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FLORIDA STATE UNIVERSITY

Mathematics for the New Millennium

View from the Chair…

*Welcome to the first issue of a new series of newsletters from the FSU Department of Mathematics. We have created **Mathematics for the New Millennium** to share departmental news with you.*

If you studied with us in the Love Building, I have a story for you. As a young faculty member in the early 70's, I taught a senior honors course in which a very bright young man, Frank Baker of Marianna, FL, was a student. Now an attorney, he and his son, Chris, came to see me recently.

Entering the building, Frank exclaimed, "It hasn't changed a bit!" How right he was, but it is home to us – and to Chris Baker, who is now a mathematics/ computer science major.

Our Department, however, is undergoing many changes. In August, Chris Hunter completed his sixth year as Chair and Perrin Wright, 15 years as Associate Chair. On behalf of the department, I thank them for their outstanding service and contributions. As new Chair, I prevailed upon Phil Bowers to accept the Associate Chair position. We are learning on the job.

We have initiated new interdisciplinary graduate programs. Dr. Bettye Anne Case leads the development of a popular professional master's degree program in financial mathematics, and Dr. Jack Quine and I have organized a degree program in bioinformatics and computational molecular biology that will admit its first students this fall. These programs are discussed in this newsletter. The Board of Regents also approved an Actuarial Science undergraduate degree program guided by Dr. Case.

Mark Sussman joined our faculty in 1999. He completed doctoral studies with Stanley Osher at the University of California/LA on incompressible two-phase flow and served as research assistant professor at the University of California/Davis. Agnes Szanto will join us next year. She completed her Ph.D. degree with Dexter Kozen at Cornell University on symbolic computation with polynomial systems, and served a postdoctoral fellowship at the Mathematical Sciences Research Institute in Berkeley. She is currently on academic appointment at Canada's Simon Fraser University.

Retired faculty Ralph McWilliams and Fred Kreimer often visit, and Nick Heerema continues to teach. I am sorry to report that Jim Andrews died in Tallahassee on July 28, 1998. As major professor for five Ph.D. students before retiring in 1994, he was known for his generosity and sense of humor.

Susan Minnerly now serves as Office Manager after she and Pam MacManus transferred duties with the Department of Religion. Upon earning B.Sc. (Biological Science) and M.Sc. (Science Education) degrees from FSU, she taught at Leon High School (Tallahassee) for seven years. She is a music, reading, and needlepoint enthusiast.

We will experience major personnel changes in upcoming years. John Bryant, Robert Gilmer, Chris Hunter, Joe Mott, Perrin Wright and Eutiquio Young have elected to participate in Florida's new Deferred Retirement Option Plan (DROP). By 2003, several senior faculty members will retire or relocate. We plan future hires to offset these losses.

Multidisciplinary computational science is currently a priority. Yousuff Hussaini (who holds the Thinking Machines Chair in Mathematics) will lead FSU's new school of Computational Science and Information Technology (CSIT). CSIT faculty, based in academic departments, will pursue computational multidisciplinary work. In cooperation with CSIT, we expect new hires in computational finance and computational number theory, among other areas.

FSU may soon have a medical school devoted to producing doctors to work with the elderly and in rural areas of Florida. Anticipating this, the 1999 Legislative Session appropriated substantial recurring funds for improvement of science at FSU. We anticipate that some of these funds will support new mathematics faculty.

Recently established Francis Eppes professorships are endowed chairs open to nominations from departments and programs. Francis Eppes, grandson of Thomas Jefferson and a 19th century mayor of Tallahassee, once owned the land upon which Westcott Hall stands. We have nominated Fabrizio Catanese of the University of Goettingen, Germany, who holds the chair formerly associated with Gauss, Riemann and Hilbert. He is a world expert in Algebraic Geometry, an area of increasing research interest among FSU pure mathematicians.

