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Nara Workshop on Nonlinear Dynamics 2016 Dec.
under HAS-JSPS Joint Research Project

At the meeting room of Faculty of Human Life and Environment
on the **5th floor in Bldg. F** in Nara Women's University
(http://www.narawu.ac.jp/nwu/intro/access/campusmap/index.html)

7 December 2016 (Wed.)

Chairman: S. Kitsunezaki

15:00 - 15:20 Zoltan Halasz (**Invited**, Univ. Debrecen, Hungary)

The role of disorder in desiccation induced cracking

15:20 - 15:40 Zsuzsa Danku (**Invited**, Univ. Debrecen, Hungary)

Fracture process in the limit of strong disorder

15:40 - 16:00 Subhadeep Roy（Earthquake Research Inst., Tokyo Univ.）

I*nterplay of Stress Release Range and Disorder in Fracture*

16:00 - 16:20 Hiroki Tanaka（Earthquake Research Inst., Tokyo Univ.）

Statistical properties of the Olami-Feder-Christensen model on the Barabasi-Albert scale-free network

16:20 - 16:40 Yuhei Yamada (Waseda Univ.)

Analysis of fiber bundle model with displacement which is vertical to applied load

-- 20 min. break ---

Chairman: A. Nakahara

17:00 - 17:30 Yoshihiro Yamazaki (**Invited**, Waseda Univ.)

Dynamical transition between uniform and rhythmic growth modes of ascorbic acid crystal domain induced by fluidity of its thin solution film

17:30 - 17:40 Chika Yamanaka (Nara Women's Univ.)

Pattern formation of solidification in paraffin melt by injection of cool water

[19:00- Banquet at *Ryozanpaku*（http://www.nara-ryozanpaku.com/）]

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8 December 2016 (Thu.)

Morning: meeting of the project members or a short lab. tour (or free time)

--- lunch ---

Chairman: N. Ito

13:00 - 13:30 Ferenc Kun (**Invited**, Univ. Debrecen, Hungary)

Discrete element modelling of the effect of magnetic field on dessiccation induced cracking

13:30 - 13:50 So Kitsunezaki (Nara Women's Univ.)

The memory effect and the particle arrangement in granular paste

13:50 - 14:10 Satoshi Yukawa (Osaka Univ.)

Statistical properties of the drainage network in Japan

14:10 - 14:20 Risa Yoshioka (Doshisha Univ.)

Transition of cracking pattern on drying starch paste

--- 15 min. break ---

Chairman: S. Yukawa

14:35 - 15:05 Takeshi Kawasaki (**Invited**, Nagoya Univ.)

Macroscopic yielding in jammed solids is accompanied by a nonequilibrium first-order transition in particle trajectories

15:05 - 15:25 OOSHIDA Takeshi (Tottori Univ.)

Calculations of deformation gradient correlation in a 1D system of Brownian particles

15:25-15:45 Takeshi Matsumoto (Department of physics, Kyoto university)

Modeling of the reversal of large-scale flow in randomly forced two-dimensional turbulence in a square domain

--- 15 min. break ---

Chairman: Ooshida Takeshi

16:00 - 16:20 Nobuyasu Ito (Tokyo Univ.)

Social simulation with Exascale computer

16:20 - 16:40 Naoki Yoshioka (RIKEN)

Stability and macroscopic behavior in urban traffic network

16:40 - 17:00 Tsuyoshi Mizuguchi (Osaka Pref. Univ.)

Size distribution of names and their correlations between local societies

17:00 - 17:20 Haruka Adachi (Nara Women's Univ.)

Characteristics of language usage in questions asked to an online help desk

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[18:00- Banquet]

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Abstract

12/7(Wed.)

The role of disorder in desiccation induced cracking

Zoltán Halász

Department of Theoretical Physics, University of Debrecen, Institute of Nuclear Research (Atomki), Debrecen, Hungary

Based on a discrete element model we study how the dynamics of cracking and the size of fragments evolve during the desiccation induced breakup of a thin layerwhen the amount of disorder is varied. In the model a thin layer is discretized on a random lattice of Voronoi polygons attached to a substrate. Two sources of disorder are considered: structural disorder captured by the local variation of the stiffness, and strength disorder represented by the random strength of cohesive elements between polygons. Increasing the amount of strength disorder our calculations reveal a transition from a cellular crack pattern,generated by the sequential branching and merging of cracks, to a disordered ensemble of cracks where the merging of randomly nucleated microcracks dominate. In the limit of low disorder the statistics of fragment size is described by a log-normal distribution, however, in the limit of high disorder a power law distribution is obtained.

Fracture process in the limit of strong disorder

Zsuzsa Danku

Department of Theoretical Physics, University of Debrecen, Institute of Nuclear Research (Atomki), Debrecen, Hungary

We study the effect of strong disorder on the fracture process of heterogeneous materials analytically and by computer simulations. We used a fiber bundle model where heterogeneous materials are represented as a parallel set of fibers. We assigned failure thresholds to the fibers following a power law distribution over an infinite range where the amount of disorder can be controlled by the power law exponent. We found that the system undergoes a transition between a quasi-brittle phase and a brittle phase as the amount of disorder is decreased. When the load of a broken fiber is shared globally, the fat tailed disorder leads to a homogeneous fracture process without any acceleration despite of the increasing load in the quasi-brittle phase. We showed that the transition can be described as a continuous phase transition. When the distribution has a finite upper cutoff the behaviour of the system becomes more complex, i.e. the size scaling of macroscopic strength has an increasing and a decreasing regime. In the decreasing regime the system does not show acceleration towards global failure even if the system has a finite critical load.

