Presentations, Symposia, Workshops

Nicholas Ercolani, Department Head and Professor, is the co-organizer of a Symposium on “Waves: Patterns and Turbulence” for the Annual Meeting of the American Association for the Advancement of Science in Boston, February 14-19, 2002.

Dr. Ercolani will be a Plenary Speaker for the AMS Spring Eastern Section Meeting in Montreal May 3-5, 2002.

Professor **Hermann Flaschka** will speak at the workshop on Geometry, Mechanics, and Dynamics, for the Field Institute in Toronto, August 7-11, 2002.

Yi Hu, Associate Professor, is an invited speaker at the ICM 2002 Satellite Conference in Algebraic Geometry in Shanghai, China, August 13-17, 2002.

Professor **Moshe Shaked** has been invited to give a presentation for the Third International Conference on Mathematical Methods in Reliability, Methodology, and Practice, June 17-20, 2002 at the Norwegian University of Science and Technology in Trondheim.

Doug Ulmer, Associate Professor, is co-organizing the AMS & Italian Mathematical Union, Special Session on Arithmetical Algebraic Geometry, Pisa, Italy June 12-16, 2002.

Professor **Maciej Wojtjiwski** will be an invited Speaker for the International Congress of Mathematics 2002 in Beijing, China, August 20-28, 2002.

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MATHEMATICS
Spring 2002

In this Issue

A VIEW FROM THE CHAIR

Nicholas Ercolani
Department Head of Mathematics and Professor

Nicholas Ercolani

Our Mathematics Department has traditionally embraced a broad view of its mission. Faculty members, as well as students, participate in a wide range of activities that extend outside of the Department per se. These include contributions to the profession of Mathematics at all levels, interdisciplinary research and service to the community. The present newsletter gives us the opportunity to describe recent developments in some of these endeavors.

Many of our faculty participate in cross-disciplinary research and educational projects through the Department’s unique relation with the Interdisciplinary Program in Applied Mathematics. This issue of the newsletter illustrates two such connections. One is the article by Jim Cushing that describes the interplay between modern Dynamical Systems theory and the modeling of complex biological and ecological systems. Another is the article by former Applied Mathematics graduate student Annalisa Calini whose research applies techniques of nonlinear science to the study of classical problems in Differential Geometry. Annalisa is one example of a number of former graduate students in both the Mathematics and Applied Mathematics graduate programs whose advisors were Departmental faculty and who went on to successful research careers at the interface between pure and applied Mathematics.

Funding from VIGRE and GIG grants as well as other sources support a number of ongoing activities that enrich the research experiences of our students and faculty. Examples of this are described in the articles of Jeff Selden, David T. Gay and Doug Ulmer.

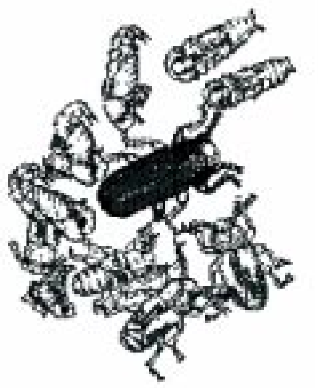
Departmental faculty continue to be successful in garnering gifts and awards which enable us to maintain a multifarious array of outreach activities such as enrichment and support of regional secondary Mathematics teachers, as described in the articles by Fred Stevenson and Elias Toubassi, and Program ACCESS whose story is recounted in David Lovelock’s article.

In future issues we will be telling you more about our programs and activities. To our alumni, I would also like to extend an invitation to write to us. We would be delighted to hear from you and perhaps some of you would even like to share your experiences in these pages. So please contact us and let us know what you are doing!

Contact us at: http://www.math.arizona.edu/~mcenter/alum/alum.html

COMPLEX POPULATION DYNAMICS

J. M. Cushing, Professor
Department of Mathematics
Interdisciplinary Program in Applied Mathematics



A central goal in population biology and ecology is to understand temporal fluctuations in population abundance. Such fluctuations, however, often appear erratic and random, with annual variances spanning several orders of magnitude. For example, a recent literature survey showed that annual numbers of new adults can vary by factors of over 30 in terrestrial vertebrates, 300 in plants, 500 in marine invertebrates, 2200 in birds[1]. In the early 1970's Lord Robert May put forth a bold new assertion concerning the possible explanation of the perplexing dynamic patterns so often observed in biological populations. The prevailing point of view had been that complex patterns have complex causes and simple causes have simple consequences. May's theoretical work showed, on the other hand, that complex patterns (including what is now called "chaos") could result from simple rules.[2] This non-intuitive fact raised the intriguing possibility that some of the complexity of nature might arise from simple laws.

The complexity about which May wrote is a result of nonlinearity. Although the classical mathematical models of theoretical ecology from the first half of the twentieth century are nonlinear, the theories derived from them were centered on equilibrium dynamics. The famous logistic equation and the Lotka-Volterra systems of competition and predation equations are prototypical examples found in most undergraduate textbooks on differential equations and ecology. Fundamentally, the mindset at the heart of these theories encompassed the notion of a "balance of nature" in which ecological systems are inherently at equilibrium and the erratic fluctuations and complexity observed in data are due to "random disturbances" (or "noise"). From this point of view, ecosystems are noisy perturbations of underlying stable configurations. The point of view suggested by May, however, was not based on "noisy equilibrium" states. As he put it in his seminal 1976 paper, the fact that a simple, deterministic equation

> "can possess dynamical trajectories which look like some sort of random noise has disturbing practical implications. It means, for example, that apparently erratic fluctuations in the census data for an animal population need not necessarily betoken either the vagaries of an unpredictable environment or sampling errors: they may simply derive from a rigidly deterministic population growth relationship."[3]

May's tenet raised the possibility of new ways to understand ecological systems. Although unexplained noise will always be present in ecological data, these insights provided a broad new hypothesis concerning the role of nonlinear mathematical models in ecology, namely, that the fluctuation patterns of abundances in many population systems can be explained, to a large extent, by nonlinear effects as predicted by simple (low dimensional) mathematical models.

Despite the fact that mathematical and theoretical ecology developed and expanded profusely during the decades following May's seminal work, his hypothesis has proved both controversial and elusive to test. Efforts concentrated on finding "chaos" in available historical data sets taken from field observations of animal populations. However, many formidable difficulties need to be overcome in order to provide a convincing argument for the presence of chaotic dynamics in a biological population. These difficulties include the identification of the appropriate state variables (phase space), the paucity of sufficiently long time series of data, missing data, lack of replicated data sets, and the ubiquitous presence of noise in ecological data sets. Another major shortcoming is the unavailability of mechanistically based models that are tied rigorously to data, that is to say, models that can be parameterized, statistically validated, and shown to provide quantitatively accurate descriptions and predictions of a population's dynamics.

Nonetheless, there were concerted efforts – particularly during the late 1980s and the 1990s – to find evidence of chaos in available ecological data sets. One approach, taken by Professor W.M. Schaffer (of the University's Ecology and Evolutionary Biology Department) and his colleagues in their influential studies of certain ecological and epidemiological data sets, was based on the "reconstruction" theorems of F. Takens. These theo-

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[1] N. G. Hairston Jr., S. Ellner, and C. M. Kearns, *Population Dynamics in Ecological Space and Time* (O. E. Rhodes, R. K. Chesser and M. H. Smith, eds.), University of Chicago Press, 1996, 109-145

[2] Lord R M. May was not the first to study and write about chaos, although he, together with E. Lorenz, did as much as anyone to stimulate interest in complex dynamics and "chaos". This interest had lain dormant in the scientific community since Henri Poincaré stumbled across chaos nearly one hundred years earlier.