Other areas of departmental research interest are computational and mathematical biomedicine, where new mathematics and new applications of old mathematics are required for the analysis of increasingly complex data. Our research will continue to expand as the new millennium advances.

De Witt Sumners

Professional Master's Degree Programs

Computational Molecular Biology

A new MS degree program in bioinformatics/computational molecular biology will be offered this fall. Students will develop biological, mathematical, statistical, and computational skills to qualify for positions in the modern biotech industry. Internships will be encouraged.

Four academic departments have joined Mathematics in planning and implementing this interdisciplinary degree – Biological Sciences, Chemistry, Computer Science, and Statistics.

New courses are being developed in mathematics, the biological sciences, and statistics for the 2000-01 academic year. The 36 required semester hours allow students to take extra courses for background preparation. Details and a required course list may be found at http://www.math.fsu.edu/~smith/Guides/compbio.html. Applications are also being accepted for Fall 2000 from students who wish to complete the degree in conjunction with doctoral study.

Drs. Jack Quine and De Witt Sumners, both of whom have active research programs in mathematical molecular biophysics applications, direct this new degree initiative. Interacting faculty members include Lloyd Epstein, Tom Keller, and Timothy Moerland (Biological Sciences); Michael Chapman and Tim Cross (Chemistry); Ted Baker, Ladislav Kohout, and Michael Mascagni (Computer Science); and Myles Hollander and Lei Li (Statistics).

Scientists now working in the biotech industry and government agencies, several who are former students or colleagues of the program faculty, advise and assist in planning program improvements. Seminars, symposia, and colloquia will bring field researchers to campus to share information and expertise.

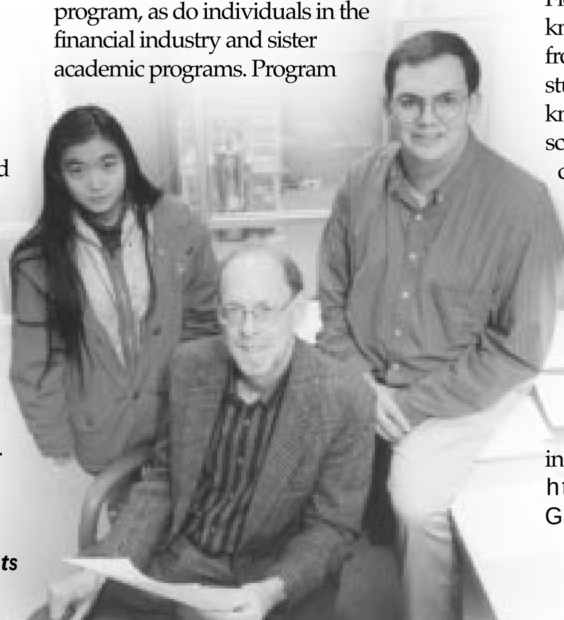
Each student will have a first-year adviser and a supervisory committee of three or more faculty, at least one each from Mathematics and another department. Typical first-semester courses require knowledge of undergraduate mathematics, including multivariate calculus and linear algebra. A basic knowledge of statistics, differential equations, computer programming, genetics, and upper division mathematics is desirable but not required.

Many biotech employers and research groups need researchers at all levels to fill their teams, which provides a career path in biotechnology for scientists at the master's level. Students interested in these programs are likely to have recently earned bachelor's degrees in biological fields or computational fields. Many have biological skills but limited abilities in mathematics and computer science, or mathematics and computational skills without familiarity in biological applications. This program will attempt to produce graduates with interdisciplinary skills.

Says Quine, "In this era of the human genome project, biological research requires quantitative skills that weren't as needed in the last decade. The obvious answer is to hire mathematicians and computer scientists to help with research, but it doesn't much help unless they understand some basic biology. You can teach the biologist more math and computer science, but it's often easier to teach biology to the quantitatively literate."

