Mathematics People

Hirachi Receives Bergman Prize

KENGO HIRACHI of the University of Tokyo has been awarded the 2006 Stefan Bergman Prize. Established in 1988, the prize recognizes mathematical accomplishments in the areas of research in which Stefan Bergman worked. The prize consists of one year's income from the prize fund. Currently this income is about US$25,000 per year.

The previous Bergman Prize winners are: David W. Catlin (1989), Steven R. Bell and Ewa Ligocka (1991), Charles Fefferman (1992), Yum Tong Siu (1993), John Erik Fornæss (1994), Harold P. Boas and Emil J. Straube (1995), David E. Barrett and Michael Christ (1997), John P. D'Angelo (1999), Masatake Kuranishi (2000), László Lempert and Sidney Webster (2001), M. Salah Baouendi and Linda Preiss Rothschild (2003), Joseph J. Kohn (2004), and Elias M. Stein (2005). On the selection committee for the 2005 prize were Michael Christ, John P. D'Angelo (chair), and Charles Fefferman.

Citation

The Bergman prize for 2006 is awarded to Kengo Hirachi of the University of Tokyo for his deep work on the singularities of the Bergman and Szegő kernels and their relationship to CR geometry. Hirachi's work employs a wide range of tools in geometry and analysis, including several complex variables, the complex Monge-Ampère equation, microlocal analysis, parabolic invariant theory, explicit computations, and computer algebra packages.

In a paper in the *Annals of Mathematics* (2000) Hirachi constructed CR invariants of strongly pseudoconvex boundaries via a deep study of the logarithmic singularity of the Bergman kernel. He has proved various results linking the Bergman and Szegő kernels, and he has made significant progress to a program in which the Bergman kernel function plays a role analogous to the heat kernel of Riemannian geometry.

The Bergman kernel function of a bounded domain D in complex Euclidean space $\mathbf{C}^n$ is the integral kernel for the orthogonal projection from $L^2(D)$ to the closed subspace of holomorphic functions in $L^2(D)$. Let $\overline{D}$ denote the closure of D, and let Δ denote the boundary diagonal. When D is strongly pseudoconvex (more generally when the $\overline{\partial}$-Neumann problem is subelliptic) the Bergman kernel function is smooth on $\overline{D}\times\overline{D}-\Delta$. In 1974 Fefferman established an asymptotic expansion for the Bergman kernel K on strongly pseudoconvex domains. Let r denote a smooth defining function for D. There are smooth functions ϕ and ψ on $\overline{D}$ such that $K=\phi r^{-n-1}+\psi\log(r)$.

In 1979 Fefferman described an analogy between CR geometry and Riemannian geometry in which the Bergman kernel is analogous to the heat kernel. Since then many authors have studied the relationship between the singularities of the Bergman kernel and CR geometry, relating the complex Monge-Ampère equation to the invariant theory developed by Chern-Moser-Tanaka, thereby developing the analogy. Bailey-Eastwood-Graham expressed the singularity of ϕr^{-n-1} in terms of CR invariants of the boundary of D, but the coefficient ψ of the logarithmic term has remained more mysterious.

Kengo Hirachi

One of Hirachi's striking contributions is an expression for the singularity of $\psi\log(r)$ in terms of so-called Weyl functionals of weight k. For weight k, with $k\le n+2$, he proved that all Weyl invariants of weight k are CR invariants and vice versa.

Hirachi has also done important work relating the Bergman and Szegő kernels. The Szegő kernel is analogous to the Bergman kernel; its domain is square-integrable functions on the boundary with respect to some smooth surface measure dm, and it projects to boundary values of holomorphic functions. There is an asymptotic expansion for the Szegő kernel on strongly pseudoconvex domains as well, where the exponent $-n-1$ aboveis replaced by $-n$.

Consider $\int_{bD}\psi dm$, where ψ is now the coefficient of the log term in the formula for the Szegő kernel. Hirachi proved that this integral is independent of the choice of smooth measure dm, and that it is invariant under smooth (strongly pseudoconvex) deformations of the domain D. Any smooth *convex* domain whose boundary has nowhere vanishing Gauss curvature can be deformed smoothly to a ball, whose Szegő kernel has no logarithmic terms. Hirachi's theorem therefore implies that $\int_{bD}\psi dm=0$, and consequently ψ must vanish somewhere. Hirachi

shows in many other cases (e.g., in dimension two) that $\int_{bD} \psi dm = 0$.

