

# CMRR Report

Center for Magnetic Recording Research

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## Shannon Symposium and Statue Dedication at CMRR

**A**t 2 PM on October 16, 2001, a statue of Claude Elwood Shannon, the Father of Information Theory, was dedicated in the lobby of the Center for Magnetic Recording Research (CMRR) at the University of California, San Diego. In conjunction with the dedication, a symposium honoring Shannon's life and work was held on October 15th and the morning of October 16th. The symposium and dedication ceremony were attended by approximately 100 persons, many of them UCSD students.

plied the resources to videotape the symposium proceedings, as well as interviews with many of the speakers, for use in a pair of UCSD-TV documentaries highlighting the enormous impact of Shannon's genius.

The acquisition of the sculpture and the organization of the Shannon Symposium were spearheaded by Professor Jack K. Wolf, a member of the Electrical and Computer Engineering department in the Jacobs School of Engineering, and holder of one of the four CMRR endowed chairs.

The Shannon Symposium program included invited technical presentations and personal reflections by fourteen information theorists from industry and academia, including CMRR Director Paul Siegel and UCSD Professor Alon Orlitsky. Many of the speakers themselves have made enormous contributions to the astounding advances in telecommunications that have transformed our world in the past half-century. Among them were six recipients of the prestigious Claude E. Shannon Award, the highest technical honor bestowed upon an individual by the IEEE Information Theory Society. The Shannon Award, which

*continued on page 2*



OCTOBER 16, 2001, SHANNON STATUE UNVEILING. LEFT TO RIGHT: DEAN ROBERT CONN, SCULPTOR EUGENE DAUB, SHANNON STATUE, DR. IRWIN JACOBS, VICE CHANCELLOR MARSHA CHANDLER, HOST JACK WOLF

Generous support for both events, including a live webcast of the symposium, was provided by the California Institute of Telecommunications and Information Technology (Cal(IT)<sup>2</sup>) at UC, San Diego. The Jacobs School of Engineering and UCSD-TV sup-

# Shannon Symposium and Statue Dedication at CMRR

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Prof. Wolf himself received in 2001, is given annually in recognition of consistent and profound contributions to the field of information theory.

The Symposium speakers and their presentation titles were as follows:

- Toby Berger**, "Living Systems are Shannon Optimum Without Coding"
- Paul Siegel**, "The Continuing Miracle of Information Storage Technology"
- Jacob Ziv and Alon Orlitsky**, "Universal Data Compression"
- David Neuhoff**, "Time Stamp Coding-A Problem Shannon Did Not Answer"
- Thomas Cover**, "The Value of State Information in Communications and Data Compression"
- G. David Forney Jr.**, "Approaching Channel Capacity"
- Edward van der Meulen**, "The Duality Between Successive Refinement of Information by Source Coding with a Fidelity Constraint and Efficient Multilevel Channel Coding Under Cost Constraints"
- Robert Lucky**, "Impact of Shannon on Modern Telecommunications"
- Ian Blake**, "Randomness and Determination in Coding Theory"
- Andrew Viterbi**, "Quantized Iterative Decoding with Closed-Form Density Evolution Recursions for LDPC Codes on the AWGN Channel"
- Solomon Golomb**, "The Claude Shannon I Knew"
- Elwyn Berlekamp**, "Shannon's Work on Block Code Performance and It's Impact"
- Shu Lin**, "Construction of Low Density Parity Check Codes: Combinatorial Approaches"
- Robert McEliece** "The Generalized Distributive Law (with Loops) and Free Energy Minimization"

The dedication ceremony that followed the Symposium, hosted by Jack Wolf, included remarks from UCSD Senior Vice Chancellor Marsha Chandler; UCSD Professor and Director of the San Diego Division of the Cal(IT)<sup>2</sup> Ramesh Rao; and

Jacobs School of Engineering Dean Robert Conn. The next speaker, Qualcomm Chairman and CEO - and former UCSD faculty member - Dr. Irwin Jacobs, commented on the enormous impact of Shannon's work upon communications and shared a fascinating historical tidbit, namely that in 1967 Claude Shannon was named a Fellow of Muir College at UCSD. Sculptor Eugene Daub concluded with remarks about the creative process from which emerged his beautiful and moving work of art. Finally, to the delight of all in attendance, the bust was unveiled by Rachel Wolf, Jack Wolf's granddaughter.

