No. 29 March 2015

=Foreword=

International Research Activities at RISH in 2014

Professor Junji Sugiyama
Chair of the Public Relations Committee of RISH, Kyoto University

In 2004, Director Prof. Hiroshi Matsumoto launched a new interdisciplinary Research Institute for Sustainable Humanosphere, a cooperative institute designed to serve as a hub for the discovery of creative solutions for sustainable development. In the decade since, the institute has brought together researchers with expertise ranging from wood science to radio science. The spirit of interdisciplinary collaboration has expanded into partnerships with experts not only at Kyoto University, but also researchers and groups across the country and around the world. Thanks to the efforts of the faculty and supporting communities, the Research Institute for Sustainable Humanosphere, Kyoto University, has successfully accomplished its mission by overcoming barriers across academic disciplines through innovation and cooperation. On June 6, 2014, RISH commemorated its 10-year anniversary.

Professor Lee (second left) and Assistant Professor Zhai: a graduate from RISH (leftmost) at the campus of Nanjing Foresty University

International activities have produced 19 cooperative Memoranda of Understanding (MOU): seven with foreign counterparts in Asian, three in Europe, and two with North American countries. In 2014, Prof. Sanga-Ngoie Kazadi, Chair of the RISH International Academic Exchange Committee, evaluated and reactivated some of the sleeping MOUs by reassigning new faculty for sustainable partnerships. One good example is our MOU with Nanjing Foresty University in China, which was both renewed and extended. The committee continues to encourage more productive partnerships as it helps strengthen the quality and effectiveness of research on global issues. According to Prof. Sanga-Ngoie, research and academic institutions in Africa and South America are good candidates for future partnerships.

There are currently increasing concerns about social accountability and the role of public information. Now, at the beginning of 2015, we are ready to go another decade for seeking solutions for sustainable development through interdisciplinary academic activities of various disciplines, which is in the DNA of our institute.

=Overseas Visiting Scholar=

Some reflections on my stay at RISH during the fall of 2014

Professor Lars Berglund
Wallenberg Wood Science Center, KTH Royal Inst of Technology, Sweden

RISH in Uji is such an interesting place. It is one of the best institutes in the world for wood-related research, but it is also a very peaceful location. During my 3 months stay in the fall of 2014, not only did I learn new things about cellulose materials, but I also enjoyed many walks, jogging and biking tours in the Uji surroundings and along the river. This included visits to the temples and many cups of green tea.

My host, Professor Yano, is a pioneer in the field of nanocellulose composites, and has had many visitors over the years. My privilege was not only to stay in his lab at RISH, but also to meet many of his Japanese colleagues at universities and industrial companies. As foreigners, we often find professional life in Japan quite formal. This time I learnt that there is also related social life in the evenings. I also found out that it can be very informal and enjoyable, to say the least.

The contrast between my everyday work in Sweden and my time at RISH could not be greater. In Sweden I travel frequently, participate in meetings and help students with their PhD-thesis work. As a consequence, I do not have enough time for thinking, reading and even writing, which I had plenty of time to do at RISH. There was also time to discuss research with colleagues. There are many strong scientists at high international level at RISH, with highly original research ideas. It is interesting that many professors work on fundamental problems and can focus on those problems for a long time. This is difficult in many Western countries, where external funding has become too important. Perhaps RISH should also try to better exploit the unique competence of its professors and researchers by stimulating more collaboration within RISH. International research is very much about multidisciplinary collaboration, and RISH offer unique combinations of competence at very high level.

An interesting example of how nature is using cellulose: the protective skeleton of a tunicate sea animal is part of Prof Sugiyama's collection at RISH.

Nanocellulose has become a very strong international research area, with around 1000 international scientific publications per year. A very positive effect is that many researchers from different fields of chemistry and of materials have joined the community. However, it also means that many nanocellulose researchers have a weak interest in wood science. This is different at RISH. In Japan as a whole, there is a strong general interest in wood and paper for esthetic reasons, as you can tell from small details such as the decorations in better restaurants. Many researchers at RISH also have a sense of wonder and even admiration for structural aspects of wood and cellulose, and this is less common in the West. Perhaps this is the most important thing I learnt this time. For example, the plant cell wall is close to a miracle in terms of its molecular and nanostructural design details. The exoskeleton of the tunicate sea animal is one example, see figure. No man-made material can even approach this level of sophistication. Maybe we can find inspiration through studies of cell wall structure, and use the knowledge to design new materials suited for the needs of humans.

I find Japan very interesting, but it takes time for Japanese people before they will speak more sincerely to Gaijin-san. The politeness is almost unlimited, and I was not used to interpret the meaning of words from body language, tone of voice and details in the way words are selected. I went to a meeting in Nagano of the Wood Physics Society. The discussions with Professor Okano and Nakatsubo were very interesting. For the first time, it was also possible to speak at length with the usually very shy wood science students. It was fascinating, young students have a strong interest in what it is like to live in a country such as Sweden. This was also the case for the students attending my lectures in Uji. Not only were they very curious, but they also treat the teachers with a level of respect, which is unusual in Sweden. We also visited several companies in fields such as wood plastic composites (Misawa Home, Nagano), fiberboard materials (Daiken Kogyo, near Okayama) and wood-based nanocellulose (Oji Paper, Tokyo). The level of technology was shockingly high, much superior to similar companies in Sweden. The interest in knowledge and research even at fairly small companies is very encouraging. It seems many smaller Japanese companies should make more efforts to export its products.

Perhaps the most interesting private trip was to the island Shikoku. Foreigners tend to think of Japan in terms of cities such as Tokyo and Kyoto. At Shikoku, I realized not only that the Japanese countryside is beautiful. There are also very few people living in certain areas, it looked very similar to small villages in Northern Sweden. My family also visited, and one of the funniest moments was when my wife talked to sumo-wrestlers in Kurashiki. Since she is a pottery artist, we visited many pottery artists in the Kyoto area. The most incredible meeting, thanks to Dr Yokoyama, was with Raku Kichizaemon XV. The cultural richness of Japanese pottery is impressive. A visit to Sagawa art museum strengthened our impression.

