In a country such as Singapore, with its reliance on technological progress, but with a modest number of mathematical scientists, and where anyone can get anywere in under and hour, it makes eminent sense to have an Institute for Mathematical Sciences, but it does not make sense to have two, or to have one attached to a particular institution, except as providing a physical home. I note that one of the planned programs of IMS is primarily coming from the School of Physical and Mathematical Sciences at NTU, and an earlier program was also. Programs have also been initiated by other institutions, and participants have come from many organizations in Singapore. I regard this as healthy. It is how IMS should work; but when IMS itself is funded through NUS this raises questions of financial responsibility. I hope that, as the challenge of finding a successor to Louis Chen as Director of IMS is addressed, the question of the funding mechanism that is commensurate with Singapore's dependence on mathematical infrastructure and its physical size, will also be addressed.

Thank you,
Roger Howe
Yale University

The International Congress of Mathematicians (ICM) 2010 at Hyderabad >>>

The ICM 2010 was held at Hyderabad 19–27 August 2010. The IMS held two satellite conferences of the ICM, in late July and early August, they were the workshop and the conference organized as part of the two month program on the "Geometry, Topology and Dynamics of Character Varieties", and attracted a large number international researchers. Two of the speakers for the conference, Gaven Martin and William Goldman were also invited session speakers for the ICM, and several speakers at the workshop and conference were also invited speakers of previous ICM's. The director Louis Chen and the chairman of the management board Chi-tat Chong attended the ICM, the former in his capacity as a member of the Program Committee for the ICM. Several prizes were awarded by the IMU during the ICM including the Fields medals to Elon Lindenstrauss, Ngô Bảo Châu, Stanislav Smirnov and Cédric Villani, the Chern medal to Louis Nirenberg, the Nevanlinna prize to Daniel Spielman and the Gauss prize to Yves Meyer.

People in the News >>>

Ms. Doreen Liu awarded the coveted title "Entrepreneur of the Year" for Women in Asia

Ms Doreen Liu, managing director of World Scientific Publishing has been named "Entrepreneur of the year" 2010 for Women in Asia by The Financial Times/RBS Coutts. The award is to give recognition to the growing ranks of successful women in Asia. World Scientific Publishing has been the publisher of our institute's Lecture Notes Series and printer for our newsletter – *Imprints* since their inception. Our heartiest congratulations to Ms. Doreen Liu!

CHONG Tow Chong presented with the most prestigious "2010 President's Science and Technology Medal"

Currently the Provost of the Singapore University of Technology and Design, Professor Chong Tow Chong was honoured for his exceptional contributions to Singapore's Science and Engineering landscape through his work in A*STAR's Science and Engineering Research Council, and Data Storage Institute. Professor Chong serves as a member of the IMS Management Board.

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never met Professor Chung spoke of deriving inspiration from his writings, especially his books which were well known for their elegant, clear and precise style.

In addition to the invited talks, two poster sessions featured a diversity of results by researchers from China and other countries. Substantial book exhibits by Springer Verlag and World Scientific allowed participants to peruse a range of modern titles in probability as well as copies of Professor Chung's eleven books. The exhibits included World Scientific's volume of his selected works and a special conference publication produced by Springer featuring his papers published previously in the Lecture Notes in Mathematics series. The sumptuous banquet held at the Chu Yue Tang Restaurant on Tuesday evening provided an opportunity for further reminiscences by Professor Chung's colleagues and family. An afternoon excursion to the Great Wall at Badaling on Wednesday capped off the highly successful meeting.

Two long term initiatives have been developed to honor Professor Kai Lai Chung as a leader in the field of stochastic processes. First, a "legacy" website will be established at Peking University featuring publications, photos and other items pertaining to Professor Chung's 70-year long mathematical career. Second, the "Kai Lai Chung Lecture" will be featured at the annual Seminars on Stochastic Processes; this series of highly successful conferences was initiated by Professor Chung in conjunction with Professors Erhan Cinlar and Ronald Getoor in 1981. The first Kai Lai Chung lecture will be delivered by Professor S. R. S. Varadhan at the next "Seminar" to be held at the University of California, Irvine, in March 2011. Initial funds to support these initiatives have been generously provided by Mrs. Lilia Chung and her family. Mrs. Chung has also kindly donated Professor Chung's mathematical library to Peking University.

Many of the conference participants commented on the high quality of the program and local arrangements. On behalf of the participants, we extend hearty congratulations and many thanks to the other members of the organizing committee: Dayue Chen, Louis Chen, Zhen-Qing Chen, Jim Dai, Zhiming Ma, and Rong Wu for organizing an excellent meeting. We are also grateful to the sponsors:

National Natural Science Foundation of China,
Beijing International Center for Mathematical Research,
Institute for Mathematical Sciences -- National University of Singapore,
Institute of Advanced Studies -- Nanyang Technological University,
Nankai University,

and the co-sponsors:

Institute of Mathematical Statistics and
IMS-China for their support of this meeting.