The bronze plaque on the pedestal of this statue reads:

**CLAUDE ELWOOD SHANNON  
1916-2001,  
Father of Information Theory  
His formulation of the mathematical  
theory of communication provided  
the foundation for the development  
of data storage and transmission  
systems that launched the  
information age.  
Dedicated October 16, 2001,  
Eugene Daub, Sculptor**

As depicted in the sculpture, Shannon holds in his left hand a sheet of paper. On this sheet is inscribed a formula taken from Shannon's landmark 1948 paper, "A Mathematical Theory of Communication," that is universally acknowledged to be the genesis of information theory. The formula, selected by Jack Wolf for its relevance to both digital data recording and transmission, gives the capacity of a discrete noisy channel:

$$C = \text{Max} (H(x) - H_Y(x)).$$

Be sure to enjoy the sculpture that now graces the CMRR lobby on your next visit, and look for the symposium proceedings and further details about the UCSD-TV documentaries on the CMRR and Cal(IT)<sup>2</sup> websites. 

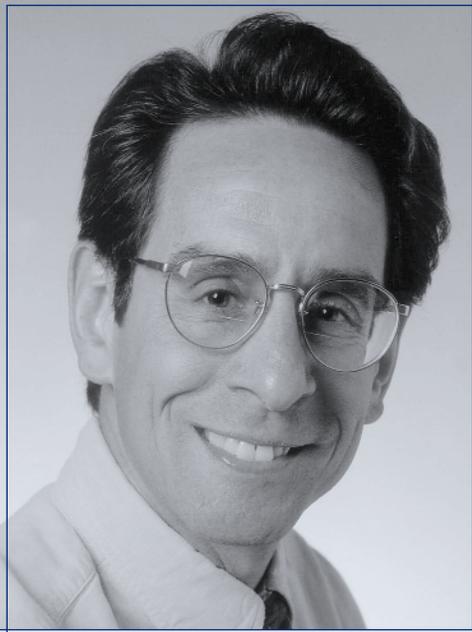
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**CLAUDE ELWOOD SHANNON  
1916-2001**

*Father of Information Theory*

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# FROM THE DIRECTOR



**T**he CMRR newsletter is back! The revival of the newsletter is part of the Center's overall effort to more effectively communicate with our partners in industry and in government agencies, to more actively engage with our many alumni/ae, and to more clearly articulate to the general public the importance of information storage technology in today's networked infrastructure. To this end, the newsletter will highlight important research developments, offer background on new technical initiatives, showcase students and researchers, and provide news for and about CMRR alumni/ae.

This semi-annual publication is intended to complement the other resources that CMRR provides to our partners for information about the Center's progress: the Spring and Fall Research Reviews, the CMRR Information Center, and the CMRR Website. (The newsletter will also be posted on our Website at <http://www.ucsd.edu/cmrr>)

During the past 18 months, the Center has not only maintained its strength in core research areas, but also expanded into new areas vital to the future of magnetic recording.

Our Fiscal Year 2000-2001 research budget was close to \$2.5M, including contributions from our industrial partners, federal and state funding agencies, and the University of California. We have supported collaborations with affiliated UCSD faculty in Computer Science and Engineering (SMART - drive failure prediction), Electrical and Computer Engineering (coding for optical fiber channels for storage networks), Mechanical and Aerospace Engineering (servo control), and Physics (magnetic semiconductors and magnetic nanoparticles). The National Security Agency (NSA) is sponsoring a particularly timely research project addressing two seemingly opposite objectives - secure erasure of information on disks and tapes, and recovery of information from "erased" storage devices.

CMRR faculty and scientists are active participants in the National Storage Industry Consortium (NSIC) research programs, with several projects now being funded by the Extremely High Density Recording (EHDR) "Terabit per square inch" project and the TAPE project. The Center is also playing an active role in, and benefiting from, the evolution of the California Institute for Telecommunications and Information Technology, or Cal(IT)<sup>2</sup>, which recently celebrated its first anniversary. The Institute sponsored a Workshop on Non-Volatile Memory (organized by CMRR Affiliated Faculty Professor Frances Hellman of Physics), the Shannon Symposium and Statue Dedication (organized by CMRR Professor Jack Wolf), and a Summer Undergraduate Research Fellow. The Institute is also fostering and providing support for evolving CMRR collaborations with researchers in Physics and in the San Diego Supercomputer Center.

In this issue of the newsletter, you will find articles about several of

these activities, as well as profiles of some of our visiting students and researchers. You will also learn of professional and technical recognition received by our faculty, research scientists, and students, including Jack Wolf's selection by the IEEE Information Theory Society as the recipient of the prestigious 2001 Claude E. Shannon Award, and UCSD senior Heidi Buck's first prize in the ECE Department's undergraduate research conference for her CMRR research project. And there is more that I believe will be of interest and value to you, as well.

In closing, let me thank you for your interest in CMRR. Information storage technology is a vital pillar - along with communications and computing - in the evolving networked infrastructure that will be the foundation of our global society. The research and educational programs at CMRR have a proud tradition, combining technical innovation in magnetic recording with a commitment to produce creative, motivated, and skilled graduates who will accelerate the evolution of storage technology from positions in industry, government labs, and academia.

