DEPARTMENT OF NATURAL SCIENCES
FAYETTEVILLE STATE UNIVERSITY

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

November 21, 2004

Dear Professor Krim:

I am interested in a faculty position in the area of Biocomplexity at Indiana University that you advertised recently. Currently I am an Associate Professor in the Department of Natural Sciences at Fayetteville State University teaching different courses in Physics, Biophysics and Astronomy. I am sending you my vita and this letter with some information about myself that may be of interest. Please let me know when you will need the recommendations and I will arrange to have them sent to you directly.

My research interests center on Computational Soft-Matter and Biophysics, with specific emphasis on modeling dynamics of biochemical processes and nanoscale phenomena. In the years following my terminal degree, I have built an internationally recognized research program in Computational Materials Physics and Biophysics. In my research I utilize a combination of theoretical and computational methods, which allow me to study real materials problems and compare my results with experiments.

As you can see from my vita, I have been successful in obtaining external funding for my research projects. Last academic year I received a Grant from the Army Research Office in the area of Nanotechnology (total amount $276,000). This year I submitted collaborative proposals in the area computational modeling with the researchers from NIST and NC State University. All my grants and proposals have substantial undergraduate involvement.

I have enjoyed very much my research activity in the area of Materials Physics and Biophysics. At the same time I am excited about my work as a teacher. My research experience allows me to promote strong interest in science and technology in young people and have best undergraduate students involved in the scientific programs in the area of Computational Physics and Biophysics. I am committed to working with my students and have maintained professional relationships with many of them years beyond the classroom.

I have been an active member of the academic and social communities at Fayetteville State. I have served on numerous committees and have been a vigorous and enthusiastic participant in university life. My involvement spans endeavors as serious as the Faculty Senate, Applied & Education Physics and Cooperative Engineering Programs, and as short-term as the Physics outreach campaign devoted to the 2005 World Year of Physics where I agreed to make a presentation about Einstein's life and accomplishments.

As much as I can judge from the brief description of your Department in the ad and your website, I expect to find in your Department a nearly perfect match for my interests in both teaching and research. I am particularly attracted by the quality of your academic programs, the dedication of the faculty, and the accomplishments of the students. I would be most interested in developing a Computational Biophysics Program in your Department.

This is why I would like to obtain a faculty position in the area of Biocomplexity (possibly in the Department of Physics) at Indiana University. I consider myself qualified to teach general undergraduate and graduate courses in Physics, Biophysics, and Astronomy as well as more advanced courses in the area of my expertise. At this stage of my career I am eager to take on a new challenge and can bring to your Department a faculty member experienced in all aspects of higher education. I believe that my experience will be beneficial for your Department.

I would appreciate an opportunity to discuss my qualifications with you in greater detail. Looking forward to hearing from you.

Sincerely yours,

AUmantsev

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U.S. Citizen

PROFESSIONAL OBJECTIVE

Teaching: undergraduate and graduate courses in Physics and Biophysics.
Research: Computational Soft-Matter Physics, Biophysics, Physics of Nanostructures.
Directing research of undergraduate and/or graduate students.

PROFESSIONAL EXPERIENCE

2002-present Fayetteville State University, Fayetteville, NC 28301
Associate Professor, Department of Natural Sciences

2001-2002 Northern Arizona University, Flagstaff, AZ 86011
Visiting Assistant Professor, Department of Physics and Astronomy

June-July 2001 Technion-Israel Institute of Technology, Israel
Visiting Scholar, Department of Materials Science

1997-2001 Saint-Xavier University, Chicago IL
Assistant Professor, Department of Chemistry/Physics

1997- 2001 Northwestern University, Evanston, Illinois 60208
Adjunct Professor, Department of Materials Science and Engineering

1995-1997 City Colleges of Chicago, Chicago IL
Instructor, Physical Science & Engineering Department, Truman College, Chicago, IL

1993- 1994 University of Alabama at Birmingham
Research Assistant Professor, Department of Materials Science and Engineering
Adjunct Professor of Materials Science, University of Alabama, Tuscaloosa

1990-1993 Northwestern University, Evanston, Illinois 60208
Research Associate, Department of Materials Science and Engineering,

1989-1990 Northwestern University, Evanston, Illinois 60208
Post-Doctoral Fellow, Department of Engineering Science and Applied Mathematics,

1980-1988 National Research Laboratory for Metallurgy, Moscow, Russia.
Doctoral Study to Post-Doctoral Fellow, Division of Theoretical Physics, Institute for Physics of Metals,

RESEARCH EXPERIENCE

BIOPHYSICS

Biophysics of neurons. [Ref. 1]

- Analyzed adhesion effect of Acetylcholinesterase on the development of nervous system.
- Elucidated effects of certain toxic substances on the growth of neurons.

Origin of life research. [Ref. 2, 7]

- Hypothesized the structure and process of formation of protocells.
- Computer simulation of polymerization of biomaterials.

Synergetic approach in medicine. [Ref. 4]

- Analyzed human disorders as examples of dynamical chaos in biological organisms.
- Introduce principle of compensation to explain the adaptive nature of biological chaos.
- Applied this principle to a human organism and suggested new treatment strategies.

Morphogenesis and development in biological systems.
Computer simulation of motility, chemo-, and thermo-taxes of *DICTYOSTELIUM DISCOIDEUM* amoebae.

MATERIALS PHYSICS

Self-Organized Nanostructures: Equilibria and dynamics at Nanoscale. [Ref. 14, 17]
Properties of thin films and nanoparticles of pure materials and solid solutions.
Computer simulation of nanoparticle dynamics.

- Predicted theoretically existence of a new phase that appears only in small particles and changes mechanical, electrical, magnetic and optical properties of the material.
- Proposed an explanation for amorphization of pure metals.

Thermal effects in continuous and discontinuous phase transitions. [Ref. 5, 6, 8-13, 15, 17-19, 21, 23]
Role of transport phenomena in symmetry breaking.
Structure and dynamics of interfaces.
Dynamics of phase transitions from nucleation to coarsening using the phase-field approach.

