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Vote of Confidence: IMA Gets Five-Year, $19.5 Million Renewal from NSF

By Barry A. Cipra

The Institute for Mathematics and its Applications at the University of Minnesota has been an attracting fixed point in the mathematics community since its inception in 1982. It will remain so for at least the next five years, courtesy of a whopping 77% increase in funding from the National Science Foundation.

With the five-year renewal, NSF support for the IMA will increase from the current $2.2 million per year to $3.9 million for the next five years. The $19.5 million total, according to William Rundell, director of NSF's Division of Mathematical Sciences, is the largest single research grant ever awarded by DMS. The IMA's total budget, including support from the University of Minnesota and 50 participating universities and corporations, will be $5.5 million per year.

Joining IMA director Doug Arnold (center) in Minneapolis for the announcement that the Institute for Mathematics and its Applications would enter the upcoming five years with a significant funding increase from the National Science Foundation were Steve Crouch (left), dean of the Institute of Technology at the University of Minnesota, and William Rundell, director of NSF's Division of Mathematical Sciences. "There seems to be no end to the new problems waiting to challenge mathematicians willing to enter into interdisciplinary collaborations and think in new ways," Arnold says. "The potential payoff—to the health, prosperity, and security of the country and the world, but also to the vitality of mathematics itself—is immense. The need for institutes like the IMA is greater than ever." Photo by Patrick O'Leary.

"The IMA has become a preeminent mathematics institute that serves as a model for other institutes worldwide," Rundell said at a July 20 announcement ceremony at the IMA. "Its innovative interdisciplinary programs are an essential component of the NSF's portfolio."

"Our basic mission remains unchanged," promises IMA director Doug Arnold. The main mission, he says, is to identify cutting-edge areas of science and technology in which mathematics can make major contributions and to facilitate interdisciplinary work in those areas.

The IMA is also devoted to developing a cadre of interdisciplinary-oriented mathematicians through its well-established postdoc program (which in 23 years has hosted 198 regular and approximately 40 industrial postdocs) and its more recent "New Directions" program, begun in 2003, which is designed to help mid-career mathematicians segue into interdisciplinary research. With the new budget, Arnold says, "It'll be a lot easier to put together programs and get the best people."

Arnold sees the synergy between the annual thematic program and the IMA postdoc program as a particular strength of the institute. An IMA postdoc, he points out, "has a chance to interact with a tremendous variety of scientists relevant to his or her research area: some junior and some senior, some from mathematics and some from an area of application, some with a similar background and some coming at the same questions from a very different perspective. The resulting contacts, collaborations, and research directions have proved to be the foundation for many brilliant careers."

Also up for NSF renewal this year were the IMA's fraternal twin, the Mathematical Sciences Research Institute at the University of California, Berkeley, and their younger sibling, the Institute for Pure and Applied Mathematics at UCLA. Arrangements remained to be worked out for both MSRI and IPAM, but in Minneapolis Rundell described the IMA to its assembled supporters as "primus inter pares"—first among equals.

A 77% increase would be a vote of confidence in any circumstances. In a time of generally flat funding for federal agencies and, in fact, a 3% cut in the overall budget for NSF in the coming fiscal year, it becomes even more remarkable.

"The IMA made a convincing case," Rundell says. "We saw an effort that was running extremely well, and we bought it—we chose to invest."

In making the investment, DMS looked beyond money budgeted specifically for institutes, tapping funds allocated to other activities that the IMA, as thoroughly documented in its proposal, has carried out extremely well. Rundell points to the IMA's postdoc and New Directions programs as two examples—what the IMA was doing was so effective that the efforts would have been funded under separate proposals to, say, workforce programs.

Another important DMS objective successfully addressed by the IMA is that of broadening the range of participation in DMS programs—

not only by women and ethnic minorities, but also by mathematicians from institutions in states that do not receive much if any direct funding from DMS. Here, too, DMS was able to add to the IMA award by drawing on funds set aside for expanding the geographic reach of the division. “The IMA didn’t wake up one day and decide that this was a good thing to do,” Rundell says. “Their track record was exemplary, and it was well documented.”

Careful documentation of another type was an important component of the IMA proposal. According to DMS program directors, the NSF reviewers and site inspectors were particularly impressed with a collection of informational “nuggets” describing research results and scientific breakthroughs traceable to IMA programs and workshops, ranging from a simulation tool for cardiac ablation therapy (see sidebar) to the analysis of a rash of dead phone lines.

These brief descriptions, Rundell says, are vital to efforts to explain the importance of research in the mathematical sciences. “They are used by NSF’s public relations office, and by the NSF director in preparing budget submissions and justifications to the OMB [the White House Office of Management and Budget] and, ultimately, to Congress.”

