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Nov.1. 2003.

Biocomplexity Faculty Search Committee,
c/o Prof. Rob de Ruyter van Steveninck,
Biocomplexity Institute, Indiana University,
Swain Hall West 117, Bloomington, IN 47405-7105

Please consider this my application for the position you advertised in the American Institute of Physics listings. Enclosed you will find a copy of my resume, a statement of interests and several teaching evaluations. I bring to this application significant experience in both research and teaching. The main focus of my research is magnetism, magnetic measurement, novel magnetic materials and nanoparticles and Biophysics applications of magnetism. There is currently a great deal of research being conducted in the use of magnetic nanoparticles in in vivo drug delivery, cancer detection and in vitro cell separation and DNA and Protein identification. In a recent paper, which is included, we have analyzed the use of magnetic nanoparticles in cancer detection. If I can be of any further assistance, please do not hesitate to ask. I look forward to hearing from you in the near future.

Best Wishes,

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Gregory G. Kenning
Statement of Interests

The primary focus of my research is magnetism including fundamental magnetic measurements, nanoscale and magnetic material science and biophysics applications of magnetism.

Current Research

I am currently working on several projects, which fall into the above mentioned categories:

1) **Fundamental Magnetic Measurements**
   - 1.1) Nanosecond Imaging and Spintronics Devices
   - 1.2) Frustrated and Disordered Magnetic Materials

2) **Nanoscale Physics and Applications**
   - 2.1) Intercalated Zeolites
   - 2.2) Magnetic Nanoparticles
   - 2.3) Dimensional Crossover in Spin Glasses

3) **Applied Bio Physics and Medical Devices**
   - 3.1) Cancer Detection using Monoclonal Antibody Targeted Magnetic Nanoparticles and SQUID Scanner Magnetometery
   - 3.2) Mapping the Magnetism of the Human Body

1) Fundamental Magnetic Measurements

1.1) Nanosecond Imaging and Spintronics Devices

I am currently using fast (pico-second) laser pulses to effectively produce a nanosecond camera capable of taking up to six microscopic (~200 μm x200 μm) visual images at times chosen between 1ns and 150 ns. This is a unique device and offers an experimental probe for analyzing the evolution of such important physical processes such as shock waves and cracking. This project is part of a DOE investigation initiated by Harry Tom and Alan Mills, at UCR, to analyze laser-induced damage in transparent materials. This could lead to important developments in both understanding the role of disorder in material integrity and provide methods for enhancing material integrity.

I chose to work on this project, as I believe it has significant applications in the field of magnetism. It is clear to me that this technique is quite flexible and analysis of the optical Kerr effect would provide a powerful technique for analyzing both the spatial (2D) and temporal evolution of spin systems. Applications of such a method include imaging (spatially and temporally) the evolution of conduction electron spin polarization in semiconductors and spin evolution in magnetic multilayers (spintronic applications) as well as microscopic properties of magnetic correlations in cooperative systems. Extension of these techniques to other parts of the electromagnetic spectrum may in the future allow imaging of events on atomic time scales.

1.2) Frustrated and Disordered Magnetic Materials

Much of my past research has been in frustrated and disordered magnetic materials. In particular, I have designed and built SQUID magnetometers to measure aging and memory effects in spin glasses. We have used these measurements to help elucidate the structure of spin glass phase space and have worked to understand the nature of the phase transition. Gilberto Rodriguez, Ray Orbach and I have spent the last year and a half performing a series of experiments analyzing initial state preparation on memory effects in spin glasses. This work has definitively elucidated the long time dynamics in spin glasses and has recently been published in Physical Review Letters (Vol. 91, No. 3, 037203-1, July 18, 2003). We have also completed a manuscript and are preparing to submit for publication the results of a simulation that probed the limitations of the Non-Ergodic Barrier Model.

I have significant experience with SQUID (Superconducting Quantum Interference Devices) having build several SQUID magnetometers in the past. Last year, a collaboration between myself, Ward Beyerman, Ray Orbach and Chris Reed successfully proposed, to NSF, a user facility including a Quantum Design MPMS (Magnetic Properties Measuring System) and a PPMS (Physical Properties Measuring System) (DMR-0114442). The addition of these two devices will significantly increase the resources at UCR for physical and magnetic property analysis. We expect heavy use of these devices by workers in materials science, pure physics and the new UCR Nanotechnology Fabrication Facility.

2) Nanoscale Physics and Applications

2.1) Intercalated Zeolites

I am the PI on a Nanoscale Interdisciplinary Research Teams (NIRT) proposal in collaboration with Yushan Yan of Chemical Engineering and Ward Beyerman of Physics. We are proposing to construct zeolite thin films with one-dimensional continuous pores extending lengthwise from the substrate to the surface. There are many known zeolites with pore sizes ranging from 0.3-30 nm. We are proposing to intercalate metals, semiconductors and ferromagnetic and antiferromagnetic materials into the pores. We intend to use these hybrid systems, with a range of pore sizes, to quasi-continuously probe the 3D to 1D transitions in the phases of matter mentioned above, as well as to design devices such as a cold cathode field emitter and a spin injector for spintronic applications. I have also recently begun an investigation to test the efficacy of using zeolites to pattern atomic scale dots of various types of materials.

