# US-Africa Workshop on Nanosciences

**27 – 28 January 2007**
**Cape Town**
**South Africa**

**A SUPPLEMENTAL PROPOSAL FOR THE NATIONAL SCIENCE FOUNDATION**


**Prepared by** :
**Alfred Z. Msezane**
December 28, 2006

**Organizers:** **Alfred Msezane (USA)**
**Malik Maaza (South Africa)**
**Milton Slaughter (USA)**
**Aboubaker Beye (Senegal)**
**Kennedy Reed (USA)**

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## Project Summary

The Workshop, the US-Africa Workshop on Nanosciences, is proposed to be held in Cape Town, South Africa, January 27-28, 2007, immediately following the EBASI Conference, also to be held there, January 24-26. The main aim of the Workshop is to explore areas of common interest and initiate collaborative research between US scientists and their African colleagues in the area of nanoscience. The Workshop will benefit from two different contexts: the EBASI Conference (many of its participants will attend) and the successful US-Africa Advanced Studies Institute on Photon Interactions with Atoms and Molecules, held in Durban, South Africa, last year; the latter has already generated ongoing collaborative research. The Workshop's participants will be Professors, Graduate Students, Post-docs, and Scientists, from the US and Africa. The topic of the Workshop is being studied actively around the world and, specifically in both the US and Africa. So, it is an ideal area for US and African scientists to explore commonality of interests and the possibilities of various kinds of collaborations through nanosciences. In the US there is cutting-edge experimental and sophisticated theoretical work concerning laser and synchrotron light impacting upon atoms and molecules as well as on nanosciences, while the African effort focuses primarily on experimental studies of laser interactions at mainly the African Laser Centers in the areas of Nanoprocessing by laser ablation; Nanophotonics for VIS-IR modulation; Nano-plasmonics for tunable ultrafast optical switching; Nano-Transparent Conducting Oxides TCO's; Nano-porous materials; Nano-materials based Carbon; Nanopolymers and Ultra-porous polymers; Nanomaterials for solar energy applications and Nanohybrids.

The multi-polar Nanosciences African Network, modelled along the lines of the African Materials Research Society (AMRS) and the African Laser Centre (ALC), represents a wide multidisciplinary approach to materials science and engineering, as well as in the design of novel processes and miniaturized devices. NANOAFNET's main aims are to exploit nanosciences to accomplish cost-effective and easy implementation of nanotechnologies compatible with the African landscape needs and to enhance the international visibility and capacity of the African scientific contributions through maintenance of world class research in nanosciences and related technologies. It is therefore appropriate to hold the US-Africa Workshop on Nanosciences, bringing from the US such experts as Professor Uzi Landman of Georgia Tech and others. Thus, there is a synergy of interests that we will capitalize on in the execution of the Workshop. Of particular importance is that ample opportunity will be given over to discussions among the participants in a "total-immersion" atmosphere to engender the maximum co-mingling of ideas. The Workshop will acquaint the participants with hot topics as well as equip them with some tools to understand and explore new manifestations in and impact of nanoscience as well as the effects of photon interactions so that further collaborations and partnerships can be established and enhanced.

**Intellectual Merit:** The Workshop will focus the sophisticated experimental and theoretical methodologies that can be employed to uncover new and fundamental manifestations of the interaction of radiation with atomic and molecular matter in the context of nanosciences. Aside from being one of the basic processes of the universe, photoabsorption is also of applied importance in astrophysics, radiation physics, biological physics, materials research, etc. Furthermore, atoms and molecules are the basic building blocks of the macroscopic world, and a knowledge of their response to electromagnetic radiation goes a long way to explaining the properties of mesoscopic and macroscopic phenomena. Some of the important problems requiring both theoretical and experimental understanding are: 1) Electronic excitations in carbon nanotubes induced by femtosecond pump-probe laser pulses; 2) electrons emitted from carbon nanotubes following femtosecond pump-probe laser pulses generated by the ultra-fast light source to deduce the energy and temporal behavior of the electronic states of carbon nanotubes; 3) spectroscopic tools for nano-material and nano-device research and 4) a variety of molecular nanowires, and metal nanoclusters as well as nanomaterials for solar energy applications and nanohybrids. The experts and other participants in the field will define where we are now, and map a pathway to the future.

