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CMRR Report

Center for Magnetic Recording Research

Number 14 Winter 1991

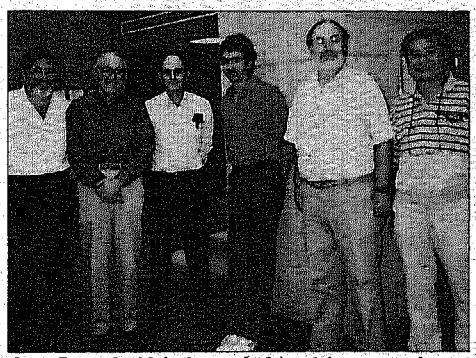
Conner Peripherals and Maxtor, New Sponsors

Conner Peripherals, the world's leading manufacturer of the sub-3 1/2" rigid disk drives used in very small lap top computers, is one of CMRR's two newest sponsors. Conner has operations in Longmont, Colorado, and San Jose and Leucadia, California.

Maxtor is one of the high-end leaders in extremely high capacity 5 1/4" and 3 1/2" rigid disk drives. The 5 1/4" units now exceed 2 Gigabytes of capacity and, costing about $2,000, have broken the long-awaited megabyte-per-dollar barrier. Maxtor also manufacturers a 3 1/2" magneto-optic disk drive made in Japan. The company is headquartered in San Jose, California, and is CMRR's newest sponsor.

Joseph Smyth Graduates

Joseph F. Smyth, a recent graduate from UCSD, began working at IBM's T. J. Watson Research Center, Yorktown Heights, New York, last October. Smyth completed all his tertiary studies at UCSD, beginning with his B.A. in physics in 1983, followed by his M.S. in physics in 1984 and his Ph.D. in 1990. Professor Sheldon Schultz, director of CMRR, was Smyth's adviser for his thesis, entitled "Hysteresis in Nano-Lithographic Arrays of Permalloy Particles."



Joe Smyth (4th from left) with committee.

Smyth received an IBM Fellowship which paid his tuition in 1988–89 and a research assistant salary while he completed his doctoral studies. A travel stipend enabled him to attend the 1989 American Physical Society meeting in St. Louis, followed by the International Magnetics Conference in Washington, D.C. During his fellowship, Joe spent a considerable amount of time at IBM, Yorktown Heights, where he was able to fabricate the arrays used in his thesis.

At IBM, Smyth is working as a postdoctoral student with David Awschalom of the Physical Sciences Department on ultra fast (femtosecond) spin dynamics in dilute magnetic semiconductors.

Copies of Smyth's thesis will be available from the Information Center to CMRR sponsor companies.

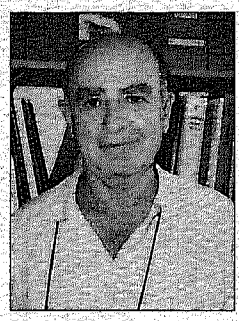
CMRR Professor Receives Prestigious Award

Jack Keil Wolf, one of CMRR's chaired professors, received the IEEE Communications Society's Edwin Howard Armstrong Achievement Award. The presentation was made during a luncheon on December 3, 1990, at the GLOBECOM '90 conference, which was held in San Diego. The award consisted of a plaque, an honorarium funded by the Armstrong Memorial Research Foundation, and a certificate bearing the citation: "For outstanding contributions to multi-user information theory and coding for magnetic recording."

Of particular significance is the recognition by the IEEE Communications Society of the magnetic recording channel as a communication channel.