Interplay of Stress Release Range and Disorder in Fracture

Subhadeep Roy (Earthquake Research Inst., Tokyo Univ.)

Fracture is a complex phenomenon involving large span of time and length scales, starting from atomic scale or laboratory scale to geological scale like earthquake. A failure process can take place showing precursory rupture events, or catastrophically without showing such precursor. Also the rupture events might show correlation among themselves or might happen in a random manner. So the

important question is:What are the physical criteria that govern the mode of failure ? In statistical mechanics, disorder systems and systems out of equilibrium are extensively studied in the last decade. So it will be interesting to study fracture in statistical mechanical point of view. In this work we have implemented the two main factors, disorder and stress release range, that guides failure process, in a statistical model namely Fiber Bundle Model and studied their effect on the failure process.

Statistical properties of the Olami-Feder-Christensen model on the Barabasi-Albert scale-free network

Hiroki Tanaka (Earthquake Research Inst., Tokyo Univ.)

Earthquake is a fracture phenomenon on the fault plane. Many simple physical models have been proposed to model the dynamics of earthquakes. Olami-Feder-Christensen (OFC) model is one of such models which represents the stress propagation on the fault plane by simple two dimensional cellular automaton. OFC model is known to reproduce many statistical laws of seismology including Gutenberg-Richter (GR) law for magnitude frequency and Omori law for aftershock frequency. Although the OFC model stands on the viewpoint that the seismicity depends only on a fault plane, on the other hand it is known that the seismicity of an area is affected by others. For example, aftershocks are thought to be triggered by stress changes produced by the fault on which mainshock occurred. Moreover, the hypocenter network

is not random graph but scale-free network, showing characteristic complexity of fault-fault interaction. In this study, we model such a fault-fault interaction by the OFC model on the Barabasi-Albert scale free network to see the activity and statistical properties similar to the earthquakes. In this model, each node is regarded as a fault, and the degree of node is proportional to the fault size. By changing the strength of interaction, three types of activities are observed, each of which is similar to the real seismicity. In each activities, GR law is confirmed with characteristic magnitude and Omori law like behavior is found for some parameter sets. Moreover, the correspondence between the b-value for the GR law and the shear stress on faults is confirmed.

We define a geometrical parameter which characterizes the heterogeneity of energy distributed on the network to explain the activities emerged in this model. Aftershocks are regarded as a regaining process of heterogeneity that is lost in mainshock, through the interaction between nodes. Once the heterogeneity is recovered, the activity enters a quiescence period. Foreshocks can be explained as an adjustment process of heterogeneity that is not fully regained in aftershock region. In this way, not the total energy on the network but the heterogeneity of the energy controls the activity in this model. Although this model represents too simplified fault field, our result suggests that not only how large stress is now accumulated on a large fault that will lead to the future major earthquake, but also how globally stresses are distributed on smaller faults surrounding the major one is important to understand the seismicity.

Analysis of fiber bundle model with displacement which is vertical to applied load

Yuhei Yamada (Waseda Univ.)

Fiber bundle model (FBM) is a simple model to study fracture. In usual FBM, we consider a situation that all fibers are in parallel each other and discuss how they break when they are loaded to the length direction. Here we consider a model in which fibers have some displacement which is vertical to the applied load. From analysis of the model, we get some interesting results which is not seen in usual FBM.

Dynamical transition between uniform and rhythmic growth modes of ascorbic acid crystal domain induced by fluidity of its thin solution film

Yoshihiro Yamazaki (Waseda Univ.)

There exists a threshold-sensitive dynamical transition between uniform and rhythmic growth modes in the domain growth of ascorbic acid crystals from its aqueous supersaturated solution film. The crystal growth induces solution flow. Humidity controls the fluidity of the solution. The solution flow varies the film thickness. The threshold exists in the thickness of the solution film. If the thickness becomes lower than the threshold, the solution flow and the crystal growth almost stop.

Pattern formation of solidification in paraffin melt by injection of cool water

Chika Yamanaka (Nara Women's Univ.)

We did experiments of fingering pattern formation that appeared in paraffin melt by injection of cool water. We investigated features of the patterns in a Hele-Shaw cell by changing the flow rate of injection and the height of spacers, the effect of impurities such as air bubbles. We will report and discuss these results.

12/8(Thu.)

