

海外研究者による拠点活動の評価と助言

(1) IIASA 国際セミナー招聘研究者の評価と助言

本拠点では、毎年、IIASA を国際拠点として、拠点活動の成果を発信することを目的とした国際セミナー（IIASA 国際セミナー）を開催している。ここに、諸外国から著名な研究者を招聘し討論に参加してもらうとともに、本拠点活動の評価を依頼している。外国人評価委員から寄せられたコメントを紹介する。

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Report on IIASA – Kyoto University Fourth Joint International Seminar on Applied Analysis and Synthesis of Complex Systems

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1. Introduction

The “Fourth Joint International Seminar on Applied Analysis and Synthesis of Complex Systems” of IIASA and Kyoto University was held on June 28-29, 2007 at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria.

As two of the preceding events since 2004, the seminar was a joint initiative of Kyoto University and IIASA with the main objectives of reporting on new research findings, as well as exchanging ideas and discussing about concepts and methodologies for analysis and modeling of complex systems. The COE program “Center of Excellence for Research and Education on Complex Functional Mechanical Systems” at Kyoto University belongs to the COE (Center of Excellence) Program of the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT). The previous COE Project Leader was Kazuo *Tsuchiya* of Kyoto University, followed since recently by the current COE Project Leader Tetsuo *Sawaragi* of Kyoto University who has also been one of the Seminar Organizers, again together with Marek *Makowski* of IIASA.

2. Presentations at the Seminar

The seminar was opened with greetings by Tetsuo *Sawaragi* and Kazuo *Tsuchiya*, as well as by Marek *Makowski* with his welcome on behalf of IIASA. Further brief opening greetings were given

by Gunnar *Johannsen* and Martin *Buss*, as Honorary Evaluators.

This time, all four research groups of the whole COE program participated in the seminar, namely the scientific groups on (1) Complex Fluid Mechanics, (2) Complex Material and Structure Analysis, (3) Complex System Control and Design, and (4) Complex System Mathematics Analysis.


The first session started with “A Report on the Activities of Complex Fluid Mechanics Group in 2006” presented by Kazuyoshi *Nakabe*. He reported on the “Kyoto-Birmingham University International Symposium on Recent Advances in Fluid Mechanics” in September 2006 in Birmingham. The eight sessions of the symposium covered Environmental Fluid Dynamics I and II, Solid/Fluid Interaction and Industrial Flow, Chaotic Mixing, Micro Fluid Dynamics, Transition, Capillary, and Turbulence. Then, Kazuyoshi *Nakabe* explained the research topic on Multi-Jet Mixing Control in more detail.

The next presentation by Ryosuke *Matsumoto* was from the Complex Material and Structure Analysis Group and dealt with “Molecular Dynamics Simulation of Hydrogen Related Fracture of Iron”. Atomistic simulations of crack growth in iron crystals with and without hydrogen had been performed, and the hydrogen effects on crack growth behavior had been analyzed from atomistic viewpoints. Thereby, two types of crystal orientation were compared.

The first speech of the Complex System Control and Design Group was on “Learning Nonlinear Robust Control Systems by Use of Neural Networks” presented by Hiroaki *Nakanishi*. The design of control systems had been achieved by using neural networks with training methods for assuring robustness against uncertainties. – In his presentation on “End Milling Process Control Schemes for Autonomous Machining Process Planning”, Soichi *Ibaraki* described the analysis and the modeling of several processes in machining and the proposal of a scheme to control such processes. Also, the process planning for high-productive machining shall be performed by a support system which can autonomously monitor the machining process and adaptively optimize machining conditions. How to deal with the expert machine operators’ tasks, experience and knowledge has been further discussed after the presentation.