The future holds both opportunity and challenge for CMRR, as it does for the data storage industry as a whole. We are delighted to be in a strong position to contribute to what I like to refer to as the "continuing miracle of information storage technology."

I hope that our corporate and governmental sponsors will continue to recognize the enormous value - to them, the storage industry, and society as a whole - that derives from their investment in CMRR.

**Enjoy the newsletter!**

A handwritten signature in black ink that reads "Paul H. Siegel". The signature is written in a cursive, slightly slanted style.

— Paul H. Siegel, Director

# Cal (IT)<sup>2</sup> Workshop on Non-Volatile Memory

**F**rances Hellman, Professor of Physics at UCSD and CMRR Affiliated Faculty member, organized and hosted the Cal-(IT)<sup>2</sup> Workshop on Non-Volatile Memory, held at CMRR, September 21-22, 2001. The objective of the workshop was to develop a plan for collaborative research, in partnership with industry, in the area of advanced non-volatile memory technologies. A blue-chip roster of speakers from leading companies in the information storage industry delivered stimulating technical presentations to a group of more than 50 academic and industrial researchers. Among the speakers were representatives of Seagate Technology and IBM, two of the founding sponsors of CMRR and both vital partners in collaborative research ever since.

The audience included 14 faculty members from UC Irvine and UC San Diego, including 3 from CMRR, representing the Materials and Devices layer and the Networked Infrastructure layer within Cal-(IT)<sup>2</sup>. "The institute recognizes the importance of putting academics and business researchers together," said Hellman. "It quickly became clear that there are a number of areas where our research can complement what industry is doing, especially on technologies that won't be commercial for a few more years."

In welcoming workshop participants, Cal-(IT)<sup>2</sup> director Larry Smarr said that the institute's buildings at

UC Irvine and UC San Diego are being designed to enhance research in key areas for materials and devices. "Opto-electronics, quantum computing and communications, non-volatile memories, and materials research are all core competencies for Cal-(IT)<sup>2</sup>," said Smarr. "Non-volatile memory has a major role to play in a future where billions of wireless sensors and other

will involve self-assembly, nanomagnetism, and "spintronics" (spin electronics). Added Schuller: "If you look 20 years into the future, you're talking about quantum magnetics, working at the molecular level, and quantum computing."

After Schuller's presentation, Dieter Weller, director of media research at Pittsburgh-based Seagate

Technology, expanded on "The Future of Magnetic Recording."

"Magnetic recording will not be dislodged in the foreseeable future," he said. "It is a very low-cost method of storing vast amounts of data with almost no competition. Magnetic recording is hard to compete with from a capacity perspective

as well as from a technology maturity perspective. At the moment, recording densities of about 100 Gigabits per square inch have been demonstrated. We think we can push the technology up to perhaps 150-200 Gigabits per square inch using conventional longitudinal [technology], then we may move to perpendicular recording pushing toward 500 Gigabits per square inch or higher. At terabit per square inch areal densities a bit cell is only 25 nano-meters on the side. We are eventually approaching the point where we have single-, as opposed to multiple-particle-per-bit recording. At Seagate we are very interested in novel media approaches.

*continued on page 10*

*"The institute recognizes the importance of putting academics and business researchers together. It quickly became clear that there are a number of areas where our research can complement what industry is doing, especially on technologies that won't be commercial for a few more years."*

*— Frances Hellman*

devices will be gathering, storing, transmitting and even processing vast amounts of information."

UCSD Professor Ivan Schuller updated attendees on basic research issues related to the future of magnetism, urging scientists to "follow your nose! Don't let applications or immediate business dictate where you look for the answers." Schuller also advised researchers to "push limits"-to smaller sizes, more complex materials, using state of the art technologies, and exploring unusual geometries. Looking out ten years, the leader of Cal-(IT)<sup>2</sup>'s Materials

and Devices group at UCSD (his counterpart at UC Irvine is Professor G.P. Li) said the technology frontier

**C**MRR hosted members of the CMRR Industrial Sponsor companies and special invited guests at the semi-annual Research Review and Advisory Council meeting on October 17-18. The two days of talks highlighted the work of the CMRR researchers and graduate students. The Wednesday agenda began with talks on Signal Processing for Recording from Prof. Jack Wolf's group, followed by presentations on Coding and Modulation by members of Prof. Paul Siegel's group. The afternoon activities began with a special session featuring a talk on Storage Systems and Networks by Chaitanya Baru and Phil Andrews, Program Co-Directors, Data and Knowledge

Systems Program, San Diego SuperComputer Center.