- First self-consistent derivation of the equation for describing heat effects in phase transitions.
- Predicted theoretically the phenomenon of heat trapping with formation of a metastable phase.
- Predicted theoretically slowing down of the antiphase domain boundary due to heat conduction.
- Predicted theoretically existence of thermal waves that accompany continuous phase transition.
- Analyzed the effect of elastic stresses and strains on the segregation at heterophase interfaces.
- Computer simulation of the structure formation and evolution in complex materials.

Diffusion and coarsening in multicomponent alloys. [Ref. 16]

- Elucidated the cross effects of different species on the coarsening rate of multicomponent alloys.

Crystallization. Dendritic Growth. [Ref. 20, 22, 24-31]
Computer simulation of the dendritic pattern formation during crystallization.

- Developed a physical model and computer simulated formation of the dendritic structures.
- Reproduced numerically the experimental results of the dendritic structure formation and coarsening.
- Predicted theoretically the phenomenon of restoration of morphological stability at large supercoolings of the melt.
- Constructed the morphological diagram of pattern formation at different temperatures.

Intermetallic Compound Growth. [Ref. 3]
Formation and Evolution of microstructures during crystallization of intermetallic phases.

- Elucidated the physical mechanism of the intermetallic compounds structure formation and predicted different regimes of the compound growth.
- Developed a physical model for computer simulation of the intermetallic compounds growth using the phase-field approach.

UNDERGRADUATE INVOLVEMENT

Supervision of undergraduate and graduate students' research work.
FSU—4 undergraduate students
NAU—2 undergraduate students
SXU—1 undergraduate student
UAB—2 graduate students.

Supervision of the Research Seminar.
"Modeling of the Microstructure Evolution during Phase Transformations"—UAB.

TEACHING EXPERIENCE

BIOPHYSICS

Biophysics. The course introduces the use of physical methods, with appropriate mathematics when necessary, in the study of biological systems, including macromolecules, membranes, nerves, muscle, photosynthetic systems and visual systems. The biological systems to which the methods are applied will be surveyed and current interpretations of their structure and function will be discussed.

Life in Cosmos. (*new*) The course will be open to all students; no prior knowledge of astronomy, physics or biology will be assumed or required. The aim of this course is to convey the detailed conceptual ideas associated with the important question of the formation of life in the universe. The course will discuss all the environmental circumstances that encourage the start of any life form and investigate the current state of our knowledge of life outside of the earth. These questions are looked at from a multi-disciplinary viewpoint, which includes astronomy, biology, chemistry and geology. However, other perspectives such as the historical, cultural and philosophical are included.

PHYSICS

Phase Transitions in Metals/Alloys. Graduate course in Materials Physics which covers basic transitions in materials: crystallization, order-disorder, magnetic; transport processes: heat conduction, diffusion, fluid flow; basic phenomena: nucleation, growth, dissolution, spinodal decomposition, coarsening.

Statistical Mechanics and Thermodynamics Topics include entropy and temperature, Boltzmann distribution, chemical potential and the Gibbs distribution, kinetic theory of gases, Fermi and Bose gases, energy transformations, the first and second laws of thermodynamics, thermodynamic processes in open and closed systems, reversibility, equilibrium and chemical reactions.

Quantum Mechanics and Spectroscopy. As a part of the sequence on Physical Chemistry, the course investigates the wave-particle duality as resolved by the Bohr-atom model, Dirac wave mechanics, and eigenvalues of the Schroedinger equation, with applications to atomic and molecular vibrations, rotational, electronic spectra, and the nature of chemical bond.

Mechanics. (for engineering sciences students) Topics include: kinematics and dynamics, conservation of energy and momentum, angular momentum, wave motion and sound, solid mechanics, stress and strain, elasticity.

Electromagnetism. (for engineering sciences students) Topics include: charge, electric field and potential, Gauss law, Ampere’s law, Faraday’s law, magnetic properties of matter, inductance, capacitance, Maxwell’s equations and laws of electromagnetism, physical optics.

Modern Physics. Topics include: theoretical foundation of wave-motion, Maxwell's equations, special relativity, introduction to quantum physics, Schrodinger equation, atomic structure, solid state physics.

General Physics. (for students majoring in liberal arts, health care: pre-medical, pre-pharmacology, biological and environmental sciences) Topics include: *Part I*: Kinematics. Newton's laws of dynamics. Oscillations. Fluid and solid mechanics. Heat and thermodynamics. Application of physical principles to related scientific disciplines including life sciences. *Part II*: Electricity and magnetism. Wave motion. Laws of geometrical and physical optics. Introduction to concepts of relativity, quantum mechanics, atomic and nuclear physics.

Physics for Non-scientists. Web-based Introductory Physics Course. Discussion of the scientific method; Newton's laws of dynamics; Descriptive Astronomy; Introduction to Geology, Weather and Climate.

Freshman/Sophomore Physics Seminar. Discussion session and analysis of problem-solving strategies

Freshman/Sophomore Physics Laboratory. Fully computerized laboratory experiments based on Vernier Software. The courses include hands-on experience in mechanics, heat, electromagnetism, and optics.

ASTRONOMY

The Solar System. Celestial sphere and constellations, measurement of time, astronomical instruments, earth as a planet, moon, eclipses, comparative planetology, satellites, comets, meteors, theories of origin of solar system.

Stellar Astronomy. The sun as a star, physical properties of stars, principles of spectroscopy as applied to astronomy, double stars, variable stars, star clusters, gaseous nebulae, stellar motions and distributions, Milky Way system, external galaxies, expanding universe, cosmic time scale.

Introduction to Cosmology. (Honors course) An introduction to the ultimate structure and evolution of the universe. Topics include history of cosmology, nature of galaxies, space-time and relativity, models of the universe, black holes, quasars, and sources of gravitational radiation.

Observational Astronomy Lab. Astronomical observations and experiments that underscore the use of telescope. Outdoor observations of the Moon, stars and planets, and classroom work. Used 10-inch reflectors (NAU), 24-inch telescope (the Atmospheric Research Observatory at NAU), and 16-inch Star Liner Cassegrain (FSU Observatory).

Planetarium Demonstrations. Presented educational shows using FSU's Spitz Space Systems Planetron.

FEDERAL GRANTS AND RESEARCH AWARDS

FUNDED

Nanolayers and nanoparticles of solid solutions: theory and computer simulation of phase equilibria and dynamics.
DoD, ARO, Materials Science Program 2004-2007
Role: PI; K.C. Wong Co-PI.