[3] R. M. May, *Nature* 261 (1976), 459-467

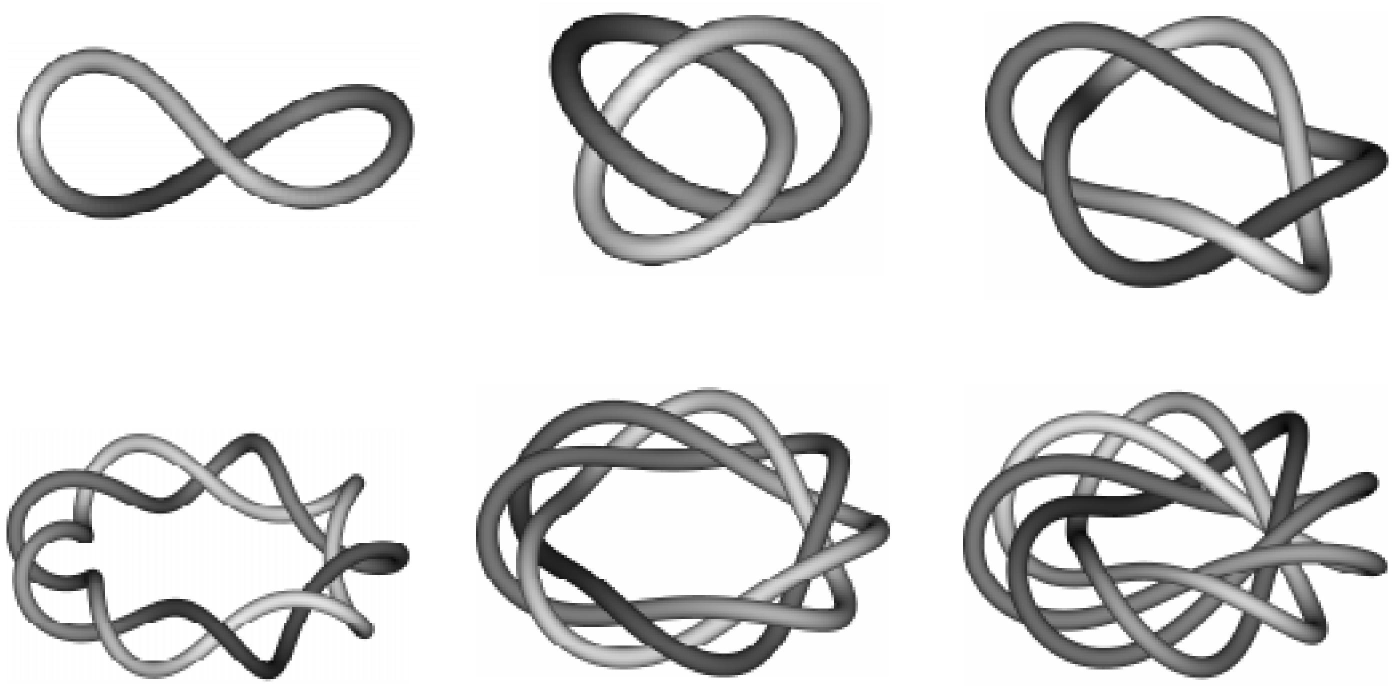

Figure 4. A gallery of solitary smoke rings. From left to right, top row: an unknot, a trefoil knot (a (2,3) torus knot), a (2,5) torus knot, bottom row: (2,9), (3,8) and (4,9) torus knots.

dynamic: these knots evolve by rigid motion, translating in space and sliding along themselves without any change in their topological type.

Many more solutions with increasingly complex geometric and topological properties can be obtained and studied, using a growing number of old and new techniques, and involving many diverse fields of Mathematics. They include Bäcklund transformations and Floquet theory, methods of Algebraic Geometry and Perturbation expansions, Knot Classification theory and Symmetry methods. With my colleague Tom Ivey at the College of Charleston, we continue our investigations of higher soliton solutions of the Vortex Filament Equation and of related geometric evolution equations, with a keen interest in uncovering the deep connections between the infinite number of symmetries and the amazing complexity of "solitary smoke rings".

Annalisa Calini is currently an Associate Professor with the Department of Mathematics at the College of Charleston. She received her Ph.D. in Applied Mathematics in 1994 at The University of Arizona.

REFERENCES

1. A. Calini, Recent developments in integrable curve dynamics. *Geometric Approaches to Differential Equations*, Lecture Notes of the Australian Mathematical Society, 15 (2000), 56-99.

2. A. Calini, T. Ivey, *Connecting Geometry, Topology and Spectra for Finite-Gap NLS Potentials*, Physica D, 152-153 (2001), 9-19.

3. G.K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge University Press (1967).

which first exhibited "solitary waves" amongst its solutions. A "solitary wave," or "soliton" (as it was later called), is a hump-shaped solution which moves without changing its shape and interacts elastically with other like solutions. Solitons sparked and have continued to renew vivid interest amongst communities of physicists (searching for particle-behaving waves) and applied mathematicians modeling anything from rogue waves in the North Sea to optical signals in the Trans-Pacific cable.

As a Ph.D. student of Nick Ercolani at the University of Arizona, I became interested in an equation describing smoke ring dynamics, which provides a remarkable and perhaps the richest application of soliton theory to the realm of curve geometry.

A ring of smoke travelling through the air (as those produced by our grandfather's pipes) is a region of vorticity confined to a thin filament in space. Vortex filaments are commonly observed in fluids and superfluids, in plasmas, and as far away as in the flares of the solar corona and in stellar atmospheres as magnetic arches. They are often open (like pieces of string), but can be closed curves, like smoke rings and plasma loops, and they can even be knotted.

As a first approximation, the evolution of a smoke ring is suprisingly simple, and yet rich in symmetries (there is an infinite number of symmetries, in fact). By modeling a very thin vortex filament as an embedded curve *C in* 3-space parametrized by arclength *s*, we introduce at each point along the curve its unit tangent vector **T**, the unit normal vector **N** (directed like the radius of curvature) and complete the pair with the binormal vector **B** to obtain an orthonormal triple (**T, N, B**) (the Frenet-Serret frame of the curve).

Assuming the smoke ring moves without stretching under the effect of its own vorticity, one derives the Vortex Filament Equation[1]

$$\frac{\partial \mathbf{r}}{\partial t} = \kappa \mathbf{B}$$

where κ(*s*,*t*) is the curvature of the curve at the point **r**(*s*,*t*). The equation indicates that the higher the curvature, the faster the motion in the direction of the binormal vector, just as the smaller the smoke ring, the faster it travels upward.

This nonlinear partial differential equation possesses a wealth of conserved quantities: the total length $\int_C \|\mathbf{r}_s\| ds$ is constant in time; neither the total squared curvature, $\int_C \kappa^2 ds$, nor the total torsion can change during the dynamics, and the integral of the torsion times the curvature square $\int_C \tau\kappa^2 ds$ will also remain invariant while the curve evolves, and so will

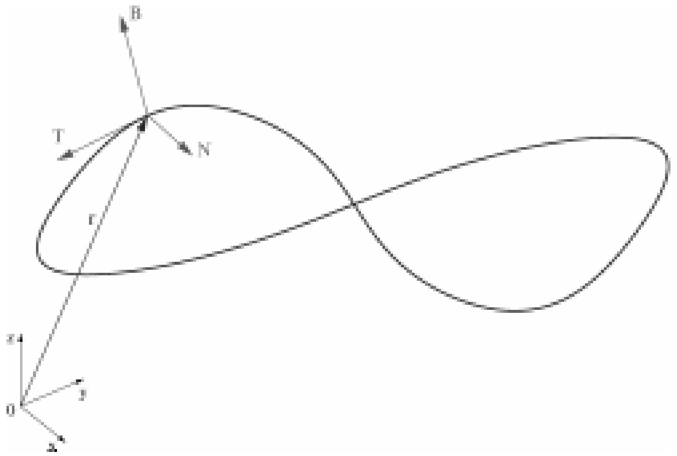

*Figure 3. A space curve of position vector **r** and Frenet frame **(T, N, B)***

an infinite number of conserved quantities expressed in terms of the curvature κ and torsion *τ*. This is the main signature of a soliton equation.[2]

What do solitary wave solutions of the Vortex Filament Equation look like? The simplest one, the zero-soliton (with no humps) is readily discovered: one can verify that the planar circle of radius $\frac{1}{\kappa_0}$ and position vector **r**(s,t) = $\frac{1}{\kappa_0}\cos(\kappa_0 s)\mathbf{i} + \frac{1}{\kappa_0}\sin(\kappa_0 s)\mathbf{j} + (\kappa_0 t)\mathbf{k}$ is a solution which rigidly translates with speed $\mathbf{k}_0$ in the **k** direction.