It is often useful to provide links between the Bergman and Szegő kernels. Hirachi introduced a meromorphic family of kernel functions including both the Bergman and Szegő kernels as special values, thereby relating their asymptotic expansions. Hirachi also formulated and proved a transformation law for the Szegő projection on abstract strongly pseudoconvex CR manifolds, generalizing work of Fefferman for boundaries of domains.

In addition, Hirachi modified the microlocal methods of Kashiwara and used results of Webster to study the Bergman kernel on real ellipsoids. Hirachi proved, for example, that for all small perturbations (as real ellipsoids) of the ball, the log term must be present (whereas both kernels for the ball have no log term). With Komatsu, Hirachi developed a successful theory of local Sobolev-Bergman kernels (where one projects to the holomorphic functions in various Sobolev spaces). Hirachi and Komatsu used microlocal analysis to compute various universal constants in CR geometry. With Fefferman, Hirachi showed that the coefficient of the log term in an asymptotic expansion of the Szegő kernel is a multiple of the CR curvature. Also in that paper the CR curvature is expressed in terms of the Fefferman-Graham metric.

In summary, Hirachi has contributed new and basic facts on the Bergman and Szegő kernels for strongly pseudoconvex domains, and he has related the singularities of these kernels to polynomials in the Chern-Moser-Tanaka invariants. His work establishes deep and important connections between complex analysis and CR geometry.

Biographical Sketch

Born on November 30, 1964, Kengo Hirachi received his B.S. (1987), his M.S. (1989), and his Dr.Sci. (1994) from Osaka University. The advisor for his doctoral dissertation was Gen Komatsu. After holding a position as a lecturer at Osaka University, Hirachi took his present position as an associate professor at the University of Tokyo. He has been a visitor at the Mathematical Sciences Research Institute in Berkeley, at the Erwin Schrödinger Institute for Mathematical Physics in Vienna, and at Princeton University. His honors include the Takebe Senior Prize (1999) and the Geometry Prize (2003), both given by the Mathematical Society of Japan.

About the Prize

The Bergman Prize honors the memory of Stefan Bergman, best known for his research in several complex variables, as well as the Bergman projection and the Bergman kernel function that bear his name. A native of Poland, he taught at Stanford University for many years and died in 1977 at the age of 82. He was an AMS member for thirty-five years. When his wife died, the terms of her will stipulated that funds should go toward a special prize in her husband's honor.

The AMS was asked by Wells Fargo Bank of California, the managers of the Bergman Trust, to assemble a committee to select recipients of the prize. In addition, the Society assisted Wells Fargo in interpreting the terms of the will to assure sufficient breadth in the mathematical areas in which the prize may be given. Awards are made every one or two years in the following areas: (1) the theory of the kernel function and its applications in real and complex analysis and (2) function-theoretic methods in the theory of partial differential equations of elliptic type with attention to Bergman's operator method.

—Allyn Jackson

Mathematics Wunderkind Wins Siemens-Westinghouse Competition

"I don't think I have ever met anyone with such enthusiasm and raw talent for math," said Peter Ebenfelt of the University of California, San Diego. He was talking about Michael Viscardi, an extraordinarily talented young man who in December 2005 was named the top individual winner in the Siemens-Westinghouse competition. Viscardi, sixteen years old, wrote a paper on the Dirichlet problem that netted him the top prize of a US$100,000 college scholarship. The paper has already been accepted for publication. In addition to excelling in mathematics, Viscardi is a talented musician and has won several music prizes.

Michael Viscardi

Of the nineteen students winning scholarships in the prestigious Siemens-Westinghouse competition (six went to individuals and six to teams), Viscardi was the only one with a mathematics project. His success was widely reported in the local and national media, including an interview on National Public Radio and an appearance on ABC *World News Tonight* as "Person of the Week".

Viscardi, whose father is a software engineer and whose mother holds a Ph.D. in neuroscience, is home-schooled. He studied high school mathematics on his own, using standard textbooks. When he reached eighth grade, he started taking mathematics courses at UCSD. His first course there was calculus, taught by Ebenfelt, who recalled that Viscardi, then thirteen years old, was the best student in the class. He would often come to Ebenfelt's office hours, not so much to discuss the course material, which he could study on his own, but to talk about mathematics problems he found in the *American Mathematical Monthly*.

The next year, Viscardi took an analysis course intended for junior and senior mathematics majors preparing for doctoral work in mathematics. UCSD faculty member Linda

Photo of Michael Viscardi is courtesy of the Siemens Foundation. Photograph by Peg Skorpinski.

