November 9, 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

Dear Prof. Steveninck:

I am writing to apply for the open biocomplexity faculty position at the Assistant Professor level in Biocomplexity Institute, Indiana University. My research background is in biological physics (theoretical and experimental neuroscience), computational science, and nonlinear dynamics. My doctoral and postdoctoral studies are in theoretical and computational nonlinear dynamics, neuroscience, and applications of nonlinear science in different fields of science, engineering and medicine. My research interests and background closely correspond with several research areas of the existing faculty members of the department. That is why, I am very happy to enclose my CV, statements of research, statements of teaching, list of referees, and selected publications for your consideration.

Currently, I a postdoctoral fellow at the Center for Complex Systems and Brain Sciences, Florida Atlantic University, FL. I am working on the study of human behaviors and brain using advanced imaging technology (fMRI, EEG and MEG) and dynamical systems theory. My previous two years of postdoctoral work was on *(i)* experimental study of spatiotemporal dynamics of the human brain with fMRI and *(ii)* the study of nonlinear oscillators (Josephson junction arrays, neural networks) at Georgia Institute of Technology School of Physics and Emory University School of Medicine. In August 2003, I have already had three years of postdoctoral research experience at these two great places,(i) Georgia Tech and Emory University, Atlanta, and (ii) the Center for Complex Systems and Brain Sciences, FAU, Florida. My M.S. and Ph.D. research was on chaotic dynamics. My M.S. research in Nepal was on the detection of brain tumors by magnetic resonance imaging (MRI) techniques at Tribhuvan University Institute of Medicine, Nepal.

Over the years, by working on various interdisciplinary research projects, I have acquired skills useful for interdepartmental research in an university setting. Because of my research background in nonlinear science and neuroimaging, I am certain that I can find interesting research questions in many areas, namely,

- computer science (scientific programming, image visualization, pattern recognition)
- biomedical engineering (biomedical imaging, fMRI, EEG & MEG)
- electrical engineering (electrical power systems and their stability, signal/image processing, visualization)

- theoretical physics (condensed matter physics, nonlinear dynamics, biophysics)
- neuroscience and psychology (neuroimaging: fMRI, EEG, MEG, and brain-behavior relationship)
- applied mathematics and statistics
- computational biology

I have a total of four years of physics teaching experience : two years here in the US as a teaching assistant and two years in Nepal as a physics lecturer. I have taught a variety of physics courses.

I believe that I have a comprehensive background, both in teaching and research, that would benefit your department in various academic efforts. I will appreciate the chance to visit the faculty and to discuss my qualifications and future research plans in greater details. I thank you and look forward to hearing from you.

Yours Sincerely,

Mukesh Dhamala, Ph.D.
Center for Complex Systems
& Brain Sciences
Florida Atlantic University, FL 33431

encl: CV, List of referees, Research statements, Teaching statements & selected publications.

Research Interests

My main research interests are in nonlinear dynamics, theoretical and experimental neuroscience, computational science, and applications of the concepts of applied mathematics and physics in different fields of science, engineering and medicine. Please find listed below some of the areas I am interested in and the relevant references:

1. **Nonlinear dynamics & chaos.** The areas of current interest in this field are (i) collective synchronization of coupled oscillators and the effect of different network structures and properties, (ii) chaos (transient, sustained and spatio-temporal), characterization and control, (iii) the applications of the nonlinear dynamics concepts to understand the functioning of biological systems. The publications in the related areas are as follows:

   - M. Dhamala, V. K. Jirsa, and M. Ding, "Transitions to synchrony in bursting neurons," submitted to Phys. Rev. Lett. (2003).
   - M. Dhamala, V. K. Jirsa, and M. Ding, "Enhancement of neural synchrony by time delay," submitted to Phys. Rev. Lett. (2003).
   - M. Dhamala, G. Pagnoni, K. Wiesenfeld, C. F. Zink, M. Martin, and G. S. Berns "Neural of the complexity of rhythmic finger-tapping,", NeuroImage **20**, 918 (2003).
   - M. Dhamala and K. Wiesenfeld, "Generalized stability law for Josephson series arrays," Physics Letters A **292**, 269-274 (2002).
   - M. Dhamala and Y.-C. Lai, "The natural measure of nonattracting chaotic sets and its representation by unstable periodic orbits," Int. J. Bifurcat. Chaos **12**, 2991-3006 (2002).
   - M. Dhamala, G. Pagnoni, K. Wiesenfeld, and G. S. Berns, "Measurements of brain activity complexity for varying mental loads," Physical Review E **65**, 041917 (2002).
   - M. Dhamala, Y.-C. Lai, and E. J. Kostelich, "Analyses of transient chaotic time series," Physical Review E **64**, 056207 1-9 (2001).
   - M. Dhamala, Y.-C. Lai, and R. Holt, "How often are chaotic transients in spatially extended ecological systems ?, " Physics Letters A **280**, 297 - 302 (2001).
   - M. Dhamala, Y.-C. Lai, and E. J. Kostelich, "Detecting unstable periodic orbits from transient chaotic time series, " Physical Review E **61**, 6485-6489 (2000).
   - R. Davidchack, Y.-C. Lai, E. Bollt, and M. Dhamala, "Estimating generating partitions of chaotic systems by unstable periodic orbits," Physical Review E **61**, 1353-1356 (2000).
   - M. Dhamala and Y.-C. Lai, "Unstable periodic orbits and the natural measure of nonhyperbolic chaotic saddles," Physical Review E **60**, 6176-6179 (1999).
   - M. Dhamala and Y.-C. Lai, "Controlling transient chaos in deterministic flows with applications to electrical power systems and ecology," Physical Review E **59**, 1646-1655 (1999).