Modeling formation of microstructure of intermetallic compounds during crystallization.
NSF, DMR, Materials Theory Program 2000-2005
Role: PI

Summer Mentoring Program at FSU.
DoD, ARO, REAP Program 2004
Role: PI

Research Experience for Undergraduates.
NSF, DMR, Materials Theory Program 2003
Role: PI

Faculty Increasing Student Achievement Success, Learner-Centered Education.
Arizona Board of Regents, Phoenix AZ. 2001-2002
Role: Co-Investigator

Atomic Scale Studies of Heterophase Metallic Interfaces.
NSF-ROA, DMR, Metals Program. 1999
Role: Co-PI, D. N. Seidman PI.

Design of Interfacial Microstructures in Creep Resistant lead-free Solders for Electronic Interconnects.
NSF-ROA, DMR, Metals Program. 1999
Role: Co-PI, M. E. Fine PI.

Small Grants for Undergraduate Participation in Research
SXU, Center for Educational Practice 1998-1999
Role: PI.

Microstructural Evolution during Materials Processing.
NSF, DMR, Metals Program. 1994
Role: Co-Investigator, R. Thompson PI.

SUBMITTED

NSF-NIST Interactions in Materials Research.
NSF, DMR, Materials Theory Program
Role: PI

IN PREPARATION

Role of toxic substances on brain development and socio-economical consequences of their abuse.
FSU, Research Center for Social and Behavioral Studies in Health Disparity
Role: Co-PI; S. Chao PI, S. Huang Co-PI.

Role of the enzyme AChE on the early stages of development of neurons in neuroblastoma culture.
DARPA, DoD, Signaling Pathways Program
Role: Co-PI; S. Chao PI, S. Han Co-PI.

Biophysical nature of strictly periodic sleep apnea: interconnections between biorhythms of brain, heart and respiration.
NIH NIGMS Exploratory Studies for High Impact/High Risk Research Program.
Role: Co-PI; A.Z. Golbin PI

Investigation into the failure of solder joints by combined low-cycle fatigue and electromigration.
NSF, DMR, Metals Program
Role: Co-PI; H. Conrad (NCSU) PI.

UNFUNDED

Development and behavior of DICTYOSTELIUM DISCOIDEUM amoebae in adverse ambient conditions: a Systems Biology approach.
NSF, Directorate of Biological Sciences, BIO, C-RUI Program.
Role: PI; V. P. Fleming Co-PI, M. Kanipes Senior Per.

Effect of reactive fluxes on properties of solder joints.
Northrop Grunman Corporation.
Role: PI, J. Breitzer Co-PI

Accentuating the integration of math and science at Fayetteville Sate University.
NSF, HBCU Program.
Role: Co-Investigator; P. Massey and S. Chao Co-PIs

UNC Bronco Initiative in Computational Science and High Performance Computing.
UNC System.
Role: Co-Investigator; K.C. Wong and D. Pearson Co-PIs

HP Technology for Teaching.
HP Grant Initiative.
Role: Co-Investigator; R. Grier PI

TEACHING AND SCHOLARLY AWARDS

Scholar Recognition Award. Saint-Xavier University, Chicago IL. 1998 and 2001

Summer Research Fellowship, Materials Research Center, Northwestern University. 1998

SERVICE

ACADEMIC SERVICE

Referee for the Physical Review E. Subject: Pattern formation and phase transitions.

Reviewer for the National Science Foundation, Division of Materials Research. Subject: Microstructure formation and computer modeling.

Reviewer for the NASA. Subjects: Biophysics, Nanotechnology.

UNIVERSITY SERVICE

Faculty Senate Member, Fayetteville State University.

School of Basic and Applied Sciences Grants and Development Committee, FSU

Applied Physics and Physics Education, New Program Committee, FSU.

Biotechnology, New Program Committee, FSU

Forensic Science, New Program Committee, FSU

Search Committees, Department of Natural Sciences, FSU.

Cooperative Engineering Program between FSU and NC State University, NC A&T, UNC Charlotte.

Faculty Improving Student Achievement Success Program. Northern Arizona University, 2001-2002

Ph.D. Committee, Department of Materials Science, Northwestern University. 2001.

University Core Curriculum Committee, Saint-Xavier University, Chicago IL. 1999-2001.

Outreach and Student Recruitment Program, Saint-Xavier University.

COMMUNITY SERVICE

The North Carolina Partnership for Improving Mathematics and Science (NC-PIMS)
Serve as a STEM professional (Science, Technology, Engineering and Mathematics) 2005.

Zap the Gap in Education Program.
Served as a facilitator of the discussion circles, Fayetteville. March-April, 2004.

International Science and Engineering Fair
Served as a Judge in the Category Physics 1994.

EDUCATION

Ph.D. in Solid State Physics from the Institute for Physics of Metals (Division of Theoretical Physics), National Research Laboratory for Metallurgy, Moscow, Russia.
Thesis: "*Computer simulation of a dendritic structure formation during solidification of metals and alloys.*" **1986-Best Dissertation of the Year Award.**

M. S. in Applied Mathematics from the Department of Applied Mathematics, Moscow Institute for Transportation Engineering, Moscow, Russia.
Thesis: "*Control of cracks by the Natural Frequency Method.*"

B. S. in Applied Physics from the Department of Molecular and Chemical Physics, Moscow Institute for Physics and Technology, Moscow, Russia.

DESCRIPTION OF GRADUATE COURSES (taken at The Moscow State University).

Philosophy of Physics. Philosophical problems involved in understanding of natural phenomena. Conceptual foundations and philosophical implications of modern physics. Impetus of discoveries in physics and technology on a modern society at large.

Statistical Physics. Microcanonical, canonical, and grand canonical ensembles revisited. Statistical basis of thermodynamics. Quantum statistical mechanics. Statistical mechanics of interacting systems. Fluctuations. Correlation function and response theory. Spontaneous symmetry breaking and phase transitions. Landau theory and critical phenomena. Superconductors.

Solid State Physics. Crystal symmetry, structure and binding. Lattice vibration and phonons. Free electron model of metals and semi-conductors. Energy band theory. Transport theory and scattering processes. Hall effect, optical properties. Magnetism: spin waves and magnetic ordering.