"What we expect to do is find some graduates in computer science or mathematics, and maybe a few biologists, who have braved their way through calculus and teach them a few skills needed to analyze these new vast databases of biological information. This will require an array of graduate courses from several different departments."

"We hope to find students interested in, and up to, the challenge."



Dr. Quine and students

Financial Mathematics

This spring, the first graduates of FSU's Financial Mathematics interdisciplinary master's degree will join the ranks of mathematicians, engineers, physicists, and business and economics graduates who work as financial engineers and quantitative analysts.

Recent higher mathematics graduates currently employed in this field advise the program, as do individuals in the financial industry and sister academic programs. Program information is listed at the International Association of Financial Engineers website, http://www.iafe.org.

This program is intended to prepare students for work in financial institutions and markets. Specialized courses in computational and theoretical mathematics, statistics, economics, and finance are required. A supervisory committee assists each student in choosing courses that fit his or her interests. Internship participation is encouraged either in the U.S. or through the London Study Center, for those interested in international finance.

Dr. Case

These new specialized courses are valuable to doctoral students in participating departments who want to enhance their employability. An Actuarial Science concentration is available, as are doctoral programs with participating departments.

Faculty members from five departments in three participating colleges developed and guide this degree option – including Bettye Anne Case, David Kopriva, Jerry Magnan, Warren Nichols, Craig Nolder, and Michael Navon (Mathematics); Paul Beaumont and Milton Marquis (Economics); James Ang, Pamela Coats, and Donald Nast (Finance); Kevin Eastman and Patrick Maroney (Risk Management); and Myles Hollander, Fred Huffer, Fred Leysieffer, Ian McKeague, Zufeng Niu, and Kaisheng Song (Statistics). Director Case works with a Steering Committee on program recommendations.

Students from a wide variety of academic backgrounds inquire about the program. Flexibility of course choice (based on previous knowledge and experience) receives high marks from the diverse group of twenty enrolled students. Typical first-semester courses require knowledge of undergraduate mathematical sciences and computing, including multivariate calculus, linear algebra, differential equations, and probability.

Each student must complete five or more courses from the Department of Mathematics and at least five jointly from the departments of Economics, Finance, Risk Management, and Statistics. Supervisory committees include members of all participating departments.

Detailed information, including course offerings, financial aid information, and internship guidelines, may be found at website http://www.math.fsu.edu/~smith/Guides/finmath.html.

Dr. Christopher Tam

Aircraft Noise Research through Applied Mathematics

FSU's Department of Mathematics is internationally recognized as a center of excellence in aircraft noise research. For 25 years, a group of Applied Mathematicians led by Dr. Christopher Tam, a distinguished research professor of mathematics, has focused its scientific expertise on this environmental challenge.

The research team's efforts have led to a better understanding of the generation mechanisms of aircraft noise and the development of noise prediction theories and computer codes. In addition, they are pioneers in the use of computers to simulate jet flows and noise generation, an area of research and application now known as Computational Aeroacoustics.

Dr. Tam's team is credited with first recognizing that both the large turbulence structures and fine scale turbulence of jet flows produce noise almost independently. NASA engineers and the aircraft industry are currently using this information to develop devices and nozzle configurations to reduce jet noise. In fact, NASA has incorporated the FSU theory into its Aircraft Noise Prediction Program, and the prediction code is being used by the aircraft industry here and abroad.

Ten years ago, the team began developing high quality computational methods that would allow them to simulate the generation and propagation of aircraft noise in high performance computers – an extremely attractive research tool which eliminates the need of large and costly testing facilities. Because jet engines operate at extremely high temperatures that are very difficult to handle or reproduce in the laboratory, experimentation and testing by computer is very attractive and cost effective.