**Broader Impact:** This Workshop will involve some African American faculty and students, along with their African counterparts. Thus, the Workshop will contribute to the NSF goal of engaging underrepresented minorities in the US, along with the goal of outreach to scientists in developing countries; with the possible exception of South Africa, the scientists of Africa work in relative isolation. In addition, the collaborations developed will open the door to more African graduate students receiving their training at the Historically Black Colleges and Universities and other US institutions, thereby helping the research enterprise in the US, *and* creating a positive view of the US among the students as well as enhancing the geopolitical interest of the US. The Workshop will also impact the day-to-day industrial and medical applications of nanosciences. Specifically, the extensive scientific, technological, and engineering demands of the African mines (some of whose products are gold, platinum, vanadium, uranium, diamonds, coal) and associated industries provide unlimited opportunities for research, entrepreneurship and graduate student education. For example, ongoing research in South Africa of the noble metal nanoparticles embedded in various media have applications in nonlinear optical devices, Pt-TiO2 nano-composites are important in solar cells, necessary for cheaper and more stable sources of energy and gold clusters supported on TiO2 are useful in decomposing and composing CO2, with implications to environmental integrity. Also, photon interaction is important in Radiation Therapy and nano-medicine. The education of the underrepresented minorities in nanosciences is another area of national need.

## I. Introduction: NANOAFNET

The current global research at the nano-scale frontier is unified by the human society needs to develop novel knowledge, tools, techniques and expertise at the atomic and molecular levels, befitting the new millennium pressures such as energy and health. Nanosciences blossom from modern advances in chemistry, physics, biology, engineering, medical, and materials research and contribute to cross-disciplinary education and training of the 21st century science and technology workforce. Through several nano-initiatives worldwide, it is established that this emerging nanoscience will have a profound economical and societal impact, perhaps comparable to that of the information technology and molecular biology. Atoms and molecules and their photonic interactions are the natural building blocks of any nano-compound and, hence their spatial and time controllability would play a key role in the ultimate goal of nano-devicing and multi-functionality. Hence, NANOAFNET was established.

The broad research interest of NANOAFNET is focus on nanophotonics in close collaboration with and complementary to the major ongoing initiative, i.e. the African Laser Centre. The broad goals of this discipline of nanophotonics in the context of its global status, are to develop new concepts in optics and to engineer new functionalities at the smallest possible spatial scale in materials sciences, at the sub-wavelength resolution, and on the shortest possible timescale of the current femto-regime. At such a spatial scale, smaller than the wavelength of the electromagnetic probing beam, where the free electrons are spatially localized, quantum confinement phenomena and, consequently size effects are not seldom but rather recurrent. In general, such size-dependent effects are related to mostly surface/volume enhancement, crystallographic 3-D symmetry breaking and electronic environment/charge transfer.

Nanoscience/Nanotechnology has become one of the fastest growing areas in science today. Precise manipulation of matter at the atomic level using various processes is important and revealing. It will further enhance the synergy in distinctly focused nano-areas, such as nanosciences related to cost-effective energy, water purification and health issues technologies.

The major aims of the NANOAFNET are: i) to exploit nanosciences to accomplish cost-effective and easy implementation of nanotechnologies compatible with the African landscape needs, ii) to introduce nanosciences academic programs at the undergraduate and graduate levels, iii) to enhance the international visibility and capacity of the African scientific contributions through maintenance of world class research in nanosciences and related technologies, (iv) to enable African scientists and engineers to cross-disciplinary collaborate in the field of nanosciences and address the critical human issues and the vital human capital within the continent and (v) to partner with ongoing African initiatives such as ALC and AMRS for an optimal sharing of the existing R&D Infrastructures.

## II. Reasons for the Workshop

### A) EBASI

MISSION OF EBASI

It is to provide mechanisms for synergistic scientific and technical collaborations between African, African Diaspora and American physical scientists, engineers, and technologists. Enhance the impact of science and technology on the sustainable development of the countries on the African continent. Increase the technical manpower pool working in Africa today by facilitating the training of Ph.D. students from African universities.