One-soliton solutions are more complex, and far more interesting objects than translating circular smoke rings. One-humped solitons are typically obtained as travelling wave solutions of the nonlinear partial differential equation, by assuming the position vector **r** to be a function of the single phase variable $\phi = s - ct$ (*c* is the speed of the travelling wave) and so reducing the problem to an ordinary differential equation. Just like for the Kepler model, the presence of symmetries allows one to find explicit formulas for such solutions, involving, in this case as well, elliptic functions.

The resulting curves are shown in Figure 4, they turn out to be beautifully symmetric knots of a special type, well known to topologists. One can imagine creating a knot by wrapping a piece of string on the surface of a donut: *p* times along the meridians and *q* times around its longitudes, and then gluing the ends together. After eating the donut, what is left is a (*p*,*q*) torus knot. Torus knots of every (*p*,*q*)-type are realized by one-soliton solutions of the Vortex Filament Equation: a remarkable way in which symmetry manifests itself. Symmetries are also responsible for a very simple

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[1] More realistic models of vortex filament dynamics account for stretching, non—local vorticity effects as well as for non—zero thickness of the filament core (a discussion can be found in {3}

[2] The curvature κ(s) of a parametrized curve measures the acceleration of the position rector **r**(s), while the torsion *τ*(s) measures how rapidly the curve deviates from its osculating plane- *τ*=0 for a planar curve.

The Beetle Team: Shandelle Henson, Jim Cushing, Robert Desharnais, Brian Dennis, and Bob Costantino

rems allow attractors to be studied from knowledge of only a small number of a system's state variables and thereby provide a means to investigate chaos in a lower dimensional and more tractable setting. Another approach taken by other researchers was based on attempts to determine whether any available time series of ecological data demonstrates a dynamic property characteristic of chaos called "sensitivity to initial conditions"[4]. This was done by utilizing statistical methods – based on fitting the data with elaborate (often parameter rich) phenomenological models – for the ultimate purpose of estimating a single diagnostic quantity, called the "dominant Lyapunov exponent", whose positivity indicates this signature property of chaos. The insufficient length of available data sets proved to be a severe constraint on these approaches. Another significant difficulty is the presence of high levels of noise in ecological data. Given the similarity of chaos to random noise, how does one distinguish between the two?

Because of these difficulties it is perhaps not surprising that results from this "hunt for chaos" were equivocal. No data sets were found to be convincingly chaotic, according to the tests used, although some were judged tantalizingly "on the edge of chaos." By the end of the century, various opinions were formulated which ranged from "chaos is rare in nature" to "the jury is still out." From the first opinion arises the question "why is chaos rare in nature?" especially in light of the fact that ecological models abound with chaotic dynamics. With the latter opinion, one recognizes that the formidable difficulties involved in detecting chaos in ecological data have not been adequately overcome by the phenomenological methods of time series analysis. Researchers have had to rely on such methods until adequate mechanistic models and data are available. However, as J. N. Perry puts it in a recent book that surveys these issues, "the consensus [among population ecologists] is that there is no substitute for a thorough understanding of the biology of the species, allied to mechanistic modeling of dynamics using analytic models, with judicious caution against over-parameterization."[5].

The complexity of the natural systems, along with the inherent difficulties in confidently linking data from such systems with theory and models, pointed to a need for controlled laboratory experiments–experiments designed and analyzed with the specific intent of testing the predictions of nonlinear population theory. Laboratory microcosms, while no substitute for field experiments, are one of the best ways to test theories and hypotheses. In a laboratory setting one can carefully control environments and reduce or eliminate the effects of confounding elements, identify important and unimportant mechanisms, make accurate census counts and other measurements, replicate results, and manipulate parameters. For nearly decade J. M. Cushing (professor of mathematics and member of the Program on Applied Mathematics) has worked with an interdisciplinary team of biologists, statisticians and mathematicians[6] (with the support of the National Science Foundation) on a variety of projects designed to investigate nonlinear phenomena in a real biological population by means of controlled laboratory experiments tied closely to a mathematical model and its predictions. One of the team's major efforts involved an investigation of May's famous tenet concerning complex and chaotic dynamics.

May's approach to chaos was to ask how a population's dynamics change if some of its fundamental demographic characteristics change. He looked at equations of the form $x_{t+1} = f(x_t)$ as mathematical models for the prediction of population abundance (or density) x_t from one census time to the next. Given an initial population density x_0 such an equation predicts recursively a unique sequence of future population densities $x_0, x_1, x_2, \ldots$. In specific cases the sequence depends on the numerical values assigned to "parameters" appearing in the equation (i.e., "coefficients" in the expression $f(x)$). Famous examples include the "discrete logistic" equation that uses $f(x) = b\,x\,(1 - cx)$ and the more biologically applicable "Ricker" equation with $f(x) = b\,x\,e^{-cx}$. May was interested in how the sequence of predictions changes if the number *b* changes. More precisely, he was interested in the long term properties of the sequence–the "attractor"–which might be as simple as

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[4] This property means that populations starting close to each other rapidly (exponentially) diverge from each other with time, eventually to become uncorrelated.

[5] J. N. Perry, R. H. Smith, I. P. Woiwod, and D. R. Morse, *Chaos in Real Data: the Analysis of Nonlinear Dynamics from Short Ecological Time Series*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2000

[6] R. F. Costantino (Department of Biological Sciences, University of Rhode Island), Brian Dennis (Department of Fish and Wildlife Resources and Division of Statistics, University of Idaho), Robert A. Desharnais (Department of Biology and Microbiology, California State University), Shandelle M. Henson (Department of Mathematics, Andrews University), and Aaron A. King (Department of Environmental Science and Policy, University of California at Davis). Supported by the National Science Foundation.

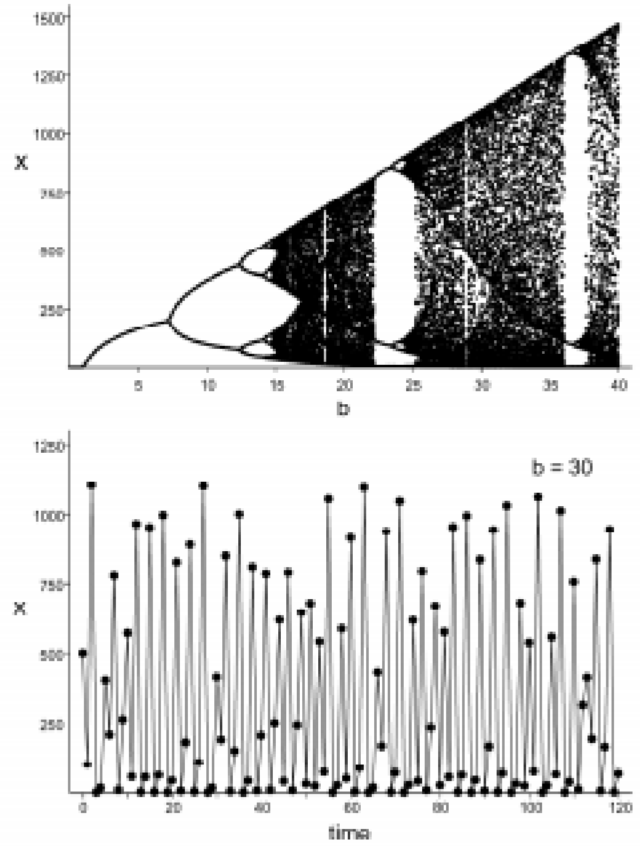

FIGURE 1. The upper graph shows the attractor of the Ricker equation plotted against the corresponding value of b (with c = 0.01). For small values of b, less than approximately 7.4, there is a single point lying on the graph, indicating that the attractor is an equilibrium point. For values of b between approximately 7.4 and 12.5 there are two points on the graph, indicating the attractor is a periodic 2-cycle. For increasing values of b, the attractor consists of more and more points (with some exceptions). For b = 30 the time series of x plotted against t in this case, shown in the lower graph, exhibits the kind of random appearing oscillations to which May refers in his seminal paper.