Professor Shtrikman Returns to UCSD

Distinguished magnetician Shmuel Shtrikman, the Samuel Sebba Professor of Pure and Applied Physics at the Weizmann Institute, Rehovot, Israel, is spending this quarter at UCSD as an adjunct professor in the physics department. He is teaching the Topics in Applied Magnetism course, a graduate-level program offered in the Department of Physics. The twice-weekly lecture series is being videotaped for use by students and corporate sponsors of CMRR. Topics to be covered in the course are as follows:

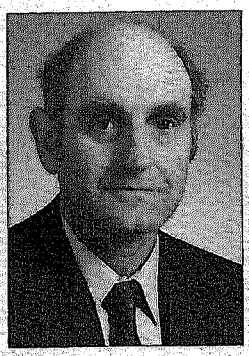


Mula Shtrikman

- Permanent Magnets
- Magnetic Resonance Imaging
- Magneto Optics
- Fine Particle Magnetism
- Microwave Devices
- Magnetometry

Shtrikman spent his 1983/84 sabbatical at UCSD and was very involved in the establishment of the Center for Magnetic Recording Research. Since 1985 he has been an adjunct professor in the Department of Physics here at UCSD. Professor Shtrikman's career, which spans some thirty years, includes a number of prestigious awards and citations. He was the IEEE Magnetics Society Distinguished Lecturer for 1983 and most recently was awarded the 1988 First Prize in Applied Electronics by the Ben-Gurion University in the Negev. His list of publications numbers over 230 titles, and he has some 15 patents to his credit.

While at CMRR, Professor Shtrikman will work closely with Professor Ami Berkowitz's group in areas of spark erosion and large magnetoresistance effect. He also expects to continue an earlier collaboration with Professor H. Neal Bertram on magnetic fields associated with MR heads, and in cooperation with Professor Schultz, will work on magnetization processes.



Shelly Schultz

FROM THE DIRECTOR

A brief survey of this issue will suffice to convince any reader that the Center has a lot going on. We are pleased to welcome Conner Peripherals and Maxtor as new sponsors, and to highlight distinguished visitors, the seminar series, and our research program and its associated activities. In addition to all the above, in November John Mallinson resigned as Director of CMRR and I was asked to assume that position. We all owe John a round of thanks for the contributions he made during his tenure.

In the past five years CMRR went from a plan to a reality. John made many contributions to the development of the Center during this period, including the construction of a beautiful building, the appointment of four endowed chairs, and the formation of our vibrant research programs. In summary, a great success story. We all join in wishing him well in his new professional career.

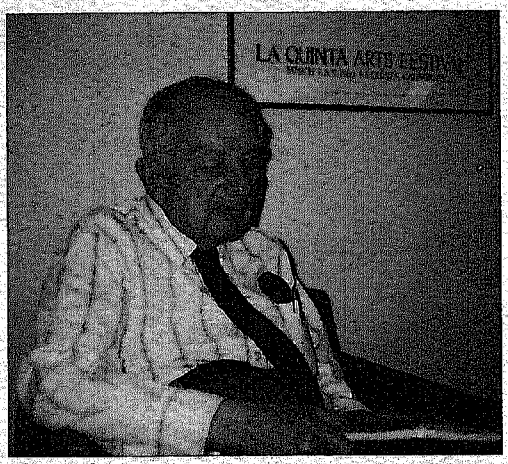
What new directions do I foresee for the Center? In future issues of this Report I trust you will see the *results* of some new directions, not just discussions. In brief, I envision our Center expanding its efforts — not by expansion for its own sake, but rather by a carefully selected program of areas chosen to complement our existing strengths, with emphasis on collaboration with our sponsors. This latter point warrants some amplification. I believe the long-term success of the Center is best assured by choosing research projects that are a true collaborative effort between our students, faculty, and staff with corresponding researchers at our sponsoring companies' facilities. I believe that catalyzing and developing such projects is the primary responsibility I face as director. I look forward to the challenge in meeting this responsibility and welcome all your suggestions for projects and procedures.

I plan to discuss our efforts along these lines in future issues of the Report. Of course, in the interim the entire staff at CMRR, and I, will be happy to hear from you, either in person when you visit, or by any other communication channels. Let's hear from you.