The stay at RISH has been one of the most important professional periods for me, for which I am grateful to RISH. The quality of the people, the kindness of my hosts, the focus on wood-related research and the peaceful surroundings in Uji made the stay unforgettable.

=Overseas Visiting Scholar=

Report by Overseas Visiting Researcher

University Research Professor Danny Summers
Memorial University of Newfoundland, Canada

It is always a great pleasure to visit the Research Institute for Sustainable Humanosphere, Kyoto University. My visit to RISH during March-August, 2014, was particularly rewarding. I collaborated with Professor Yoshiharu Omura and his students on problems related to the Earth's inner magnetosphere. Specifically, we are interested in the interaction of various types of electromagnetic wave with radiation belt particles. Such wave-particle interactions can be key in controlling the structure and dynamics of Earth's radiation belts. We investigated "plasmaspheric hiss", which is an electromagnetic whistler-mode wave occurring in the cold, dense plasmasphere, typically at frequencies in the range from about 100 Hz to several kHz. Hitherto, plasmaspheric hiss has been regarded by the space physics community as a broadband, structureless incoherent emission. By examining burst-mode vector waveform data from the EMFISIS instrument on the NASA Van Allen Probes mission, we were able to show that plasmaspheric hiss is actually a coherent emission with complex fine structure. That is, plasmaspheric hiss appears as discrete rising tone and falling tone elements (see Figures 1 and 2). By means of waveform analysis, we identified amplitudes, phase profiles and sweep rates of the rising tone and falling tone elements. Our study resulted in the publication of what we consider to be an exciting, seminal paper in the Journal of Geophysical Research (Space Physics). This paper is ground-breaking as it overturns

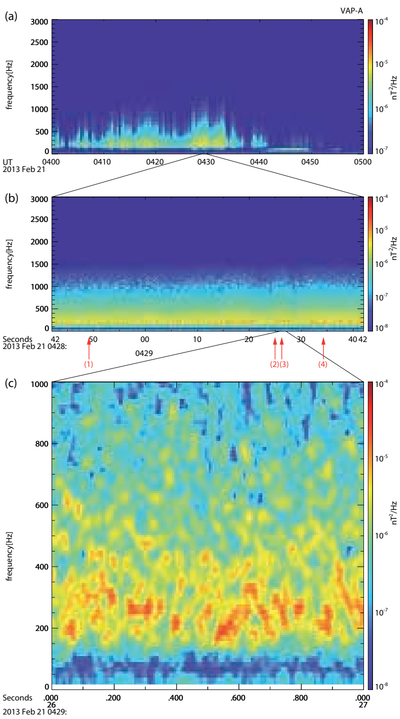


Figure 1

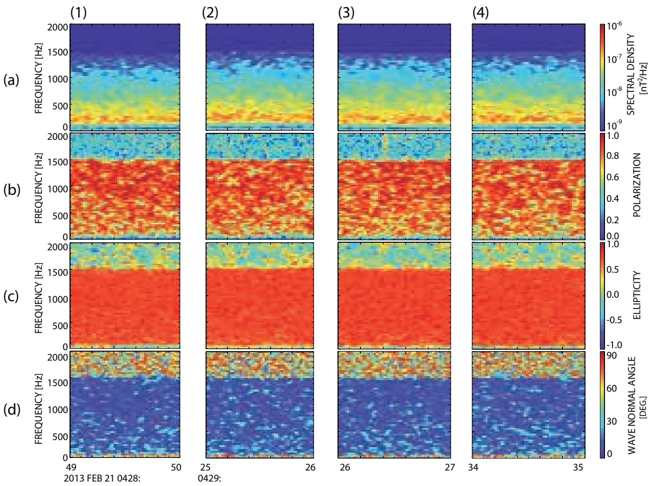


Figure 2

previously held traditional beliefs in the science community.

Other projects on which Professor Omura, his students and I worked include the following:

(a) Sub-packet structures in EMIC triggered emissions observed by the THEMIS probes

We investigated observations of electromagnetic ion cyclotron (EMIC) rising tone emissions comprising sub-packet structures, using waveform data obtained by the Time History of Events and Macroscale Interactions during Substorms (THEMIS) probes. EMIC rising tone emissions have recently attracted much attention because of their strong nonlinear interaction with energetic particles in the inner magnetosphere. We studied two typical cases in detail, one case with a continuous single rising tone and the other characterized by a patchy emission with a broadband frequency. The degree of polarization of each sub-packet is generally higher than 0.8 with a left-hand polarization, and the wave direction of the sub-packets is typically field-aligned. We found that the observed frequency sweep rates and amplitude growth rates are consistent with estimations based on nonlinear wave growth theory. In addition, we compared the observed time duration of each sub-packet structure with the theoretical trapping time for second-order cyclotron resonance. These show reasonable agreement, indicating that individual sub-packet elements are continually generated through a triggering process which generates an element with the theoretically predicted optimum amplitude.

(b) Relativistic electron microbursts due to pitch-angle scattering by EMIC triggered emissions

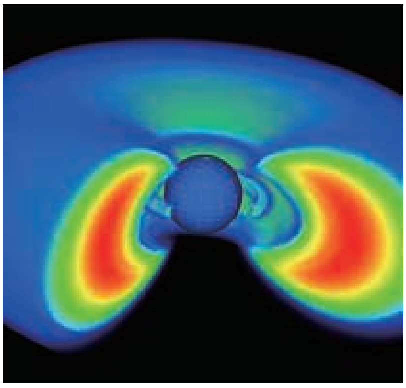
We performed test particle simulations of relativistic electrons interacting with electromagnetic ion cyclotron (EMIC) triggered emissions. EMIC triggered emissions are characterized by large wave amplitudes, rising-tone frequencies, and coherent left-hand circularly polarized waves. EMIC triggered emissions are generated by energetic protons injected into the inner magnetosphere. We studied trajectories of relativistic electrons drifting eastwards interacting with longitudinally distributed EMIC triggered emissions. Relativistic radiation belt electrons interact with EMIC triggered emissions. Some are trapped by wave potentials and efficiently guided down to lower pitch angles. Repeated interactions occur due to the mirror motion, and result in the scattering of particles into the loss cone. We used two EMIC wave models for the test particle simulations. One assumes that the wave amplitude is constant and the other assumes a time dependent wave amplitude that characterizes sub-packets. For both models, 25% of the total injected number of particles in the energy range 0.5-6.0 MeV are precipitated in approximately 2 minutes. We determined the timing, distribution in pitch angle, and longitudinal location of the relativistic electron precipitation with respect to different particle energies.