an equilibrium point (the sequence's limit point, if it should happen to converge) or a periodic cycle (a 2-cycle, for example, in which the sequence oscillates alternately between two different numbers.) Or, as May discovered, the attractor might be a very complicated oscillation indistinguishable from random noise. Which attractor results, depends on which value of *b* is used in the formula *f(x)*. Changes in the type of attractor caused by changes in *b* are called "bifurcations" and the graphical summary of these bifurcations depicted in Figure 1 for the Ricker equation has become a virtual icon of chaos theory. It shows a progressive complexity in attractor dynamics as b is increased, a "route-to-chaos."

Will a real biological population exhibit a sequence of dynamic bifurcations, and a route-to-chaos, like those predicted by such simple mathematical equations? There is a demanding prerequisite required for answering this question, namely, the identification of an adequate mathematical model for the particular population involved; a model that provides more than good statistical fits to data. The model needs to be biologically-based, that is to say, derived from biological mechanisms known to be important for the dynamics of the population under consideration, and it needs to be quantitatively accurate in its predictions. Unfortunately models that "work" in this sense are rare in population dynamics and ecology. The track record of relating mathematical models to data is not good, particularly when it comes to the successful formulation of hypotheses and predictions that are quantitatively testable. Therefore, a major hurdle faced by Cushing and his colleagues in conducting a study aimed at documenting a route-to-chaos in a real biological population was the mathematical modeling of the population dynamics of the organism used in the study–the common flour beetle (*Tribolium castaneum*).

Cultures of flour beetles make an ideal experimental system for such a study for several reasons. First of all, a great deal is known about their biology (genetics, physiology, and behavior). This is primarily because they are a significant agricultural pest (that has contaminated stored grain products since ancient Egyptian times) and therefore have been the object of scientific scrutiny for many decades. Furthermore, cultures are easy to maintain, easy to census accurately, and easy to manipulate. Long time series of census data can be gathered in a reasonable length of time since the beetle produces, under normal laboratory conditions, a new generation in only four weeks. Important for the project is that they have a complete insect life cycle (larvae, pupae, and adult) with inter-stage interactions (cannibalism) that induce nonlinear effects. These nonlinear effects, which biologically regulate population density even when a continual supply of food resources is available, provide the necessary ingredients for dynamic complexity.

The mathematical model devised by the "Beetle Team" predicted population numbers from one census time to the next, in a manner similar to the famous Ricker equation except that each data point consists of three numbers instead of one, namely, counts of each life cycle stage. The model uses larval, pupa and adult stages as its state variables so as to account for the dominant biological mechanism that drives the nonlinear dynamics of the beetle cultures — the cannibalism practiced by individuals in one stage on those of another. The "LPA model" is three dimensional, unlike the one-dimensional Ricker model, and therefore is more difficult to analyze mathematically. While some mathematical results have been obtained, there re-

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Hotel Work Session

The response to the AWS has been tremendous. Our original proposal called for inviting and funding the expenses of 30 graduate students each year. Last year, we stretched our funds with matching contributions from various departments including Princeton, Harvard, and Stanford, and were able to fully or partially fund about 84 students. There were about 140 participants in all, so it's clear that many people find the AWS a must-attend event, even if they have to spend their own money.

In addition to the AWS, the Southwestern Center grant (a "Group Infrastructure Grant" from the NSF) has sponsored a distinguished lecture series, both at the UA and other participating institutions (which are the Universities of Texas, New Mexico, and Southern California). At Arizona, we've had lecture series by Ken Ribet, Jim Carlson, Anand Pillay, David Rohrlich, and Alexander Goncharov. The Center also sponsors a post-doc (currently Shuzo Takahashi), provides summer support and travel for graduate students, and has bought computer equipment for the local principal investigators.

The local PIs on the grant are Minhyong Kim, Bill McCallum, Dinesh Thakur, and Doug Ulmer. The outside PIs are Alex Buium at the University of New Mexico, Wayne Raskin at USC, and Felipe Voloch at UT Austin. We've benefitted from the collaboration of many other mathematicians, and the tremendous efforts of Sandy Sutton who handles all our administrative work.

For more about the activities of the Southwestern Center, especially the upcoming Arizona Winter School (March 9-13, 2002), see our web site at
http://swc.math.arizona.edu/

SOLITARY SMOKE RINGS

Annalisa Calini, Associate Professor
Department of Mathematics, College of Charleston

The main successes in solving nonlinear differential equations come when the equations have lots of symmetries, often appearing as conserved quantities, like energy and momentum. One well-known example is the Kepler problem for planetary motion around the sun, for which conservation of angular momentum allows one to solve the equations explicitly.

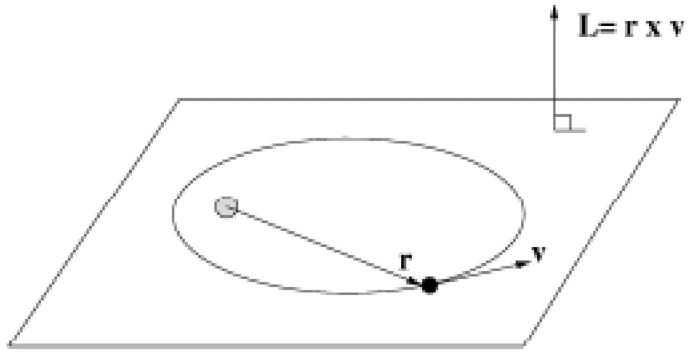

Figure 1. The equation for $\frac{d^2 r}{dt^2} = -k\frac{\mathbf{r}}{|\mathbf{r}|^3}$ *planetary motion has the group of rotations as symmetries. Correspondingly, conservation of angular momentum L reduces the model to a planar system of equations solvable by quadratures*

When the equation contains partial derivatives, in certain lucky situations, there is an infinite number of conserved quantities, some of them carrying a direct physical interpretation, most coming from more abstract symmetries. Among these equations is the famous Korteweg-de Vries (KdV) equation, a model of water waves in shallow water,

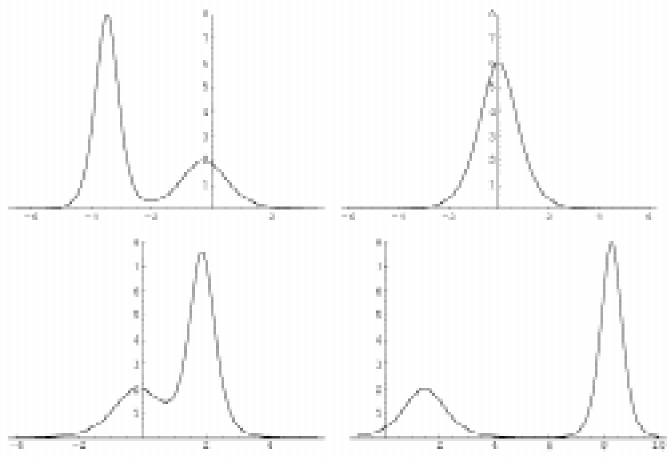

Figure 2. Interaction of two solitons of the KdV equation. Frames are shown for four consecutive values of time

Motivation is as much the responsibility of the student as the professor.