Rothschild taught the course. "His performance was truly remarkable, and I would have been very happy to recommend him then for a top Ph.D. program in mathematics," she recalled. The following fall he took a graduate class in complex analysis from faculty member Salah Baouendi, who also raved about Viscardi's performance, which was at the level of the top graduate students in the course. "He is simply in a class by himself, truly amazing," Baouendi commented. "I am convinced that he has an enormously bright future ahead of him."

Baouendi's course awakened in Viscardi a deep interest in complex analysis, so much so that he decided to try to do research in this area and asked Ebenfelt for a topic. Ebenfelt proposed the topic that led to Viscardi's winning paper on the Dirichlet problem for the Laplace operator in a smoothly bounded, simply connected planar domain U. As Ebenfelt explained it, the problem is the following. Given a continuous data function h on the boundary ∂U, find a harmonic function in the interior whose boundary values are h. This problem is already well understood, but Viscardi considered the case where the data function h is the restriction to ∂U of a *rational* function (of z, that is, a quotient of two holomorphic polynomials) and asked for what U is it the case that all solutions are *rational* harmonic functions? His paper completely characterizes all such domains both geometrically and function-theoretically. The paper, which lists Ebenfelt and Viscardi as joint authors, has been accepted by the journal *Computational Methods and Function Theory*. Ebenfelt noted that he is not usually a coauthor on his student's papers but that Viscardi insisted on it.

"Michael is a wonderful person," Ebenfelt commented. "He is extremely pleasant and very enthusiastic about math. It is a real treat to discuss math with him. It's not very often one has a student who gets so excited about a theorem or lemma that his face practically glows." If his UCSD professors are effusive about his prodigious mathematical talent, they are equally charmed by his winning personality. According to Rothschild, Viscardi is "extremely likeable, sociable, and modest, with a great sense of humor."

And what is he up to nowadays? Viscardi replied in an email message that captures his astounding capacity for mathematics in the winsome voice of a sixteen-year-old: "When I started taking Calculus with Professor Ebenfelt back in 8th grade, I learned that he wrote a book with Professor Baouendi and Professor Rothschild titled *Real Submanifolds in Complex Space and Their Mappings*. I thought that was a pretty cool title, and I also couldn't get past the first page! It's part of Differential Geometry, so my temporary goal in math was to eventually take that subject. That's exactly what I'm taking now, which is very nice! I can now read a few more pages of the book." In fall 2005 he was taking graduate courses in differential geometry and analytic number theory.

Viscardi is also continuing to do joint research with Ebenfelt, focusing on the Pompeiu problem, which was originally proposed in the 1920s by D. Pompeiu as a problem in integral geometry. The problem is the following. One is given a function f continuous in the plane and a bounded simply connected domain U. The integral of f over U is zero, as are all integrals over rigid motions of U. Is f identically zero? The problem can be stated in other, equivalent, ways, in particular as a partial differential equations problem. Ebenfelt's and Viscardi's work is still in the very early stages, and it is not clear yet where it will lead.

When he is not doing mathematics, Viscardi loves to play music. If he does more of one and less of the other, he starts to feel "a little bit funny," he said. "I really need both in order to feel somewhat balanced. But math and music are in fact very similar—both are beautiful and elegant." He is an accomplished pianist and violinist, a composer, and concertmaster of the San Diego Youth Symphony. He is also the first violinist of the San Diego Youth Symphony String Quartet. Among his honors in music are the first place prize in the 2005 H. B. Goodlin Foundation Scholarship Competition in the Senior Piano Division, and the first place prize in the 2005 Music Teachers' Association of California Concerto Competition, for violin.

Viscardi has applied to Harvard, the Massachusetts Institute of Technology, and Caltech. At the time of this writing he had been accepted at Harvard, and it seems inevitable he will be accepted anywhere he applies. As far as future career plans go, Viscardi said he would like to become a mathematician, "while doing as much music as I can." Clearly this is a young man with a brilliant future ahead of him. According to Baouendi, the work for which Viscardi won the Siemens-Westinghouse competition could easily be a Ph.D. dissertation. "What more can I say?" Baouendi declared. "Sixteen-year-old Michael is already performing as a professional mathematician of high caliber. This is indeed truly extraordinary."

—Allyn Jackson

Raman Awarded TWAS Prize

PARIMALA RAMAN of the Tata Institute of Fundamental Research has been awarded the 2006 prize of the Academy of Sciences for the Developing World (formerly the Third World Academy of Science, TWAS). Raman was awarded the prize in mathematics "for her work on the quadratic analogue of Serre's conjecture, the triviality of principal homogeneous spaces of classical groups over fields of cohomological dimension 2 and the u-invariant of p-adic function fields."