Elton Hsu
Northwestern University

Ruth J. Williams
University of California, San Diego

Programs & Activities >>>

Past Programs in Brief

From Markov Processes to Brownian Motion and Beyond: An International Conference in Memory of Kai Lai Chung (13 – 16 June 2010)

Website: http://www2.ims.nus.edu.sg/Programs/010KaiLaiChung/index.php

An article on this conference is found in this issue of *Imprints*.

Geometry, Topology and Dynamics of Character Varieties (18 June - 15 August 2010) and Summer School (28 June – 16 July 2010)

... Co-sponsored by Global COE (Center of Excellence) of the Tokyo Institute of Technology, Compview and the National Science Foundation (USA)

Website: http://www2.ims.nus.edu.sg/Programs/010geometry/index.php

The program consisted of three main activities, a three week summer school followed by a two week workshop, and a one week conference in the final week of the program. The response for the program was overwhelming, with over 160 overseas and local participants for the program.

There were 9 lecturers who each gave a series of 4 lectures. These included a special series of lectures by a computer expert, Yasushi Yamashita, who explained how to write python programs for studying character varieties, starting from scratch. Over 60 students and young post-graduates attended the tutorial lectures. Among this group were several graduate students from NUS and NTU, with the others coming from the region (Asia and Australia), America, Europe and the UK. Topics were carefully chosen to give students a feel for various directions for research. Many of the students who stayed on campus during the summer school continued informal discussions of the lecture topics covered during the evenings. The careful choice of the tutorial lecturers, who included some young and very promising researchers, also allowed the students to bond and interact well with the lecturers.

The workshop consisted of a series of ten survey talks by leading experts. They were carefully selected to show the links and connections between various areas of research in this field; for example, hyperbolic geometry and Teichmueller Theory, Higgs bundles, character varieties and higher dimensional geometric structures. These were complemented with shorter talks by other participants on recent results. The workshop was especially popular and attracted about 80 participants, including at least 60 from overseas. The mix of senior and junior researchers, and the related but slightly different fields resulted in very spirited interactions among the participants.

The conference showcased fourteen talks by leading experts from around the world who spoke on the main topics of the program. The talks were uniformly excellent and outlined the main directions of research in this area for the future and proved extremely inspiring to the participants. This was also an ICM satellite conference, many of the speakers were either former invited speakers to the ICM (Steve Kerckhoff, Francois Labourie, Caroline Series, Scott Wolpert and Shicheng Wang), or were invited to speak at the ICM in Hyderabad (Gaven Martin and Bill Goldman).

Japanese representations at the workshop

On the geometry of pleating rays and lines of minima – Caroline Series

A variety of characters at the summer school

Asian Initiative for Infinity (AII) Graduate Summer School (28 June – 23 July 2010)

... Jointly organized with Department of Mathematics, National University of Singapore, funded by the John Templeton Foundation

Website: http://www2.ims.nus.edu.sg/Programs/010aiiss/index.php

The Graduate Summer School bridged the gap between a general graduate education in mathematical logic and the specific preparation necessary to do research on problems of current interest in the subject.

The summer school consisted of three series of lectures delivered by Moti Gitik (Tel Aviv University), Denis Hirschfield (University of Chicago) and Menachem Magidor (Hebrew University), to introduce students to exciting and current research topics. Before the series of lectures, two postdoctoral fellows gave introductory lectures to prep the students. The students were also given the opportunities to present their talks and engage in discussions after the lectures. This year, the summer school saw an increase in the participation level. There were 54 graduate students, half from Asia, as well 18 professors and postdocs who participated in the activities.

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Set theorists and logicians with initiative, from Asia and beyond

Infinitely captivated

Cofinal discussions with Menachem Magidor (far left)

Workshop on Recent Advances in Bayesian Computation (20 – 22 September 2010)

Website: http://www2.ims.nus.edu.sg/Programs/010bayc/index.php

Over the last 15 years there has been an explosion in the use of Bayesian methods in applied statistics. Due to advances in technology for data collection in many fields of science, engineering and the social sciences, applied statisticians increasingly have to deal with problems of combining data and information from different sources. This leads naturally to the use of richly structured hierarchical models, and advances in Bayesian computational methods have meant that a Bayesian approach is often the most easily implemented one for inference in such models. The purpose of this workshop was to bring together leading researchers in the area of Bayesian computational methods to discuss challenges and opportunities in the area, with a focus on dealing with large data sets.

The workshop achieved its main objective of looking at the field of Bayesian computation broadly, with a view to applications involving large data sets. Several of the invited participants have commented that a similar workshop should be arranged in a few years as a follow up. There were 17 invited talks. In all, there were over 90 participants, including 35 graduate students from the local universities. The graduate students had the chance to mix with leaders in the field, and several local students and postdocs served as session chairs. They have certainly benefited from contact with international researchers at the highest level. The overseas researchers were from Australia, Canada, Finland, France, Germany, Malaysia, UK and USA.

Expecting auxiliary variables: Arnaud Doucet

Grasping the R-INLA project: Håvard Rue

Bayesians do compute!