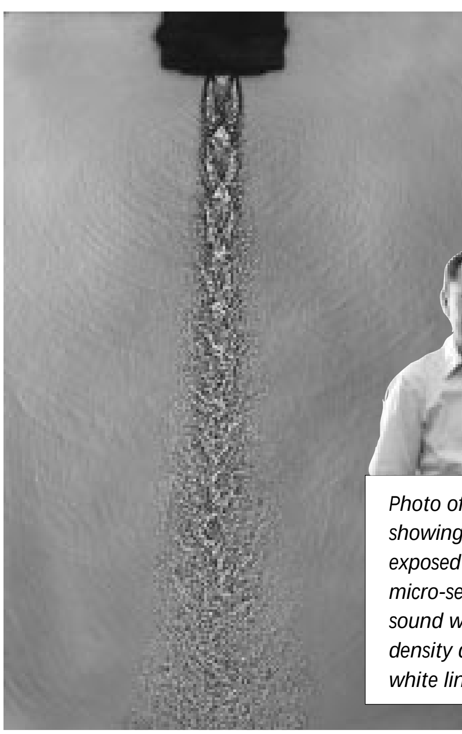


Photo of a supersonic jet discharging from a nozzle showing intense acoustic radiation. This photo was exposed to a strong light source which lasted for a micro-second. During this short period of time, the sound waves hardly moved at all. Because of the slight density difference, the sound waves appear as black and white lines in the photo.

Since then, Dr. Tam has worked with the American Institute of Aeronautics and Astronautics to teach engineers this new technology. He has also, in conjunction with NASA, organized a series of international workshops on Computational Aeroacoustics. Countries such as Germany, France, and England are initiating university and government research centers in this field to support their aircraft industries.

Most of the team's research utilizes high performance computers to develop computational mathematics and algorithms and to conduct large-scale computing and simulation of jet noise, fan noise, and airframe noise.

Dr. Tam stresses that aircraft noise is both an environmental and a business competitiveness issue. In the U.S. and Europe, more and more people live near major airports where noise pollution is a critical environmental problem. Creative noise suppression efforts have significantly reduced aircraft noise *levels* in the last four decades, but the *number* of commercial aircraft continues to increase dramatically. The overall situation is worsening.

Although U.S. airport noise is regulated by the Federal Aviation Administration, some airports have set more stringent noise requirements, such as the night curfews set by the Reagan National Airport in Washington, D.C. and the John Wayne Airport in Orange County, CA. Amsterdam's Schiphol Airport and London's Heathrow Airport also enforce strict regulations. Thus, from a business standpoint, it makes good sense for aircraft manufacturers and jet engine companies to invest significant resources into building quieter jets.

An immediate goal of NASA and the aircraft industry is developing technology to reduce jet aircraft noise by ten decibels within a decade. Computational methodology developed by the FSU research team will play an important role in these efforts.

Dr. Tam envisions future application areas for these methods and fast computing algorithms, such as the automobile industry. He believes that with improved design, assisted by computer simulation, we may someday travel highways in cars so quiet that the music we listen to will sound as clear as if we were at home.

From the Faculty...

Pure Mathematics and Algebraic Geometry

PAOLO ALUFFI

Dr. Paolo Aluffi researches Algebraic Geometry, a sector of Pure Mathematics that he explains both eloquently and with humor:

"This field is growing at an explosive rate, as are several other branches of Pure Mathematics, with frequent major breakthroughs in understanding followed by frantic work to carry these advances to their ultimate consequences. The latest breakthroughs have linked an important abstract construction in the field, called the moduli space of complex algebraic curves, with the most advanced development in particle physics."

"The moduli space of curves is what we call a "variety," an abstract notion to which we apply many operations of the ordinary space we live in. We do so, however, in as many dimensions as we please (rather than the three dimensions we're used to), we work over complex numbers rather than real numbers, and so forth. Such abstract objects are as concrete and real to pure mathematicians as the space we live in."

"The moduli space of curves is a variety whose points correspond to one-dimensional objects. Moving a point within the moduli space can be pictured as having a curve wiggle around – changing shape, length, breaking into two curves, etc. The moduli space is a particularly beautiful and natural object in Algebraic Geometry."