The EBASI Conference will be held January 24-26, 2007. Consequently, the African presenters and participants will already be there. Also, ICTP presenters will be available; their importance is in the context of supporting many African initiatives, including the now institutionalized COPROMAPH at the University of D'Abomey-Calavi, Cotonou, Republic of Benin. Professor Msezane is both the founding member and organizer of COPROMAPH.

### B) US-Africa Advanced Studies Institute on Photon Interactions

Because of its impact on research partnerships and collaborations, it is appropriate to briefly describe the Advanced Studies Institute on Photon Interactions. The importance of the present Workshop is that it is a direct follow up of the unprecedented, highly successful and visible Institute on Photon Interactions. It also ushers the Institute on Environmental and Biological Applications of Lasers (EBAL) to be held in Cairo, Egypt, November, 2007 as the second of the series.

#### B.1. Overview

Organized by Dr. Alfred Z. Msezane of Clark Atlanta University, Dr. Sekazi K. Mtingwa of North Carolina A&T State University, Dr. Vincent McKoy of California Institute of Technology, Dr. Edmund Zingu of the South African Institute of Physics and Dr. Philemon Mjwara of the South African Council on Scientific and Industrial Research, the NSF-funded Advanced Studies Institute, held in Durban, South Africa, November 3-12, 2005, brought together from the US and Africa approximately 60 advanced graduate students and postdoctoral researchers and 20 lecturers, including 4 from Europe. The African participants came from mainly the institutions that make up the African Laser Centre, a virtual center of excellence that links scientists and laser infrastructure in at least six African nations; it is one of the strongest combinations of human and physical infrastructure for science in Africa (see Table I). The general theme of the intensive set of lectures was light-matter interactions, incorporating a range of fields being actively studied in the US and Africa, including Atomic, Molecular, and Optical Physics, Physical Chemistry, and Materials Science. The lectures addressed the most recent findings in these fields, as well as the theoretical, computational and experimental tools that will be key to future advances.

**Table I. African research institutions that form the initial set of ALC User Facilities.**

| Facility | City and Country | Field of Specialization |
|---|---|---|
| National Laser Centre | Pretoria, South Africa | Manufacturing, Machining, and Materials Processing |
| University of Cheikh Anta Diop | Dakar, Senegal | Atomic and Molecular Physics and Laser Spectroscopy and Processing |
| Laser and Fibre Optics Centre | Cape Coast, Ghana | Agricultural and Environmental Science |
| National Institute of Laser Enhanced Science | Cairo, Egypt | Medical and Biological Applications of Lasers |
| Tunis el Manar University | Tunis, Tunisia | Plant and Environmental Science an Molecular Spectroscopy |
| Advanced Technologies Development Centre | Algiers, Algeria | Laser Spectroscopy and Surface Studies |

The Institute provided excellent scientific training for both US and African young scientists. It also helped to establish an international network of collaborating scientists, linking them through the African Laser Centre. A significant number of African-American, African and women faculty and students were involved, contributing to the US National Science Foundation (NSF) goals of engaging underrepresented groups in the US and developing a more globally-engaged cadre of scientific leaders.

Collaborations in fields of science that can positively impact the US and Africa were forged, for example by enhancing industrial and medical applications of photon interactions or by accelerating research on cheaper energy sources through nanoscience. Finally, the Institute was timed to coincide with the World Conference on Physics and Sustainable Development also held in Durban the preceding week, thus enabling some of the Institute participants to contribute to and learn from that important meeting.

Optics, spectroscopy and laser applications have been found to be fertile fields for the promotion of physical research in developing countries because they are fundamental and affordable. Most importantly, they also connect to real world applications. This has been endorsed by such organizations as the European Physical Society, the International Commission on Optics and Optical Society of America.

In this context and to place the Institute in perspective, the first talk entitled “Laser Spectroscopy for Environmental and Medical Diagnostics” was presented by Professor Sue Svanberg of Lund University and Chairman of the 2005 Nobel Committee on Physics. He has been instrumental in the development of Laser Spectroscopy in many African countries.