In addition, Lesch and I began looking at a problem that Friedlander told me about before my trip. Let us consider a domain in R^2 which is invariant when acted upon by a group. Suppose in addition that the action of this group commutes with the Laplacian, where we are considering Dirichlet boundary conditions. Then the eigenspaces of the Laplacian are representation spaces of this group. One now asks a question involving the multiplicities of the irreducible representations occurring in the eigenspaces. Results along these lines have been obtained for domains with dihedral symmetries. Much of my time in Köln was spent trying to understand these results and attempting to understand the problems with using similar techniques to get results for cyclic groups.

I also spent some time in Aachen, a town about 40 miles west of Köln on the border of Germany, the Netherlands, and Belgium where Tom Hoffman, another Arizona graduate student studying representation theory of finite groups, was visiting the Nordrhein-Westfalen Institute of Technology (RWTH). Hoffman's advisor and Arizona professor, Klaus Lux, was also in Aachen and I spent some time grilling them about representation theory while we happily drank our fill (and sometimes a wee bit more) of German beer.

The end of my trip was spent in Edinburgh, Scotland, at a conference entitled "Progress in Partial Differential Equations." The conference took place in the historic Royal Society of Edinburgh and I got the chance to listen to many good talks by people from all over Europe and the U.S. One of the highlights of the conference for me was a talk by Nikolai Nadirashvili from the University of Chicago. His talk was entitled "New Results and Open Problems in Elliptic PDE," in which he discussed the current state of elliptic PDE, including the problem I had been working on in Köln. In addition to the talks, the conference was a chance to meet European mathematicians and form contacts. Saadia Fahki of the Université Paris XII graciously offered to show my wife and me around Paris if we should ever make it there.

In sum, my trip was an unforgettable experience. I saw parts of Europe that I had never seen, and even learned "ein bisschen Deutsch." I met other mathematicians with whom I sincerely hope I will maintain at least a friendship, if not a working relationship. As I look back upon everything that I saw and did, I realize I have only begun to reap the benefits of my time abroad.

THE SOUTHWESTERN CENTER FOR ARITHMETICAL ALGEBRAIC GEOMETRY

Douglas Ulmer, Associate Professor
Department of Mathematics

What brings one hundred or so top graduate students and a handful of world experts in number theory to Tucson during the second week of March each year? It could be the beautiful Sonoran desert weather that time of year, but a more likely reason is the Arizona Winter School!

The Arizona Winter School (AWS), which is one of the main activities of the Southwestern Center, is an annual meeting for advanced graduate students and post-docs in arithmetical algebraic geometry (or, more briefly, modern number theory). It has quite a different flavor from a traditional conference—rather than having a loosely related sequence of talks, with each speaker reporting on his or her recent work, the AWS features a tightly integrated set of courses by leading and emerging experts on a theme of current interest. The program has included such luminaries as Pierre Deligne, Barry Mazur, Karl Rubin, and Peter Sarnak, as well as local talent like Bill McCallum and Doug Ulmer.

A characteristic feature of the AWS is that great effort is expended to make sure that there is significant interaction between participants at all levels. For example, each speaker is assigned a group of students who work together on a project related to that speaker's course, and the students report on their projects at the end of the School. There are evening working sessions in the hotel (often lasting until midnight) and several social events. The Winter schools have led to collaborations between researchers and students at various universities and to a real sense of camaraderie among the next generation of number theorists.

Another unique aspect of the AWS is the "professional development component." This part of each AWS is meant to give students some training in an aspect of the profession beyond mathematics. The professional development components have ranged from a workshop on teaching, (including viewing a tape from the Third International Mathematics and Science Study -the famous TIMSS study comparing math education in various countries- with a panel discussion), to sessions on mathematical writing, jobs in industry, and symbolic computation.

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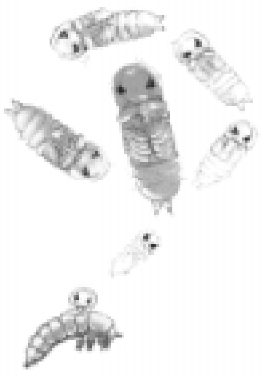
main many interesting unsolved problems associated with the model. Nonetheless, the simple recursive nature of the three equations in the model makes the model easy to study using computers.

In order to connect the LPA model to real beetle data it was necessary for the team to "parameterize" or "calibrate" the model. This means numerical estimates for the parameters appearing in the model (of which there are six) needed to be obtained and the resulting fitted model shown to be accurate. This statistical effort required a description of the inevitable deviations of real data from the model predictions. In general such deviations, or "noise," can arise from a variety of different causes. In the case of data from the laboratory cultures of flour beetle, however, there is virtually no census error and, because of the highly controlled laboratory conditions, there is minimal "environmental noise," i.e., few external random disturbances that significantly affect the populations as a whole (such as changes in temperature, humidity, light, or food resources). The source of the noise is "demographic," that is to say, results from random differences among individuals in the populations–differences that are ignored by the model (gender, chronological age, body size, egg laying rates, mortality rates, etc.). The team had to devise mathematical ways to describe this precise kind of "stochasticity" within the beetle system and then incorporate demographic noise into a stochastic version of the LPA model. With this model in hand, a large number of statistical techniques became available for both the parameterization and the validation of the model.

In the mid 1990's the team successfully demonstrated the accuracy of the LPA model in preliminary tests that used existing historical data sets for flour beetle populations. A more important test of the prediction capability of the model followed when the team designed and successfully implemented a yearlong experiment that documented a predicted period doubling bifurcation. This bifurcation is like that occurring in the Ricker model except in this preliminary experiment the prediction did not include chaos. Nonetheless, this work was praised in an editorial appearing in the journal *Nature*[7] (where the experiment was announced by the Beetle Team) as "an unusual blend of nonlinear dynamics theory, statistics and experimentation" with results that "are of uncommon clarity for ecology" in showing "how the marriage of nonlinear models and experiments can help" ecologists accomplish the task of understanding and anticipating the consequences of environmental perturbations. In short, the Beetle Team had provided an example in ecology "of a model that actually lives up to [its] promise."

With the preliminary work of deriving, analyzing and calibrating a model finished, the Beetle Team was set to design and implement an experiment to test a model predicted route-to-chaos. Two years later the team announced the results in the journal *Science*. In that same issue, an editorial remarked that the Beetle Team had provided "the most convincing evidence to date of complex dynamics and chaos in a biological population." and that "ecologists at last have a convincing example of chaos that they can use as a base to understand better complex dynamics in other laboratory systems and, more importantly, in the field."[8] Furthermore, this project demonstrated quite clearly that a real biological population can indeed traverse a route-to-chaos as predicted by a "simple" (i.e., low dimensional) mathematical model, providing a direct verification of May's famous tenet.



While the demonstration of chaos in a biological population was a milestone for the Beetle Team, it was in many ways just the beginning of its study of nonlinear population dynamics. The flour beetle system, with its validated mathematical model and its statistical and laboratory components, constitute a powerful tool with which to delve into the fascinating intricacies of nonlinear theory and to discover new phenomena that are more than just mathematical theories.

The "chaotic" beetle populations from the route-to-chaos experiment are still being maintained. Data from these populations is now nearly seven years–nearly ninety generations–in length. This long time series of data permits the Beetle Team to carry out a detailed study of a biological population exhibiting chaotic dynamics. Chaotic dynamics, while appearing random in their oscillations, nonetheless have discernible temporal patterns. They also paint distinctive geometric patterns in state space. It is rather amazing that the Team has been able to document the occurrence of many such patterns predicted by the LPA model–subtle patterns involving not only "attractors" (around which most ecological theory revolves) but unstable entities (called "saddles"). Furthermore, in a study to appear in the journal *Science* later this year and led by the newest Team member, Professor Shandelle Henson (former Hanno Rund Visiting Professor in the Department of Mathematics), unusual patterns in the data are shown to be "lattice effects," i.e., caused by the fact that animals come in whole numbers (mathematical models, like the LPA model, deal with mean numbers). This is yet another source of potentially predictable patterns in ecological data whose occurrence was observed for the first time in real data by the Team.