Crystal Defect Theory. Basic characteristic of point (vacancies), line (dislocation), and planar (grain boundaries) defects in crystalline materials. Atomic theory of diffusion in metals.

Advanced Physical Metallurgy. Properties of liquids. Solidification of pure metals and alloys. Directional solidification process. Thermodynamics and kinetics of phase transitions. Transport phenomena. Theory of nucleation and growth. Ferrous transformations. Structure--property predictions.

PROFESSIONAL SOCIETIES

American Physical Society
American Society for Engineering Education
Minerals, Metals, Materials Society
Materials Research Society
Computational Materials Science Network
Nano-Magnetics Consortium

INVITED LECTURES

September 23, 2004. "Nanoscale Materials: a Physicist's Perspective"
Department of Chemistry/Physics, UNC Pembroke, NC.

April 21, 2004 "Adaptive Chaos: Mild disorder may help contain big disease"
Moving Boundaries: New Perspectives. Celebration of the FSU's Tenth Chancellor Installation.

March 26, 2004. "Recent Advances in Nanotechnology"
Department of Physics, Norfolk State University, VA.

September 26–28, 2003 "*Thermal effects in dynamics of interfaces*."
International Conference "Multiscale Effects in Material Microstructures and Defects", The University of Kentucky in Lexington, KY.

June 23-28, 2002 "*Thermal effects in dynamics of interfaces*."
Fourteenth U.S. National Congress of Theoretical and Applied Mechanics, the Truesdell Symposium. Virginia Tech, Blacksburg VA.

January 24, 2002 "*Dendritic Structures: A New Paradigm in the Physics of Complex Systems.*"
Department of Physics, New Mexico State University, Las Cruces NM.

July 5, 2001 "*Phase stability in Nanostructures.*"
Department of Materials Science, Technion-Israel Institute of Technology, Israel.

June 18, 2001 "*Morphological stability of intermediate phases.*"
Department of Solar Energy & Environmental Physics, Ben-Gurion University of the Negev, Beer Sheva Israel.

January 6, 2000 "*Thermal effects in phase transitions.*"
John Cahn's lunch-bag seminar, National Institute of Standards and Technilogy, MD.

December 4, 1997 *"Adiabatic transformations in nanostructures*."
Fall Meeting of the Materials Research Society, Boston Massachusetts.

December 23, 1996 *"Modeling dendritic solidification."*
The University of Iowa, Iowa City, Iowa.

June 20, 1995 *"Continuous modulations during martensitic transformation."*
Workshop on Martensitic Transformations, Northwestern University, Evanston Illinois.

September 15, 1994 *"Dendritic growth in Metallic Alloys."*
The University of Alabama, Tuscaloosa, Alabama.

May 1993 *"Numerical simulation of a dendritic growth."*
"Continuum models of phase transformations."
Institute for Mechanical and Aeronautical Engineering, Carlton University, Ottawa, Canada.

May 6, 1993 *"Ostwald ripening in multicomponent alloys."*
Metallurgical and Materials Engineering Department, Illinois Institute of Technology, Chicago IL.

August 20, 1992 *"Motion of a plane front during crystallization."*
University of Oxford, Mathematical Institute, Oxford, Great Britain.

March 9, 1992 *"Decomposition of unstable states with conservation of energy*."
Materials Seminar, Courant Institute of Mathematical Sciences, New York University

PROFESSIONAL CONFERENCES, MEETINGS AND WORKSHOPS

(*)–undergraduate student involvement.

March 6–10, 2005	(*) Society of Toxicology Annual Meeting, New Orleans, Lousiana.
November 30, 2004	NASA Technical Assistance Workshops, Shaw University, Raleigh, NC.
September 15-17, 2004	North Carolina Initiative—Biotechnology Supported Products and Systems for National Defense, Durham, NC.
April 19, 2004	New Programs at NSF, Workshop at UNC Greensboro, Greensboro, NC.
April 14, 2004	DoE-HBCU Partnership, Workshop at Brooknaven National Laboratory, Upton, NY.
April 1, 2004	Oral and a poster (by an undergrad*) presentations at the Second Annual RISE Colloquium, FSU, NC.
March 26, 2004	Poster presentation (by an undergrad*) at the SOARS (Seizing Opportunities to Advance Research Scholars) Conference, FSU, NC.
March 9-12, 2004	Annual Meeting of the Metallurgical Society, Charlotte, NC
November 9-12, 2003	Fall Meeting of the Metallurgical Society, Chicago, IL.
March 25, 2003	First Annual RISE (Research Initiative for Scientific Enhancement) Colloquium, FSU, NC.
June 23-28, 2002	Fourteenth U.S. National Congress of Theoretical and Applied Mechanics, Virginia Tech, Blacksburg VA.
October 26-28, 2001	Workshop "The New Cosmology: From Quantum Fuzz to the Accelerating Universe", The University of Chicago, IL
July 23-27, 2001	International Conference on Internal Boundaries, Technion, Israel
April 11-12, 2001	Workshop of the Computational Materials Science Network, NIST, Gaithers. MD
February 12-15, 2001	Annual Meeting of the American Metallurgical Society, New Orleans, Louisiana.
November 3, 2000	(*) Argonne Symposium for Undergraduates in Science, Engineering, and Math, Argonne National Laboratory, IL
September 6-10, 2000	"Physics for the 21st Century", University of Rome Tor Vergata, Italy
April 13-15, 2000	The Midwest Faculty Seminar "New Cosmology", The University of Chicago, IL