2. **Theoretical & experimental neuroscience.** I am interested in understanding how the human brain works on different levels for different functions using modern imaging technology (EEG, fMRI, MEG) and theoretical biophysical models. Although it is a very active area, the brain research lacks thorough understanding of the underlying principles and mechanisms behind whole brain functioning on different levels. I believe only a combination of theoretical and experimental approaches will help us achieve this goal. In my postdoctoral research at GaTech/Emory and FAU, I have done behavioral and neuroimaging studies on (i) the applications of complex systems concepts, (ii) neural correlates of rhythmic finger-tapping, (iii) multisensory integration, (iv) effect of rewarding and non-rewarding stimuli, along with some biophysical modelling to understand neural synchronization on different time scales and in time-delayed networks. Here is the list of relevant papers:

   - M. Dhamala, C. G. Assisi, V. K. Jirsa, and J. A. S. Kelso, "Multisensory integration in the human brain," in preparation (2003).
   - M. Dhamala, V. K. Jirsa, and M. Ding, "Transitions to synchrony in bursting neurons," submitted to Phys. Rev. Lett. (2003).
   - M. Dhamala, V. K. Jirsa, and M. Ding, "Enhancement of neural synchrony by time delay," submitted to Phys. Rev. Lett. (2003).

- G. Pagnoni, M. Martin, C. Zink, M. Dhamala, and G. S. Berns, "Decreased striatal response to natural reward in heroin addiction," submitted.
- M. Dhamala, G. Pagnoni, K. Wiesenfeld, C. F. Zink, M. Martin, and G. S. Berns "Neural of the complexity of rhythmic finger-tapping,", NeuroImage **20**, 918 (2003).
- C. Zink, G. Pagnoni, M. Martin, M. Dhamala, and G. S. Berns, "Human striatal response to salient non-rewarding stimuli," J. Neuroscience **23**, 8092 (2003) (Featured in the editorial).
- P. R. Montague, G. S. Berns, S. M. McClure, G. Pagnoni, M. Dhamala, et. al., "Hyperscan: simultaneous fMRI of human interaction," NeuroImage **16**, 1159 (2002).
- M. Dhamala, G. Pagnoni, K. Wiesenfeld, and G. S. Berns, "Measurements of brain activity complexity for varying mental loads," Physical Review E **65**, 041917 (2002).

3. **Computational science.** I view Computational Science as a field emerged out of collaborative research across mathematics, physical/ biological sciences, and computer science. It is a new mode of scientific enquiry along with theoretical and experimental sciences. I am interested in computer modelling and simulations of physical/biological processes and developing new algorithms to extract useful information from experimentally measured signals and images. Here are the relevant references:
   - M. Dhamala, G. Pagnoni, K. Wiesenfeld, C. F. Zink, M. Martin, and G. S. Berns "Neural of the complexity of rhythmic finger-tapping,", NeuroImage **20**, 918 (2003).
   - M. Dhamala, G. Pagnoni, K. Wiesenfeld, and G. S. Berns, "Measurements of brain activity complexity for varying mental loads," Physical Review E **65**, 041917 (2002).
   - M. Dhamala and K. Wiesenfeld, "Generalized stability law for Josephson series arrays," Physics Letters A **292**, 269-274 (2002).
   - M. Dhamala, Y.-C. Lai, and E. J. Kostelich, "Analyses of transient chaotic time series," Physical Review E **64**, 056207 1-9 (2001).
   - M. Dhamala, Y.-C. Lai, and R. Holt, "How often are chaotic transients in spatially extended ecological systems ?, " Physics Letters A **280**, 297 - 302 (2001).
4. **Electrical systems.** Some dynamical models of electrical power systems and superconducting circuits are known to be the best physical examples to exhibit nonlinear (ordered and chaotic) phenomenon. The stability study of such systems will definitely help improve their designs in applications. I am interested in the study of collective synchronization in Josephson junction arrays and stability of electrical power systems. Listed below are the relevant references:
   - M. Dhamala and K. Wiesenfeld, "Generalized stability law for Josephson series arrays," Physics Letters A **292**, 269-274 (2002).
   - M. Dhamala and Y.-C. Lai, "Controlling transient chaos in deterministic flows with applications to electrical power systems and ecology," Physical Review E **59**, 1646-1655 (1999).
5. **Signal/image processing, analysis, & visualization.** I am interested in the theoretical and practical aspects of processing, analyzing and visualizing signals and images. It includes noise filtering by fourier or wavelet techniques, signal/image decomposition, spectral analysis, calculation of statistical quantities, nonlinear analysis and visualization by plotting the results in certain ways. The relevant references are:
   - M. Dhamala, G. Pagnoni, K. Wiesenfeld, C. F. Zink, M. Martin, and G. S. Berns "Neural of the complexity of rhythmic finger-tapping,", NeuroImage **20**, 918 (2003).
   - P. R. Montague, G. S. Berns, S. M. McClure, G. Pagnoni, M. Dhamala, et. al., "Hyperscan: simultaneous fMRI of human interaction," NeuroImage **16**, 1159 (2002).
   - M. Dhamala, Y.-C. Lai, and E. J. Kostelich, "Analyses of transient chaotic time series," Physical Review E **64**, 056207 1-9 (2001).