These, and other studies, support a general tenet that has evolved from the Team's research. It is unlikely that one

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[7] Peter Kareiva, *Nature* 375, 1995, 189

[8] C. Godfray and M. Hassell, *Science* 275 (1997), 323

can provide adequate explanations of ecological data by means of model attractors alone (or even fuzzy stochastic versions of attractors). Instead, one must expect to observe patterns attributable to a variety of deterministic entities, both stable and unstable and also transient and asymptotic, all mixed into randomly occurring episodes by stochasticity. Nonetheless, what the Team has also shown–in at least one laboratory system–is that this rather daunting mix of complexity can be sorted out by means of a low dimensional mathematical model.

The Beetle Team's decade long project on complex dynamics and chaos in population dynamics is the subject of the inaugural book in a new series on Theoretical Ecology, scheduled to be published by Academic Press next summer. The Beetle Team has also carried out other experiments designed to delve further into the complexities of chaos. For example, an experimental documentation of a dynamic property called "sensitivity to initial conditions"–widely recognized as the signature characteristic of chaotic systems–was recently published by the Team in the journal *Ecology Letters*. In another example the Team, together with Dr. Aaron King (a former student of W.M. Schaffer and also a Flinn Postdoctoral Fellow in the Applied Mathematics Program at the University of Arizona), has recently completed new experiments designed to study sublte model predicted, temporal patterns within the chaotic dynamics of the beetle cultures (patterns involving complicated quasi-periodic motion with various rotation numbers associated with unstable cycles embedded within the chaotic attractor).

The Beetle Team, with its unique interdisciplinary blend of mathematics, statistics, and experimentation, has not restricted its studies in nonlinear dynamics to chaotic dynamics. Past studies have included investigations of multiple attractors, resonance in periodically fluctuating habitats, phase shifting, and saddles and their stable manifolds. Characteristic of these studies is that they have, in some cases, provided explanations previously unavailable for patterns that had been observed in data and, in other cases, the identification and documentation of unexpected and non-intuitive phenomena predicted by the LPA model.

Currently studies are underway that extend the Team's research in several new directions. For example, a modification of the model has been formulated to include the genetics involved in flour beetle adaptation to the insecticide Malathion. An experiment is under way that tests the prediction of this model that the beetle dynamics will undergo a dynamic bifurcation as the population genetically adapts to the insecticide. Another example involves a multiple species version of the LPA model studied by Dr. Jeff Edmunds, recent graduate of the Department of Mathematics. In his thesis, Dr. Edmunds showed that two competing flour beetle species, placed in the same habitat, do not always support a classical tenet of ecology concerning competitive exclusion–a principle on which the notion of ecological niche is based. This is particularly interesting because flour beetles were used in early studies that supported that now widely accepted theory. However, there were anomalies in those early experiments that Dr. Edmunds hopes to explain and with this as a starting point the Team hopes to conduct experiments that lead to new insights into competition theory.

The interdisciplinary projects carried out by the Beetle Team have brought mathematical models into a closer connection with population biology and ecology. One of the Team's hopes is that its successes not only provide insights into nonlinear population dynamics, but that they provide a modest step towards the "hardening" of ecological science–a step towards raising its explanatory power beyond purely theoretical speculation and a satisfaction with only qualitative accuracy, reasonable "guesstimates," and verbal metaphors. It is true that the laboratory system used in the flour beetle experiments is a relatively simple biological system, and that the low dimensional LPA model is a simple mathematical model of that system. Nonetheless, we can find motivation and inspiration for the study of simple systems from May's seminal 1976 paper:

> "Not only in research, but also in the everyday world of politics and economics, we would all be better off if more people realized that simple nonlinear systems do not necessarily possess simple dynamic properties."

CENTER FOR RECRUITMENT & RETENTION OF SECONDARY MATH TEACHERS

Fred Stevenson, Professor
Department of Mathematics

The University of Arizona is establishing a Center for Recruitment and Retention of Secondary Mathematics Teachers in the Department of Mathematics. The Center is in response to a critical shortage of qualified secondary mathematics teachers. This crisis is national in scope; experienced teachers are retiring or quitting in droves; it is estimated that 35% of new mathematics teachers leave the profession within five years and 30% of University students who get a teaching degree in mathematics do not

topology for advanced undergraduates. The latter was designed to prepare undergraduates for a lecture series to be given by Bruno Harris, who will be visiting Nankai this fall. Dr. Harris's visit grew out of a conference in Tianjin in memory of K. T. Chen and W. L. Chow; Dr. Harris will be lecturing on Chen's iterated integrals. I tried to get the students as quickly as possible to a basic understanding of differential forms and integration on manifolds so that I could touch on the idea of differential forms and De Rham cohomology on path spaces. It was a challenge but the students were very good, most of them having been accepted to Nankai after winning a national math competition.

Beyond teaching and research, we really came to enjoy daily life in Tianjin. We lived on campus (as do most faculty there); we would begin most days with an early walk around campus and then get breakfast at a local outdoor market. We did essentially all of our shopping at open-air markets, which were much more convenient and accessible than your average grocery store in the U.S. Everything we ever needed was within an easy (and safe) walk or bike ride from home.

Food was a highlight of our time in China, and it will probably be a while till we dare to go to a Chinese restaurant in the U.S. Ultimately, though, it was the social atmosphere of our many wonderful Chinese meals that made them so special. The best meals were at friends' homes and most special of all were the meals that we were lucky enough to share with Professor Chern, a kind, cultured and very gracious host. Several times during the year we were invited to dinner at his house and it was always a great honor. When Chern turned 89 the Institute arranged a festive birthday dinner at a fancy campus restaurant with many friends and mathematicians from around Tianjin and Beijing; the dishes were too numerous to keep track of but I do remember delicious crabs.

Perhaps the most surprising thing about our visit was that it was so novel. Chinese mathematicians regularly experience the mathematical environment in the U.S. and bring back new perspectives to China, yet the situation is rarely reversed. It seems that foreign mathematicians have visited for a few weeks or a few months, but hardly any seem to have visited for a whole year or more.

I'm sure it will only get easier in the future to arrange such visits; Chinese mathematicians want more visitors and often asked for my ideas on how to attract them. My position was not advertised and didn't even exist until I asked about it, but all it took was the initiative to ask and a good word from my advisor. A good place to start asking might be the mathematical division of the Chinese Academy of Sciences in Beijing, since they do have a lot of short-term visitors at the moment. Even without any Chinese language, life in a major Chinese city is quite easy to adapt to, and one could always ask the host institution to organize a crash course in basic Chinese. I am certain that any future mathematical visitors to China will encounter the same warm-heartedness, generosity and hospitality in his or her daily interactions that made our visit so easy and so memorable.

A GRADUATE EXPERIENCE IN GERMANY

Jeff Selden, Graduate Student
Department of Mathematics

I spent the month of June working with Matthias Lesch at the University of Köln in Germany. Lesch, who studies global analysis and geometry, was an Associate Professor in the Department at the University of Arizona until January, 2001, when he took a position at the University of Köln. I began working with him in the spring of 2000 when I was preparing for the oral preliminary examination, which entails studying and then presenting a talk on a current research paper. After he left, I started working with Lennie Friedlander, a Professor in the Department, who studies spectral theory and geometry. In order to keep a working relationship with Lesch, I applied for and received a VIGRE grant which covered the airfare for my trip to Europe.

