Name: Jagadish Kumar

Mailing Address: 1433 Highland Street, Apt L
Columbus, Ohio 43201, USA.

Email Address: jagadish.mrc@gmail.com

Phone : Mobile: +1-614-286-9908

Nationality: Indian

Marital Status: Single

Academic Background:

- Master of Science (Physics)- 2003, Utkal University (Vani Vihar), Bhubaneswar, India.
- Ph.D (Materials Science)- June, 2010, Materials Research Centre, Indian Institute of Science, India.
- Postdoctoral Fellow, July, 2010- December, 2010, Materials Research Centre, Indian Institute of Science, India.
- Postdoctoral Scientist, January, 2011- Present, Ohio State University, Columbus, Ohio, USA.

Fellowships:

- Junior Research Fellowship, Council of Scientific and Industrial Research, India, 2004 - 2006.
- Senior Research Fellowship, Council of Scientific and Industrial Research, India, 2006 - 2009.

Research Area:

• Dynamics of host associated microorganisms in Drosophila gut. Homeostasis, Population dynamics. Chemical Kinetics, Bio-chemical reactions.
• Time-series analysis.

• Phenomena of adhesive and adhesion: visco-elastic behaviour of solid, detailed dynamical and spatio-temporal study of peeling of an adhesive tape.

• Equilibrium and non-equilibrium statistical physics and Non-linear dynamics with emphasis on stick-slip dynamical systems.

• Modeling, simulation and analysis of dynamical phenomena in materials science, nonlinear dissipative dynamical systems, chaos and fractals, application of concepts of nonlinear dynamics in interdisciplinary areas of research.

• Deformation dynamics at micro/nano-length scales, contact mechanics, contact charging and deformation of soft polymer.

·

• Collective behavior of dislocations in the Portevin-Le Chatelier (PLC) effect.
• Acoustic emission during plastic deformation.
• Deformation dynamics at micro/nano-length scales, contact mechanics, contact charging and deformation of soft polymer.

Computer Skills /Experiences:

Programming experience in C, Fortran, Matlab, Mathematica and Maple packages.

Programming experience as a part of the development of codes for specific numerical algorithms for the research work.

Time Series Analysis: Embedding, Singular Value Decomposition, Calculation of autocorrelation, correlation integral, Lyapunov spectrum and statistical analysis.

Numerical methods to solve ordinary and partial differential equations.

Talks and Posters Presented in Conferences:

Oral Presentations:

• "Dynamics of Crackling Noise during Peeling of an Adhesive Tape". *International Conference on Recent Developments on Non-linear Dynamics, Tiruchirappalli, India, February, 2008.*

Poster Presentations and participation:

• "Unfolding the Hidden Order in Acoustic Emission Data in the Peeling of an Adhesive Tape", *International Conference on Multi-scale Materials Modeling -III, Freiburg, Germany, September - 2006.*

• Conference on Functional Metamaterials at the Nanoscale (FMN 2005), MRC, Bangalore, India-July 2005.

• International conference on statistical mechanics of plasticity and related instabilities, MRC, Bangalore, India-September 2005.

• National conference on Nonlinear systems and dynamics (NCNSD-2006), Chennai, India - February 2006.

• Workshop On Dynamical System , IISc Mathematics Initiative(IMI), India, October 2007.

• DST-SERC School on Nonlinear Dynamics, IISc Mathematics Initiative(IMI), India, June 26 - July 16, 2008.

Invited Talks:

(1) Dept. of Chemical Physics, Weizmann Institute of Science-76100, Rehovot, Israel, Sept. 2010.

Publications:

(1) Unfolding the Hidden Order in Acoustic Emission Data in the Peeling of an Adhesive Tape., **Jagadish Kumar**, Rumi De, M. Ciccotti and G. Ananthakrishna, *Proceeding of International Conference on Multi-scale Materials Modeling -III*, p. 330, (2006) .

(2) Hidden Order in Crackling Noise During Peeling of an Adhesive Tape., **Jagadish Kumar**, M. Ciccotti and G. Ananthakrishna, *Physical Review E (Rapid Comm.)*, **77**, 045202 (2008).

(3) Dynamics of Crackling Noise during Peeling of an Adhesive Tape., **Jagadish Kumar**, M. Ciccotti and G. Ananthakrishna, *in Nonlinear Dynamics (Norosa, New Delhi), p. 191, (2008).*

(4) Intermittent Peel Front Dynamics and the Crackling Noise in an Adhesive Tape., **Jagadish Kumar**, Rumi De and G. Ananthakrishna, *Physical Review E*, **78**, 066119, (2008).