(c) Electromagnetic ion cyclotron waves in the inner magnetosphere with a kappa-Maxwellian proton distribution

We studied electromagnetic ion cyclotron (EMIC) waves in a kappa-Maxwellian plasma. The plasma was assumed to have five-components, i.e., electrons, cold and hot protons, singly charged helium and oxygen ions. The hot anisotropic protons were assumed to have a kappa-Maxwellian anisotropic particle distribution function. Numerical results were obtained using KUPDAP (Kyoto University Plasma Dispersion Analysis Package), a full dispersion solver developed at Kyoto University. The growth/damping of the oxygen, helium, and proton bands and higher harmonics of the EMIC waves were studied. The effects of the kappa distribution on the growth/damping of these waves were clearly demonstrated. Our model was applied to EMIC wave observations in the inner magnetosphere by the Cluster spacecraft.

During April 28-May 2, 2014 I attended the JpGU 2014 Meeting in Yokohama, where I presented the paper "Nonlinear analysis of magnetospheric wave-particle interactions", and was Main Convener of the International Symposium on the Inner Magnetosphere. I also presented the paper "Limiting energy spectrum of an electron radiation belt" at the AOGS 2014 Meeting in Sapporo (July 27-August 1).

A social highlight of my visit was the RISH 10-year Anniversary party on June 6 at which I was able to re-connect with friends and colleagues from my earlier visits to RISH. During a rather hot August weekend, I visited the famous Shinto shrines at Ise-shi in Mie prefecture. I was fascinated by the sacred shrines and their history, and as well I was immensely impressed by the magnificent Japanese cedar (Cryptomeria) trees in the nearby 2000-year old preserved forest.



The Earth is surrounded by the radiation belt that consists of high-energy charged particles. The particles moves near the speed of light, and encircles the Earth.

=Overseas Visiting Scholar=

Research Activities at the Research Institute for Sustainable Humanosphere (RISH)

Associate Professor Hubert Luce
Mediterranean Institute of Oceanography, University of Toulon, France

My stay at RISH under the status of Kyoto University Visiting Associate Professor from July to November 2014 is part of a long scientific collaboration started in 1997 mainly with Prof. Fukao and Prof. Yamamoto. I was post-doc student and it was my first encounter with Japan. Unforgettable experience I have taken further for about 4 years until 2002 with two post-doctoral fellowships funded by the French Ministry of Foreign Affairs (MAE) and the Japanese Society for Promotion of Science (JSPS). Since then, I kept a close relationship with RISH due to their excellent support and the unique tools made available to outside researchers.

My research field is primarily in small-scale dynamics of the lower atmosphere. It aims at characterizing atmospheric turbulence, its sources and its interactions with larger scale dynamics and clouds by means of remote sensing and in situ observations. The Middle and Upper atmosphere (MU) radar operated by RISH is one of the most suitable instruments for detecting turbulence and stable interfaces in the free atmosphere at any time and in clear air or cloudy conditions. Moreover, the MU radar is regularly upgraded for being operated with advanced technologies and processing techniques. In the early 2000s, I participated to the exploratory phase and applications of a radar interferometry technique, now commonly called "range imaging", on the MU radar. Based on the transmission of several closely spaced carrier frequencies, this technique is devoted to improve the range resolution of pulse Doppler radars. The signals received at the various frequencies are processed using methods inspired by optimal beamforming in antenna array processing. The implementation of the range imaging technique permitted us to collect time-height cross-sections of radar echo power at unprecedented range resolutions: significant advances have been achieved with regard to the interpretations of radar echo patterns and to the identification of the sources of turbulent events. In recent years, all the measurement campaigns in which I took part have involved the MU radar in range imaging mode with complementary instruments (e.g., radiosondes, lidars, UHF and meteorological radars) for the validation of the technique and turbulence studies.

The studies I conducted at RISH in 2014 in collaboration with Dr R. Wilson from LATMOS (Laboratoire Atmosphères, Milieux, Observations Spatiales, CNRS, France) are part of these activities and focused on the estimation of turbulence statistics from complementary balloon and MU radar data. The ongoing resolution and accuracy improvements of operational WMO radiosondes now make it possible to detect reliably turbulence and to estimate some turbulence parameters from measured temperature profiles. Outer scales of turbulence that specify the largest scales of the inertial domain of fluctuation spectra can now be estimated independently from radar and balloon data and can be compared. One of our most significant outcomes of our studies is to have shown the statistical equivalence between the Thorpe scale (an outer scale of temperature turbulence estimated from balloon data) and the buoyancy scale (defined for stratified turbulence and mainly estimated from radar data), at least for the deepest turbulent events (~> 100 m). It follows that atmospheric turbulence parameters can be obtained by the two techniques as stand-alone systems. However, operational radiosondes are still limited in vertical resolution and by the instrumental noise so that spectral characteristics of small-scale turbulence are still difficult, if not impossible, to determine. Estimating fluctuation spectra from in situ data is now of primary importance for a more thorough description of turbulent energy parameters and scales. In October 2014, we carried out a 10-days radar-balloon campaign at Shigaraki MU Observatory with radiosondes recently developed by Meisei Electric Company, LTD for high resolution (16 Hz, ~30 cm) temperature measurements. These radiosondes should meet our expectations because they have the necessary resolution for accessing the small-scale temperature fluctuation field. In addition, the MU radar was operating with a new digital receiver for testing an improved version of range imaging technique with oversampling. A 1.3-GHz boundary layer radar, a 95-GHz meteorological radar and Rayleigh-Mie lidars were also simultaneously operated by RISH so that a large variety of atmospheric phenomena can be investigated. The data are presently under analyses and we hope to make new decisive conclusions regarding small-scale processes and radar/balloon measurement physics in general.