Upon arrival in Germany, I met Lesch's doctoral student, Christian Frey. Together we studied K-theory for C*-algebras and I gave two introductory talks on the subject to a group of pre-diploma students in Köln. Working with Christian in preparing my talks was an invaluable experience; not only for the mathematical benefits of collaboration but for the education I received in the German student attitude. German students do not have to pay to go to university. While they are there, no one forces them to do homework, attend class or study. It is up to the individual student to decide why they want to study a certain subject.

lating intellectually and exciting culturally. My wife and I made close friends, enjoyed the small pleasures of daily life in a Chinese city, ate incredible food, and accumulated quite a lot of frequent train rider miles travelling around China.

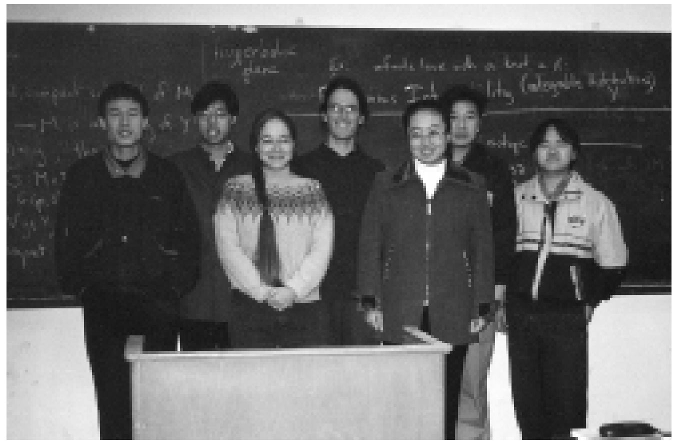
During the last year of my doctoral program, while sending off a huge stack of job applications to universities all across North America, I wondered what options were out there to do mathematics elsewhere. I asked Alan Weinstein at Berkeley for his thoughts on this. First he asked how my French was, and when I replied that it was pretty rusty but that I had studied some Chinese in college, he immediately said something to the effect of, “Well, just ask Chern, he can probably send you to China.”

Shiing-Shen Chern is a Chinese mathematician, an emeritus professor at Berkeley and one of the great modern differential geometers, so with some trepidation I sent him a letter asking how one might arrange a mathematical visit to China. First he called my advisor for a background check, and then he called me and said, “So, you want to go to China? You should go to my institute.” Chern founded the Nankai Institute of Mathematics in 1985, after China opened up to the west and Chern began visiting China again after so many years away. Now, at the age of 89, he lives nearly full time in Tianjin, on the Nankai University campus, and he is tremendously respected throughout China. It is not uncommon to meet taxi drivers in China who know his name. Therefore, it is not surprising that once Chern took to the idea of my visit to Nankai, the rest of the arrangements went very smoothly.

When I was offered a three year postdoctoral position at the University of Arizona, the hiring committee was kind enough to let me take one year off to spend in China. Furthermore, my wife was kind enough to agree to come with me, and so all things conspired to make the trip a reality. After a first year and a summer in Tucson, we set off for China in September 2000.

My work is in low-dimensional symplectic and contact topology; while no one at Nankai works in precisely this field, there were many researchers and graduate students eager to learn what they could about the subject and to teach me about their own related work in geometry, topology and analysis.

The Institute has a well-endowed mathematics library, so that access to books and journals was never a problem. Early on in our visit a colleague, Fuquan Fang, and I organized a working seminar on the topology of contact structures and foliations with several graduate students and a few other researchers. Almost all mathematical discussions happened in English, since my Chinese is not good enough for mathematics. The Institute had weekly colloquia with speakers from all over China and often from other countries; the theme was usually differential geometry and Chern was always an active participant unless he was out of town.



I often visited Peking University, an hour and a half train ride away, to give or listen to talks, and I attended several international conferences around China. The most memorable was a symplectic geometry conference that spanned three cities: we started in Chengdu, the capital of Sichuan province, then moved to Tianjin and finally ended up in Beijing. I gave a talk on my own work and learned a lot from an excellent mix of mathematicians from all across China together with prominent symplectic geometers and topologists from Japan, the U.S. and Europe.

The mathematical content was stimulating enough but just in case we needed more stimulation, we were served three banquet-style meals each day; in Chengdu the food was the best, Sichuan being particularly well known for its cuisine. At our final lunch in Chengdu, a meal of Sichuan-style dimsum, the tables had motorized lazy susans that seemed to magically sprout new dishes every time you looked away. It was a tough meal to keep up with, and when we got back to Tianjin we skipped several meals just to rest our stomachs.

I taught two classes each semester, all quite a change from my teaching routine in Tucson. The first semester I taught basic graduate differential topology (with six students) and a special “Mathematical English” course (with 30 students). Differential topology was lots of fun and we became good friends with all of the students. The English course was more difficult; I didn’t really feel qualified but obviously none of the real English teachers on campus were qualified either. I decided to focus on oral skills, since the students seemed pretty good at reading and writing. We ended up swapping short lectures on elementary topics, so that they could all practice listening to lectures in English as well as giving presentations.

The second semester I taught “Topics in low-dimensional geometric topology” and a special course on differential

enter the classroom at all, but opt instead for the higher salaries and prestige of other professions. We mirror the situation here in Tucson. Ten years ago the University of Arizona would provide the school system with at least 15 new mathematics teachers per year; this year we have only two on track to graduate.

The shortage of qualified mathematics teachers has been exacerbated by a recent mandate from the State Board of Education. Last year the Board ordered that all entering high school students must take two consecutive years of mathematics covering material that has traditionally been taken only by the better math students. In most schools this meant that all students were to take Algebra 1 their freshmen year and Geometry their sophomore year. Unfortunately middle schools cannot prepare all students for Algebra 1 in the 9th grade. The failure rate for freshmen was expected to be bad and it turned out to be embarrassing: in many high schools more than half the students failed freshman mathematics. This year, those failed students are in 10th grade Geometry, and failure rates may very well be even higher. The mandate was made necessary because of the creation of the AIMS test (Arizona Instrument to Measure Standards), the Arizona state high school exit examination. This test is first given to all students at the end of their sophomore year and, on the advice of lawyers, it was decided that all mathematics tested by AIMS must be presented to the students before they take the test. The test includes Algebra 1 and Geometry. Naturally schools are scrambling to salvage students by offering supplementary remedial courses but finding qualified teachers is a virtual impossibility nowadays.

The Center is attempting to help with this difficult reality. Our first job is to address this emergency in the secondary mathematics classrooms. This fall we are piloting a program employing 20 tutors from the University and Pima College and 15 cooperating teachers from two middle schools and six high schools. The tutors are taking a one credit hour course and receiving $10 per hour for their tutoring. This is only a beginning; bear in mind that there are close to 60 secondary schools in Tucson and several of them have at least 100 students who need and want extra help in mathematics. In the spring semester we begin a second program placing as many as 40 high school students in middle schools and high schools. In the second year we hope to expand our programs even further, perhaps involving as many as 80 tutors and 40 coordinating teachers. This is not only an initiative to help students and teachers in the schools but it is also a recruiting tool. There are many university students who have an aptitude for mathematics and who love to help others. We want to give them the opportunity to experience what it is like to use their talents in a meaningful way.

We also plan a large scholarship initiative to attract young students into teaching. Already this fall we have secured funding to provide 13 scholarships to juniors and seniors at the University who are considering a teaching career. In the future we hope to have as many as 25 scholarships and include high school seniors and university freshmen and sophomores as recipients.

In the near future we intend to initiate a program where new teachers and experienced teachers can link together, get to know each other, and provide mutual support, encouragement, and advice. We hope that this will alleviate the exodus from the classroom by first and second year teachers. We also want to provide a professional component to the life of the classroom teacher. This involves funding teachers who wish to return to the classroom and take advantage of our graduate courses in Mathematics Education and also provide support for those who wish to attend and participate in regional and national professional meetings.