(5) Dynamics Friction at Nano-Scales., G. Ananthakrishna, **Jagadish Kumar**,. *Proceeding of II International Workshop on Correlation Microstructures - Properties and Multi-scale Modeling of Plasticity*, p. 91, (2009)

(6) Influence of Viscoelastic Behaviour During Peeling of an Adhesive Tape., **Jagadish Kumar**, G. Ananthakrishna, *Physical Review E*, **82**, 016211, (2010).

(7) Correlation Between Stick-Slip Frictional Sliding and Charge Transfer., G. Ananthakrishna, **Jagadish Kumar**, *Physical Review B*, **82**, 075414, (2010).

(8) Multi-Scale modeling approach to acoustic emission during plastic deformation., **Jagadish Kumar**, G. Ananthakrishna, *Physical Review Letters,* **106***, 106001,(2011).*

(9) Source of acoustic emission during collective behavior of dislocation motion., **Jagadish Kumar**, G. Ananthakrishna, (*Submitted to Physical Review B).*

Referees:

(1) Prof. G. Ananthakrishna
Materials Research Centre,
Indian Institute of Science, Bangalore - 560012, India.
Email: garani@mrc.iisc.ernet.in

Phone: +91 80 2293 2780, Fax: 91 80 2360 7316.

(2) Prof. S. A Shivashankar
Materials Research Centre,
Indian Institute of Science, Bangalore - 560012, India.
Email: shivu@mrc.iisc.ernet.in

Phone: +91 80 2293 2782, Fax: 91 80 2360 7316.

(3) Prof. Matteo Ciccotti
Professeur de l'ESPCI
Laboratoire PPMD
10 rue Vauquelin- 75005 - Paris - France.
Email: matteo.ciccotti@espci.fr

Phone: +33 (0) 140794419, Fax: +33 (0) 140794640.

Summary of the research work:

My general area of interest is to model driven far from equilibrium realistic systems using methods of non linear dynamics. Main emphasis so far has been on complex spatio-temporal dynamics of systems which exhibit stick-slip phenomena. Stick-slip behavior is commonly observed in a large number of systems of which I have work on a model of peeling of an adhesive tape subjected to a constant pull speed and in developing a model for stick-slip in a surface force apparatus. I have carried out a comprehensive study of a model for the peel front dynamics of an adhesive tape. In order to compare the acoustic signal from the peel model, I have carried out the time series analysis of experimental acoustic emission signal and compared intermittent peel front dynamics of the model. In addition the peel front model has been modified to include the visco-elastic nature of glue (adhesive). I have also developed the necessary frame work for explaining the nature of acoustic emission signals arising from the collective behavior of dislocations in the Portevin-Le Chatelier (PLC) effect with the context of the Ananthakrishna model for the PLC effect. The idea in studying these different systems is to understand the generic nature of the underlying dynamics in the stick-slip phenomena.

Time Series Analysis and Intermittent Peel Front Dynamics During Peeling of an Adhesive Tape:

My first task was to study and report a comprehensive investigation of a model for peeling of an adhesive tape to understand the origin of intermittent peeling of an adhesive tape and its connection to acoustic emission. The model represents the acoustic energy dissipated in terms of Rayleigh dissipation functional that depends on the local strain rate. We show that the nature of the peel front exhibits rich spatio-temporal patterns ranging from smooth, rugged and stuck-peeled configurations that depend on some parameters, namely, the ratio of inertial time scale of tape mass to that of the roller, the dissipation coefficient, elastic constant of the glue (adhesive) and the pull velocity. The stuck-peeled configurations are reminiscent of fibrillar peel front patterns observed in experiments. We show that while the intermittent peeling is controlled by the peel force function and, the acoustic energy dissipated depends on the nature of the peel front and its dynamical evolution. Even though the acoustic energy is fully dynamical, it can be quite noisy for a certain set of parameter values suggesting the deterministic origin of acoustic emission in experiments. Our analysis shows the unambiguous presence of chaotic dynamics within a subinterval of pull speeds within the intermittent regime. Based on the detailed theoretical investigations of the dynamics of a model for peeling of an adhesive tape that suggests the possibility of chaotic behavior, we have undertaken a dynamical analysis of the acoustic emission data obtained over a wide range of pull velocities. The time series analysis involves embedding procedure that calculates converged values of correlation dimension and demonstrative existence of positive Lyapunov exponent for a range pull velocities which turns out to be in the intermediate range. This confirms that the dynamics of peeling is chaotic in a mid range of pull speeds observed in the model. Further, the model provides insight into several statistical and dynamical features of the experimental AE signals including the transition from burst type acoustic emission to continuous type with increasing pull velocity and the connection between acoustic emission and stick-slip dynamics. The model also offers an explanation for the recently observed feature that the duration of the slip phase can be less than that of the stick phase. The time series analysis of model acoustic energy signals is also found to be chaotic within a subinterval of pull speeds.