Shelly Schultz

Academic Visitor, James Lauer

Professor James Lauer will spend two months at CMRR, interacting closely with Professor Frank Talke and his students. In particular, Professor Lauer, a chemical physicist, will provide expertise in chemistry and spectroscopy as they relate to the tribology of the head/media interface.

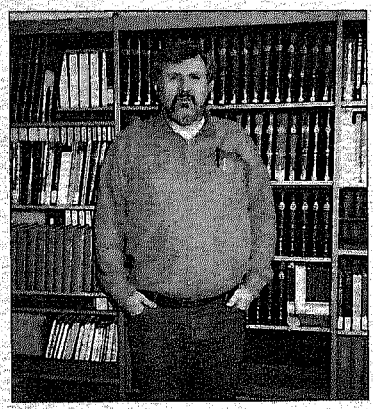


James Lauer

Lauer is no stranger to UCSD, having spent a year in the Department of Aerospace and Mechanical Engineering Sciences back in 1964-65 on a postdoctoral fellowship. He has also attended all of Professor Talke's tribology workshops for the past four years and will again be a participant this year at the March workshop.

At Rensselaer Polytechnic Institute in New York, Lauer is a professor of mechanical engineering in the School of Engineering's Department of Mechanical Engineering, Aeronautical Engineering and Mechanics (MEAM). He earned his Ph.D. in physics at the University of Pennsylvania, after which he taught theoretical physics before joining the Sun Oil Company. He has been with Rensselaer for the past thirteen years.

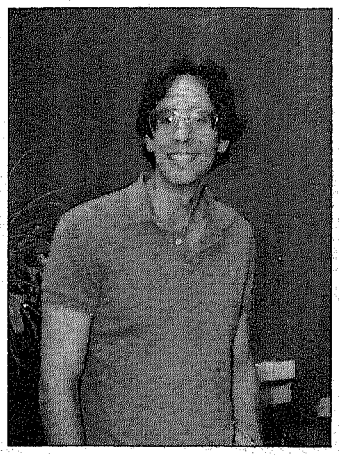
DEC Engineer to CMRR



Mike Mason

Mike Mason, a senior test engineer with Digital Equipment Corporation (DEC) for the past twelve years, is currently attending UCSD as a master's student. He is enrolled in the Department of Electrical and Computer Engineering with CMRR's Professor Jack Wolf as his adviser. Mike received his undergraduate degree in engineering physics from the University of Illinois, Champaign-Urbana in 1966. Despite an absence of some 24 years, Mike decided to return to school after becoming involved in a 1987 R&D project involving multilevel recording for the magnetic disk channel — a project that convinced him of the value of a thorough understanding of the recording process in order to meet today's challenges in manufacturing.

Mason has the full support of DEC, Colorado Springs in this novel arrangement, a first for DEC. While studying at the Center, Mason receives support for tuition and books, while retaining his salaried position. Mike chose CMRR since it offers a unique combination of communications engineering and magnetic recording technology, a perfect fit for his needs. Although returning to pursue graduate studies after a long absence from university life is proving challenging, Mason describes his experience to date as stimulating and is sure it will be of very definite benefit when he returns to the manufacturing arena.



Paul H. Siegel

CMRR — A Visitor's Perspective

A year at CMRR, on sabbatical from IBM, provided me with the opportunity to experience many of the ways in which active sponsor participation in the Center's technical programs can bring mutual rewards, on the level of individuals as well as in the broader context of strengthening the positions of the sponsoring organizations in a competitive, international storage market.

For an industrial visitor, undoubtedly the greatest benefit is the chance to interact technically with the faculty, students, and staff at the Center as well as in affiliated departments at UCSD. My own research interests brought me into closest contact with members of Professor Jack Wolf's team — formerly called "Codes-R-Us" but more recently dubbed "The Wolf Pack," no doubt in recognition of the fiercely competitive stance that magnetic recording has taken with regard to other emerging storage technologies. I found at CMRR a broad spectrum of activities ranging from theoretical investigations to real-time experimental channel measurements on tape and disk drives. There was evident a contagious enthusiasm to learn about, and tackle, problems of theoretical and practical significance motivated by actual storage device technology objectives, and I witnessed notable progress during the year.