The next two presentations were strongly related to each other and belong to the Complex Fluid Mechanics Group. Both dealt with “Effects of Rainfall on Mass Transfer across the Air-Sea Interface”. Naohisa *Takagaki* reported in Part 1 on “Laboratory Measurement of CO₂ Transfer Velocity by Impinging Droplets” whereas Naoya *Suzuki* reported in Part 2 on “Estimation of the Global Air-Sea CO₂ Flux Due to Rainfall Effects”. The laboratory study of Part 1 has shown that rainfall enhances CO₂ transfer across the air-water interface. Further, mass transfer velocity of rainfall is well correlated with its momentum flux. In Part 2, the effects of rainfall on the global and local CO₂ transfer across the air-sea interface have been investigated by using the daily precipitation data set as well as the empirical correlation between the CO₂ transfer velocity and the mean vertical momentum flux. The results show that the rainfall effects are significant for the local CO₂ budget between atmosphere and ocean in the equatorial and mid-latitude regions, but they are not so important for the global budget, compared to wind shear effects.

Takahiro *Shimada* presented the research results on “First-Principles Investigation on Stress-Induced Domain Switching in PbTiO₃” from the Complex Material and Structure Analysis Group. The atomistic and electronic structure of the ferroelectric domain wall has been investigated where the polarization direction is discontinuous in PbTiO₃. Also, the domain switching has been studied which is an abrupt movement of the domain wall induced by shear stress.



The Complex System Control and Design Group contributed another presentation by Shinya Aoi titled “From Robot Locomotion to Animal Locomotion”. Locomotion control of a biped robot has been realized with nonlinear oscillators resulting in adaptive walking. This has been compared with adaptive walking of a Japanese monkey. Similar mechanisms of adaptive behaviors have been found. The locomotor behavior of the monkey has been reconstructed based on the obtained skeletal model with physical kinematics and motion capture data. Spinal central pattern generators have been modeled by the nonlinear oscillators which generate motor commands to activate the skeletal model. Sensory feedback modulates the motor commands. A convincing video clip of the simulation results was shown in the presentation.

The only contribution from the fourth scientific group on Complex System Mathematics Analysis was presented by Naoya Fujiwara on “Nonlinear Dynamics in a Periodically Driven Coupled Oscillator System”. Nonlinear dynamics of dynamic phase transitions have been modeled. Pattern dynamics in a system with coupled oscillators have been investigated for a domain wall in 1-D systems and for various patterns in 2-D systems such as spiral, vortex, and spatio-temporal chaos. The stabilization of unstable patterns using time delayed feedback has been achieved.

This time, two invited keynote speeches were held. In the first one, Martin Buss spoke about the “Excellence Cluster of “Cognition for Technical Systems” (CoTeSys)”. This cluster of excellence examines cognition for technical systems, such as automotives, robots and plants. Research competence in (medical) neurosciences, natural sciences, engineering, informatics, and humanities are united in the CoTeSys cluster at Technical University of Munich (TUM), Ludwig Maximilian University (LMU), Federal Armed Forces University (UBM), German Aerospace Center (DLR), and Max Planck Institute of Neurobiology (MPI). CoTeSys is funded by the German Research Council DFG from 2006 to 2011. The cognitive system architecture has been explained with the perception-action loop and the interplay of the cognitive capabilities. The research areas of the Excellence Cluster are (1) perception, model acquisition, and diagnosis, (2) learning and knowledge, (3) control, action planning, and joint action, and (4) human interaction. Demonstrators will be built and validated with three scenarios, namely cognitive mobile vehicles, cognitive humanoid robots, and cognitive factories. In addition to the main endeavors of research, a new teaching concept has been built up with Bachelor and Master curricula, summer schools for doctoral students, and means for attracting researchers from international, top-level institutions.

The other keynote speech by Ruth Marzi dealt with “Competence Enhancement versus Adaptation in a Complex Application”. The system ComPASS (competence enhancing multi-agent-system with speech output) was introduced as a support system for human operators in fault-finding tasks at CNC machine tools. Because these machines are usually very reliable, such a support system is rarely used and only in difficult situations. A navigation concept for speech interfaces with mobile devices has been developed. Several competence enhancing functionalities have been realized. Guidelines for software development which facilitate the competence enhancing aspects are an important idea. Competence enhancement, icon selection, speech output and usability have been evaluated. The individualization of the user interface needs to be restricted to a certain extent in order to ensure competence enhancement.