"It seems that Nature also thinks this way, since the latest progress in string theory shows that we can better understand the world of the extremely small, the place where particles such as quarks interact, by understanding moduli spaces. This connection is expressed through numbers computed by counting points of intersections of certain special subsets in the moduli spaces."

"Since 1987, I've focused on Intersection Theory, the branch of Algebraic Geometry that studies performance of

intersection computations, and have developed abstract tools that can be applied to questions involving algebraic curves. I'm refining these tools to apply them to specific questions connected with physics."

"I've also worked on understanding to what extent a variety can acquire "singularities," that is, creases, corners, and other ways a variety can fail to be smooth. To draw another connection with physics, "black holes" are sometimes interpreted as singularities in our ordinary space. My work is aimed at understanding such features from an abstract viewpoint."

"Pure Mathematics work has traditionally been done at a table with pencil and paper, or while talking at the blackboard to other mathematicians. This still happens, but increasingly, a computer often replaces the paper and the blackboard (but not the mathematician!)."

"Two essential components of my work are intense thinking and communicating with other mathematicians, the latter accomplished through extensive traveling to conferences and other institutions. After visiting a collaborator in Stockholm, Sweden, I attended an international conference on intersection theory in Bologna, Italy, and swung by Harvard, where I spent the fall semester on leave."

What is the place of pure, abstract mathematics in a world increasingly dependent on practical applications of science?

Dr. Aluffi feels, "The best answer to this important question looks back a hundred years: what was the point of studying analysis on infinite dimensional normed spaces over the complex numbers at the end of the Nineteenth Century?"

"Without that abstract foundational work, we wouldn't later have had a language to express quantum mechanics. Without quantum mechanics, we wouldn't have understood how to use semiconductors in electronics a few decades after that. Without semiconductors, we wouldn't have supercomputers, CAT scan machines, CD-players, cable televisions, or cellphones today."

"What would be missed by not supporting Pure Mathematics today? Ask your great-grandchildren."

You now have an opportunity to support the students and faculty of FSU's Department of Mathematics with a tax-deductible gift that will enhance our teaching and research efforts. Checks made payable to FSU Foundation Mathematics Fund No. 0223 may be sent to: Philip Bowers, FSU Department of Mathematics, Tallahassee, FL 32306-4510, or to the FSU Foundation, Tallahassee, FL 32306-2660. Questions may also be directed to Dr. Bowers, Associate Chair, by phone (850.644.7405) or e-mail (bowers@math.fsu.edu).

From the Faculty...

Researching Mathematics and Protein Structure At the Mag Lab

JACK QUINE

During a 1999-2000 sabbatical, Dr. Jack Quine, along with a team of scientists and graduate students, is conducting research to determine the structure of proteins using solid-state nuclear magnetic resonance (NMR) at FSU's National High Magnetic Field Laboratory (NHMFL, Mag Lab).

Partially funded by an interdisciplinary grant in the Mathematical Sciences Program from the National Science Foundation (NSF), Quine is contributing mathematical expertise to studies begun by Timothy A. Cross (NHMFL, FSU Department of Chemistry). Mathematics student Jeffrey K. Denny, a key member of the team, is being supported by an NSF Research Training Grant as he completes his doctoral studies with Dr. Quine's direction.

Since the 1950s, the structure of most proteins has been found through the technique of X-ray crystallography, but in recent years, scientists, such as Dr. Cross, have used NMR because proteins can be difficult to crystallize.

Both crystallography and NMR protein structure determination depend on mathematical techniques: structure is not immediately evident from scientific data. The success of this structure determination depends on both mathematical analysis and scientific hardware.

Dr. Quine is working with Dr. Cross to clarify mathematical details of how the geometry of the protein follows from the orientational constraints, such as those obtained in data from Mag Lab experiments.