April 11-12, 2000	Workshop of the Computational Materials Science Network, NWU, Evanston, IL
April 5, 2000	XCITE/APS Conference, Argonne National Laboratory, IL
March 29, 2000	(*) Sixth Annual Research Conference, Saint-Xavier University, Chicago, IL
September 23,1999	Workshop of the Computational Materials Science Network, CMU, Pittsburgh, PA
August 15-18, 1999	"Interfaces for the Twenty- First Century", Monterey, California.
March 30, 1999	Fifth Annual Research Conference, Saint-Xavier University, Chicago, IL
October 8-9, 1998	"Opportunities in Materials Theory", Workshop at the National Science Foundation, Arlington, VA.
October 11-15, 1998	TMS Fall Meeting, The John W. Cahn Symposium. Rosemont, Illinois
March 27, 1998	Fourth Annual Research Conference, Saint-Xavier University, Chicago, IL
July 10-21, 1995	The Mechanics-Materials Linkage, IMM Summer School, Northwestern University
December, 1994	Fall Meeting of the Materials Research Society, Boston Massachusetts,.
October 2-6, 1994	Materials Week, Rosemont, Illinois
July 17-22, 1994	"Solid-Solid Phase Transformation in Inorganic Materials", International Conference, Pittsburgh, PA
October 17-21, 1993	Materials Week, Pittsburgh, Pennsylvania
August 2-6, 1993	Gordon Research Conference on Physical Metallurgy, Plymouth, New Hampshire
July 12-16, 1993	SIAM Annual Meeting, Philadelphia, Pennsylvania
February 22-25, 1993	TMS Annual Meeting, Denver, Colorado
December 1992	Fall Meeting of the Materials Research Society, Boston Massachusetts.
August 10-14, 1992	ICMS Workshop on Kinetics of Phase Transitions, Edinburgh, Scotland, UK
July 20-24, 1992	International Conference on the Martensitic Transformations, Monterey, CA
March 1992	March Meeting of the American Physical Society, Indianapolis, Indiana.

REFERENCES

RESEARCH:

Professor T. Porter, Chair,
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Mathematics, Northwestern University,
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TEACHING:

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Physical Science and Engineering Department
Harry S. Truman College,
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SUMMARY OF PREVIOUS AND CURRENT RESEARCH INTERESTS

My background covers a broad spectrum of condensed- and soft-matter physics and computational materials physics, particularly processes of pattern formation, nonequilibrium thermodynamic and dynamics of material interfaces. In my research I employ different theoretical methods and computer simulations. A better understanding of the physical mechanisms by which structures are generated in materials is important for practical purposes. Recently my background of a materials physicist found application in another branch of science—biophysics.

MATERIALS PHYSICS

Crystallization. Dendritic Growth. [Ref. 20, 22, 24-30]

The well-known phenomenon of *dendritic* growth is important for crystallization of metals and organic materials from a supercooled melt. The purpose of my dissertation work was *to create the physical model and numerically simulate* different regimes of this phenomenon in conjunction with the large-scale modeling of solidification [24,26]. For the first time the model was able to reproduce the snowflake-like patterns seen experimentally [25,27-30]. The result of this research was twofold. On the one hand, this model allowed us to predict properties of a material obtained in real processing and by choosing the appropriate thermal regime increase the homogeneity of the latter.

On the other hand the model revealed many of the *physical features* pertaining to the growth of a dendrite [25,27]. For example, for the first time the model was able to predict the mechanism of coarsening of the side-branch structure by *period doubling* which was confirmed later by experimental results and provides an important connection with the transition to chaotic structures. Also the model predicts the *restoration of morphological stability* under conditions of rapid solidification, i.e. far from equilibrium. Because of potential importance for applications this effect was analyzed later in the framework of a "string" or geometric model where the interface is viewed as a line of heat sources moving according to the evolution of the diffusion field and in compliance with the natural (geometric) properties of a string. In a strongly supercooled melt, the diffusion field in front of a moving interface is confined to small vicinity and a thermal boundary layer approximation can be introduced. Being applied together with a string model, this approximation allows one to study stability properties of the interface and its dynamics close to the point of absolute morphological stability [20].

Intermetallic Compound Growth. [Ref. 3]

My experience with dendritic solidification recently found an application in a technologically important problem of soldering. When a drop of melt (Sn-based alloy, solder) is brought into contact with a solid Cu-substrate, a layer of intermetallic compound Cu_6Sn_5 starts to grow between the two. Experimental observations demonstrate formation of an intricate microstructure on the surface of the layer, which is interplay of the metal's crystalline properties and dissolution kinetics [3]. My previous theoretical analysis of the intermetallic phase growth highlighted the early stage of soldering as the critical step for the microstructure formation. On the basis of those theoretical ideas I introduced a novel experimental technique, which allowed us to study entire early-stage evolution process on one micrograph. At present in collaboration with NIST I am working on a computer model that will reproduce experimentally observed behavior the intermetallic phase structure [Grants].

Thermal Effects of Phase Transitions. Dynamics of Interfaces. [Ref. 5, 6, 8-13, 15, 17-19, 21, 23, 31]

The solidification problems have stimulated my interest in the physics of interfaces, which are crucial elements of modern sophisticated materials, and dynamics of their motion. Dynamics of interfaces is accompanied by the processes of heat redistribution, which affects the rate and morphology of the evolution in thermodynamic systems. In my early work, using a theoretical approach of a free-boundary problem, a previously unknown regime of interface motion was revealed and verified in numerical simulations [31]. In my later studies, to analyze material's structure on different length scales, I adopted the continuum (phase-field) approach because it allowed me to study time evolution and equilibrium properties on the same basis. In the framework of this method the state of a system undergoing phase transition is characterized by the coarse-grained Hamiltonian (nonequilibrium Ginzburg-Landau free-energy) which, in addition to pressure, temperature and composition, depends upon one more variable, order parameter, that changes continuously from one phase to another [5, 8]. Such parameter has relevance to many different transitions, e.g. crystallization, order-disorder, structural, ferromagnetic, ferroelectric, having different physical interpretations therein. Parameters of the phenomenological Hamiltonian can be obtained from the *ab initio* calculations or interatomistic computer modeling.

Previous attempts to describe heat release along with phase transitions had been based on heuristic ideas; my objective was to develop *a thermodynamically consistent* approach [23]. The free-boundary problem is just a limiting case of this theory when the thermal length and the radius of curvature of an interface are much greater than its thickness. The analysis of systems with slow heat conduction shows that an adiabatic transition is possible such that the temperature of the final phase *is higher than the equilibrium temperature* (metastable or superheated phase production) [5, 6, 8, 10, 12, 15, 17, 21, 23]. This effect was called "heat-trapping" by analogy with the solute-trapping or partitionless solidification of alloys.