Public Lecture

Mr Jiayi Chong of Pixar Animation Studios gave a public lecture on "Numbers and Code, Behind the Magic of Visual Effects" at the NUS High School on 7 July 2010, introducing the audience to the fascinating world of special effects and computer simulation in the movies. He captivated the audience of over 300 students, explaining how the realistic jiggling of the body of a fat, over-sized human in the movie Wall-e as it collided with the ground is achieved through a mix of physics, mathematics

Jiayi Chong: Movie Magic

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and computer science. He also shared a little with the audience on his job as the Technical Director which involves researching, designing and implementing simulation tools for use in films at Pixar – a dream place to work for many thereby stoking many dreams of future careers in the movies.

Next Program

Hyperbolic Conservation Laws and Kinetic Equations: Theory, Computation, and Applications (1 November – 19 December 2010)

Website: http://www2.ims.nus.edu.sg/Programs/010hyperbolic/index.php

Organizing Committee
Claude Bardos, *Université Paris VI*
Russel Caflisch, *University of California, Los Angeles*
Thomas Hou, *California Institute of Technology*
Cedric Villani, *École Normale Supérieure de Lyon*
Shih-Hsien Yu, *National University of Singapore*

This program will provide a forum for people working in hyperbolic conservation laws, kinetic equations, mathematical physics, scientific computation, and engineering to jointly promote research on kinetic equations for rarefied gas dynamics. The program will offer a series of comprehensive tutorial lectures by senior scientists from rarefied gas theory, semi-conductor industry, and nonlinear hyperbolic PDE to train PhD students and others interested in these topics.

Period I (1 – 26 November): Asymptotic theory in Boltzmann equation and mathematical theory for hyperbolic conservation and kinetic equation.
Period II (29 November – 3 December): International Conference on Nonlinear Partial Differential Equations: Mathematical Theory, Computation, and Applications.
Period III (6 – 17 December): On macroscopic and microscopic flows.

Upcoming Activities

Workshop on Algebraic Geometry, Complex Dynamics and their Interaction (4 – 7 January 2011)

Website: http://www2.ims.nus.edu.sg/Programs/011walgeb/index.php

Chair
De-Qi Zhang, *National University of Singapore*

The purpose of the workshop is to report on some recent progress in Algebraic Geometry, especially in the area of Birational Geometry in connection with the MMP (minimal model program), the equivariant MMP and the Dynamics of Symmetries on compact complex manifolds.

Workshop on the Probabilistic Impulse behind Modern Economic Theory (11 – 18 January 2011)

Website: http://www2.ims.nus.edu.sg/Programs/011wprob/index.php

Chair
M. Ali Khan, *The Johns Hopkins University*

The objective of this conference is two-fold: first to review the exciting advances that have been made in (need to mention some areas here), and second, to expose the developed, and developing, theory to differing expert perspectives and points of view. With individuals necessarily working in their individual narrow domains, the main mission of the workshop is to foster interdisciplinary communication and dialogue between economists and mathematicians, and by participating in this exciting venture, local scholars will have ample opportunities of interacting with international experts at the highest level.

Programs & Activities in the Pipeline

Workshop on Recent Advances in Nonlinear Time Series Analysis (7 – 18 February 2011)

Website: http://www2.ims.nus.edu.sg/Programs/011wnlinear/index.php

Chair
Howell Tong, *London School of Economics*

The main mission of the workshop is to bring together international researchers with expertise in non-parametrics, semi-parametrics, dimension reduction, high-dimensional time series, and many others, so as to gain a deeper and wider understanding of the dynamical world. By participating in this exciting venture, local nonlinear enthusiasts will have ample opportunities of interacting with international experts at the highest level. There is no doubt that the workshop will be an important milestone in the development of nonlinear time series analysis on an international scale. It will also help bring about a quantum leap in research in non-linear time series analysis in Singapore.

Mathematical Science of Understanding and Predicting Regional Climate: A School and Workshop (28 February – 11 March 2011)

… *Partially supported by NCAR, TMSI and SDWA*

Website: http://www2.ims.nus.edu.sg//Programs/011climate/index.php

Chair
Douglas Nychka, *National Center for Atmospheric Research*

This program explores from a mathematical and statistical perspective how to improve prediction of regional climate changes. Mathematics can support improvements in physical models, the combination of models with observations and also characterizing the uncertainty of climate predictions. The goal of this program is to bring together mathematical and geophysical scientists to address this problem from a multidisciplinary and collaborative perspective. The program will consist of a school (28 February – 4 March 2011) and a workshop (7 - 11 March 2011).

Probability and Discrete Mathematics in Mathematical Biology (14 March – 10 June 2011)

Website: http://www2.ims.nus.edu.sg//Programs/011mathbio/index.php

Co-chairs
Andrew Barbour, *University of Zurich*
Malwina Luczak, *London School of Economics*

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Mathematical Conversations

James V. Zidek: Bridges Bayesians Build >>>

James V. Zidek

Interview of James V. Zidek by Y.K. Leong

James V. Zidek is world-renowned for his research on Bayesian decision analysis, monitoring network design and spatial prediction.