Dr. Gordon Hughes discussed Intelligent Disk Drives, and Prof. Ami Berkowitz's group ended the first day's session with presentations on Magnetic Materials and Devices. Late afternoon and evening activities included tours of the CMRR laboratories, private discussions with students and researchers, and dinner. The Advisory Council meeting followed. Day two began with presentations on Recording Physics and Micromagnetics by members of Prof. Neal Bertram's group, followed by talks on Tribology and Mechanics from Prof. Frank Talke's group. The

meeting adjourned at 4:30 p.m., however guests were invited to stay for optional lab tours, private discussions, and the IEEE San Diego Magnetics Society Chapter meeting. Guest speaker, Nick Rizzo, from Motorola Labs, gave a presentation entitled "Magnetoresistive Random Access Memory - 256kb MRAM Wafer Progress."

**The next CMRR semi-annual Research Review is scheduled for May 22-23, 2002.**

CMRR Industrial Sponsor company employees may contact Cheryl Hacker (858-534-6563 or chacker@ucsd.edu) to ensure that your name appears on our invitation list

## Research Highlights

S.M.A.R.T. (Self-Monitoring and Reporting Technology) is a UCSD/CMRR research program to improve the failure warning technology currently built into disk drives. Long term goals include drive reliability improvement by SMART technology assessment of individual drives during their manufacturing final test, and by building expert systems for computerized failure analysis. The program is described in the SMART web site at [cmrr.ucsd.edu/smart](http://cmrr.ucsd.edu/smart) and is sponsored by the UCSD Information Storage Industry Center, a Sloan Foundation Center.

The research program works with disk drive manufacturers on their

SMART technology, to assist them in enhancing their failure warning accuracy and warning time, while reducing false alarms from good drives. Experimental SMART failure warning data is analyzed by data mining and pattern recognition statistical techniques.

Significant opportunities exist for SMART enhancements. Its maximum failure warning accuracy is estimated to be about 30% overall in the disk drive industry today. Disk drive field return rates are about 1% per year, and more than one-third of these are false alarms. The drive checks out okay. The SMART false alarm rate needs to be kept at 0.1%-0.2% to

minimize the number of good drives returned, while maintaining maximum accuracy.

Improved SMART prediction methods have been developed at CMRR that achieve the maximum accuracy possible, at these low false alarm rates. They are simple to implement in disk drive internal firmware.

# Recent Gifts, Grants, Awards, and Internships

**National Storage Industry Consortium (NSIC)** grant to **Paul Siegel** as part of the Extremely High Density Recording (EHDR) 1 Terabit-per-square-inch program. The project title is "Error Control Coding for Terabit per Square Inch Recording." The research addresses performance and implementation issues for enhanced error-correction coding schemes, particularly soft-decision Reed-Solomon decoding algorithms.

**NSIC** grant to **Neal Bertram, Paul Siegel and Jack Wolf** as part of the EHDR 1 Terabit-per-square-inch program. The project title is "Software Development of a Data Stream Simulator for Perpendicular Recording at Densities of 300 Gbit-per-square-inch and Beyond." The purpose of the study is to develop a data simulator that can rapidly generate large streams of playback pulses while incorporating realistic physical models of the perpendicular recording process.

**Prof. Frank Talke and Dr. Fred Spada** have each recently received continued funding from **NSIC** under their Program in Advanced Magnetic Tape Storage Technology. Prof. Talke's research centers on the "Investigation of Tape Edge Wear," which addresses the characteristics of tape edge defects and tape edge wear as a function of tape velocity, tape lateral guide force, local contact pressure, mechanical properties of the guide pad, and thickness of tape substrate and tape magnetic coating.

**Dr. Spada's** research involves the "Contribution of Electrochemical Processes to Increased Head-Media Spacing in Tape Drives." It is expected that the results of the studies will identify potential electrochemical incompatibilities among the tape/environment and candidate head materials that can contribute to increased magnetic spacing during operation.

**Prof. Ami Berkowitz** has recently received funding from the **Lawrence Livermore National Laboratory, IAP Research, Inc.**, and a Multi University Research Initiative (MURI) funded by the **ONR** via the **Massachusetts Institute of Technology**.

The Livermore project's objective is to eliminate chard formation during the spark erosion of Terfenol. Prof Berkowitz's group will investigate two approaches to eliminate this problem. The first is to produce very short (<1 millisecond) pulses for the spark erosion in order to drastically reduce the strained area. The second approach is to use the chards and/or small Terfenol particles formed by milling and subject them to arcing in argon in a confined Delrin cell with 60 Hz power source. This process is referred to as "refrying" the Terfenol.

The **IAP Research** project calls for the selection of appropriate magnet powder compositions suitable for high frequency applications (<100 MHz) and preparation of powders using a spark erosion process.