### B.2. Accomplishments

"The Institute assembled some outstanding researchers in the field of Photon Interactions, from premier research institutions in the US, Europe and Africa. It will certainly have significant impact on Africa's science revolution, being just at its infancy, but which is gaining momentum and strength on a broad scale throughout Africa. In particular, the Nelson Mandela Institution for Knowledge Building and the Advancement of Science and Technology in Sub-Saharan Africa will be a major player toward this direction. Its specific goals are very similar to those of the Advanced Laser Separation Institute. The initiative is driven by the African Institute of Science and Technology, a catalyst for African transformation and integration into the modern world and global economy. This is an all-African effort needing support not only from the Africans in the continent but also from the Diaspora, particularly the African-Americans. The US-Africa Advanced Studies Institute on Photon Interactions with Atoms and Molecules was an excellent example for such endeavor, which should be continued in the future", IUMRS Facets **5**, 11 (2006)

Some of the immediate consequences of the Institute were: 1) Professor Beye of Senegal visited Clark Atlanta University, January, 2006 and wrote a Report on the Institute "US-Africa Advanced Studies Institute on Photon Interactions with Atoms and Molecules: Report on Materials Activities", A.Z. Msezane, A.C. Beye and U. Becker (Germany), IUMRS Facets **5**, 11 (2006). 2) Professors M. Maaza of iThemba Labs in South Africa and A. C. Beye wrote an article for IUMRS Facets "Nanosciences African Network: NANOAFNET", which has also been published. 3) Egypt's NILES will host the Institute in November, 2007 and 4) Dr. Ra'anan Tobey, then a graduate student participant of the Institute and currently visiting there, has assembled an International collaborative research team on the interesting material $VO_2$, involving the University of Colorado, UC Berkeley, Oxford University and iThemba Labs. He will present a talk at EBASI.

Additionally, many other notable developments have followed the Institute, for example Dr. Philemon Mjwara, a member of the Organizing Committee, was promoted to Director General of the Department of Science and Technology in South Africa and Professors Mtingwa and Msezane have been appointed members of the International Advisory Committee on "Synchrotrons - Series of Four Meetings" to be held in South Africa, February, 2007. Several organizers of and presenters at the Institute were selected to be members of the International Advisory Committee of the Institute on Environmental and Biological Applications of Lasers (EBAL), Cairo, Egypt, November 2007. Dr. Msezane assisted in the evaluation of research proposals for the ALC, November, 2006 and while there, connected Professors at Wits (Drs. Connell and Hearne) with Dr. Evans-Lutterodt of Brookhaven National Lab for a perfect fit collaborative research on Synchrotron applications in materials. In fact, Professor Msezane left Dr. Evans-Lutterodt at Wits and returned home.

**The details of the Institute are found in the website:** www.africanlasercentre.org

## B.3. Impressions of the Institute from some of the participants

*Bruno deHarak, University of Kentucky*

I went to South Africa expecting to: learn some physics; gain exposure to new cultures; and form connections with researchers working both in the US and abroad. My expectations were greatly exceeded. The majority of the lectures were excellent; I feel that several should even be described as exciting (Amusia's talk on the use of Feynman diagrams and Hearne's talks on diamond optics and high pressure measurements particularly stand out for me). Learning about the ways scientific research is conducted (i.e. the focus, funding, and hurdles) served to give me a better perspective on the way we conduct research in this country. Getting to experience part of Africa first hand; to see the wildlife and countryside and talk to the people was fantastic. The best part of the conference however was the interaction between the participants. The organizers managed to structure the workshop in a way that really brought us together; I made several friends during the workshop.

In short the workshop was wonderful. I don't mean "wonderful" in some trivial way (as the word is often used), I mean "wonderful" as in full of wonder.

*Ignatius Fomunung, University of Tennessee at Chattanooga*

The Institute was a resounding success if for nothing else, because it provided a unique forum for interaction of African and US scientists and students in an atmosphere that was at once serious, jovial, and cordial. The lectures were quite profound in content and engaging in delivery. The organization was superb and showed that careful thought was put into the planning process.

One of the objectives of the Institute was to provide opportunities to establish collaborative research among participants. The contacts that I made at the Institute and the knowledge gained through the exposés are currently being pursued and so far show great promise to open up other avenues for research. On another personal note, the scientists and students of different backgrounds and cultures that I met, as well the experiences of beautiful Durban and its people have made lasting impressions on me.

This Institute should be continued!

*Tobey Ra Anan Itzhak, University of Colorado*

This conference was a great introduction to both the people of Africa and the excellent science that is being done in various African countries.