He received his education from University of Alberta and Stanford University. Since 1967, except for a few short stints elsewhere, he has established a distinguished career in teaching and research at the University of British Columbia in Canada. He has also been actively involved in consultancy work in public health, engineering and industry; in particular, he did pioneering statistical work on long span bridges. An emeritus professor since 2005, he continues to apply his expertise and professional experience in addressing statistical problems arising in environmetrics, a multi-disciplinary discipline that has recently emerged to deal with environmental problems like pollution and climate change.

He has been invited to give lectures at conferences and workshops throughout the world. He has actively served on numerous committees of professional bodies, societies and international scientific meetings and on editorial boards of leading statistical journals like *Annals of Statistics, Canadian Journal of Statistics, Environmetrics and Journal of American Statistical Association*.

He is a Fellow of the Institute of Mathematical Statistics, American Statistical Association and Royal Society of Canada, and an elected member of the International Statistical Institute. He received the Eugene Lukacs Symposium Distinguished Service Award, Izaak Walton Research Prize, Gold Medal of the Statistical Society of Canada, and Distinguished Achievement Medal (Environmental Statistics Section of the American Statistical Association). He was a President of the Statistical Society of Canada. In addition to an impressive record of research papers, he has also produced a long line of masters and doctoral students.

Zidek's association with National University of Singapore dates back to 1995, when he was invited to the Department of Mathematics for a short period. He came back as a member of the organizing committee and speaker at the IMS program (6 – 28 January 2008) on *Data-driven and Physically-based Models for Characterization of Processes in Hydrology, Hydraulics, Oceanography and Climate Change*, jointly organized with Pacific Institute for Mathematical Science, University of British Columbia. He was interviewed by Y.K. Leong on behalf of *Imprints* on 24 January 2008. The following is an edited transcript of the interview in which he exuded tremendous energy and passion as he talked about his views and experiences in both theoretical and applied aspects of statistics.

Imprints: Your undergraduate degree was in mathematics and yet you went on to do your graduate studies in statistics, ending up at Stanford University for your PhD. What shaped the choices you made, what benefits do you see retrospectively in choosing Stanford for your degree?

Jim Zidek: I did enjoy my mathematics undergraduate training. In fact, I was generally quite good, not brilliant, but quite good in doing math. However, I found the statistics courses rather challenging, I think my love at that time was number theory. When it was time to choose my graduate program, I decided that I would be into statistics. That was at the University of Alberta. My Masters program had an immensely stimulating man by the name of John McGregor as my thesis supervisor. What made him particularly good was the fact that he let his students do pretty much what they liked under some general supervision. In my Masters thesis I worked in mathematical learning theory – construction of models which try to predict how things like rats would learn

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In this program, particular emphasis is placed on stochastic processes as models in ecology, and especially on the part which both population genetics and network structure play in their behaviour. The program aims to bring together people actively involved in different aspects of mathematical biology, to exchange ideas and to further promote the development of the field. Since many of the models of interest have characteristics similar to those encountered in other disciplines, such as discrete mathematics, statistical physics and computer science, members of these communities are warmly encouraged to participate.

Coding, Cryptology and Combinatoric Designs (15 May – 11 June 2011)
... *Jointly organized with Nanyang Technological University*

Computational Prospects of Infinity II, incorporating a Summer School and a Workshop on Infinity and Truth (15 June – 5 August 2011)
... *Jointly organized with Department of Mathematics, National University of Singapore, funded by the John Templeton Foundation*

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when they are in those maze experiments. The high point came one day when I discovered a result about something or other, which I presented to John, and he seemed immensely positive about it. He was so excited that he actually went out of his office to tell some of his colleagues about this result. That was the first time that I began to appreciate the joy of discovery. I was turned on to research at that point and decided to go on to Stanford.

I was fortunate to get in there with its high reputation in the field of statistics. By then I knew I wanted to go further on. What led me to Stanford in the first place? You ask about the benefits of Stanford. The obvious one is the great intellectual benefit that I derived from the faculty. At that time there were very few departments of statistics in the world. I picked that one in part because it was one of the few and one of the more recognized. One of the benefits I began to appreciate long after I graduated was the valuable experience I gained from meeting people from all over the world and many of them have remained friends ever since. Many students and even faculty overlook the benefit of getting to know people when the opportunity arises.

I: Was there any person at Stanford who influenced you greatly?

Z: Yes, Charles Stein, my supervisor at Stanford had a profound influence on my thinking. He is a man who has very high standards for himself and for me, but he did not impose on me in an autocratic fashion, again leaving me to my own devices. I think we all owe a great debt of gratitude to our teachers. They have given us a great gift which we sometimes overlook. I single him [Charles Stein] out though there were also other people – many of the professors there and other visitors – who influenced me greatly.

I: What were you working on at Stanford for your PhD?