**Prof. Berkowitz's MURI** project coordinates the magnetic and structural characterization of spark-eroded Ferromagnetic Shape Memory Alloy particles.

**IBM** has recently awarded **Prof. Neal Bertram** both a 2001 IBM Faculty Partnership Award, and an IBM Fellowship Award.

The Faculty Partnership Award involves computer simulations of Ultra High Speed Magnetization Reversal in Magnetic Recording Heads. The research will develop a code that focuses on the head tip region where the recording field emanates. The numerical problem involves incorporating intrinsic magnetization dynamics with the effects of the material conductivity.

The Fellowship Award supports **Zhen Jin**, a Bertram graduate student researcher for the 2001-2002 nine-month academic year. **Mary Doerner** will act as the technical liaison and main point of contact at IBM. The fellowship will support Zhen's research on the role of medium microstructural design on system performance.

**The National Security Agency** has awarded a contract to **Dr. Gordon Hughes** for a continuing disk erasure study. The project will support the implementation of the "Security Erase" technology that CMRR has developed, whereby disk drives containing confidential material can be erased in a manner assuring complete destruction of all prior recorded information ("shredding electronic data"). After a drive reports a successful Security Erase ("SE") completion, there should be no technique that would permit recovery of the information.

# HONORS AND AWARDS

## June 2001

Prof. **Jack Keil Wolf**, recipient of the 2001 Claude E. Shannon Award of the IEEE Information Theory Society, delivered the Shannon Lecture at the 2001 IEEE International Symposium on Information Theory, which was held in Washington, D.C., June 24-29, 2001. The title of his lecture was "Constrained Sequences, Crossword Puzzles and Shannon." The Claude E. Shannon award is the highest honor bestowed by the IEEE Information Theory Society in recognition of consistent and profound contributions to the field of information theory.

## March 2001

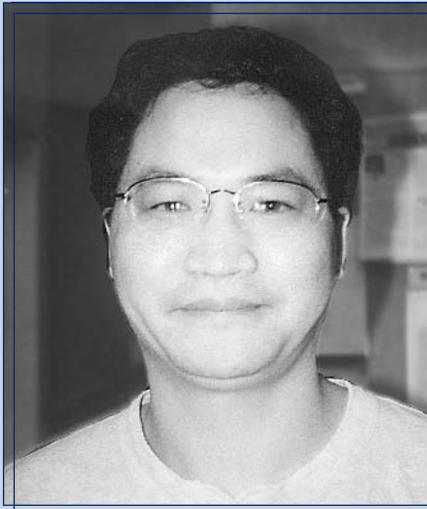
**Heidi Buck**, a senior in Prof. Jack Wolf's ECE 155B Digital Recording Projects class, Winter Quarter 2001, shared first prize at the ECE Undergraduate Research Conference and Assembly (EUREKA), which was held at CMRR, March 16, 2001. Her project was entitled "Investigation of Channel Noise Variance Estimation on Turbo Decoder Performance."

## January 2002

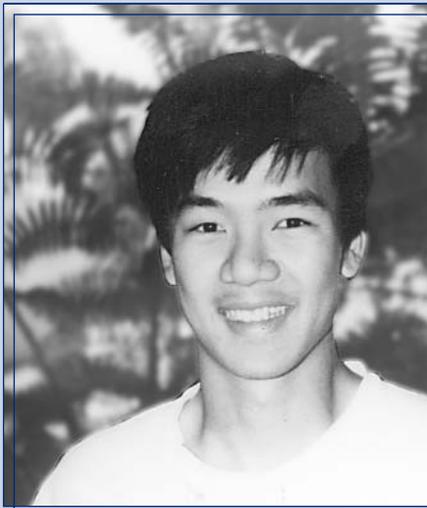
The IEEE Fellow Committee has named Senior Member **James U. Lemke** to Fellow Grade effective January 1, 2002. Dr. Lemke, a long-time friend to CMRR, was recognized for his "contributions to magnetic recording for computer data storage."

## Ph.D.'s Awarded

*Two former graduate students in Prof. Neal Bertram's research group have recently been awarded their Ph.D. degrees.*



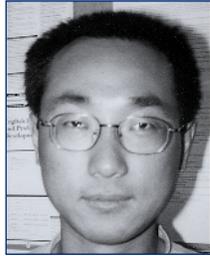
**Hong Zhou's** Ph.D. research studies involved performing large-scale numerical simulations of the magnetic recording process. The focus was the effect of granular interactions, both exchange and magnetostatic, on signals, noise, and thermal decay. He studied longitudinal (current media), both planar random and oriented, and proposed perpendicular recording for densities above 100Gbit/in<sup>2</sup>. He found optimal medium magnetic parameters for these three types of recording. After leaving CMRR, Hong was employed by Seagate Research in Pittsburgh.