Also while at RISH, I collaborated with Dr Kudo from JMA (Japan Meteorological Agency, Tokyo) on a project devoted to study the characteristics and the generation mechanisms of turbulent events underneath clouds below upper-level frontal zones. Successful comparisons between MU radar observations collected in 2011 and three-dimensional numerical simulations initialized with balloon data and performed by JMA suggested that convective instabilities due to cooling of precipitating snow in a dry and weakly stratified subcloud layer can be the dominant source of turbulence rather than shear instabilities, more commonly suggested in frontal zones.

I attended three symposiums and meetings, held at Uji (8th Symposium on MU Radar and EA Radar), at Fukuoka (2014 Autumn Meeting of the Meteorological Society of Japan) and at Matsumoto (136th SGEPSS fall meeting) where I presented my results of research conducted with RISH and LATMOS colleagues. The MUR-EAR symposium gave me the opportunity to pay tribute to Prof. Fukao with an invited review about radar imaging techniques. I also gave a presentation at the 51st GCOE-ARS Seminar and the 6th Atmospheric Science Seminar organized by RISH. Finally, I gave a lecture to students of the Graduate School of Informatics of Kyoto University on radar interferometry techniques at the Department of Communications and Computer Engineering.

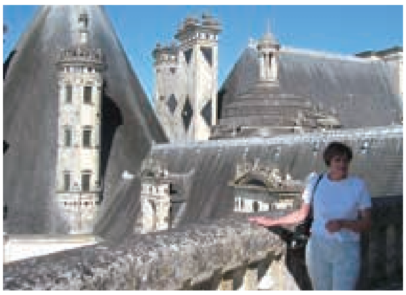
It is of course always a great pleasure for me, and my wife Kie, to spend time in Japan and to enjoy the Japanese daily life. The soothing atmosphere of Kyoto and its surroundings strongly contributes to a rewarding working environment. I would like to express my gratitude especially to Dr Hashiguchi for hosting my visit in 2014 and for the opportunity to meet with other colleagues and the excellent support given to me at RISH.

=International Activity Report=

Collaborative study in ICMN CNRS /University of Orleans

Senior Lecturer Toshimitsu Hata
RISH, Kyoto University

The Institute for Scientific Instrumentation and Techniques and Materials Characterization (l'ICMN, UMR 7374 CNRS / Université d'Orléans, ex-CRMD), where I have worked temporarily as a researcher on collaborative studies on functional wood-based carbon materials, has many advanced apparatus, such as furnaces for carbonization and graphitization, a high-resolution transmission electron microscope (TEM), an X-ray photoelectron spectroscopic analysis device (XPS), an atomic force microscope (AFM), a small-angle X-ray scattering (SAXS), and a polarizing microscope. Research staff teams are specialists in each apparatus and have positions in Orleans University and CNRS. Nanostructured carbon materials and other metal or inorganic substances have been intensively studied for many years, and enormous theoretical and practical knowledge has been accumulated there. The highest information in the fields of mathematics physics, basic engineering, environment protection, and biomaterials, as well as materials science has been gathered at this institute.



Dr. Sylvie BONNAMY, director of ICMN CNRS on the balcony of the royal Château at Amboise in the Indre-et-Loire département of the Loire Valley in France

Dr. Sylvie BONNAMY, the director of ICMN, is a colleague with whom I have studied and discussed the electrochemistry application and new features of wood-based carbons. Polymer electrolyte fuel cells, which are devices to convert chemical energy to electricity by electrochemical reactions, are recognized as a potential future source of power. However, exclusive use of platinum in the cathode catalysts needs to be overcome. Recently, nitrogen-doped carbons have been attracting attention as substitutes for platinum in catalytic electrodes. For example, the Toyota Company has recently decided to increase the production of their fuel cell vehicle (FCV). The substitution of Pt with N-doped carbons will be more and more important, and will eventually lead to the economical production of FCV.

I have performed tests to characterize the samples of functional carbonized wood with Dr. Sylvie BONNAMY, and have made clear the mechanism by which nanostructured carbons show high-oxygen reduction reactivity of cathode catalysts, mainly by TEM-EELS and XPS. About twenty communications on diamond/graphite composites, silicon carbide nanorods, lithium-ion cell, and nitrogen-doped carbons for fuel cells based on carbonized wood have been presented by our research team (T. HATA, S.BONNAMY, and others) in the CARBON International Conference and other international meetings every year since 2005. The experience and knowledge obtained by studying with the experts in ICMN is the driving force of my study, and is important for maintaining my level of study and the experimental facilities in RISH to promote international collaborative research projects.

=RISH Mission Research Fellow=

Research on atmospheric transport and mixing processes in the troposphere and stratosphere based on trace gas observations

Dr. Yoichi Inai

Greenhouse gases (GHGs), ozone depleting substances (ODSs), and other atmospheric pollutants are emitted into the atmosphere near the surface of the ground (including the sea) in association with human economic activities. Those GHGs, ODSs, and atmospheric pollutants are widely transported throughout the troposphere and stratosphere by large-scale dynamical processes such as thermal convections, global wind fields and circulations driven by several scales of waves, and atmospheric diffusion. Once there, they cause environmental problems all over the world.