2.2) Magnetic Nanoparticles

In 2001 I initiated a program to develop magnetic Nanoparticles for use in the biophysics program described below. Using the reverse micelle technique, we have produce samples of $CoFe_2O_3$ and Fe_3O_4 with size ranges between 1 nm and 10 nm. This program seeks to produce the largest magnetic moment particle while minimizing losses in the body due to filtering by the endothelio-reticular system. In the future, I will seek to produce sample sizes ranging up to 100 nm (significantly increasing the magnetic moment), attach monoclonal antibodies to the particles and initiated a collaboration to determine uptake in a rodent model.

2.3) Dimensional Crossover in Spin Glasses

My early work was on finite size effects in spin glass multilayer films. This work required extensive material science including high vacuum multilayer film deposition, X-ray diffraction, resistivity measurements, electron microscopy and other techniques. We found very large finite size effects and the first evidence of a phase transition as it crosses its Lower Critical Dimension (LCD). The LCD is a fundamental property of all states of matter and a critical physical limitation in the design of one and two-dimensional nanotechnologies. We are developing a proposal to probe the length scales and fundamental physics of this crossover. This proposal also seeks to definitively delineate between the theoretical models that have been proposed to explain memory and rejuvenation effects in terms of the growth of correlated volumes. I also am currently supervising a theoretical graduate student who is doing Monte Carlo simulations on the 3D-2D transition in spin glasses. This theoretical work is being performed in collaboration with Dr. Paolo Sibani of the University of Odense, Denmark.

3) **Applied Bio Physics and Medical Devices**

3.1) Cancer Detection using magnetic Nanoparticles and SQUID Detection

My search for practical applications began with the company I started in 1994. In 1999 I began a collaboration with Dr. Jack Kovach (Director of the Long Island Cancer Institute at SUNY, Long Island) and Raymond Orbach to design and develop a technique for magnetically labeling cancer tumors and detecting them using SQUID technology. Within this project, I have designed a screening device and the University of California has filed for a patent on this device. We are currently collaborating with Dr. Leo Hawel and Dr. Craig Byus of the Bio-Medical Department at the University of California. Recent experiments, we have performed, show that monoclonal antibody attached magnetic nanoparticles are the most efficient way to localize a magnetic moment in the body. These results will be important in both MRI contrast imaging as well as direct detection of tumors using the above-mentioned device. We are also pursuing a program to use the reverse micelle technique to optimize the magnetization and size parameters of the nanoparticles. This work was submitted to The Journal of Applied Physics in July, 2003.

3.2) Mapping the Magnetism of the Human Body

It has become clear to me, from my work on the SQUID scanner that the magnetic properties of various tissues and organs in the body need to be determined and mapped onto a sophisticated (MRI generated Finite Element) model of the human body. I have initiated an NIH proposal to extend the search for some recently discovered, unexpected, magnetic properties of organs. Mapping the magnetic properties of the body will also aid in understanding MRI signals, and provide more accurate background signals for the SQUID scanner technology.

SQUID MAGNETOMETRY FOR CANCER SCREENING
A FEASIBILITY STUDY

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Abstract

The recent demonstration that nanoparticles associated with various biological molecules and pharmacological agents can be administered systemically to humans, without toxicity from the particles, has opened a new era in the targeting of such particles to specific tissues in the body for the imaging and therapy of disease. The majority of particles used for this purpose contain iron and are detected in the body by magnetic resonance imaging. We believe a superconducting quantum interference device (SQUID) could provide quantitative and spatial information relevant to localization of superparamagnetic nanoparticles directed to a specific cell target in vivo. We envision a scanning system consisting of a DC induction field, a transport device, and an array of planar first order gradiometer coils coupled to DC SQUID amplifiers. We performed a set of computer simulations using experimentally determined values for concentrations of paramagnetic particles achievable in specific tissues of the mouse in vivo and concentrations of particles linked to monoclonal antibodies specific to antigens of two human cancer cell lines in vitro. An instrument to target distance of 10 centimeters was selected so that for an average adult scanning both the anterior and posterior surfaces could provide coverage of most of the body. The simulations demonstrate the feasibility of SQUID magnetometry for monitoring achievable concentrations of superparamagnetic particles in vivo and raise the possibility of using this approach to detect and localize collections of abnormal cells targeted by such particles.

Full paper at http://xxx.lanl.gov/
physics/0309021

Teaching

In my opinion, teaching is one of the most important aspects of academia. I currently supervise three graduate students and five undergraduates in research studies. Over the last five years, I have carried the heaviest teaching load in the Physics Department. I specialize in teaching large introductory calculus based physics classes although I believe that I would do a good job at teaching any standard undergraduate course and could teach select graduate division courses including Solid State Physics, Statistical Mechanics, E&M and Mechanics. I have now taught for over twenty years including upper-division classes at UCLA. My teaching philosophy has been to 1) develop an understanding of the level of the students, 2) teach at that level, 3) try to inspire in them the joy of physics and finally 4) make the connection (through examples and demonstrations) with the students own intrinsic understanding of how things work.

Teaching, is not limited to the classroom, but extends to the laboratory and to general interactions with students and colleagues. I am continuously seeking to learn and hone my management skills. Ray Orbach has been excellent mentor and has taught me a great deal about managing people and giving to the community. Leadership by example, is the best way to lead. Work harder than anyone working for you, set intentions and goals and go at them with passion.

Teaching renews me and the students appear happy with the courses I have taught. Included within this package are student evaluations for three different courses that I have recently taught.