I look forward to continuing my collaboration with African scientists, specifically at iThemba labs, for many years to come. They synthesize materials of the highest quality.

On a personal level this was an educational experience, both culturally and scientifically, that I will never forget.

*Mohamed Abdel Harith, Cairo University, Egypt*

Dear Alfred,

It was a great pleasure to meet you at Durban during the US-Africa school. This highly successful meeting was very beneficial to all participants, students and scientists. There is no doubt that your initiative contribution in supporting such pioneer activity was one of the main reasons of its success. I would like to thank you for your efforts and express my high appreciation for all American Universities and organizations which contributed and supported the school both scientifically and financially. As we agreed in Durban, the second meeting will be held in Egypt and NILES will organize it. I do believe that we have to start the arrangements for such meeting as soon as possible. We may start by choosing an experienced and active scientific committee from US and African scientists. November 2007 is a proposed tentative date for such meeting. I am waiting to hear your opinion and suggestions in this concern.

*Malik Maaza, iThemba Labs, South Africa*

Dear Tobey,

1-I wish to thank you indeed for accepting to visit us so to reinforce this US-Africa synergy through the ICMR-UCSB to whom we are extremely grateful.
2-We are more than honored indeed to have the opportunity to benefit from the scientific endeavour of talented US youngsters of your caliber.
3-We are preparing everything from our side to ensure you a productive sojourn and hopefully this success story will convince more other US colleagues.
4-As mentioned previously, all your accommodation and living expenses will be covered by us here in South Africa. You will have a car from our cars pool for free during your sojourn.
5-As there are numerous African young fellows from Senegal, Cameroon, Ethiopia, Nigeria, Morocco and of course South Africa, I am sure that you would appreciate the melting pot atmosphere.
6-I wish just to mention that I will be out of the country in September.

Best regards
Malik

## III. Participants

### U.S. Participants

| Name | Title | Institution | Area of Research |
|---|---|---|---|
| Uzi Landman<br>uzi.landman@physics.gatech.edu | Regent's and Institute Professor of Physics/Director, Center for Computational Material Sciences | Georgia Tech | Computational Materials Sciences; Controlling and tuning gold nanoclusters |
| Theda Daniels-Race<br>tdrace@lsu.edu<br>S. Thiruvengadam | Associate Professor<br><br>Graduate Student | Louisiana State University | Quantum Wells Quantum Confinement, Optoelectronic |
| Kimani C. Toussaint<br>kimani@uchicago.edu | Postdoctoral Associate | University of Chicago | Optical Techniques; Single Nanoparticles |
| Donna Stokes<br>dstokes@uh.edu | Assistant Professor of Physics | University of Houston | Infrared Detection and Laser Analysis – Nanostructures |
| Miguel Castro-Colin<br>mccolin@utep.edu | Assistant Professor | University of Texas at El Paso | Small-Angle X-ray scattering from crystalline materials--nanoclusters |
| Sekazi Mtingwa<br>mtingwa@mit.edu | Professor of Physics | MIT | Intrabeam Scattering Theory—Applications to Synchrotrons, Free Electron Lasers, etc. |
| Kimani Stancil<br>KAStancil@lbl.gov | Postdoctoral Associate | Berkeley | Nanosciences; nanotechnology |
| Alfred Msezane<br>amsezane@cau.edu | Professor/Director, Center for Theoretical Studies of Physical Systems (CTSPS) | Clark Atlanta University | Electron/Photon Interactions-Fundamental Processes |

## Some African Participants

| Name | Title | Institution | Area of Research |
|---|---|---|---|
| Aboubaker Beye | Professor of Physics/<br>Director of the Laboratories de Physique de Solides et Sciences de Materiaux | Cheikh Anta Diop University, Senegal | Laser Processing and Spectroscopy of Materials; Nanosciences; - Nano-Materials |
| Malik Maaza | Senior Scientist and Leader of the Nano Laboratories of Materials Research | iThemba LABS,<br>South Africa | Metal Nanoparticles; Nanocomposites; nonlinear optical devices; optical spectroscopy; Laser Ablation; Matter Waves. |
| N. Manyala | Associate Professor of Physics | National University of Lesotho | Nanomaterials photonics and spintronics – magnetic semiconductors |
| P. Ngoepe | Professor/Director Materials Modelling Centre | University of Limpopo,<br>South Africa | Computational Materials – Bulk and nanostructures; gold and Pt nanoparticles |
| Mourad Zghal | Professor | Ecole Superieure des Communications de Tunis | Materials/Photonic Crystal Fibres |