**Alfred Liu** completed his Ph.D. degree in December 2000 and continued as a postdoc with Prof. Bertram until February 2001. He did a TA ship with UCSD's Physics Department until June 2001. Alfred focused during his Ph.D. studies on micromagnetic effects in thin films, including the effects of finite temperature. He applied these models to explain measurements of experimental groups at UCSD. The areas were switching mechanisms in multilayered soft thin films and temperature effects in thin granular films. He concluded his thesis with a theoretical study to explain details of the magnetization susceptibility at a reversal point.

# CMRR WELCOMES NEW VISITORS

**Yun Jun Tang** from the Institute of Physics, Chinese Academy of Sciences will spend the next year with Prof. Ami Berkowitz's research group. Dr. Tang received his Ph.D. from the Chinese Academy of Sciences in 1995/6, and was an Alexander von Humboldt fellow from 1997 - 1999 at Kaiserslautern University. He was a visiting scholar for one year, in 2000, at the Hong Kong University of Science and Technology before returning to the Chinese Academy of Sciences where he is an Associate Professor.



Dr. Tang will be working on two programs in the Berkowitz laboratory. He will be carrying out the magnetic and structural characterization of the ferromagnetic-shape—memory-alloy (FSMA) particles that CMRR will be producing by spark erosion under the MURI-FSMA program. He will also be involved with the preparation and processing of these materials. The second program is an investigation of finite size effects in antiferromagnetic and ferromagnetic nanoparticles, which will be carried out in collaboration with Prof. Frances Hellman of the Physics Department. Dr. Tang will be responsible for the heat capacity measurements that are the heart of the investigation. The nanoparticles will be supplied from IBM Watson Research Center, Yorktown Heights, and Dr. Tang will be characterizing the magnetic and structural properties of these materials, as well as preparing suitable samples for the heat capacity measurements.

Dr. Tang's wife, Jing Xu, and son Owen will join him later this year.



**Andreas Hanke** and **Matthias Panzer** joined Prof. Frank Talke's group in September. Both Andreas and Matthias received their pre-Diploma certificate from the University of Rostock in 1999 and are enrolled as graduate students in mechanical engineering under the advisement of Prof. Christoph Worernle in collaboration with Prof. Talke. Andreas' focus is on structural mechanics and engineering dynamics, while Matthias is specializing in engineering dynamics and vehicle engineering.



**Eirik Rosnes** Visiting scholar, from the University of Bergen, Norway, will be working jointly with Profs. Paul Siegel and Jack Wolf and their research groups through February 2002. Eirik has both a bachelor's and master's in Physics from the University of Bergen and is currently enrolled in the Ph.D. program in the Department of Infomatics, under the supervision of Øyvind Ytrehus. Some of you may remember that Øyvind was a visiting scholar at CMRR from July 1998 to June 30, 1999. Eirik's research will focus on parallel concatenated convolutional codes ("turbo codes") and high rate component codes. Besides his research, Eirik says that he likes to both play and watch soccer.



**Alexandre Graell i Amat** will be working jointly with Profs. Paul Siegel and Jack Wolf and their research groups through August 2002. Alex holds double master's degrees in electrical engineering, one from the Universitat Politecnica de Catalunya and the other from the Politecnico di Torino. Alex's research activities at CMRR will be related to the field of iterative decoding for magnetic recording channels. Alex is a Ph.D. student of Prof. Sergio Benedetto at Politecnico de Torino, Italy. Alex is quick to point out that although

he is studying in Italy, he is in fact Spanish.

## Open House

**T**he University of California, San Diego celebrated its 40th anniversary at the homecoming celebration and open house on October 20 from 9:00 a.m. to 4:00 p.m. CMRR joined the celebration and entertained and educated visitors with the following activities.

Fred Jeffers, the Magnetic Magician, presented his Magnetism Magic Show in the CMRR auditorium. Fred demonstrated real magnetic physics, doing seemingly impossible things. Many of the effects demonstrated are at first completely inexplicable, even to experts. No slight of hand is involved. Each trick is based on real physics, and many serve to introduce and "bring to life" important concepts in magnetism. The goal of his talk is not only to entertain and mystify, but also to teach. Unlike all other magicians, this "Magnetic Magician" explained how each trick works and outlined the basic physics involved. Fred's show is suitable for any audience, from the grade school level through the most expert.