The mathematical problem in NMR structure determination is to obtain overall structural information from data that is expressed in many different frames of reference. Some scheme must be found to relate all of these frames of reference into a coherent whole.

Dr. Quine has used geometric and matrix algebra techniques to develop algorithms to output protein geometry from NMR data input. Often, the structure is not completely determined by the input: it is essential to determine the nature of needed extra input to obtain a complete solution. Algorithms devised by Dr. Quine and his co-workers have clarified the nature of these extra variables.

While continuing his research at the Mag Lab, Dr. Quine has spoken to local and national groups interested in NMR and structure computations. Last fall, he gave presentations to students of both the University of Massachusetts and the Complex Carbohydrate Center of the University of Georgia, Athens.

In January, Dr. Quine and Mr. Denny spoke on their work at the annual meeting of the American Mathematical Society in Washington D.C. Dr. Quine presented a poster at the Biophysical Society in New Orleans in February and has been asked to speak in a seminar at the Massachusetts Institute of Technology (MIT) in late Spring.

Alumni Updates

Kim Ruane

A native of Lowell, MA, Kim Ruane is currently conducting research in Zurich, Switzerland. Her research has been funded by the National Science Foundation for several years.

Upon receiving her Ph.D. degree in 1996, Kim accepted a three-year postdoctoral position with the topology group at Vanderbilt University. Her research there led to an invitation to research for a year at ETH, a federal technical institute in Zurich.

Before she accepted the ETH offer, Kim was offered a tenure track position as assistant professor at Tufts University in Boston. Now on a one-year leave to accept the ETH offer, she will begin at Tufts this fall.

Kim was encouraged to come to FSU by De Witt Sumners when they met at Kennesaw State University where he was lecturing on knot theory and DNA. She came to FSU with a BA degree in 1990; served as a research assistant; received the Goodner Award, the Program for Instructional Excellence Award, and a University Teaching Award; and completed an MA degree in Pure Mathematics in 1992.

After studying the basics of Pure Mathematics, Kim enjoyed several topics courses, including Phil Bowers's "Hyperbolic Geometry and Fuchsian Groups." When he gave her Peter Scott's notes on the Geometry of Three-Manifolds, she "fell in love with Geometric Group Theory," an area that explores the structure of infinite groups by studying appropriate geometries on which a given group acts. She wrote her thesis on infinite groups that act on non-positively curved geometries.

Her immediate professional goal is "to do as much research as possible while I'm on this non-teaching appointment. Actually, I'm working on several projects – some joint, some solo. I was in England recently, funded by the London Mathematical Society, to give talks at three universities, and I'd like to begin joint projects with people I met there. I'm also participating in seminars here at ETH and at the University of Zurich."

Impressively published and with too many presentations to enumerate, Kim is looking forward to fall: "I'll be quite happy to return to the classroom! I love teaching and take it seriously. My goal will be to balance teaching and research – difficult to do. I hope to earn tenure at Tufts, and look forward to working with graduate students and post-docs."

Ruane

Aleksandar Poleksic

In 1998, Aleksandar Poleksic, a native of Montenegro, Yugoslavia, received his Ph.D. degree from this department after completing a dissertation entitled, "Quasiconvex Groups." Today, he is one of a team of scientists at the Cold Spring Harbor Laboratory in New York.

He explains: "Last year, I joined a bioinformatics group at this laboratory, a leading center for research and education in biology. This interdisciplinary area brings together molecular biologists working in medical and biological fields, and mathematicians and computer scientists working on subjects like finite state machines, stochastic processes, and probabilistic modeling."

"More specifically, my research is in the area of protein sequence analysis, where most problems are statistical and mathematical. I study the ways to apply mathematical and computational tools in modeling conserved features of protein families."