It was exciting to see new theoretical limits on storage capacity of channels dominated by "timing jitter" errors, as well as the development and analysis of improved data compression algorithms that surpass the performance of those already in wide use in commercial applications. In the lab there were new channel characterization and modeling tools under study, novel modulation, coding and detection techniques being implemented using state-of-the-art programmable logic devices, and experimental evaluation of error-rate performance of some of the schemes. It was especially heartening to see activities in the areas of potentially vital importance to the industry — areas that need more attention, such as the assessment of on-the-fly error-control strategies incorporating powerful error-correction hardware that has recently become available commercially, and approaches to multilevel recording based upon coding techniques that recently revolutionized the modem industry — not to mention the construction of a new, optimally simple (1,7) run-length-limited code!

In addition to the chance to participate and contribute to this dynamic technical research atmosphere, the Center offers to the individual visitor other avenues for professional growth, such as access to the first-rate UC library system (and people who know how to make the best use of it), regular seminar series, graduate-level teaching (and learning) opportunities, and very active local chapters of professional societies. I even had the good fortune of participating in a new NSF-supported program developed by Professor Wolf to introduce advanced engineering undergraduates to some of the interesting research areas related to magnetic recording channels through direct involvement in faculty and graduate student research projects.

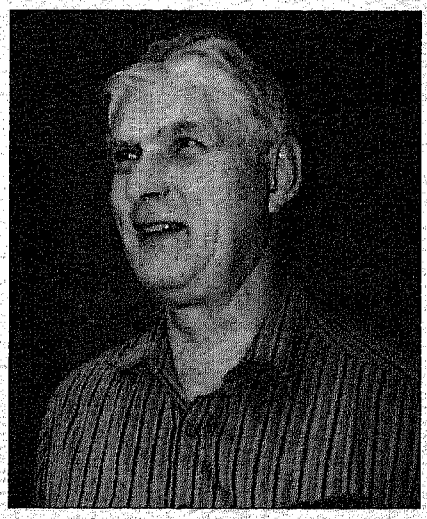
From the perspective of the sponsoring industrial organizations, perhaps the best return on investment comes in the form of bright graduates who are trained in scientific and technological disciplines that are the key to continued advances in digital data recording and then move on to positions at top-notch research universities or sponsoring companies. As a visitor, one can identify and encourage exceptional students whose potential to significantly contribute to storage technology can be enhanced through fellowships, university-industry cooperative programs, and faculty development awards.

The Center is a remarkable and, I might add, very hospitable educational institution that is contributing to the vitality of the magnetic recording industry and its related academic disciplines. It was a privilege to play a part in one sponsor's efforts to ensure the Center's continued success through active support and technical participation in its research programs.

Paul H. Siegel
Manager, Signal Processing and Coding
IBM Research Division

Queen's University Visitor

Professor Lorne Campbell from the Department of Mathematics and Statistics at Queen's University, Kingston, Ontario, is spending part of a twelve-month sabbatical at CMRR. While at the Center, Professor Campbell will continue his research on information theory, more specifically intersymbol interference and fading channels.



Lorne Campbell

Since graduate students from Professor Jack Wolf's group at CMRR are also working on intersymbol interference, albeit from a different point of view, there is much to be gained on both sides from this visit.

When Professor Campbell leaves the Center toward the end of February, he will go on to spend the next two months in Heidelberg at the Institute for Applied Mathematics.