Ryan Taylor, a graduate student in Prof. Frank Talke's group, presented a lecture entitled "Design of a Hard Disk Drive." The audience learned that magnetic recording is now the dominant information storage medium in the world. Members of the audience were asked to remember that less than 10 years ago, if you wanted to look something up in an old newspaper, you would go to the public library and look it up on microfiche film. In 1956, IBM introduced the world's first magnetic hard disk for data storage. IBM's first hard disk stored about 2,000 bits of data per square inch and had a purchase price of about \$10,000 per megabyte. By 2001, storage capacity is nearing 100 billion bits of data per square inch and the cost of storing a megabyte has dropped to around one hundredth of one cent. Visitors were asked to have a look at some of the science used to advance this technology to its present state.

CMRR Director Paul Siegel and Prof. Jack Wolf gave demonstrations of recording equipment from past ages. Demonstrations of a 1947 Majestic Radio & Television Corp.

Wire Recorder Radio Phonograph Combination, a circa 1905 Edison Cylinder Phonograph, and a unique Decca Portable Phonograph were given, followed by comparisons of modern technology including R-DAT, DCC and the ubiquitous audio CD. The Majestic was donated to CMRR by Sam Arn, and was restored to near mint condition by Dave Buck and daughter Heidi.

There were many other activities including: samples of "Scientific Ice Cream" (made by freezing the ingredients with liquid nitrogen) were served to visitors in the CMRR lobby, tours of the CMRR labs were provided, lots of posters of CMRR's on-going research activities were on display, and an information table was set up on Library Walk to acquaint visitors with CMRR's activities and to point guests in the right direction to join in the fun at CMRR.

The open house was well attended campus-wide, and CMRR had approximately 100 visitors throughout the day.

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One example is self-assembly of magnetic nano-particles with length scales in the 3-10 nm range. Writing and reading such small magnetic islands, however, will be extremely challenging.

We need a lot of innovation. Eventually, some kind of probing technology will be required: it could be based on spintronics effects, tunneling mechanisms, magnetic force

detection or perhaps advanced high sensitivity giant-magneto-resistance sensors.”

Several groups have proposed MEMS based probe storage devices involving an x-y media stage and an array of individually actuated probe tips. Such devices could provide faster access to data than conventional rotating magnetic storage, yet provide large capacities at relatively low cost. They would be intermediate in

the storage hierarchy, bridging the space between the fast but expensive DRAM and the massive and low-cost magnetic storage. The media could be non-magnetic, e.g. ferroelectric or polymer materials. “At Seagate Research, we are interested in all these areas,” added Weller. “Our philosophy is to place ‘some’ effort inside our own research laboratory, where researchers work on various approaches, materials and phenomena and stay in touch with what’s happening on the outside. The further out we go, the more we have to rely on partners and academia.”

Also making presentations at the September 21 session were two industry researchers who focused on MRAM development: NVE’s Jim Daughton, on “MRAM: Status and Opportunities”; and Motorola’s Brad Engel, on “Prototype 256-kbit MRAM.” The workshop concluded September 22 with presentations by Stuart Parkin, an IBM Fellow at the IBM Almaden Research Center, on “Magnetic Tunneling Junctions and Magnetic Memory”; Joachim Ahner, Seagate Technology, on “Novel Imaging Technology and Potential Multiple Probe Storage Devices”; and Ramamoorthy Ramesh, University of Maryland, on “Ferroelectric Memories: Science, Technology and Beyond.”

After the workshop, organizer Frances Hellman was upbeat about the prospects of increased future cooperation between UC faculty, students and industrial partners. “We will now work on a research agenda to meet some of the challenges outlined by industry researchers,” said Hellman.

For more detailed information on the Workshop, including copies of the speakers’ presentations, please visit the Cal-(IT)<sup>2</sup> website at: <http://www.calit2.net/events/2001/nv m/9-21-nonvolatile.html> 

## The Wolf Group purchases a State-of-the-Art Guzik Tester

The Guzik tester consists of two parts: the spinstand (S-1701B) and the associated read/write electronics (RWA-2585S and ANA-985B). The spinstand is capable of micropositioning repeatability of greater than 0.3 microinches and selectable embedded servo for high TPI track following. The electronics package includes a proprietary Guzik PRML channel for data rates up to 1 Gb/sec as well as an adaptor board for accepting third-party commercial R/W channels. The system also includes a built-in digital oscilloscope and spectrum analyzer.

Standard parametric magnetic recording tests are integrated into the software in addition to advanced bit error rate tests through either the Guzik or commercial R/W channel. Initially, the spinstand will be used for studying the noise characteristics of advanced heads and media as well as measuring bit-error-rate versus signal-to-noise-ratio for various read channel designs with perpendicular magnetic recording systems. The heads and media used with the spinstand are donated by CMRR sponsor companies.