The Academy of Science for the Developing World annually awards prizes of US$10,000 each to scientists from developing countries who have made outstanding contributions in the fields of agricultural sciences, biology, chemistry, earth sciences, engineering sciences, mathematics, medical sciences, and physics.

—From a TWAS announcement

Polterovich and Tsai Awarded André Aisenstadt Prize

Iosif Polterovich of the University of Montreal and Tai-Peng Tsai of the University of British Columbia are the recipients of the 2006 André Aisenstadt Prize of the Centre de Recherches Mathématiques (CRM) of the University of Montreal. Polterovich was honored for his work in geometric spectral theory, and Tsai was selected for his work in nonlinear partial differential equations.

The André Aisenstadt Mathematics Prize consists of CA$3,000 and a medal. It is awarded to recognize talented young Canadian mathematicians in pure and applied mathematics who have held a Ph.D. for no longer than seven years.

—From a CRM announcement

Montalbán Awarded ASL Sacks Prize

Antonio Montalbán of the University of Chicago has been awarded the 2005 Sacks Prize of the Association for Symbolic Logic (ASL). The prize is awarded annually for the most outstanding doctoral dissertation in mathematical logic. According to the prize citation, Montalbán's thesis "contains deep and major contributions to an impressively broad array of areas in logic, including computability theory, reverse mathematics, and effective mathematics." Montalbán received his Ph.D. in 2005 from Cornell University.

The Sacks Prize was established to honor Gerald Sacks of Harvard University and the Massachusetts Institute of Technology for his contribution to mathematical logic. The prize consists of a cash award and five years' free membership in the ASL.

—From an ASL announcement

Pillichshammer Wins Information-Based Complexity Young Researcher Award

Friedrich Pillichshammer of Johannes Kepler University in Linz, Austria, has been awarded the Information-Based Complexity Young Researcher Award for 2005. The award recognizes significant contributions to information-based complexity by researchers who have not reached their thirty-fifth birthdays by September 30 of the year of the award. The prize consists of US$1,000 and a plaque. The award will be presented at the Schloss Dagstuhl Seminar on Continuous Algorithms and Complexity in September 2006. The prize committee consisted of Josef Dick, University of New South Wales; Frances Kuo, University of New South Wales; Christiane Lemieux, University of Calgary; Peter Mathe, Weierstrass Institute for Applied Analysis and Stochastics; Joseph F. Traub, Columbia University; and Henryk Wozniakowski, Columbia University and University of Warsaw.

—Joseph Traub, Columbia University

Otto Receives Leibniz Prize

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) has announced the winners of its 2006 Gottfried Wilhelm Leibniz Prize. The DFG Grants Committee named eleven scientists and academics as recipients of the most valuable research prize in Germany. The award of up to 1.55 million € (approximately US$1.8 million) funds research work over a five-year period and can be used flexibly by the prizewinners.

One mathematician was among the Leibniz prizewinners: Felix Otto of the Universität Bonn, whose area is analysis of partial differential equations. He received a grant of 1.55 million €.

The research conducted by mathematician Felix Otto focuses on the analysis of pattern-forming processes that occur frequently in models used to describe a variety of physical phenomena and often have a multiscale nature. The mathematical tools he uses for his work include advanced analytical methods and numerical simulation. He is particularly interested in micromagnetism, which is especially important for the development of new data storage technology, as well as coarsening and growth processes, which are of particular importance in material science.

After obtaining his doctorate from the Universität Bonn, Otto first went to the USA, where he was a visiting scholar at the Courant Institute at New York University and then went to the University of California at Santa Barbara. He returned to Bonn in 1999 to take up a chair at the Institute for Applied Mathematics. Amongst the national and international prizes he has received are a Sloan Research Fellowship and the Max Planck Research Award.

—From a DFG news release

Rhodes Scholarships Awarded

Four students in mathematical sciences are among the thirty-two American men and women who have been selected as Rhodes Scholars by the Rhodes Scholarship Trust. The Rhodes Scholars were chosen from 903 applicants who were endorsed by 333 colleges and universities in a nationwide competition. The names and brief biographies of the mathematics scholars follow.

Alison Crocker of Poughkeepsie, New York, majors in physics and mathematics at Dartmouth College. She has done summer research at the Cold Regions Research and Engineering Laboratory, where she built and tested a

proof-of-concept ice detection system for aircraft. She is an All-American cross-country skier and a rower on the U.S. junior national rowing team. She plans to do a doctorate in astrophysics at Oxford.