Our study takes a dynamical and chemical point of view to examine how GHGs, ODSs, and atmospheric pollutants are carried throughout the atmosphere of the earth using a meteorological dataset. Those data combines observations from balloons, aircraft, ships, and satellites, as well as and objective analysis from a supercomputer. For example, because carbon dioxide, itself a major GHG, has a very long chemical life in the troposphere and stratosphere, carbon dioxide abundance does not change by chemical processes in the upper atmosphere away from the source and sink region of carbon dioxide. Thus, carbon dioxide abundance is mostly controlled by dynamical transport and mixing processes in the upper atmosphere, and the spatial and temporal distribution of carbon dioxide reflects temporal variation of atmospheric transport processes, as well as temporal variation of carbon dioxide emission/absorption in the source/sink region. This fact may help our understanding of atmospheric transport and global environmental problems.

In particular, we are examining carbon dioxide concentration observed in the upper troposphere, and the origins of those air masses. Trajectory analysis based on the objective analysis dataset is used for estimation of the origins of air masses. Although such trajectory analysis generally does not have high reliability, we can check the reliability ourselves since we can compare the results of trajectory analyses to observed distributions of atmospheric compositions, including carbon dioxide. So far in our study, we have shown that there is good agreement between atmospheric transport estimated from trajectory analysis and temporal-spatial distribution of carbon dioxide in the lower troposphere over the eastern Pacific, and the upper troposphere over Asia and the western Pacific. However, we have also found that the measures do not agree over Asia during the boreal winter. Thus, further analysis and observation, as well as improvement of our method, are needed.

Members of the observation team in 2014 (Biak Island, Indonesia, February 2014).

=RISH Mission Research Fellow=

Developmental instability of Heterobostrychus aequalis

Dr. Lee-jin Bong

A problem often arises during the rearing of the insect *Heterobostrychus aequalis* (Waterhouse) for experimental purposes: low survivorship. Thus, two studies were carried out to assess the fitness of the beetle.

A cuticular permeability (CP) study examined *H. aequalis* gravimetrically (Appel and Tanley 1999) to better understand the water requirements of the insect. According to Edney (1977), insects with CP values between 0 – 30 µg cm^{-2} h-1 $mmHg^{-1}$ are adaptable to xeric habitats, where those with CP values between 31 – 60 µg cm^{-2} h^{-1} $mmHg^{-1}$ and >60 µg cm^{-2} h^{-1} $mmHg^{-1}$ inhabit mesic and hygric habitats, respectively. The CP value of the immature stages and adults lay within the 0 – 30 µg cm^{-2} h^{-1} $mmHg^{-1}$ range (Table 1), indicating that this insect is capable of surviving in a dry environment. The % TBW loss in the insect after 24 h was low, only about 12% at most in the adult male. This indicated that a dry environment was not the cause of low survivorship during insect rearing.

A second experiment to observe the developmental consequences of larvae handling for *H. aequalis* was

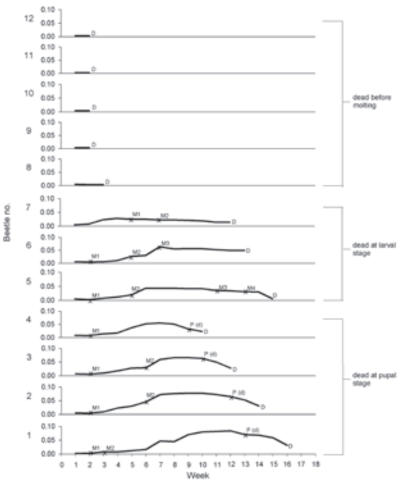


Figure 1 The development and weight of larvae over time. M, molting; P, pupal stage; (d) deformed, D dead

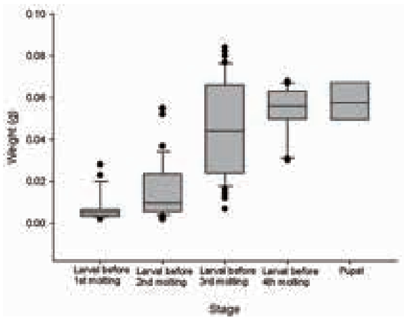


Figure 2 Weight range of larvae and pupa

carried out in a chamber at 26 ºC, 65% RH in the dark. Two ranges of larvae weight were used: a) <0.002 g, and b) 0.002 – 0.01 g. In addition, two treatments were employed for each weight range: a) handled, and b) unhandled; 12 – 17 larvae were tested for each treatment. Each larva was fed an artificial diet made from a mixture of starch, wood particle, and yeast (Titik and Yoshimura 2013) in a plastic container. Briefly, a hole (2.5-mm diameter × 1.0-mm depth) was drilled in the center of the artificial diet (2.5-cm width × 2.5-cm length × 0.5-cm depth). A larva was placed in the hole. The diet was staked with another piece of diet to cover the hole. The larva was weighed and checked for molting every week for handled treatment. For unhandled treatment, larvae were left untouched until emerging into the adult stage.

The larvae that weighed <0.002 g failed to develop into adults in both the handled and unhandled treatments. Approximately 30% of the larvae from handled and unhandled treatments molted once, then died at a subsequent stage at week 4 – 5. One of the larvae from the unhandled treatment molted twice before turning into a pupa, but was unable to develop into an adult.

Approximately 70% of the unhandled larvae weighing 0.002 – 0.01 g developed into adults at week 13, undergoing 1 – 2 moltings before turning into pupae. The development of the handled larvae was slow and impaired. Only approximately 50% of the handled larvae underwent molting and turned into pupae, but failed to develop into adults (Figure 1). Additionally, a greater number of the larvae that failed to turn into pupae had more than 2 moltings compared to those that managed to turn into pupae. The late instar larvae demonstrated a wide range of weight, ranging from 0.012 g to 0.082 g, before turning into pupae (Figure 2). The results showed that insect handling in H. aequalis might impose disturbances that cause asynchronized development patterns in the immature stage, and impaired growth to the adult stage. It was reported that the low level of the endogenous juvenile hormone present during the last larval-larval ecdysis, and the short increase in the prepupal stage ensured successful pupation (Newitt and Hammock 1986). Thus, the delayed pupation and the pupal deformation of handled larva hinted that the disturbance caused an alteration in the level of the endogenous hormone. The detection of the hormone level in both handled and unhandled larvae is still ongoing.