The COE Project Leader and also Leader of the Complex System Control and Design Group, Tetsuo Sawaragi, presented an “Overview of the Educational Activities of the COE”. Educational activities for young researchers have been organized as on-the-research training. Several types of interdisciplinary international collaborations have been implemented, such as active research

interchanges, joint seminars, and international meetings organized by doctoral course students. Also, educational activities for non-university people have been offered. The educational reform ongoing at the Graduate School of Engineering has been influenced by this COE. The educational philosophies of the COE have been determined as renewing the knowledge vision of mechanical engineering, educational research and development for promoting basic research, and mechanical engineering as an empirical science supported by qualified pragmatism. Complex Mechanical Systems Engineering has become a new subject for graduate course students. Finally, *Sawaragi* gave an outlook on possibilities for a future GCOE (Global Center Of Excellence).


In the closing session, assessments and comments were presented by the two Honorary Evaluators, Gunnar *Johannsen* and Martin *Buss*, as well as by Marek *Makowski*. These were not only related to this actual seminar but also to the whole duration of the COE and its four seminars. The overall great success of the seminar and of the whole COE was clearly emphasized by the three evaluators. Tetsuo *Sawaragi* chaired very fruitful discussions about these three assessments and invited all participating researchers of this seminar, particularly also all younger researchers, to give brief comments. Very good personal impressions and important benefits gained through this seminar and its lively international atmosphere were expressed.

3. Evaluation of the Seminar

This seminar had again a very high level of scientific quality. It was the fourth in the series of the COE program “Center of Excellence for Research and Education on Complex Functional Mechanical Systems” at Kyoto University – and it was also the last. Therefore, it is worthwhile to evaluate the recent seminar of 2007 together with the whole series of all four seminars of this COE.

Overall, the whole COE and its three scientific groups on (1) Complex Fluid Mechanics, (2) Complex Material and Structure Analysis, and (3) Complex System Control and Design demonstrated with all their work presented between 2004 and 2007 that they are among the best first-class groups in the world and that they have achieved outstanding research results of highest caliber compared with strong international standards. The financial resources provided by the Japanese Ministry MEXT have best been used for improving research and education on complex functional mechanical systems in impressive ways. All presentations of the four seminars between 2004 and 2007 were at least very good in contents and style, many excellent and some outstanding. The preparations and efforts, particularly of the Japanese colleagues and, also, of the invited speakers were admirable.

During this seminar in 2007, the educational aspects of the COE were emphasized for the first time and, also, the fourth scientific group on Complex System Mathematics Analysis participated for the first time. The contribution from this fourth group showed how much more the COE might have gained from a stronger involvement of that group over the entire duration of the program. The educational aspects were represented by the large number of excellent students’ presentations mainly on work from doctoral theses, as well as by the overview paper of Tetsuo *Sawaragi*. It was certainly a wonderful experience for most of the doctoral students to present their research findings, some of them for the first time in English, in an atmosphere of high-level interdisciplinary scientific exchange and debate within an international setting. The discussions of all papers were again open-minded, constructive, and valuable.



All scientific approaches and application domains of the COE speakers of Kyoto University and of the two invited speakers have been highly relevant for the disciplinary coherence and for the interdisciplinary mutual understanding and exchange in 2007. This was the same as in the previous three seminars. The highest degrees of complementarity and transdisciplinarity had been achieved during the seminar of 2006, as to the opinion of this evaluator. Thereby, many commonalities in functionalities and dynamical behaviors have been discovered across all complex systems under investigation in the two research fields of bio-material science and systems engineering. How can this great scientific progress, beyond excellency in the individual research achievements, be reached even more throughout the whole COE?

Looking at the wealth of research findings in this COE over the last four years, it may not be surprising that higher degrees of complementarity and transdisciplinarity cannot so simply be reached within a quite short period of time. This COE is on a very good way towards that goal of detecting even more commonalities, complementarities, and transdisciplinary coherences – always beyond the already achieved excellency of the individual research results.