Z: I worked in the field of statistical decision theory which was a subject that Charles Stein was involved in. That subject enjoyed a tremendous amount of interest in the statistical world in that period. It was stimulated by a guy named Abraham Wald at Columbia University. In his relatively short life that unfortunately ended in an airplane crash in 1951, he introduced two subjects: sequential analysis and statistical decision theory. He had emulated in statistical decision theory what Kolmogorov had done in probability theory. Kolmogorov recognized that people had been trying to define probability for a hundred years or so. He had the brilliant idea of adopting the more mathematical approach of axiomatizing probability theory. He set down fundamental axioms saying that although we may not know what probability is, or how to define it in some operational sense, let us say instead that any quantity that satisfies these simple rules will be deemed a probability or probability distribution. That frees the mathematician to go on to develop probability theory without having to figure out what it means. The subject has become a tremendously important part of mathematics. Wald's idea was to build statistics on axiomatic foundations. His decision theory was an attempt to account for uncertainty in decision making and make it a rigorous discipline.

I: Was Wald's axiomatization of statistical decision theory done after Pearson-Neyman's work?

Z: That's a really good question. It sort of generalizes it. Some credit should certainly go to Neyman and Pearson who realized that the testing theory lacked one or two important elements and added those in, and Wald then further generalized it. That came in the late 1930 or 1940s. Some 30 years later, the subject became a premier sub-discipline of statistics in North America and attracted a lot of great minds, like Charles Stein.

I: After Stanford, you went immediately to University of British Columbia and you essentially stayed there for your scientific career until you retired as Professor Emeritus in 2005. Are there any particular reasons for being so loyal to one university?

Z: That's a very interesting question. The answer is that I was never loyal to the University. In fact, I think one attaches oneself to one's department or college. So any loyalty I had was really to the department I was in. My first years in that university were spent in the mathematics department. It was a department of some size, about 70 members. While I was very well treated in that department, I found it to be an increasingly poor environment for nurturing statistics. When I was asked by a senior administrator (I guess it was 2 years after I arrived) what might be the ideal model I told him that a separate department of statistics would be a good idea. That wasn't achieved, but we did propose and get around 1971 instead as a compromise an institute of applied mathematics and statistics. At the graduate level anyway, even then at that time beginning around1970, statistics in North America had emerged from its mathematical shell and had become more focused on science. It was moving towards statistical science. I think we all sensed that, so the Institute of Applied Mathematics and Statistics was actually meant in some way to synthesize these two subjects and bring them closer. It gave us some freedom in organizing graduate programs at the institute. I realized later though the decision to set up an institute solved some of our problems, but not all of them. In fact, our effort to get a department of statistics was held back. The administrators had argued, "Listen, the institute may not be a perfect answer but it's a lot easier than setting up a department. You've already got it, so let's leave it at that." It was not until 1983 that we got a separate department of statistics at the university. By then, I had realized that things weren't going so well for statistics in the department of mathematics even though they were fine for me personally. So I decided to leave. I did, in fact, join the University of Washington's Department of Statistics. It turned out to be a wonderful department and still is. Although that move was intended to be permanent, for various reasons that we need not go into here, I eventually left and accepted the University of British Columbia's invitation to me to come back to form a new department. The department was, in fact, formed in my absence in 1983. I was lured back to become its official founding member in 1984 but my colleagues really deserve tremendous credit for pushing it through and getting it up and running before my return. Although I regretted leaving the University of Washington in many ways, I don't think with hindsight it was a mistake to go back [to British Columbia]. At the end of the day, I have certainly enjoyed my life there since.

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I: You prefer to live in Canada than in the States?

Z: Not really, I enjoyed both countries very much although the cultures are different – the way the funding agencies are set up for example. Also because we inherited our system from England to some extent, our academic programs are shaped a little bit by our history.

I: But now the Canadian is more geared towards the US system.

Z: Yes, there's a lot of evolution around the world now, [with the US system] gradually emerging as the most common choice. But at the graduate level, I think we remain different in terms of less course work and more emphasis on the thesis … as they do in England and Europe. In that sense, we remain separate. At the undergraduate level, we [Canada and US] are very similar, I think.

I: Your early work in statistics was quite theoretical dealing with more fundamental conceptual issues than applications to concrete problems. What led you into the area of applications?

Z: When I first graduated, I thought I was really smart. I thought I really understood statistics. When I wrote all those abstract symbols on the blackboard or in my notes, I understood perfectly what they meant within the mathematical context. But it was consulting that revealed my overly optimistic self-evaluation and started me on the road to getting interested in applications. I would meet with the engineers and talk to them about things like, for example, the technical idea of independence of two random variables. They wouldn't understand what I meant, so I would start to explain it to them only to realize that when I started to translate this mathematical language into something that they could understand, I was having difficulties. I realized for the first time that what I called "independence" is actually conditional independence. This kind of interaction began to make me realize that I didn't really understand what I once thought I did. I learnt a lot about my subject from trying to explain to them. They helped me in that way and, of course, I eventually helped them. I found it interesting to work on the design of long span highway bridges. Consulting did spur me on. I think statistical consulting is a very sensible or at least complementary alternative to research, as a way of keeping up with the discipline and being motivated to study more. I certainly would encourage all statisticians to get involved in some such activities. It is even better when you get to do research work with people in some other field.