James Massey at CMRR

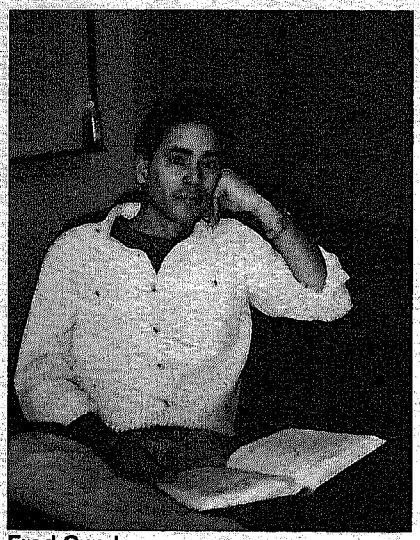
On Tuesday, December 4, 1990, Dr. James Massey presented at CMRR a seminar entitled "Confessions and Dreams of a Coding Theorist." This was the first lecture in the Distinguished Lecture Series presented by the Electrical and Computer Engineering Department at UCSD. Topics for the remaining seminars are: "Fuzzy Logic and Its Applications," "Heterostructures for New Dimensions of Electron Confinement," "NASA Imaging Programs," "High T_c Superconductors," "Recent Advances in Computer Engineering," "Signal Processing," and "Optical Computing."

Dr. James Massey is a professor of information science at the Eidgenossische Technische Hochschule Zurich (Swiss Federal Institute of Technology), Switzerland. He is a noted expert in the field of error correction codes and is well known for his research on decoding Reed-Solomon codes (the Berlekamp-Massey algorithm), on efficient multipliers in a Galois field (the Massey-Omura dual basis algorithm), and in cryptography. He has been the recipient of many international awards for his contributions to information theory.

Dr. Massey's talk was videotaped and is available to members of CMRR's sponsoring companies.

Center Hosts MMM Reception

As part of the 35th Annual Conference on Magnetism and Magnetic Materials held in San Diego October 29–November 1, the Center for Magnetic Recording Research hosted a reception and tour of the Center's labs and Information Center. Well over 100 attendees were given a brief overview of the Center by Director Sheldon Schultz and were then given a tour through the labs of the Center's four chaired professors. In the labs, students outlined current research projects and presented posters of their work; they were also available for more detailed discussion of their projects as time permitted. Many attendees also visited the Information Center/Library for a brief outline of the services available to the Center's corporate members, faculty, and graduate students.



Fred Spada

Materials Research

Fred Spada has spent the past year with Professor Ami Berkowitz's group investigating a variety of issues related to their materials program. In particular, he has assisted with the structural characterization of sputtered epitaxial antiferromagnetic oxide films, which show promise as a biasing layer for magnetoresistive heads, and he has investigated coercivity enhancement in iron oxide particles following treatment of their surfaces with polyphosphate solutions. Results of these studies were recently presented at the 35th Conference on Magnetism and Magnetic Materials in San Diego. Fred is currently organizing a new program that will study chemical aspects of wear at the head-disk interface. Initial efforts will focus on the hard carbon overcoats that protect thin film rigid disk media.

Fred comes to CMRR after six years with the Kodak Research Laboratory in San Diego, where he investigated materials for use in thin film magnetic heads.

Communications Workshop at GLOBECOM '90

As part of GLOBECOM '90, the semi-annual international meeting of the IEEE Communications Society, Jack Wolf of CMRR and Paul Siegel of IBM Almaden Research Center organized a one-day workshop entitled "Next Generation of Recording Systems." It was held at the Sheraton Harbor Hotel, San Diego on December 6, 1990. The speakers and their topics were as follows:

Jack Wolf, CMRR
Introduction

Roger Wood, IBM
"Magnetic and Optical Storage Systems: Opportunities for Communications Technology"

Tom Howell, Quantum
"Gigabit per Square Inch Magnetic Recording: Experimental Results"

Paul Siegel, IBM
"Trellis Coded Modulation for Magnetic and Optical Recording"

John Cioffi, Stanford
"Adaptive Equalization for Magnetic Disk Storage"

Stan Baggen, Philips
"Optical Storage: New Opportunities in Recording Channel Technology"

The workshop was attended by more than 60 people from both the recording and communications industries, including many from CMRR's sponsoring companies.