Table 1. Physiological parameters of preadult and adult *H. aequalis*

Species	Stage	n	Initial mass (mg)	Body water content (mg)[a]	TBW content (%)	TBW loss (%)	CP (μg cm^{-2} h^{-1} mmHg^{-1})
Heterobostrychus aequalis	Larval	10	52.90 ± 2.85a(a)	32.4 ± 1.85a(a)	61.35 ± 1.40a(a)	5.93 ± 1.70ab(a)	2.52 ± 1.68a(a)
	Pupal	12	48.50 ± 2.78a(a)	29.5 ± 1.90a(a)	60.53 ± 0.92a(a)	4.28 ± 1.02a(a)	5.89 ± 3.45a(a)
	Female	5	40.60 ± 3.26ab(a)	24.2 ± 2.08a(a)	59.50 ± 0.64a(a)	11.55 ± 2.30b(a)	13.76 ± 4.78a(a)
	Male	5	32.00 ± 2.55b(a)	20.00 ± 1.76a(a)	62.36 ± 0.83a(a)	11.99 ± 0.51b(a)	15.57 ± 4.90a(a)

Mean values followed by the same letter within a column are not significantly different (Tukey's HSD; α = 0.05).
Mean values followed by the same letter (in bracket) within the same instar are not significantly different (Student's *t*-test; α = 0.05).
[a] Parameter analyzed using ANCOVA and separated by least significant difference with initial mass as a covariate.

=RISH Mission Research Fellow=

Research associated to Mission 3 - Study of the space environment and its utilization

Dr. Yao Yao

The rising global population and growing demand for resources has caused humans to pay greater attention to the near-Earth space environment. We have begun to consider how to develop and utilize the space environment, how to find substitute resources in space to solve the problem of the Earth's limited natural resources. Although there has been great progress in the development and utilization of the near-Earth space environment, the general picture of it is still far from fully understood. The near-Earth space environment is also known as the geospace, and it consists of the Earth's magnetosphere, ionosphere, thermosphere, and nearby interplanetary space. It is difficult to understand the geospace as a single system, because each region has a different spatial scale, physical properties, and characteristic dynamic variations.

Like the ocean, geospace is not as calm and peaceful as it looks. With the deepening of our knowledge about the geospace, we find ourselves directly facing the threats contained therein. In the geospace, a disturbance phenomenon called a "substorm" (Figure 1) can be frequently observed. These events can have a great impact on elements in the humanospheric environment, such as spacecraft charging, GPS positioning error due to ionospheric perturbation, and disasters in power transmission networks caused by telluric current. The substorm is a global phenomenon, whose signature can be traced in the generation of high-energy particles in the magnetosphere, in aurora brightening and enhancement of the electro-jet current in the ionosphere, and in heating of the thermosphere. Therefore, understanding the substorm could be a breakthrough in systematic understanding on the near-Earth space environment from a global perspective. However, one-point satellite observation, or even multiple-point observations only reveal local features of substorms.

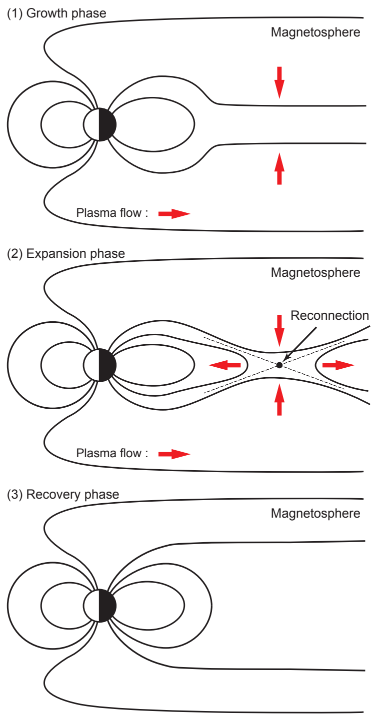


Figure 1 Three steps of a whole substorm event, which includes (a) growth, (b) expansion, and (c) recovery phases.

The goal of this study is to understand the physical process of the substorm based on a global magnetohydrodynamics (MHD) simulation together with satellite observations. From these we try to reveal the substorm's role in the humanosphere. At the present stage, we are focusing on a key question—what is the triggering mechanism of the substorm? Two major models have been proposed. One is the near-Earth neutral line (NENL) model (e.g., Baker et al., 1996), which suggests that onset is triggered by the process of magnetic reconnection at ~20 Re in the near-Earth magnetotail. The other is the current disruption (CD) model (e.g., Lui, 1996), which suggests that ballooning instability or cross-field current instability causes the CD at ~10 Re, resulting in dipolarization and formation of substorm current wedges. These two models can partially explain the observed localized phenomena; however, it is difficult for either model to fully describe the substorm signatures, such as aurora brightening and ionospheric electro-jet currents, which have several ten-minute scales. That is why Pu et al. (1999) proposed a synthesis of the tail reconnection and cross-tail current disruption models. A global MHD simulation model developed by Tanaka et al. (2010) found that the formation of a high-pressure region in the night-side magnetosphere can change the whole magnetospheric current system. This new current system can reasonably explain many substorm signatures. Comparing results of the MHD simulation to observations from the THEMIS mission shows that the MHD simulation reproduces well the observed spatial and temporal pressure variations. Future work will be carried out to reveal, for example, the relation between substorm and ionospheric response, how the energetic particles are generated and vanish during the substorm, and how to quantify the effect of the substorm on the human environment.