Close to the critical point the first-order transitions exhibit intriguing examples of *periodic pattern formation* when the transformation takes the path analogous to the spinodal decomposition characterized by the conserved order parameter (composition) although the original parameter is non-conserved (e.g. magnetization). This means that a weakly first-order transition can proceed by a *continuous modulation mechanism* controlled by heat-transfer [5, 15, 17, 18, 19]. For the case of a structural transition where the order parameter is strain, we demonstrated that estimated properties of Fe-Pd alloys make this system a possible candidate for such behavior. In simulation of the dynamic behavior of such systems, coarsening of the internal domain structure has been observed to occur on late stages of evolution. In contrast to the well known Lifshitz-Slyozov-Wagner type of coarsening kinetics, valid for a small volume fraction of precipitate, this system, which had the volume fraction of the product phase about 50%, demonstrated absolutely different type of the second-phase coarsening behavior, whose distinguished feature was period doubling [17].

A thermal effect has been predicted in materials that underwent a second-order (continuous) transition, e.g. ferromagnetic, or order-disorder, despite the lack of the latent heat in transitions [5, 8, 13]. For instance, in materials with small thermal conductivity motion of the domain walls will proceed much slower than according to the predictions of the Landau-Lifshitz or Cahn-Allen theories that does not take the energy effect into account. This effect may be important for the theory of the hysteresis loop and magnetization dynamics and the continuous transition itself, changing time exponents of the latter.

Change of the crystalline symmetry is usually accompanied by the development of the misfit strain in materials as a result of different lattice spacings in different phases. Small precipitates grow usually without loss of coherency on their interfaces. In my next project I have developed a consistent continuum approach to the problem of segregation at coherent interfaces and incorporated the coherency strain into the continuum model of microstructural evolution of multicomponent alloys [9, 11].

Diffusion and coarsening in multicomponent alloys. [Ref. 16]

The widespread use of multicomponent alloys for the first-principals designing of new smart materials has stimulated my interest in *coarsening process in multicomponent systems* whose thermodynamics is different from that of binaries due to presence of many different components. It was necessary to analyze this process without simplifying assumptions on the solution thermodynamics of alloys that are usually not confirmed in practice. The derived coarsening behavior showed marked departure from a binary case and turned out to be a fundamental contribution to an interdisciplinary program of applying physics, mechanics and materials science to alloy design [16]. This work was tested with the experimental results on the small angle neutron scattering in model alloys and at present is used in the conceptual designing of practical alloys.

Nanomaterials. [Ref. 14, 17]

Nanotechnology is defined as the creation of functional materials, devices and systems with at least one characteristic dimension at the scale of one to one hundred nanometers. It requires fundamental understanding of self-organization at the nanoscale. My interest in nanotechnology and organization at the nanoscale arose from the thermodynamic analysis of *small adiabatically insulated particles*. It showed that their phase diagrams are more complicated than those of large ones: phase separation does not occur when it is supposed to. Instead, there is a considerable extension of the single-phase regions of ordered and disordered phases into the two-phase zone of the phase diagram. Moreover, in a particular energy band, equilibrium is achieved on the homogeneous transition state that corresponds to the saddle point of the free energy [14]. Mechanical, electromagnetic and optical properties of such a state are different form those of the bulk phases. Such particles provide opportunity to study the intrinsically unstable segments of the free energy of materials. This work has also very important ramifications on the theory of amorphization of pure metals.

Many microelectronics devices rely on nanometer-scale films of solid solutions grown on substrates by different deposition techniques. Such films have properties very different from their bulk counterparts. For instance, silicon based semiconductors possess wider than normal band gaps, SnGeTe thin films become superconducting and gain anomalous Hall effect when alloyed with In. Semiconductor films may be grown in such a regime that the band-gap can be tuned by simply changing the dimensions of the material. Fe-Cu and Fe-Ag binary systems are virtually immiscible in the bulk. However, 70 nm nanoparticles of these materials were found to form supersaturated solid solutions. This inspired me to use the mean-field method in order to study the phase transitions in nanofilms of solid solutions [Grant].

BIOPHYSICS

Biophysics of neurons. [Ref. 1]

Acetylcholinesterase (AChE) is an enzyme, which is classically known for its role in hydrolyzing neurotransmitters that diffuse across the synaptic cleft in the process of neuron-muscle cell communication. Recent studies, however, suggest that AChE may have a broader role, particularly in the development of nervous system. Deviations in normal levels of AChE at the initial moments of nervous system development appear to contribute to observed neuro-anatomic abnormalities such as altered neurite (axons and dendrites) outgrowth. Sequence similarities of AChE to some cell adhesion molecules appear to indicate its structural role of neurite adhesive in neuron development process. In this study, we used physical methods to explore the influence of different AChE inhibitors on the normal outgrowth of neurites of the specific neuroblastoma cells. Our results support the hypothesis that AChE promotes neurite outgrowth through adhesive function.

Origin of life research. [Ref. 2, 7]

The experimental findings of the last couple of years inspired my interest in biophysical problems of the origin of life. Almost all tenable hypotheses of the origin of life on Earth describe transformation from geochemistry to biochemistry, which brought about the material of life, DNA-protein combination, and cellular organization of that material. Living organisms, however, are distinguished from a mixture of organic molecules by their high level of complexity, which allows them to carry out certain functions. I analyzed the hypothesis that the earliest forms of life (protocells) were formed through the process of phase transitions, e.g. crystallization. According to this hypothesis, inorganic materials helped build living systems by lending them functions so that organic chemical evolution is just one natural consequence of the evolution of matter in the universe. A self-replicating biological system with adaptation emerged from single molecules using completely abiotic mechanism of formation. This mechanism acted simultaneously at different places on the early Earth and created similar materials everywhere. Hence, the similarities in the living systems did not appear by chance, but as a necessity.

Synergetic approach in medicine. [Ref. 4]

Conventional wisdom in physiology and medicine (theory of homeostasis) holds that a healthy organism regulates itself to maintain constant rhythm, while erratic behavior of the organism is symptomatic of unfolding disease because it suppresses natural rhythms. However, interdisciplinary discoveries of the past decade in mathematics and human physiology convinced many practitioners that chaos in bodily functioning is not necessarily a bad thing. We have qualitatively analyzed many different cases of pathological symptoms in biological systems that may be explained as manifestation of the chaotic behavior and revealed the adaptive nature of chaos in them. The benefit of chaos in physiological systems is stability of the organism, structural or functional, as opposed to instability or death. A new, seemingly universal feature of the dynamical systems controlled by a chaotic subsystem was revealed. To delineate this feature we proposed the principle of compensation, according to which the loss of controlling function of one subsystem of a defective system may be compensated by chaotic behavior of another subsystem, less important for "survival" of the whole system. Briefly speaking, we are wired such that if a central organ fails, a peripheral one comes to rescue. Application of this principle to medicine may bring new treatment strategies.