## IV. Workshop Presentation Schedule (Tentative)

| Time | Saturday<br>1/27 | Sunday<br>1/28 |
|---|---|---|
| 9:00 – 9:45 | Uzi Landman<br>(Georgia Tech) | S. Mtingwa<br>(MIT) |
| 9:45 – 10:30 | A. Beye<br>(Senegal) | M. Maaza<br>(iThemba LABS) |
| 10:30 – 11:00 | Open Discussion and Summary of Possible Collaborations | Open Discussion and Summary of Possible Collaborations |
| 11:00 – 11:30 | Tea and Informal Exchanges | Tea and Informal Exchanges |
| 11:30 – 11:45 | S. Ngoepe<br>(U. of North) | N. Manyala<br>(Lesotho) |
| 11:45 – 12:00 | S. Thiruvengadam/ T. Daniels-Race<br>(Louisiana State University) | S. Ngoepe<br>(U. of North) |
| 12:00 – 12:15 | N. Manyala<br>(Lesotho) | B. de Harak<br>(U. of Kentucky) |
| 12:15 – 12:30 | Discussions and Summary of Important Problems | Discussions and Summary of Important Problems |
| 12:30 –2:00 | Lunch | Lunch |
| 2:00 – 2:15 | K. Toussaint<br>(U. of Chicago) | T. Daniels-Race<br>(Louisiana State University) |
| 2:15 – 2:30 | K. Stancil<br>(Berkeley) | M. Castro-Colin<br>(UTEP) |
| 2:30 – 2:45 | J.M. Ndjaka<br>(Yaounde/Cameroon) | A. Msezane<br>(Clark Atlanta) |
| 2:45 – 3:00 | C. Theron<br>(Ithemba) | A. Msezane<br>(Clark Atlanta) |
| 3:00 – 3:15 | Discussions and Summary of Important Problems | Discussions and Summary of Important Problems |
| 3:15 – 3:30 | Lakhdar Zohra<br>(Tunisia) | Discussions and Summary of Important Problems |
| 4:00 – 4:30 | Tea | END END END |
| 4:30 – 4:45 | Lakhdar Zohra<br>(Tunisia) | |
| 4:45 – 5:00 | N. Cingo<br>(UTUT) | |
| 5:00 – 6:00 | Discussions and Summary | |
| 7:00 – | Dinner | |

# V. ABSTRACTS

# Characterization of Hybrid Electronic Materials for Nano Molecular-Based Device Electronics

**Sathish Thiruvengadam and T. Daniels-Race**
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**Louisiana State University**

Hybrid electronic materials (HEMs) have become the foundation for fundamental research involving molecular-based electronics. Nano Molecular Electronics as a field has emerged from the concept of using individual molecules as functioning electronic components. In spite of several issues yet to be resolved, "hybrid electronics," which couples both organic and inorganic molecular species, has many potentially exciting applications ranging from quantum computing to unique in vitro drug delivery methods [1-4]. Recently, research efforts to characterize novel organic materials, in order to understand molecular level electronic transport properties, are of great interest. One such material is that of the porphyrin molecule, which exhibits behavior potentially useful for computer memory applications. In our work we investigate the physical and electronic characteristics of self-assembled monolayers (SAMs) of n-alkanethiols using techniques such as X-ray photoelectron spectroscopy (XPS), reflection absorption infra red spectroscopy (RAIRS), fluorescence spectroscopy (FL), and conductive probe atomic force microscopy (CP-AFM). SAMs of alkanethiols on gold (Au) substrates have been shown to form stable surface structures[5]. It is expected that the exchange of molecules is most active at SAM defect sites, substrate step edges, and substrate vacancy islands. Using CP-AFM a conductive AFM tip can be used to make contact to a single or a few molecules. The force on the molecule and the distance between the tip and the substrate is controlled so that electronic tunneling properties may be examined. Our long term plan involves the insertion of dithiolated porphyrin molecules into these defect sites in alkanethiol SAM on Au surfaces in order to measure the current-voltage (I-V) characteristics of porphyrin molecules under ambient conditions. This work will serve as a precursor to the I-V characterization of other organic species of potential use in HEM structures.