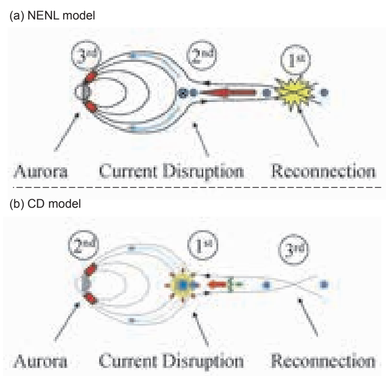


Figure 2 Two triggering models of the substorm onset (from Angelopoulos, 2008)

I would like to express my gratitude to Dr. Y. Ebihara for providing this opportunity to work with him on understanding the physical substorm processes by comparing satellite observations and global MHD simulation, and to Prof. Y. Omura for his part in fruitful discussions. I would also like to thank other members and students of the space group in RISH, and Ms. Ueoka and Ms. Ogawa for their help in daily research life at RISH.

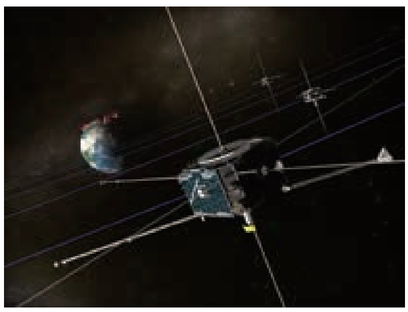


Figure 3 Probes of Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission in orbit. (From NASA)

=RISH Mission Research Fellow=

Psychological and physiological effects of cedar wood on humans

Dr. Yoshika Takahashi

Introduction

It has been reported that cedar wood with slit processing (i.e., exposed butt end on surface) purifies and humidifies the air. Here, we investigate the psychological and physiological influence of cedar wood in an actual space. In this study, slit-processed cedar wood was applied to a private room booth. The study then examined the influence of stimulations received by various senses and how they are integrated in the human psychological and physiological response to cedar wood.

Experimental method

The experiment was conducted by measuring the psychological and physiological responses of study subjects to the inside of an experimental booth. The internal walls of the booth were categorized into 3 types: gray acrylic mat plate (control), cedar wood with slit processing, and cedar wood only. There were total 4 experimental conditions; “Observation of cedar wood with slit processing — visual only”; “Observation of cedar wood only — visual only”; “Observation of cedar wood —tactile only”, and “Observation of cedar wood — both visual and tactile”.

The study subjects were 10 healthy male college students/graduate students (19~24 years old). The experiments took approximately 60 min. Temperature and humidity in the room were set at 20 °C and 50%, respectively. After entering the experimental room, study subjects were fitted with various sensors to measure physiological values. Subjects rested for 5 min in the experimental booth with gray acrylic mat plate (control), then moved to the experimental booth with cedar wood with slit processing, and the cedar wood only for 3-min observations. Rest and observations were repeated matched with the number of conditions.

Measurement index

For the psychological index, the study asked subjects to give their impressions using the SD method. With the reference to previous studies, subjects were asked to select from the following six adjective-pairs: Cold-Warm, Restless-Calm, Artificial-Natural, Dark-Light, Vulgar-Elegant, Strict-Gentle. They also selected from seven scales (-3~+3).

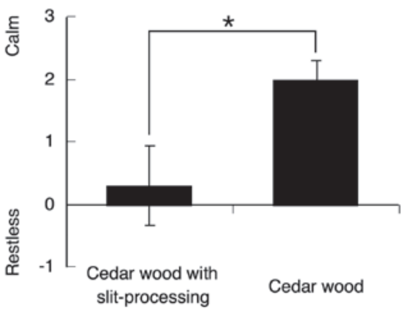
Electrocardiogram, blood pressure, and electroencephalogram were consecutively measured as physiological indexes. For the electrocardiogram, heart-rate variability (HRV) was measured with a belt sensor on the chest, and values obtained for both sympathetic and parasympathetic nervous system indexes. For blood pressure, systolic blood pressure, average blood pressure, and diastolic blood pressure were measured with a cuff on the middle finger of subjects’ non-dominant hand. Finally, for electroencephalogram, we calculated power values for α-wave and β-wave, then calculated α-wave band ratio (α/(α+β)) while subjects wore a electroencephalogram sensor on the forehead.

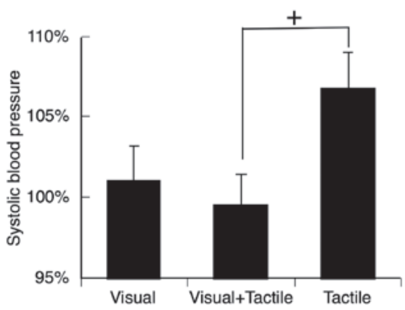
Comparison between cedar slit wood and cedar wood

A comparison of subjects’ reactions to the slit-processed cedar and cedar wood only revealed a significant difference in the “Restless-Calm” psychological index, but no significant difference in the physiological indexes. The results suggested that using slit-processed cedar wood could produce more active psychological processes compared to cedar wood.

Interaction among senses

A comparison of the effects among various senses found that there was no significant difference in the psychological indexes; a marginally significant difference was found for systolic blood pressure in the physiological indexes. A multiple comparison test found that systolic blood pressure tended to be higher in the tactile condition than in the visual + tactile condition. Since both the tactile and visual + tactile conditions included movement (touching the experimental booth), it is possible that the change in systolic blood pressure could have been caused by body motion. An active process could take place only if tactile information were given while blocking visual information. Furthermore, because an elevating effect for systolic blood pressure could rarely be observed at the time of the visual + tactile or tactile-only condition, it is likely that the influence of the visual information would be much larger than that of the tactile information when visual and tactile information are integrated.





=RISH Mission Research Fellow=

Seeing underground by a Galilean experiment of free fall

Dr. Sachie Shiomi

The universality of free fall is a postulate stating that every material (a point mass) in a gravitational field falls at the same rate. It is said that Galileo Galilei dropped two balls of different masses from the top of the Leaning Tower of Pisa to demonstrate that the postulate was correct (Figure 1). Currently, the postulate has been verified to the 10^{-13} level by various experiments, and is accepted as one of the most fundamental principles in modern physics. However, theories towards the unification of the four fundamental forces in nature (i.e., gravitation, electromagnetism, weak and strong forces) typically predict violations of the universality at levels smaller than 10^{-14} (e.g., Damour and Polyakov, Nucl. Phys. B 423, 532-558 [1994]). Further experimental verification is expected.