LIST OF THE MOST IMPORTANT PUBLICATIONS

Overall I have published over 40 articles and papers on different subjects of condensed-, soft-matter, computational materials physics, and biophysics. Many of the publications are available on my website. (*) means an undergraduate student.

1. “Structural Impact of Diazinon and Molinate on Neurite Outgrowth in N1E-115 Cells” D.T. Edge (*), R.D. Cannady (*), J.S. Ross (*), A. Umantsev, and S.L. Chao. J. Neurosci. Res. In preparation.
2. “On the structure and formation of a protobiont”, A. Umantsev. Origins of Life and Evolution of the Biosphere. Submitted.
3. “Early stages of soldering reactions”, R.A. Lord (*) and A. Umantsev. Acta Mater. Submitted.
4. “Adaptive Chaos: Mild disorder may help contain big disease” A. Z. Golbin and A. Umantsev, Journal of Theoretical Medicine. Submitted.
5. “Thermal effects in phase transformations: A review”, A. Umantsev. Journal of Elasticity. Accepted.
6. “Physical analogy between continuum thermodynamics and classical mechanics”, A. Umantsev. Phys. Rev. E **69**, 016111 (2004).
7. “Exploring the structure of a hydrogen cyanide polymer by electron spin resonance and scanning force microscopy”, M.P. Eastman, F.S.E. Helfrich (*), T.L. Porter, A. Umantsev and R. Weber. Scanning. **25**(1), 19-24 (2003).
8. “Thermal effects in dynamics of interfaces”, A. Umantsev. J. Chem. Phys. **116** (10), 4252-4265 (2002).
9. “Coherency strain assisted equilibrium segregation at heterophase interfaces”, A. Umantsev. Interface Science, **9** 237-242 (2001).
10. “Thermal effects of interfacial dynamics”, A. Umantsev. Interface Science, **9** 349-356 (2001).
11. “Continuum theory of interfacial segregation”, A. Umantsev. Phys. Rev. B **64** p.075419-075429 (2001).
12. “Thermal effects of interface motion”. In *Interfaces for the 21st Century: New research directions in Fluid Mechanics and Materials*, (Imperial College Press, 2002) p. 286. *Proceedings of the Conference*: “Interfaces for the Twenty-First Century”, Monterey, California, 15-18 August (1999)

13. "Thermal drag of the antiphase domain boundary motion", A. Umantsev. Acta Mater., **46** (14), pp.4935-4939, (1998).
14. "Adiabatic phase transformations in confinement", A. Umantsev. J. Chem. Phys. **107**(5), pp1600-1616, (1997).
15. "Continuum methods in the kinetic theory of phase transformations". *Proceedings of the PTM'94*, Pittsburgh, PA, July 17-22, p.31, (1994).
16. "Ostwald ripening in multicomponent alloys", A. Umantsev & G.B. Olson. Scripta Metal et Material, **29** 1135-1140, (1993).
17. "Phase equilibria and transformations in adiabatic systems", A. Umantsev and G.B. Olson. Phys.Rev. E **48** (6), 4229-4249, (1993).
18. "Modulation mechanism for displasive transformation", A. Umantsev and G.B. Olson. *Proceedings of the ICOMAT'92*, Monterey Institute of Advanced Studies, Carmel CA, 20-24 July, p.215 (1992).
19. "Modulation mechanism for first-order transformations with nonconserved order parameter", A.Umantsev & G.B. Olson. Phys. Rev.A **46** (10), Rapid Communications R6132-R6135, (1992).
20. "Growth from a hypercooled melt near absolute stability", A. Umantsev & S.H. Davis. Phys.Rev. A **45** (10), 7195-7201, (1992).
21. "Thermodynamic stability of phases and transition kinetics under adiabatic conditions". A.Umantsev. J. Chem. Phys. **96**(1), 605-617, (1992).
22. "Microstructure formation of the melt-spun crystalline ferrous ribbons". *Institutional report*, National Research Laboratory for Metallurgy, 1989
23. "Nonisothermal relaxation in a nonlocal medium", A. Umantsev and A. Roytburd. Sov. Phys. Solid State **30**(4), 651-655, (1988).
24. "Physical and chemical methods increasing homogeneity of metal during casting". *Institutional report*, National Research Laboratory for Metallurgy, 1988.
25. "Simulating dendritic structure-formation in the crystallization of a supercooled liquid, A. Umantsev, V.Vinogradov & V.Borisov, Industrial Laboratory, **52** (7) 1987, pp. 638-641.
26. "Theoretical development of thermophysical aspects of control algorithm of the thermal regime of solidification". *Institutional report*, National Research Laboratory for Metallurgy, 1987.

27. “Modeling the evolution of a dendritic structure”, A. Umantsev, V.Vinogradov and V.Borisov. Sov. Phys. Crystallography **31** (5), 596-599, (1986).

28. “Computer simulation of a dendritic structure formation during solidification of metals and alloys”. Abstract of Ph. D. Thesis, 1985.

29. “Numerical simulation of dendritic structure”. *Proceedings of All Union Conference on Crystal Growth.* Tzahkadzor, Armenia, September 1985

30. “Mathematical model of growth of dendrites in a supercooled melt”, A. Umantsev, V.Vinogradov and V.Borisov. Sov. Phys. Crystallography **30** (3), 262-265, (1985).

31. “Motion of a plane front during crystallization”, A. Umantsev. Sov. Phys. Crystallography **30** (1), 87-91, (1985).

OUTLINE OF MY TEACHING PHILOSOPHY

Teaching is a value-laden activity. I find teaching to be rewarding on many levels, including student mentoring, lecturing, recitation, and curriculum planning. My objectives as a teacher are to achieve excellence in undergraduate education and to convey the excitement of sciences to general students. I hope to foster critical thinking, facilitate the acquisition of life-long learning skills, and develop problem-solving strategies. I also want to make a difference in the lives of my students and prepare them for wider range of career opportunities in an information economy. To function effectively in small companies the graduates will be expected to combine many different skills: fundamental knowledge, hands-on experience, computational experience, and teamwork.