San Diego Hosts National Conferences

The Center for Magnetic Recording Research was well represented at recent national meetings held in San Diego. Papers presented by CMRR faculty and students are listed below:

35th Annual Conference on Magnetism and Magnetic Materials

F.E. Spada, A.E. Berkowitz, N.T. Prokey. "H_c Enhancement in Partially Reduced γ - Fe_2O_3 via Surface Treatment with Sodium Polyphosphate (Revisited)."

F.T. Parker, M.W. Foster, D. Margulies, A.E. Berkowitz. "Spin Canting in γ - Fe_2O_3 Particles."

F.T. Parker, A.E. Berkowitz. "Field Response of Surface Spins on Co-Adsorbed γ - Fe_2O_3."

M.J. Carey, F.E. Spada, F.T. Parker, A.E. Berkowitz, C. Leroux (Lawrence Berkeley Labs). "Exchange Anisotropy in $Ni_{80}Fe_{20}/Co_xNi_{1-x}O$ Coupled Films."

S.B. Slade, A.E. Berkowitz. "Preparation and Properties of Non-Interactive Spherical Magnetic Particles."

M.J. Carey, F.T. Parker, A.E. Berkowitz, C. Leroux (Lawrence Berkeley Labs). "Long Range Magnetic Order in Non-Percolating Granular Fe - SiO_2 Thin Films."

D.F. Fredkin, T.R. Koehler (IBM). "Magnetization Reversal in Permalloy Particles in Micromagnetic Computations."

P. Bryant, S. Schultz, D.R. Fredkin. "Modeling the Behavior of the Magnetic Force Microscope."

G.A. Gibson, S. Schultz. "Quantitative Magnetic Force Microscopy."

J.F. Smyth. "Hysteresis in Lithographic Arrays of Permalloy Particles Theory and Experiment." (Invited)

J-G Zhu, H.N. Bertram. "Self-Organized Behavior in Thin Film Recording Media."

J-G Zhu, H.N. Bertram. "Reversal Mechanisms and Domain Structures in Thin Film Recording Media." (Invited)

G.J. Tarnopolsky (Hewlett Packard Labs), ***H.N. Bertram.*** "Magnetization Fluctuations and Characteristic Lengths for Sputtered CoP/Cr Thin Film Media."

GLOBECOM '90

A.J. Armstrong, J.K. Wolf. "Coded Partial Response Signalling with Peak Detection."

P.E. Bender, J.K. Wolf. "An Improved Sliding Window Data Compression Algorithm Based on the Lempel-Ziv Data Compression Algorithm."

Copies of these papers are available to members of CMRR's sponsoring companies by contacting the Information Center.

CMRR Seminar Series

CMRR holds a weekly seminar series with invited speakers from the industry as well as presentations from graduate students and faculty. We also host the monthly seminars of the IEEE Magnetics Society, San Diego Chapter.

Talks presented during the previous six months are listed below:

Fredkin, D.R. and Rice, J.A. UCSD. "Bayesian Restoration of Single Channel Patch Clamp Recording." May 8, 1990.

Briggs, Chris. CMRR. "Dynamics of 'Micro' Sliders Using Laser Doppler Vibrometry." May 15, 1990.

****Balanson, Rich.*** IBM Corporation."Technical Challenges in the Data Storage Industry." May 24, 1990.

Howell, Tom. IBM Corporation. "Error Rate Performance of Experimental Gigabit Per Square Inch Recording Components." May 22, 1990.

Jeffers, Fred. Kodak Research Labs. "Record Head Saturation, Signal, and Overwrite." May 29, 1990.

****Blahut, Richard.*** IBM Corporation. "Linear Complexity, Bounds, and Codes." May 31, 1990.

****Ungerboeck, Gottfried.*** IBM Research, Zurich. "Block Codes with Large Euclidean Distance for Non-Binary Signals." June 4, 1990.