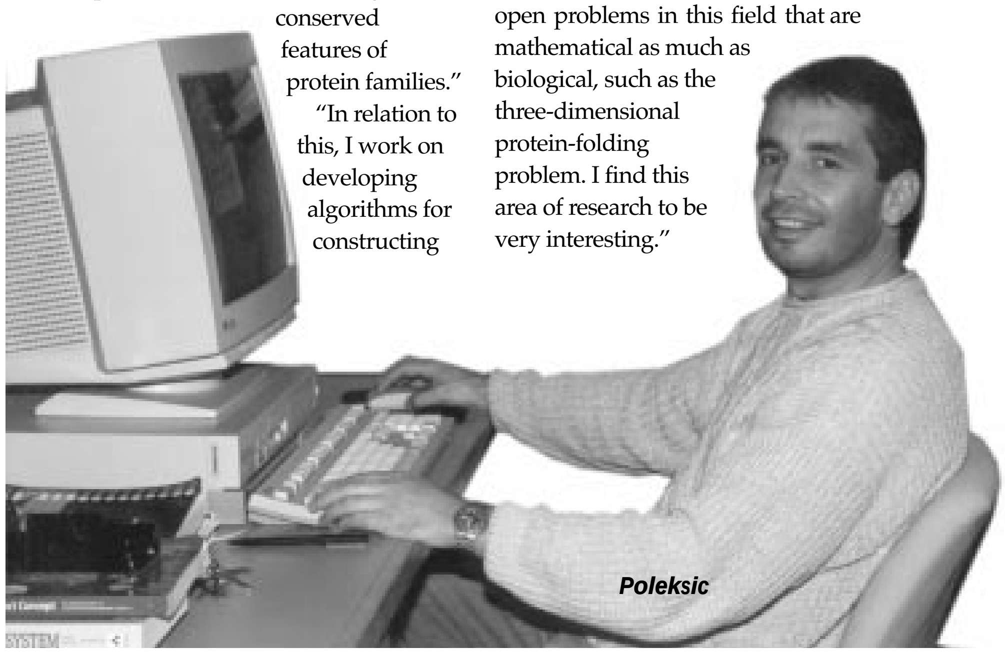
"In relation to this, I work on developing algorithms for constructing multiple sequence alignments, i.e., structures that show the relationship between the sequences in a protein family. Multiple alignments are used to study structure and function of poorly characterized proteins, and to identify new protein family members."

Dr. Poleksic came to FSU in 1994 after earning a BS degree from the Department of Mathematics at the University of Montenegro, and an MS degree in Mathematics from the University of Belgrade, Yugoslavia in 1992. His master's thesis explored the coloring and embedding of polyhedra.