We have also investigated the influence of visco-elastic nature of the adhesive on the intermittent peel front dynamics and acoustic emission by extending the earlier model. The adhesive is a visco-elastic material and thus both the visco-elastic time scale and also rate dependence information of adhesives are expected to play an important role in the peel dynamics. Here, we have studied the rate dependence deformation of adhesive by introducing an algorithm to include visco-elastic response in the dynamical situation corresponding to abrupt peeling. Again the recent experiment on peeling of a paper shows features similar to peeling of an adhesive tape. We have also extended the model by including random elastic constants term to mimic quenched disorder and acoustic emission during plastic deformation.

Dislocation Dynamics and Acoustic Emission During Plastic Deformation:

Acoustic emission is commonly observed during plastic deformation. However, there has been little progress in constructing model that explain statistical and dynamical features observed in different deformation conditions. Here, we propose frame work to accomplish this taking advantage of the model that explain most features of the Portevin-Le Chatelier (PLC) effect. The phenomenon of repeated stress drops followed by periods of reloading seen in many interstitial and substitutional alloys when tensile specimens are deformed in certain range of strain rates and temperature is referred to as the Portevin-Le Chatelier (PLC) effect or jerky flow. Each of the stress drops is generally associated with the nucleation of a band of localized plastic deformation. In this area my research work involves the modeling of dislocation to understand the cause of acoustic emission during plastic deformation. Acoustic emission studies have been carried out in plastic deformation of metals and alloys for over four decades. Since the early studies correlations have been established between the nature of the AE signals and the dislocation sources in variety of deformation conditions and different types of samples. For instance, during plastic deformation metallic alloys, the nature of AE generated during Luders band and different types of the Portevin - Le Chatelier (PLC) bands have been studied. The AE signals in these situations arising due to the collective pinning and unpinning of dislocations. The purpose of our work is to suggest a way of dealing with both dislocation dynamics and elastic degrees of freedom (inertial time scale) simultaneously to explain the cause of acoustic emission .

Deformation Dynamics at Nano-length Scales:

Other part of my research work involves modeling of friction dynamics at nano-length scales. While friction has been studied since the days of Leonardo da Vinci, even today, the concept of friction, in particular, in the context of contact at nano-scales remains ill understood. In contrast, there have been rapid advances in experiments at nano-scale even as they lack theoretical support. Here, we attempt to model experimental observations of contact dynamics associated with friction studies using scanning probe microscope with a gold tip on Polymethylemethacrylate (PMMA) sheet. When a micro-cantilever with a nano scale tip is scanned laterally over a surface to measure the nano-scales forces it exhibits stick-slip motion. The nature of the stick-slip depends on the probe stiffness, structure of the tip, surface energy and scan parameters (load, velocity, etc.). When the metal tip is contact with PMMA, it has been suggested by R. Budakian et al. (Phys. Rev. Lett., **85**, 1000 (2000)) that bonds formed. due to the difference in energy between electrons in the donor states of PMMA and the metal work function. When the contact between tip and the sample is broken, there is a transfer of charge from metal tip to PMMA. We have developed a model that explains the correlation between charge transfer and stick-slip events observed when a cantilever with a nanometer gold tip of a surface force apparatus is dragged on PMMA. We show that our results are qualitatively similar to the experiments and also suggests that the microscopic origin of friction is not necessarily due to electronic interaction between metal tip and insulator surface.

Uncovering mechanisms underlying dynamics of host associated microorganisms in Drosophila gut:

The mechanisms underlying the association between host and the diverse and dense microbiota found in the human gut are poorly understood: a major reason why common maladies such as inflammatory bowel diseases, colorectal cancers, or gastrointestinal infections remain uncontrolled. The difficulty in mechanistically understanding the gut homeostasis arises due to its inherent and enormous complexity, which involves a diverse population of microbes interacting with host gut-responses (immune, stress, and developmental) with varying environmental factors such as diet and invasion by pathogenic bacteria. We propose to use a simpler model system, the fruit fly, Drosophila Melanogaster, to elucidate the principles governing the dynamic processes contributing to gut homeostasis and its stability.

A synergistic approach based on experimental investigations and computational modeling (using nonlinear dynamics and non-equilibrium physics) will be employed to uncover the principles underlying the stability of the gut ecology. The successful completion of the project will lead to an experimentally validated computational model and insights into the systems biology of the fly gut. The fundamental principles will be valuable for understanding the human gut because of its many similarities with the fly gut. The subject of this project is of direct relevance to understanding the underlying causes of many diseases of the human gut. Discovering what helps the complex ecology of the gut resist pathogens from model systems will allow us to understand origins of inflammatory bowel diseases and gastrointestinal infections that may pave the way for successful therapies.