I: Did any of your consultation work give rise to some theoretical problems?

Z: Yes, indeed, that's the whole thing, isn't it? Unless you are working according to a very strict time table, which you sometimes have to do in consulting work, if you have the time, there is always an unsolved theoretical problem of interest hidden in the consulting problem. Indeed, textbook solutions almost never work. They have to be adapted in some way to fit the particular problem you are addressing. That is even more true today because generally academics and even non-academics have become more sophisticated about statistical methods. So when they finally come to talk to the statistical consultant the problem will likely be quite sophisticated and that means there is likely to be some interesting theoretical alternatives. In my case, the bridge design problem got me into extreme value theory. The work with my colleagues developed an alternative approach to extreme value theory. It was a useful contribution in some ways.

I: On that particular problem, did the engineers seek you?

Z: Yes, they knew they needed a statistician. Unlike structural bridges where you have to build to carry the maximum imaginable load such as an army tank or truck, in the case of the long span bridge, spanning a thousand meters say, now you have to go to the maximum statistical load of traffic since you can't realistically picture the bridge to be completely covered with say army tanks or heavily loaded trucks. That would be unimaginable as a statistical event. They understood that and that's why they came to me. I must say that they already knew a fair bit about statistics when they came to see me. That enabled a fairly rich communication on the problem and I benefited from it on what was to be my first big consultation project though I had quite a few smaller ones. This was done over one to two years, and I had 2 or 3 publications coming out of it. Also, there was a bridge design code, the first one ever published for the design of long span bridges. It was eventually endorsed by the American Society of Civil Engineers and at that time anyway, it became the code that could be used by engineers designing long span bridges – so my colleagues told me. But I'm not an engineer and I've not followed the history of what happened since then.

I: You once described yourself as a Bayesian. Could you explain to a non-specialist what that means?

Z: I think all of us are Bayesians in the sense that when we get up in the morning and go through a day, we have to make a lot of judgments based on our experience and knowledge gained in the past and our anticipation of things to come. What distinguishes the Bayesian theory is that it tries to formalize what you and I actually do to make decisions, namely use our background. The formalization equates uncertainty and probability. Now that I think of it, we all do that anyway. When we are say betting on a soccer match, we arrive at a bet where I offer you 5 to 3 odds on team A. That is a quantification of my belief about the outcome of the game. I think that was actually the famous de Finetti's idea when he proposed probability as a measure of uncertainty. He realized that in ordinary conversation we are always making predictions about things being likely or probable, rain being less likely tomorrow, etc. Since probability is already a natural language in ordinary human conversation formalizing its role in inference seems appealing. Coming back to Kolmogorov, this formalization would be a way of defining probability to fit into the Kolmogorov framework and thus make the probabilities in this Bayesian framework bona fide probabilities. This is what really distinguished Bayesian theory. When Kolmogorov developed his axioms, the relative frequency definition of probability is the one involved. You think of the probability of heads being one half for a toss of a coin as meaning the fraction you will get

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by tossing the coin over and over again, and calculating the fraction of those tosses when it turns up heads. But, of course, that theory falls on hard ground when you think about the probability of a highway bridge falling down in any one year as being 1 in 100 by design. You cannot imagine building that bridge over and over again repeatedly and running each replicate for a year to find out what fraction of them actually fell in that year. So the Bayesian theory came into its own because it gave an effective alternative to the relative frequency theory. As a result, it has become immensely fashionable these days in a whole variety of disciplines.

I: Who was Bayes?

Z: [Thomas] Bayes was actually a minister in the Presbyterian Church. Although he was a theologian, he actually wrote and published one paper on something like number theory. But he never published his famous thesis on probability. It was only published after he died, in 1764, I think, through Richard Price, a friend of his who had gone through his papers on his desk and found the famous thesis. He [Price] presented this paper to the Royal Society in England after Bayes had died. It pretty much lay dormant. The famous Bayes Theorem appeared in that paper in a certain way and he is therefore accorded the honor of being its discoverer. However, Laplace in France came to the same approach independently and some years later, Laplace developed a theory of probability based on applying probability to uncertainty. But it was only in the last half of the 20th century that the theory began to bloom and nowadays it's quite standard.

I: It wouldn't sound the same to call one a Laplacian.

Z: No, that's right [*laughs*]. Bayesian and Laplacian mean quite different things.

I: Mathematicians often see the conclusions of statistical investigations as non-rigorous and even subjective. Does statistics have rational foundations that validate the methods of inference that have been developed and used?