References:

1. Michael Galperin, Abraham Nitzan, and Mark A. Ratner, Phys. Rev. Lett. 2006, 96, 166803.
2. Mark Ratner, Nature 2005, 435,575-577.
3. Dustin K. James and James M. Tour, Chem. Mater. 2004; 16, 4423-4435.
4. Richard L. McCreery, Chem. Mater. 2004, 16, 4477-4496.
5. Marc D. Porter, Thomas B. Bright, David L. Allara and Christopher E. D. Chidsey, J. Am. Chem. Soc. 1987, 109, 3559-3568.

## General Overview of Synchrotron Light Sources with Special Comments on Beam Dynamics Issues

*Sekazi K. Mtingwa*
*Massachusetts Institute of Technology*

We provide a general overview of the physics and history of synchrotron radiation sources and how they have impacted many fields of research. We discuss the physics issues involved with special attention paid to the limitations imposed on a broad range of accelerators by intrabeam scattering (IBS). This phenomenon consists of multiple Coulomb scatterings between particles in the same bunch and sets the ultimate limitation on the luminosity lifetime in hadron colliders and, in particular, the equilibrium beam size in intense, low emittance synchrotron light sources. We comment on the importance of high brightness light sources and project how they will impact research directions in the future.

### Optical Techniques for Characterizing Single Nanoparticles

**Kimani C. Toussaint, Jr, PhD**

The James Franck Institute, University of Chicago
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Nanometer-sized particles, or nanoparticles, have attracted attention from various scientific and engineering disciplines because of their unusual size-dependent properties, and their potential to be applied to many technological areas. Metallic nanoparticles are especially of interest because they exhibit strong plasmon resonances that depend on their size, shape, and material properties. Such particles hold promise for many applications including biological labeling, nano-sensors, optical data storage, and surface-enhanced measurements. However, due to their extremely small sizes developing robust experimental characterization methods to help elucidate their behavior has proved challenging. Far-field optical techniques, such as scattering and absorption spectroscopy, have proven useful in this area because they are experimentally less invasive and demanding than other approaches. Furthermore, in recent years, far-field optical characterization approaches have been adapted to study isolated nanoparticles. Here, the goal is to characterize individual particles, rather than large ensembles, in order to avoid problems associated with ensemble measurements, e.g., dispersion in particle size and shape or potential inter-particle interactions.

A review of the various optical approaches for the detection and characterization of individual nanoparticles, including time-resolved schemes, will be presented. In addition, the optical control of single nanoparticles will also be discussed.

## Lyotropic Systems and Assembly in Nanoscience

Dr. Kimani Stancil
Lawrence Berkeley National Laboratory (LBNL)/University of California, Berkeley
California, U.S.A

Colloidal Synthesis methods are commonly used to produce nanoparticles of various morphologies: dot (sphere), rod, disk, etc…[1] As nanoscientists, we focus mainly on the nanocrystal that results from this synthesis for its potential to enable/enhance and to inspire new optical and electronic technologies. To realize novel applications using nano-crystals, a healthy understanding of assembly techniques are required. Germane to this discussion is our understanding the role that the individual components and their concentration play in influencing overall phase behavior and control. In this talk, I will briefly examine the theory of lyotropic or concentration dependent systems, and the application to systems involving semiconductor nanorods, and polymers.

The aim of this talk is to provide an overview and survey of nanosystems where concentration and assembly concepts are significant. For example, to observe nematic phase behavior in nanorod liquid crystals (nanorods oriented in the same direction), one can apply Onsager's hard rod model [2] as a guide. According to this model, entropic considerations predominate, and factors like excluded volume, aspect ratio, volume fraction are key to estimating the emergence of a nematic phase. Nematic alignment is one step toward producing nanorod arrays and potentially superlattices. Included in this talk will be a brief examination of methods using electric fields to orient nanorods [3], and polymers to affect interfacial interactions [4] in aligning nanorods.