As in my evaluative remarks during the closing session of the seminar, I like to suggest again that all the members of this COE could contribute – beyond the excellent research achievements of their individual work and of the scientific group –

by specifying not only a few highlights of their own work but also, at least, one highlight of what has been gained from the interaction within the COE, and

by deriving a common interaction matrix between all individual projects of all four scientific groups. The columns of this interaction matrix are the individual projects whereas the rows of the matrix are all possible criteria of complex functional systems. Looking at all the presentations of all four seminars, such criteria have been named as, for example: dynamics, complexity, functionality, adaptability, self-organization, robustness, safety, vulnerability, nonlinearity, etc. In at least two iterations, the list of criteria should be extended to cover enough relevant aspects of all individual projects. Then, all important interactions between the criteria and the individual projects can be cross-marked. As a result, the interactions between individual projects can be derived from this matrix. Probably, the additional insights which can be gained from this endeavor may be extremely valuable for the successful continuation of this COE.

In summary, I like to express my admiration and my sincerest congratulations to the great success of this COE Program of Kyoto University. Many excellent results have been achieved. They have been presented and discussed with overwhelming thoroughness and enthusiasm in four seminars of highest quality. New and visionary approaches for mechanical engineering, particularly towards complex functional mechanical engineering, have been determined and successfully investigated. One especially convincing example for such visionary views on mechanical engineering was the seminar in 2006 with its strong emphasis on learning from biology, linguistics, and cognitive sciences. I like to state again, as in my previous report, that the whole group of this COE at Kyoto University comprises strong potentials towards a leading role of mechanical engineering research in the world, due to their excellent research results, dedication, and research culture.

Therefore, I strongly recommend that this COE program of Kyoto University should be successfully continued with new succeeding COE activities.

The objectives for a future GCOE (Global Center Of Excellence) should be well focused, and the number of disciplines should not be extended too much – in order to achieve excellent individual research results as well as transdisciplinary coherent scientific approaches and methodologies.



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**Comments on the 21st Century COE Program
COE for Research and Education on Complex Functional Mechanical Systems
(Kyoto University)**

**First Joint International Seminar on
Applied Analysis and Synthesis of Complex Systems
IIASA, Vienna – Kyoto University**

On 28/29 June 2004 the above mentioned 1st joint International Seminar was held in Laxenburg, Austria, jointly organized by the COE (Kyoto Univ.) and the International Institute for Applied Systems Analysis (IIASA). The seminar agenda and scheduling is available at

<http://www1.mech.kyoto-u.ac.jp/coe21/seminar/20040628/agenda.html>

The presentations during the seminar were of world-leading quality, in particular the presentations by COE members of Kyoto University and the plenary talk by Prof. G. Johannsen were extremely inspiring because of their high scientific quality. Some of the presentations by people from IIASA were not a good balance in terms of quality. After all presentations by COE members there was a lively and fruitful discussion generating new ideas with all participants of the seminar. The atmosphere during these discussions and the seminar overall was very fruitful.

With the external influence by IIASA and the plenary talks it was nice to see that the COE members stood together behind their topic of complex systems and really conveyed a unified picture of a well established cooperation within the COE. It is conjectured that the COE was also strengthened in its research line and focus by the external influences in Laxenburg, also because the members were away from their usual businesses and could therewith freely discuss visionary research ideas.

Mild criticism is in order because of the weak IIASA commitment to the joint seminar. Apparently, the institution IIASA seems to be moving with too much political inertia and therefore may not be the best sparring partner for visionary scientific discussions with COE members. If one imagines a group of scientists in Europe with vividness and positive spirit like the COE members from Kyoto University, a joint seminar with such a group could have been even more productive.

The joint seminar is to be considered a very important milestone and without hesitation a very successful one for the COE in that members found together even more closely and that by external influences a fruitful scientific discussion took place.

It is my pleasure to congratulate the COE leaders to this success and wish the whole research team all the best for their future research agenda. With confidence I am looking forward to hearing more news about this COE pushing new boundaries for science and engineering in complex mechanical systems.

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