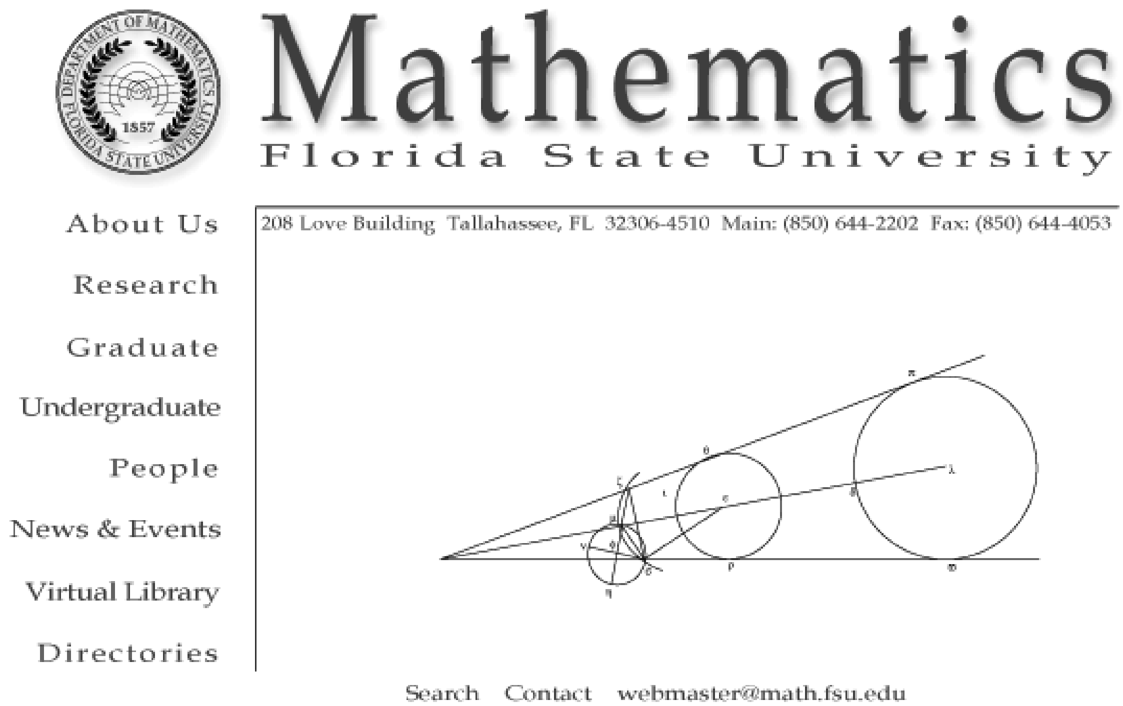
During his doctoral studies, Dr. Poleksic earned the Goodner Teaching Award while teaching a variety of courses. He is a member of Phi Kappa Phi and Pi Mu Epsilon and has published numerous papers.

His future plans? "Although trained as a pure mathematician, I want to move more toward Applied Mathematics and Computational Biology. And I want to better understand the functional and structural logic behind the data on protein structures that is available today."

"There are many interesting questions and open problems in this field that are mathematical as much as biological, such as the three-dimensional protein-folding problem. I find this area of research to be very interesting."



Poleksic



A New Doorway to Mathematics

http://www.math.fsu.edu/

The Web site of the Department of Mathematics is being redesigned.

Currently, the site provides information about our teaching and research related activities, and detailed descriptions of our various programs of study. Through its Virtual Library, it has evolved into a main portal to the mathematical information available on the World Wide Web.

Dr. Washington Mio, coordinator of the redesign project, explains, “In just two years, the site has grown to more than 200 pages and has experienced a tremendous growth in traffic. Approximately 20,000 pages are accessed daily by more than 2,000 viewers – more than half-a-million page accesses per month! Our Web site has become an important informational source and communication vehicle for students, teachers, researchers, and the general public.”

“Our goal is to facilitate navigation and enrich content, completing most of the project and running the new site in Summer 2000. Besides a new layout and a reorganization of material, we plan to offer descriptions of faculty and student research projects. We will also profile our graduates’ accomplishments to share with viewers and prospective students the wide variety of career options available in mathematics.”

“Updated descriptions of our programs in Pure, Applied, and Computational Mathematics will be available, including new professional degrees in Actuarial Mathematics, Financial Mathematics, and Computational Biology. Viewers may also read our newsletter, *Mathematics for the New Millennium*, online to be informed about current events in the Department.”

Dr. Mio will continue to develop the Mathematics Virtual Library, providing a comprehensive list of mathematics-related resources available on the Web as a free service to the online community. Categories will include mathematical education at all levels, research in Pure and Applied Mathematics, the history of mathematics, electronic journals, mathematical software, and address books.

An Associate Professor of Mathematics, Dr. Mio received his Ph.D. degree from New York University in 1984. His area of research is Geometric Topology.

Future plans include the integration of the Department’s site with the online application system currently being developed by the University. We invite you to visit our Web site at http://www.math.fsu.edu/ for more information.

Look for student articles in the upcoming fall issue!

Keep Us Posted!

We'd like to hear from you! Please return this form, with a note about your present affiliation to the address above.

Name ____________________

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