[1] **Synthesis and Characterization of Monodisperse Nano-Crystals and Close-Packed Nanocrystal Assemblies,** C.B. Murray, C.R. Kagan, M.G. Bawendi - *Annual Review of Materials Science* 30, 545-610 (2000)
[2] L. Onsager, *Ann. N.Y. Acad. Sci.* 51, 627 (1949)
[3] **Electric-Field-Assisted Assembly of Perpendicularly Oriented Nanorod Superlattices,** Ryan K.M., Mastroianni A., Stancil K.A., Liu H. and Alivisatos A.P., *Nano Lett.* 6, 7, 1479 – 1482 (2006).
[4] **"Self-Corralling" Nanorods under an Applied Electric Field,** Gupta S., Zhang Q., Emrick T. and Russell T.P., *Nano Lett.* 6, 9, 2066 – 2069 ( 2006)

**EMERGENT MATERIALS PROPERTIES AT THE NANOSCALE: OPPORTUNITIES AND CHALLENGES**

Uzi Landman

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## X-ray scattering from HgSe nanoclusters in zeolites

M. Castro-Colin**, A. M. Milinda, S. C. Moss, W. Donner, A. J. Jacobson, and E. Anokhina

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HgSe has been allocated inside two kinds of zeolites, LTL and Nd-Y, with different pore topologies, tubular and spherical, respectively. The pores are very stable and range within 7 (LTL) to 13 (Nd-Y) Angstroem sizes. We have observed a first sharp diffraction peak in the X-ray diffraction profile which we associate to clustering of the HgSe as it is bound to the pore size. It is expected that cluster-cluster correlation arises, orientational and/or occupational due to effects of electrostatic charge inside the pore, or diffusion. The correlations can only be observed through analyzing the broad diffuse modulation upon which the Bragg peaks are imposed. Our experiments using anomalous X-ray diffraction, below the Se K-edge and the Hg L-edge, and also off-edge, have suggested average crystallographic parameters of the HgSe, thus permitting better control of the system under study. We seek to understand more about the clustering mechanisms by applying the pair-distribution function technique, that has already yielded some preliminary results, still under analysis. The obvious potential technological application of these nano-clusters derives from the transparency to visible light of the zeolites, which would permit interaction with the HgSe, whose spectral sensitivity has been altered due to zeolitic confinement.

** M.C-C now at University of Texas at El Paso.

# Probing Low-Energy Electron Attachment at the Fundamental Level: A Novel Regge Pole Analysis

A. Z. Msezane[1], Z. Felfli[1] and D. Sokolovski[2],
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In quantum scattering, the presence of a sufficiently narrow resonance allows the collision partners to form a long-lived intermediate complex. In order to preserve the total angular momentum this complex must rotate as it decays back into its constituent parts. Rotation of the complex takes scattering into angular regions not readily accessible to a direct scattering mechanism, and alters the appearance of the differential cross section (DCS). In this paper we consider a system trapped in such a resonance state and allow it to decay at zero scattering angle, which through the optical theorem can be related to the total cross section (TCS).

Within the novel and elegant Mulholland description of the total elastic cross sections as implemented within the complex angular momentum (CAM) representation of scattering, wherein resonances are rigorously defined as singularities of the S-matrix, we exploit the recent successful analysis of low-energy oscillations in the elastic total cross sections for proton – hydrogen scattering [1] to study the formation of negative ions as Regge resonances in electron-atom scattering [2, 3]. The Regge trajectories allow us to probe electron attachment at its most fundamental level near threshold, thereby uncovering new manifestations and possibilities. In particular, the near threshold region in electron elastic scattering from atoms, ions and molecules is generally difficult to access experimentally. But the CAM method allows us to probe electron scattering to very near threshold, yielding unprecedented body of knowledge, which is incredibly simple to interpret and the fundamental physics is transparent (*e.g.* the Ramsauer-Townsend minima, positions of resonances and, most recently the DCS's critical minima and the Wigner threshold law).

Our methodology could also be used to extract the scattering length with significant implications for *inter alia* Bose-Einstein Condensation and related phenomena. Preliminary results in $e^-$-K and $e^-$-Rb attachment exhibit peculiarities, including a d-wave Wigner threshold law and research on $e^-$-Au and $e^-$-Pt as well as $e^-$-Ag and $e^-$-Cu reveals exciting signatures. Partial Regge cross sections, DCS's and TCS's for various electron collisions at near threshold energies will be presented and discussed.

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