ADAM D. CHANDLER of Burlington, North Carolina, is a senior at Duke University majoring in mathematics. He has conducted numerous research projects in applied computational mathematics, including work on computational quantum chemistry, molecular evolution, and traffic modeling. As a research intern at the National Security Agency, he focused on problems in cryptography. He is a Goldwater and Byrd scholar and managing editor of the *Journal of Young Investigators*. He is a cellist and president of the Duke Symphony Orchestra, and he has volunteered at an orphanage in Tanzania. He plans to study for an M.Sc. in applied and computational mathematics at Oxford.

RAHUL SATIJA of Potomac, Maryland, is a senior at Duke University who majors in biology and music and minors in mathematics. He has conducted research in bioinformatics and has won a Faculty Scholar Award from Duke University and a Meritorious Solution Award at the International Mathematical Contest in Modeling. He is the recipient of a Goldwater Scholarship and of Duke's only music performance scholarship. He is concertmaster for the Duke Symphony Orchestra and first violinist of a student string quartet; he also teaches violin to inner-city youths and plays recreational tennis. He plans to work for a D.Phil. in bioinformatics at Oxford.

ELIANA HECHTER of Phoenix, Arizona, is an eighteen-year-old senior mathematics major at the University of Washington. She has done research on the neurobiological basis of behavior in marine fauna and has been supported through a Vertical Integration of Research and Education (VIGRE) grant in mathematical sciences from the National Science Foundation. She works as a research assistant at the Center for Cell Dynamics and as a teaching assistant for advanced calculus. She is a Goldwater Scholar, a creative writer, and a long-distance runner. She plans to study for a D.Phil. in mathematics at Oxford.

Rhodes Scholarships provide two or three years of study at the University of Oxford in England. The value of the Rhodes Scholarship varies depending on the academic field, the degree (B.A., master's, doctoral), and the Oxford college chosen. The Rhodes Trust pays all college and university fees and provides a stipend to cover students' necessary expenses while they are in residence in Oxford, as well as during vacations, and transportation to and from England. The total value averages approximately US$40,000 per year.

—From a Rhodes Scholarship Trust announcement

Professor of the Year Awards Announced

M. VALI SIADAT of Richard J. Daley College in Chicago, Illinois, and JIM COYKENDALL of North Dakota State University have been chosen to receive State Professor of the Year awards by the Carnegie Foundation for the Advancement of Teaching and the Council for Advancement and Support of Education (CASE), which cosponsor the awards. The Professor of the Year Awards are intended to reward outstanding professors for their dedication to teaching, their commitment to students, and their innovative instructional methods.

The State Professors of the Year Award Program selects outstanding educators in all fifty states, the District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands. Winners receive personalized award certificates as well as national and local media recognition. State and national winners are chosen on the basis of their dedication to undergraduate teaching, determined by excellence in the following four areas: impact on and involvement with undergraduate students; scholarly approach to teaching and learning; contributions to undergraduate education in the institution, community, and profession; and support from colleagues and current and former undergraduate students.

—From a Carnegie Foundation announcement

Szpiro a Finalist for Descartes Prize

GEORGE SZPIRO, a reporter and columnist for the Swiss newspaper *Neue Zürcher Zeitung*, was named a finalist for the Descartes Prize for Science Communication, given by the European Union. Being named a finalist carries a cash prize of 5,000 € (about US$6,000). Szpiro was cited for his series of stories "Maths for Sunday Morning—50 Stories on Mathematics and Science". He writes a monthly mathematics column that appears on Sundays in the *Neue Zürcher Zeitung*. Szpiro is also the author of the book *Kepler's Conjecture: How Some of the Greatest Minds in History Helped Solve One of the Oldest Math Problems in the World* (John Wiley and Sons, January 2003), which was reviewed in the January 2005 issue of the *Notices*. His latest book, *The Secret Lives of Numbers: 50 Easy Pieces on How Mathematicians Work and Think*, will appear in spring 2006.

—Allyn Jackson

Authors Receive Chauvenet Prize for *Notices* Article

GÜNTER ZIEGLER and FLORIAN PFENDER have been honored with the 2006 Chauvenet Prize of the Mathematical Association of America (MAA) for an article that appeared in the *Notices*. Their article, "Kissing numbers, sphere packings, and some unexpected proofs", appeared in the September 2004 issue. The *Notices* editors extend their congratulations to the authors. Additional details about the prize will appear in the May 2006 *Notices*.

—Allyn Jackson