Z: The Wald framework was an attempt to rationalize decision making. The Bayesian framework is based on axioms. In fact, there is a complete Bayesian decision theory based on axioms. This framework is taken in conjunction with the axioms developed by economists to imply the existence of something called the "utility function", a measure of gain when an action is taken. So the Bayesian framework incorporates probability, which is axiomatic, and utility, which is also axiomatic. The rational theory of Bayesian statistics is based on axioms of both theories. Wald's theory was deficient in that his so-called "loss function" was not itself predicated on axiomatic foundations. Its role seems to be analogous to that of 'point' or 'line' in geometry as a basic building block on which to create an axiomatic theory. But the meaning of the loss function proved more elusive. In reality, the business of statistics doesn't derive from any axiomatic foundations and is inductive rather than deductive. One of the great things about the subject is the great freedom in exploring data and knowledge discovery. Yet there is the deductive side, which is one of the hallmarks of the subject. It does stand on rational principles. There are the algorithms and you have to know how they work. There are the various performance criteria like unbiasedness or asymptotic efficiency. These are things meant to justify the methods even though you know the samples are never going to be infinite. Nowadays what has become a fairly standard alternative to having a broader based performance theory is computer simulation – you try a whole variety of artificial situations to see whether you get the right answers. That is not the same as theorems, of course, and we can't ignore theorems. Simulation may be reassuring but it is not quite the same as the truth expressed in a theorem.

I: Are there cases where for a given problem different statistical methods actually give different results?

Z: Oh yes, indeed. It is important not to apply statistics mechanically. One has to develop some understanding of the problem and apply the methods in an intelligent way. If you do get different answers, you face a real challenge and you have to go after the data to find out why.

I: In that case what is true becomes subjective.

Z: Yes … it depends on what is meant by "true". The result of it is that the state or validity of belief depends on the evaluation of the data and the degree to which one or another of these analyses will have contributed to the change in opinion or belief. The outcome is not the same as the outcome of a theorem where by a matter of definition you have the notion of 'truth'.

I: Thirty years ago, the common perception of statistics is that it is about finding averages, standard deviations, confidence intervals and other statistical quantities. How much has this perception changed since then?

Z: Tremendously. I think the biggest thing to have changed statistics has been the recognition that it has something to contribute to science. I mentioned earlier that statistical science started to emerge as an important discipline in the latter part of the last century. It made a shift in favor not so much of applications but collaborative inquiry in other disciplines. Statistics took on a much different nature. It became a sort of detective job to look at data often in conjunction with scientists from other disciplines to try to divine some new knowledge from that data. That in turn has led to a lot of theoretical challenges for statistics. It's now in a very healthy state with questions coming from other disciplines. At the same time, I think that the core must be preserved. I fear sometimes that we are awash in applications and that people who do really work on the hardcore of mathematical statistical theory may be losing out in postgraduate programs, research programs and so on. I fear that this may lead to a loss of our identity. Statistics students know there are all kinds of options in areas like biology or biostatistics where they tend to gravitate rather than work on subjects that require a lot of hard mathematical background. But I must emphasize that this kind of work can require a lot of difficult, sometimes even mathematical, thinking.

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I: Some people seem to think that statistics does not involve too much deep theoretical thinking when one is applying it.

Z: Yes, but even in applied statistics, it can involve an awful lot of thought and understanding as I learned when I first started out in consulting. On the other hand, you are absolutely right – applied statistics can offer opportunities for purely routine analysis.

I: Your recent research interest is in environmetrics. Is that a new discipline? Could you tell us something about it?

Z: Thank you for that question. It's actually quite new and it began, I think, with a group at Stanford University in the seventies organized under the auspices of an organization called SIMS (Society of Institutes of Mathematical Scientists). It was set up to try and find important societal problems that could be addressed by mathematicians and statisticians. So a group was created at Stanford to look at air pollution problems. It was under the direction of Paul Switzer. They did a lot of very good things, both theoretical as well practical, studying air pollution. The great thing about that group is that a great many people, academics and non-academics, students, faculty got involved in seminars and projects in learning about this world of environmental statistics. That was how the subject got started. Air pollution was quite a problem in California at that time. The name itself may have come from the President of SIMS, Don Thomson, or it may have come from Abdel El-Shaarawi who is at this workshop for a couple of weeks. In any case, it was born as a discipline in the latter part of the 20th century. On the other hand, there wasn't really a lot of interest in the subject in mainstream statistics until about 10 years or so ago. Then it started to really take off. It's now a flourishing discipline with lots of sessions at conferences and so on.

I: Is it very multi-disciplinary?

Z: Yes, it's inherently multi-disciplinary. At conferences and workshops, you will find people from statistics and non-statistics coming together and talking about this kind of questions – research scientists, meteorologists, even civil engineers.

I: Recently there has been much concern about global climate change. Moreover, the Intergovernmental Panel on Climate Change said it is very likely due to anthropogenic sources rather than natural sources. What is your position on this matter as a statistical scientist?

Z: Wow, I should start out by saying that I don't have the expertise of the panel that won the Nobel Prize for their work. But from the statistical perspective, I think what is interesting is the great uncertainty that abounds in that field. A lot of discussion at our workshop has been around the question of which model to use, for example, how you plug-in the uncertainty about these models, which kind of scenarios to use, and so on. There is a healthy recognition that there is a lot of uncertainty about this whole question of climate change. In particular, there is a lot of uncertainty about how much is exactly due to anthropogenic causes, how much is due to natural process. I know that the International Panel on Climate Change has come down saying it is very likely that climate change is, to a substantial extent, due to anthropogenic causes, but trying to figure out how much seems quite a challenge. Of course, statistics is always about analyzing uncertainty and quantifying it and so on. It's an important opportunity for statisticians to get involved in what is arguably the most important issue of our age. We must do that and we must get involved in this kind of questions.