Hodges, Paul. IBM Corporation. "DASD Array Subsystems." June 5, 1990.

Thapar, Hemant. IBM Corporation. "On Equalization for Digital Magnetic Recording." August 23, 1990.

****Balanson, Rich.*** IBM Corporation. "Current Status and Future Directions for the Rigid Magnetic Storage Industry." October 16, 1990.

Bell, Alan E. IBM Corporation. "Status and Prospects for Optical Data Storage." October 18, 1990.

Armstrong, Alan and Barndt, Rick. CMRR. "Data Dependent Degradations in Saturation Magnetic Recording Systems." October 23, 1990.

Ganapathi, S.K. CMRR. "TEM Studies of the Wear of Metallic Thin Layers." November 13, 1990.

*Videotapes of the above seminars, except those marked *, are available to members of CMRR's sponsoring companies.*

Future Conferences

March 10–13, 1991 Kyoto-Duisburg Workshop on Ultrathin Magnetic Films and Multilayers, Duisburg, Germany.

April 15–17, 1991 Frontiers of Tribology, Stratford, UK. *For info:* Meetings Officer, Institute of Physics, 47 Belgrave Square, London SW1X 8QX, UK. 44–1–235–6111.

April 16–18, 1991 Magneto-Optical Recording International Symposium, (MORIS '91), Tokyo, Japan. *For info:* MORIS Secretariat, 3–23–1 Hongo, Bunkyo-ku, Tokyo, Japan. 113. 03–3817–5836.

April 16–19, 1991 European Magnetic Materials and Applications Conference (EMMA '91), Dresden, Germany . *For info:* Prof. J. Schneider, AdW d. DDR, ZFW, Helmholtzstrasse 20, PF, Dresden, DDR–8027.

May 19–29, 1991 International Workshop on Magnetism, Magnetic Materials and Their Applications, Havana, Cuba.

May 20–23, 1991 Comdex, Atlanta, GA.

May 27–31, 1991 2nd International Conference on Rare Earth Development and Applications, Beijing, China. *For info:* Sr. Engineer Siu Aisheng, Chinese Society of Rare Earths, 76 Xueyuan Nan Lu, Beijing, 100081, PRC.

June 12–15, 1991 2nd Magnetic Recording Conference (MRC), Pittsburgh, PA . *For info:* Courtesy Associates, 655 15th St., NW, Suite 300, Washington, DC 20005. (202) 639–5088.

June 18–21, 1991 5th Joint MMM/Intermag Conference, Pittsburgh, PA . *For info:* Courtesy Associates, 655 15th St., NW, Suite 300, Washington, DC 20005. (202) 639–5088.

July 29–August 2, 1991 Thin Film Science and Technology in the 21st Century, Evanston, IL. *For info:* J. Turner, Northwestern University, 2145 Sheridan Road, #2033, Evanston, IL 60208–3116, (708) 491–3606.

August 26–30, 1991 13th International Colloquium on Magnetic Films and Surfaces, Glasgow, Scotland. *For info:* Sue Lippmann, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX, UK.

August 29–31, 1991 3rd International Symposium on Research in High Magnetic Fields (RHMF), Amsterdam, The Netherlands. *For info:* Meetings Officer, Institute of Physics, 47 Belgrave Square, London SW1X 8QX, UK.

September 1–7, 1991 International Conference on Magnetism, Edinburgh, Scotland. *For info:* Meetings Officer, Institute of Physics, 47 Belgrave Square, London SW1X 8QX, UK.

September 11–13, 1991 International Conference and Exhibition on Soft Magnetic Materials, Dresden, Germany.

October 8–11, 1991 Perpendicular Magnetic Recording Conference '91 (PMRC '91), Iwate, Japan. *For info:* Prof. Y Nakamura, Research Institute of Electr. Communication, Tohoku University, 2–1–1, Katahira, Aoba-ku, Sendai 980, Japan.

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