This is an expensive undertaking. Setting up the Center requires finding space, hiring directors and staff, and providing for operating funds. Carrying out our plans is costly; in fact, elementary mathematics will show that the tutoring initiative alone has a surprisingly high price tag. We have begun operations thanks to generous gifts from private individuals. These funds, along with some state funds, have given the Center the chance to carry out its plans for the first year and even begin outlining plans for the second year. We have hired two of Tucson’s finest teachers to direct operations of the Center. Sue Adams has been a mathematics educator for over 30 years in the Tucson area. During the past two decades she has served as Head of the Mathematics Department at University High School and then as High School Mathematics Coordinator for Tucson Unified School District. Ann Modica has also been a mathematics educator in Tucson for over 30 years. She has won a number of prestigious teaching awards including the Presidential Award for Excellence in Science and Mathematics Teaching. For the past decade she served as Head of the Mathematics Department at Rincon High School. And thanks go to Professor Steve Willoughby of the Mathematics Department who has provided a temporary home for the Center in his office. This is an especially generous offer in our space-starved Mathematics Building.

The Center has the support of the University Administration. While it is not yet incorporated into the University structure we have been given assurances that if the Center can make a tangible difference in the next few years the University will provide necessary resources and fund it long term. We are hopeful that the work of the Center will make a clear difference in the near future so that we can continue this work.

ENRICHING HIGH SCHOOL MATHEMATICS

Elias Toubassi, Professor,
Department of Mathematics
Associate Head for the Entry Level Program

The Mathematics Department, in cooperation with local school districts, has developed a two-year project to work with high school mathematics teachers to develop curriculum material that helps mathematics teachers assist their students to meet the State standards as measured on the AIMS test. This collaboration has resulted in an Eisenhower grant proposal which was funded by the Arizona Board of Regents. The first workshop was held in June 2000 and the second in June 2001. The participating districts are: Amphitheater, Catalina Foothills, Flowing Wells, Marana, Sunnyside, and Tucson Unified School District.

The 2001 workshop was held from June 4 through June 15 on the campus of the University of Arizona and:

- Provided a forum for teachers to create curriculum material that addresses the State standards in mathematics;
- Included instruction on mathematics topics such as probability, statistics, and logic, that give teachers a deeper background in standards-related topics; and,
- Focused some sessions to develop new ideas to teach traditional subjects such as algebra and geometry.

In addition, participating teachers took part in two full days of in-services during the 2001-2002 academic year. The Fall in-service was held at Sahuaro High School in October and the Spring in-service will be held at Flowing Wells High School in March, 2002. The highlight of the in-services is time when teachers share how the new curriculum lessons are being received by students in their classrooms. These programs result in the formation of community support among faculty and high school teachers.

Participating teachers received a $400 stipend, a small curriculum allowance, and a classroom set of graphing calculators. The following faculty assisted with the workshop: Christopher Goff, Brigitte Lahme, Carl Lienert, Bin Lu, Jerry Morris, Diann Porter, Maria Robinson, Joseph Watkins, and Stan Yoshinobu.

A MYOPIC VIEW OF PROGRAM ACCESS

OR HOW SOME STUDENTS CHANGED MY LIFE

David Lovelock, Professor
Department of Mathematics

In Fall 1990 I was teaching honors Calculus 1 in our mathematics computer classroom. We had just opened this room – the first in the U.S. – and had made it accessible to students in wheelchairs, even though in my previous 30 years of teaching, I had never had a student with a physical disability in any of my classes. Imagine my surprise when one of the first students to enter the room was in a wheelchair. This was John Olsen, a freshman in the Department of Electrical and Computer Engineering. Some will remember him tearing around campus with a Mickey Mouse flag attached to the top of an antenna fixed to his electric wheelchair.

John and I remained in touch after he finished Calculus 1. John graduated and started postgraduate studies in ECE. Then one day in 1997 he introduced me to another graduate student, Ali Mehrabian, in Civil Engineering. Ali also whips around campus in an electric wheelchair. The two of them then told me a story.

Ali and John had been remorsing over how few students with physical disabilities were studying Science, Engineering, Mathematics, or Technology (now known as SMET) at UA. They had done a web search, and stumbled upon a National Science Foundation (NSF) request for proposals to encourage more students to study SMET. They wanted to write such a proposal, but didn't know what to do. They turned to Georgia Ehlers, the Coordinator of Grant and Scholarship Development in the UA Graduate College. She advised them to find a faculty member to spearhead the project.

Building bridges - with toothpicks and jellybeans

Grocery store botany

To cut a very long story short – and despite all my kicking and screaming explaining that I knew nothing about disability issues – I became that person, and so Program ACCESS (Accessing Career Choices in Engineering and the ScienceS) was born, and my life was changed forever.

With the help of an interdisciplinary cross-campus group, Ali, Georgia, John, and I wrote the proposal, and the NSF funded the $500,000 three-year request in July 1998. It is a multi-faceted project aimed at students with physical disabilities from middle school to graduate school.

We have undergrads mentoring school kids, and graduates mentoring undergrads –all with physical disabilities. We give encouragement grants to school teachers to help them make their classes more accessible. Ali and John give in-class demonstrations at schools to show that their handicaps are not handicaps. We work with the College of Architecture and have their sophomores analyze various labs on campus and suggest ways to make them more accessible. And we offer a summer camp (Camp ACCESS) for 12 middle school kids.

The camp is our pride and joy. It lasts for 2 ½ weeks, and is run by Faith Bridges, an adjunct faculty member in the mathematics department, who has experience as a middle / high school teacher. The camp emphasis is on science, not on disabilities. The program is a smorgasbord of hands-on activities and is presented by UA faculty from many disciplines. These activities range from Grocery Store Botany to Mammals With Wings, from Being a Paleontologist to How Spaceflight Affects Humans, from Practical Dendrochronology to Experiments With Liquid Nitrogen, from Hands-On Math to Blood and Guts!, from Building and Testing Model Bridges to What's Inside My Computer? The campers visit a clean room, play with an electron microscope, take a tour of IBM and spend time selecting science books at Borders bookstore.

The schedule for the Camp ACCESS 2001 can be seen at http://www.math.arizona.edu/~dsl/camp2001.htm. Photos are visible at http://w3.arizona.edu/~access/.

I have been involved with a number of rewarding and worthwhile activities in my 40-year career as a faculty member at universities around the world, but this has been the most rewarding and the most worthwhile. I can do no better than quote from a letter from one of the camper's parents, the full text of which can be read at http://w3.arizona.edu/~access/letters/letters.html. (You may need a Kleenex while reading the full letter. I do.)

> "I have thought a lot about what it is that made your camp so wonderful for my son Justin as well as his fellow campers. To say you changed my son's life is not hyperbole. When I brought Justin to camp 2 weeks ago, I entered with a disabled child. Two weeks later, I am going home with an able child who happens to have challenges in life. He has gone from withdrawn and frustrated to friendly with other children and excited about learning. You have taught him more in 2 weeks than you will ever know."

By being frugal, and accepting donations, we will be able to run Program ACCESS for an extra year beyond the end of the initial three, until summer 2002. After that, the future is unclear, but of all things we have done, we will try to keep the camp going. Finally, I should report that John now has his Ph.D. and is working for IBM. Ali is close behind.

Thank you John and Ali for twisting my arm.

A YEAR IN CHINA

David T. Gay, Visiting Instructor, Postdoctoral Scholar
Department of Mathematics

I just returned from a year of teaching and research at Nankai University and the Nankai Institute of Mathematics in Tianjin, China; this article is a report on my mathematical and cultural experiences there. For a good number of mathematicians in the U.S. (those originally from China) this story won't have too many surprises but it might be entertaining to hear it told from the point of view of someone not Chinese. To those who have never been to China or even thought of visiting, I hope the story is interesting and encourages more foreign mathematicians to visit China in an academic capacity.

It was a wonderful year: productive mathematically, stimu-