I: Were there any statisticians on the Panel itself?

Z: Hardly any, Peter Guttorp being the only one I know. But I was involved in the early 1990s, thanks to the International Statistical Institute, in trying to get ourselves as statisticians on that Panel, and we did not succeed. I don't know why. At the same time I do know that these scientists do know a lot of statistics, so I'm not saying their work is flawed. On the other hand, there's a lot of discussion recently about something called a "hockey stick", with a blade that rises steeply from the handle and tells us that the climate changed, tentatively anyway, a lot over the last century. There has been a lot of controversy about that stick among non-statisticians, as to what that really represents and there is an argument that it is flawed. That analysis anyway might have benefitted from some input by statisticians. How such an expensive project was launched and collected so much data without having statisticians on board is a mystery.

I: Do you have any reservations about the general findings?

Z: No, it only exemplifies that all these things are uncertain and that things could be a lot worse than you would have it … One other thing is the "Prudence Principle" says that if you don't know what's going on, you had better be conservative. Even though we are uncertain about what has happened, I think it's appropriate to take some action to reduce our impact on the environment, just in case the worst case scenario might in fact obtain.

I: Do you think that statistics should be made compulsory in the undergraduate science curriculum or even in high school?

Z: I certainly do. In my university, a great many students do and they take it over a period of 4 years – 3500 to 4000 students in any one year. They are not all taught by statisticians. High school is a bit trickier because I know some examples where teachers, who don't have the resources in terms of projects or interesting demonstration examples, tend to rely on using these methods that you described in one of your earlier questions on standard deviations, confidence intervals and that that kind of mechanical exercises. I've seen some of that in my own experience. In that case, it might do more harm to do statistics in high school because it might just turn students off and make them not do it in the university. .. About 100 years ago, H.G. Wells said, "Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write." I believe that the time has come and everybody ought to have some knowledge of statistics. In the modern world, we are inundated with data. It used to be that there

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was not enough data, but nowadays, there is far too much data. I think the average citizen has to cope with figures and information and make important decisions about his or her life, the government and so on. I think that knowledge of statistics will certainly be needed.

I: Statistics is often perceived to have wide applicability to other disciplines and hence have higher market value in terms of career opportunities. What advice would you give to undergraduate or graduate students who are motivated to specialize in statistics?

Z: I guess these are valid reasons. I think the subject has its own beauty and worth studying for its own sake, but I am amazed to have found a demand for statisticians over the entire span of my career. Except for a brief period following the Tiananmen Square episode, statistics graduates, particularly at the Masters and doctoral degree level had no difficulty finding work. Over the last 30 years or so, there has been a tremendous demand and the trend seems be growing. The specific advice I would give to someone interested in a non-academic career in statistics would be to attain the Masters level because at that level you learn statistics to some depth where you can apply it on a wide range of problems. Undergraduates sometimes get jobs in that field but I think those jobs tend to be less than interesting. They do not really open up a wide range of interesting problems. It's not the money issue. The job satisfaction is much greater based on a Masters degree than an undergraduate degree.

Volume 20:

Mathematical Horizons for Quantum Physics

edited by **Huzihiro Araki** *(Kyoto University, Japan)*, **Berthold-Georg Englert** *(Centre for Quantum Technologies, National University of Singapore, Singapore)*, **Leong-Chuan Kwek** *(Centre for Quantum Technologies, National University of Singapore, Singapore & Nanyang Technological University, Singapore)*, & **Jun Suzuki** *(National Institute of Informatics, Japan)*

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Institute for Mathematical Sciences
National University of Singapore

3 Prince George's Park
Singapore 118402

Phone: **+65 6516-1897**
Fax: **+65 6873-8292**

Email: ims@nus.edu.sg

Website: http://www.ims.nus.edu.sg

Editors: TAN Ser Peow
mattansp@nus.edu.sg

Denny LEUNG
matlhh@nus.edu.sg

Drafts & Resources: Claire TAN
Web: Stephen AUYONG
Printer: World Scientific Publishing Pte Ltd

For calls from outside Singapore, prefix **65** to local eight-digit telephone numbers.
For email, add the following domain name: **userid@nus.edu.sg**

IMS Staff

Louis CHEN	Director	6516-1900	imsdir
TAN Ser Peow	Deputy Director	6516-1898	mattansp
Emily CHAN	Assistant Manager (Finance)	6516-1893	imscec
Claire TAN	Executive (Human Resource)	6516-1892	imstlf
Stephen AUYONG	IT Manager	6516-1895	imssass
Jolyn WONG	Laboratory Technologist	6516-1890	imswwy
Agnes WU	Management Assistant Officer (Secretary)	6516-1897	imswua
Nurleen BINTE MOHAMED	Management Assistant Officer (Housing)	6516-1891	imsnm
Rajeswri	Operations Associate		imsrs