JASON GOLDBERG, MEMBER OF THE WOLF GROUP

## Obituary for Peter A. McEwen

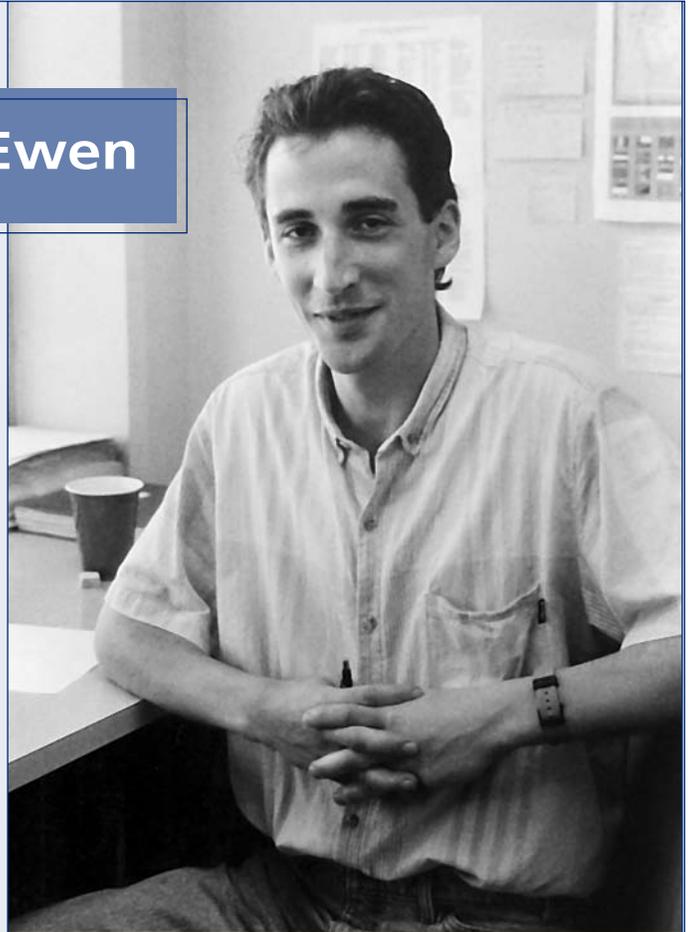
**P**eter A. McEwen, a leading expert in coding and signal processing for data storage, died Nov. 25, 2001 in Sunnyvale, California. He was 37.

Dr. McEwen was manager of the Advanced Recording Channel Architecture Group at Maxtor Corporation in Milpitas, California. His group was responsible for evaluating coding, detection, error correction, and servo algorithms and selecting the ones to be used in read channels for next-generation products. He had the valuable capacity to integrate all the various signal processing details into an elegant read channel architecture whose performance was excellent but whose implementation was simple.

Dr. McEwen's interests were diverse. He contributed to research in the areas of detection theory, modulation codes, synchronization, equalization, mitigation of thermal asperities, and in matching read channel architectures to specific head and media technologies. Dr. McEwen was educated in electrical engineering, receiving his S.B. degree from the Massachusetts Institute of Technology in 1986. He went to work for Digital Equipment Corporation in 1986, returning to school and receiving an M.S. degree from Carnegie Mellon

University in 1990. Dr. McEwen joined Quantum Corporation when it acquired Digital's storage business in 1994. He returned to school again at CMRR, receiving his Ph.D. degree in 1999. He joined Maxtor Corporation in 2001 as it merged with Quantum's disk drive business.

Dr. McEwen's favorite topic was coding for the magnetic recording channel. This was the subject for his dissertation, and he continued to show great interest in this area throughout his career. His thesis included work on construction of trellis codes and forbidden list codes. Later he complemented these constructions with higher rate codes such as event error control codes.



A congenial colleague, Dr. McEwen collaborated with dozens of coauthors on research papers, meticulously ensuring they all received proper credit for their contributions. He was always willing to spend time explaining codes and channel architecture to coworkers.

Dr. McEwen's success was achieved despite being afflicted with scleroderma, a rare, chronic autoimmune (arthritis) disease which impaired his ability to do everyday activities such as writing and typing.

— *Thomas Howell*  
— *Pablo Ziporovich*  
— *Ara Patapoutian*

**Director:**

*Paul H. Siegel*

**Newsletter Editor:**

*Cheryl Hacker*

**Contributors:**

*Neal Bertram*

*Jason Goldberg*

*Cheryl Hacker*

*Gordon Hughes*

*Doug Ramsey*

*Paul H. Siegel*

*Jack Kiel Wolf*

**Design & Layout**

*Sirious Design*

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University of California, San Diego  
Center for Magnetic Recording Research, 0401  
9500 Gilman Drive  
La Jolla, CA 92093-0401  
<http://www.ucsd.edu/cmrr>

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