The IMA has just finished a yearlong program on the mathematics of materials and macromolecules. The theme for 2005–06 is imaging. The focus (so to speak) in the fall will be on obtaining images from sensor data, with workshops including Imaging from Wave Propagation (October 17–21), Frontiers in Imaging (November 7–11), Integration of Sensing and Processing (December 5–9), and New Mathematics and Algorithms for 3–D Image Analysis (January 9–12). The emphasis of the spring program will be on “understanding” images—something that human observers do very well, but that computers still need help with. Scheduled workshops are The Mathematics and Art of Film Editing and Restoration (February 6–10), Natural Images (March 6–10), Shape Spaces (April 3–7), and Visual Learning and Recognition (May 22–26).

Beyond—and in part because of—the network of visitors the IMA has hosted over the years (upward of a thousand people spend from a few days to several months each year at the IMA), the institute has had a profound effect on the mathematical culture, Arnold says. In NSF’s original call for proposals, in the late 1970s, “there was no suggestion that a non-mathematician would ever visit a math institute,” he says. But Minnesota’s Willard Miller, George Sell, and Hans Weinberger had a radically different vision. “They proposed an institute where people were engaged with scientists. The IMA we have now was pretty well visualized there back in that proposal.”

Nowadays there are strong industrial and interdisciplinary ties virtually across the board in mathematics. “There’s no doubt that having a strong institute showing it works, getting people involved, involving the best people, was a big part of it,” Arnold says

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A Healthy Kind of Heartburn

Cardiac ablation is a surgical technique for treating patients with atrial fibrillation—an abnormal rhythm caused by electrical discharges from portions of the atria (the upper two chambers of the heart) other than the sino-atrial node, which is the heart’s official pacemaker. Working with the Minneapolis-based medical technology firm Medtronic, Inc., IMA industrial postdoc Jayadeep Gopalakrishnan developed a mathematical model for a particular approach to cardiac ablation. Medtronic uses Gopalakrishnan’s model in the evaluation of designs for ablation therapy.

The idea of ablation is to destroy rogue tissue with radiofrequency energy delivered from the end of an electrode. The procedure can be carried out either endocardially, via a catheter threaded into the heart, or epicardially, which involves exposing the heart and destroying the offending tissue from the outside. Although more invasive than the endocardial approach, epicardial ablation offers distinct advantages that make it appropriate for some patients. In particular, the surgeon can see exactly what he or she is doing. Certain regions of the heart, moreover, are not easily reached by a catheter.

Endocardial ablation has been much studied. Gopalakrishnan tackled the more novel epicardial case. In both approaches, the system is irrigated with saline to remove heat from the area being ablated and, thus, prevent overheating of surrounding tissue. (The ideal temperature is above 50 but below 100 degrees Celsius.) In endocardial ablation, the saline is washed away in the bloodflow. But in epicardial ablation, the saline, administered through the electrode, forms a thin film on both electrode and heart surface.

Gopalakrishnan, who did his graduate work at Texas A&M University and is now at the University of Florida in Gainesville, used the theory of thin films to derive a velocity profile for saline (inspired, he points out, by similar arguments used to study lava flows!). He incorporated the velocity profile into a finite element model for equations describing the electric field generated by the electrode and the temperature profile of the tissue and underlying bloodflow, which figures prominently in the analysis (see Figure 1, from an IMA “nugget” poster).

Gopalakrishnan’s model can be used to study how ablation is affected by the thickness of the tissue and the saline layer, as well as by changes in the rates of irrigation and bloodflow. In particular, the model suggests that the maximum tissue temperature is considerably higher—by as much as 40 degrees Celsius—than the temperature at the tip of the electrode,

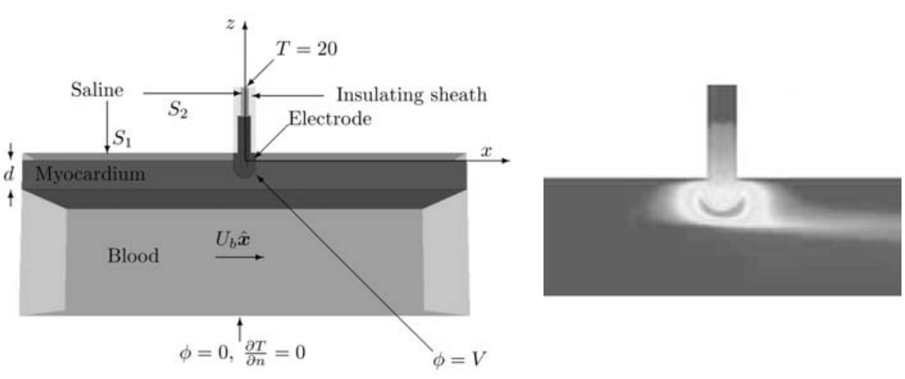

Figure 1. *Simulation of cardiac ablation; from the work of Jayadeep Gopalakrishnan.*

which of course is where temperature is easiest to monitor. The temperature difference levels off after about 5 seconds, however, suggesting that tip temperature is still a useful indicator. Guided by the simulations, biomedical engineers can design equipment for more effective ablation therapies.—*BAC*