In my lectures I require students to understand the fundamental concepts underlying the material. Above all, however, I am interested in mechanisms that help students come to appreciate the beauty and wonder of Physics. Scientists discover new things by doing experiments, making observations, and immersing themselves in the subject. If we hope to inspire students to become scientists or even expect them to respect what scientists do, we have to find a way to show them the excitement of discovering something new, of experiencing the acquisition of new scientific knowledge. I aspire to challenge students to truly engage with the subject matter and give them firsthand experience with the magnificence of science.

Traditional physics courses and classroom problem solutions do not always help our students to see "how objects move in space and time". As an educator I am trying to broader utilize in my classroom national-level teaching methods and contemporary interactive educational technology in the form of computer simulations and web-based physics courses. This improves an effective, active-learning environment and does not compromise intellectual standards.

I value process of critical thinking, independence, and individual problem-solving skills. To verify if this objective has been reached, I develop my exams to test students' ability to solve problems. I also value group skills and cooperation. In order to develop these skills I use hands-on laboratory experience and help students attain the highest level of performance that I am seeking. I have developed my own evaluation means that are more directly related to the specific goals and objectives that I am trying to achieve in education. In this evaluation questionnaire I am asking the students to reflect on the most important aspects of the lecture and hands-on courses.

In the future I intend to:

1. Develop an interdisciplinary unifying curriculum for Science Education, which includes Mathematics and Chemistry courses together with regular courses in Physics. Implementation of such curriculum requires cooperation with other departments' members.
2. Develop an Astrobiology Program (in cooperation with Biology Departments' members).
3. Develop or strengthen an already existing Biophysics program.
4. Develop a Computational Biophysics course, which will give the student a firm basis in the main computational techniques used in modern physics.
5. Communicate the role, importance, and impact of physics, engineering and astronomy to the community. Work with high school science teachers to promote the pre-college Science Education, getting young people interested in different areas of physics.

Computational Biophysics

Outline of the proposed course

The use of computers in physics and other branches of science and engineering has increased tremendously along with rapid development of faster and cheaper hardware. This course will aim to give the student a thorough grounding in the main computational techniques used in modern physics and biophysics. It will be particularly important in the course that the students will be learning by doing. The course is therefore designed in such a way that a significant fraction of the students' time is spent actually programming for specific physical problems rather than learning abstract techniques. This is, however, neither a short course in computing science, nor in programming. It focuses specifically on methods for solving physics problems. The students will be expected to be familiar with basic programming techniques.

The course will cover broad sections:

- Interpolation and extrapolation.
- Numerical methods for ordinary differential equations.
- Linear systems.
- Numerical methods for partial differential equations.
- Monte Carlo and other simulation methods, such as molecular dynamics.
- Scientific visualization.

Project material may come not only from physics, but also from mathematics, chemistry, biology, and medicine. It will focus on realistic physical problems, which apply and extend the techniques:

- Chaos from non-linear dynamical systems and mappings.
- Phase transitions and magnetization (Ising model).
- Monte Carlo methods for surface particle transport.
- Crystal growth and diffusion limited aggregation (DLA).
- Seismic wave propagation and ocean circulation models.
- Biophysical problems.
- Computer simulation of evolutionary and population genetics processes.
- Cardiac dynamics.
- Issues in computational astrophysics.

Text and reference books:

1. H. Gould and J. Tobochnick "An Introduction to Computer Simulation Methods", Addison-Wesley.
2. N.Gershenfeld "The Nature of Mathematical Modeling", Cambridge.
3. W. Press, B. Flannery, S. Teukolsky, W. Vetterling "Numerical Recipes" Cambridge.
4. Caswell, H. 1989. Matrix Population Models. Sinauer Associates, Sunderland.

Life in Cosmos

The course will be open to all students; no prior knowledge of astronomy, physics or biology will be assumed or required.

Because new planets are being created and discovered all the time, scientists believe there may be as many as 10 billion earth-like planets in the universe. Thus the odds of primitive life existing elsewhere in the cosmos are very high. Many of modern scientists believe that extra-terrestrials not only exist, but may be sending us signals at this very moment. Others think that there may be many examples of primitive life to be found in the Cosmos, advanced intelligent life (like ours), however, may be very rare.

The aim of this course is to convey the detailed conceptual ideas associated with the important and topical question of the formation of life in the universe. The course will discuss all the environmental circumstances that seem to encourage the start of any life form and investigate the current state of our knowledge of life outside of the earth. These questions are looked at from a multi-disciplinary viewpoint, which includes astronomy, biology, chemistry and geology. However, other issues such as the historical, cultural and philosophical perspectives are included.

This course addresses the fundamental questions:

- Are we alone?
- What are the prospects for intelligent life elsewhere in the Universe?
- How do we search for evidence of such life?
- Will life only be found in the traditional "comfort zones" of solar systems?
- Where are complex hydrocarbons and other sophisticated molecules found in space?
- How are they created, and how do they survive?

The major topics of the course are:

- The evolution of life on Earth, including examples of life that don't appear to require sunlight and/or oxygen to survive.
- The evidence for possible astronomical causes of major mass extinctions.
- The possible origin and evolution of life in an extraterrestrial planetary context: the birth of exobiology.
- A discussion of the panspermia theory for the spreading of life through the solar system.
- Life in the Solar System: our expectations about potential life on Mars, Europa and elsewhere.
- Searching for other planetary systems: a detailed discussion of the techniques used, and the recent discoveries of the many planetary systems around nearby stars.
- The astronomical background to the Drake Equation, in particular, the evolution of stars and planetary systems.
- SETI: searching for signals from extraterrestrials and the intrinsic difficulties in communicating with, and visiting, other “civilizations”.

Text and reference books:

1. “An Introduction to Astrobiology” Edited by Ian Gilmour and Mark A Sephton, (Cambridge University Press, Open University Textbooks, 2004).
2. Zubay, G., “Origins of Life on the Earth and in the Cosmos” (Academic Press, N.Y. 2000)
3. “Life in the Universe”, Jeffrey Bennett, Seth Shostak, and Bruce Jakosky, (Addison Wesley).