Discrete element modelling of the effect of magnetic field on dessiccation induced cracking

Ferenc Kun

Department of Theoretical Physics, University of Debrecen, Institute of Nuclear Research (Atomki), Debrecen, Hungary

We present a discrete element modelling approach to understand the the effect of an external magnetic field on desiccation induced crack patterns. In the model first the structure formation of magnetic particles with permanent magnetic moment is considered under the action of a strong magnetic field. Particles are found to form chains and coloumns aligned with the external field. This configuration serves as the starting point for the simulation of the cracking process. At the onset of desiccation, cohesive elements (springs) are introduced between the particles where desiccation is captured by uniform shrinkage of the springs. Assuming that the dipolar particle chains act as reinforcing units in the shrinking system with stiff, unbreakable contacts, we could reproduce the transition from the cellular isotropic crack patterns to the emergence of straight cracks well aligned with the external field as the concentration of magnetic particles is increased.

The memory effect and the particle arrangement in granular paste

So Kitsunezaki (Nara Women's Univ.)**, A.Nishimoto, Y.Matsuo, A.Nakahara, and T.Mizuguchi**

As with the memory effect of clay paste, paste of granules with largersize, cornstarch and Lycopodium spores, and water also exhibit the memory of an initial external perturbation as an anisotropic pattern of desscication cracks. We investigated particle arrangements of Lycopodium paste by using micro X-ray computerized tomography and found anisotropic arrangements induced by initial oscillation in paste samples consolidated with agar in a drying process.

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Statistical properties of the drainage network in Japan

Satoshi Yukawa (Osaka University) **and Kenji Hara** (Tokyo Institute of Technology)

A drainage network shows interesting morphology and statistical properties. Recently it is shown that an angle distribution of branching has a characteristic angle: $2\pi/5 \sim 72°$ in the unconsolidated sand region of Florida. [Devauchelle et al. PNAS, 2012] In order to investigate universality of the distribution, we have studied the drainage network in Japan. In this talk, I will show results in Japan and discuss the universality.

Transition of cracking pattern on drying starch paste

Risa Yoshioka (Doshisha Univ.)

It was found that drastic change of the cracking pattern is generated on the drying paste of starch by the addition of glucose. With small glucose content, usual cracking pattern, whereas multiple layer is caused with higher content. It will be also shown that bistability of the cracking pattern between usual and multilayer structure is observed depending on the way of mixing the paste before drying.

Macroscopic yielding in jammed solids is accompanied by a nonequilibrium first-order transition in particle trajectories

Takeshi Kawasaki (Nagoya Univ.)

We use computer simulations to analyze the yielding transition during large-amplitude oscillatory shear of a simple model for soft jammed solids. Simultaneous analysis of global mechanical response and particle-scale motion demonstrates that macroscopic yielding, revealed by a smooth crossover in mechanical properties, is accompanied by a sudden change in the particle dynamics, which evolves from nondiffusive motion to irreversible diffusion as the amplitude of the shear is increased. We provide numerical evidence that this sharp change corresponds to a nonequilibrium first-order dynamic phase transition, thus establishing the existence of a well-defined microscopic dynamic signature of the yielding transition in amorphous materials in oscillatory shear.

Calculations of deformation gradient correlation in a 1D system of Brownian particles

Ooshida T. (Tottori Univ.)
[**in collaboration with Goto S., Matsumoto T. & Otsuki M.**]

Instead of Eulerian density correlation commonly used in analysis of glassy liquids such as colloidal suspension, recently we have proposed to use Lagrangian correlation of deformation gradient tensor, which allows an analytical approach to collective motion in such systems. In an attempt to relate this statistical theory to numerical simulation of particles more directly, here we would like to report some numerical results and discuss how it is related with other statistical quantities such as overlap density correlation and bond breakage correlation.

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Modeling of the reversal of large-scale flow in randomly forced two-dimensional turbulence in a square domain
Takeshi Matsumoto (Department of physics, Kyoto university)

When a turbulent flow is somehow sustained in a closed container,
a large-scale coherent flow often emerges. Moreover, in some situations,
the direction of the large-scale flow changes in a stochastic manner.
We numerically study such random reversal phenomena in a two-dimensional
flow with an emphasis on the reversal time scale (in some part via modeling).

Stability and macroscopic behavior in urban traffic network
Naoki Yoshioka (RIKEN)

Macroscopic fundamental diagram (MFD) is a reproducible unimodal relation between average vehicle density and average flow rate in urban traffic. Although this idea is tested by a few observations and simulations, its mechanism is not well understood. In order to understand it, a simple graph-based model of urban traffic is proposed. MFDs in our model system are investigated numerically for grid networks. It is found that MFDs in our system are discontinuous, which is inconsistent with the observation of real urban traffic.

Size distribution of names and their correlations between local societies
Tsuyoshi Mizuguchi (Osaka Pref. Univ.)

A power law behaviour is widely observed in the size frequency distribution of several kinds of names as a typical example of Zipf's distributions. We focus on the distribution of person's name in Japanese local societies and analyze correlation between them.

Characteristics of language usage in questions asked to an online help desk
Haruka Adachi (Nara Women’s Univ.)

We will present our study on how to characterize language usage in questions from costomers to an online help desk. Such studies would be useful to improve customer service provided by online help desks. We will classify questions from costomers based on their statistical properties such as frequencies of words used and their correlations. We will also investigate the possibility that such statistical analysis enables us to foresee difficluties in dealing with those questions.