I would be more than happy to discuss my research interests in greater details. Thank you.
Mukesh Dhamala
November 2, 2003

My Teaching Philosophy and Experience

Teaching Philosophy

To me, teaching is to actively help and motivate those who want to learn in their learning process. It is the transfer of knowledge, skills, or information. So the way the information is presented becomes vitally important to achieve the general goals of teaching. The most important point in good teaching is to stimulate students' interest in the subject matter so that they can perform at higher level than they would do normally. Teaching in a sense itself is a learning process, in which teachers learn great deal about students' general difficulties and to explore the new and effective ways to present the material. From my viewpoints, here are the requirements one needs to meet to be a good teacher:

1. A high level of enthusiasm toward the subject matter.
2. An ability to prepare and present well-organized lectures for the entire course.
3. An ability to make students inquisitive towards the subject by asking important questions and involving the entire class in important discussions.
4. An ability to sense what the students know and what they don't know in class through discussions or the questions they ask.
5. An ability to set examinations which will not only test how much they gained but also encourage them to learn more.
6. Willingness to offer help beyond a call of duty.
7. An ability to evaluate one's own teaching style and to improve with the students' overall performance as a feedback.

In my experience of several years of teaching here in the US as a TA and in Nepal as a lecturer, I found one thing in common. Talking to students individually or in groups and involving them in class quizzes always help achieve more participatory learning. Not only that it helps determine what the students learned and what they don't understand. It also helps teacher to evaluate own teaching style and improve. If there is a passion for teaching, it is a proven fact that, with practice, teaching skills improve and get refined. Since learning is a never ending process, I always believe in opening doors to students for further information about the subject matter. In that sense, research and teaching are closely related. An excellent researcher should be able to bring the flavor of forefront research into a classroom. An excellent teacher should be able to talk about recent developments in the field and on-going research efforts in the department. It always helps students to find the research areas of their interest. Involving students (even undergraduates) in research projects is another integral part of teaching-learning process, which always needs to be encouraged. For effective presentation in teaching, one should always be open to try and use modern computer devices, etc.

Teaching experience

I have taught a variety of undergraduate physics courses at the Engineering Institute, Tribhuvan University Nepal from 1994 July to 1996 July, and at the physics department, the University of Kansas, Lawrence from August 1996 to May 1999. The students' evaluation of my teaching skills has always been very good. Here are the courses I taught:

Lecture classes

1. General physics (text: Nelkon and Parker)
2. Mechanics (text: Halliday and Resnick)
   (calculus-based)
3. Heat and Thermodynamics (text: Halliday and Resnick)
   (calculus-based)
4. Geometrical and Wave Optics (text: Jenkins and White)
5. Electricity and Magnetism (text: Halliday and Resnick)
   (calculus-based)
6. Modern Physics (text: Arthur Beiser)
   (calculus-based)
7. Quantum Mechanics (text: Liboff)

Lab classes

1. Phsx 114 - General physics I
2. Phsx 115 - General physics I: Electricity and Modern Physics
3. Phsx 211 - General physics II: Mechanics and Thermodynamics
   (calculus-based)
4. Phsx 212 - General physics II: Electricity and Magnetism
   (calculus-based)

(I was the head teaching assistant for two semesters.)

Apart from the standard courses in the department, I am also interested to design and teach very specialized courses, for example, applications of dynamical systems theory in various fields of science/engineering, modern neuroimaging technology, and the processing/analysis of neuroimaging data.

Mukesh Dhamala
November 2, 2003