In the drop tower experiment (Figure 1), a violation of the universality of free fall would result in a differential acceleration between the test masses. However, because of the limited height of the tower, the test masses would fall to the ground in a few seconds; it would be difficult to detect the tiny violation signal in such a short time. The longer the measurement time, the more sensitive the experiment. To acquire a longer time of measurement, test masses are to be put in a low Earth orbit in a modern version of the drop tower experiment, called STEP (Satellite Test of the Equivalence Principle) (Figure 2). The test masses are to fall toward the Earth while orbiting. As the test masses fall in the Earth's gravitational field, the differential acceleration between them is to be detected by a position sensor. STEP is one of the most ambitious proposals aimed at testing the universality to the level of 10^{-18}; it could be sensitive enough to verify some of the theories toward the unification of the fundamental forces.

Imperfections in the STEP test masses, such as density inhomogeneity and thermal distortion, could pose a problem to achieving the unprecedented sensitivity of 10^{-18}. My Ph.D. thesis was on the verification of the STEP test masses (Test mass metrology for tests of the Equivalence Principle, Ph.D. thesis, University of Birmingham, UK [2002]). I developed a device to check the thermal distortion of the STEP test masses nondestructively. The key technique developed for the device was the mounting system, which allows test-mass samples to have sufficient resistance to vibration during the temperature cycle of measurements. By applying the principle of this nondestructive mounting system, we have developed a new type of gravity gradiometer.

Gravity gradiometers are devices to detect gravity gradients, which provide information on local density variations beneath the observation points. Gravity gradiometers can be used to detect, for example, soil moisture, magma beneath a volcano, and mining resources. Different types of gravity gradiometers have been developed worldwide for various applications, including spring gravity gradiometers, superconducting gravity gradiometers, and atom-interferometer-based gravity gradiometers. Our gravity gradiometer is different from those developed so far. Its working principle is similar to the drop tower experiment; a pair of test masses is dropped in a vacuum tank and the differential acceleration between the test masses is detected by a laser interferometer. Because of this detection method, our gravity gradiometer can be called a laser interferometric gravity gradiometer. The test masses for our gravity gradiometer are made from the same material, as we are not interested in the differential acceleration caused by their chemical compositions. It should be noted that the test masses are dropped from different heights in the vacuum tank to detect vertical differences in gravity (namely, vertical gravity gradients).

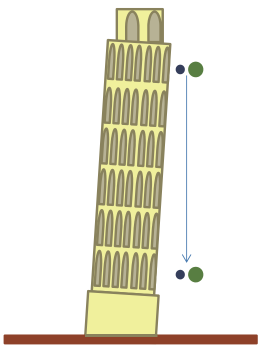


Figure 1 A schematic view of a typical Galilean experiment of free fall (not drawn to scale). A pair of test masses, made from different chemical compositions, is dropped from the top of the tower. The differential acceleration between the test masses is monitored by a position sensor (not drawn) to check the universality of free fall.

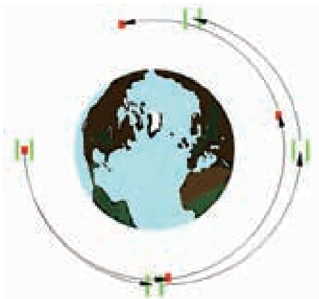


Figure 2 A schematic view of an orbiting drop tower experiment (quoted from http://einstein.stanford.edu/STEP/ ; not drawn to scale). A pair of test masses, made of different materials, is put in a low Earth orbit (about 500 km above surface); the test masses are in free fall in the Earth's gravitational field. If the universality of free fall were violated, there would be differential acceleration between the test masses, as shown in this schematic figure (not drawn to scale). Any differential acceleration between the test masses is detected by a position sensor (not drawn).

We carried out the first measurements using our gravity gradiometer on the active volcanic island of Mt. Sakurajima, Kyusyu, Japan. Our preliminary results showed that the gravity gradiometer could measure vertical gravity gradients with a resolution better than a few Gal/m (=10^{-8} 1/s^2) on the active volcano. This resolution is better than commercial gravimeters; it appears that our gravity gradiometer has high resistance to seismic vibrations, and could be applicable for on-board measurements. A detailed description of our gravity gradiometer is given in the paper: S. Shiomi, et al., Journal of the Geodetic Society of Japan 58, No. 4, 131-139 (2012).

Among other gravity gradiometers, our gravity gradiometer is small in size and could be designed to be portable. I am working on the design and fabrication of a new portable interferometric gravity gradiometer for fieldwork at RISH. The new gravity gradiometer could be used for mapping soil moisture of agricultural land.

I would like to thank all the staff at the Sakurajima Volcanologial Observatory of Kyoto University for their help during the measurements.

List of international MOU in FY2014

No.	Institution	Country
1	Nanjing Forestry University	China
2	Center National de la Recherche Scientifique, Center de Recheerches sur les Macromolecules Vegetales	France
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4	School of Biological Sciences, Universiti Sains Malaysia	Malaysia
5	VTT Technical Research Centre of Finland	Finland
6	Zhejiang Forestry University	China
7	The Centre for Research in Earth and Space Science (CRESS) of York University	Canada
8	National Atmospheric Research Laboratory (NARL)	India
9	The College of Atmospheric and Geographic Sciences, the University of Oklahoma	USA
10	Institute of Mathematics and Informatics of the Bulgarian Academy of Sciences	Bulgaria
11	Southwest Forestry University	China
12	National Cheng Kung University (College of Planning and Design)	Taiwan
13	Tanjungpura University (Faculty of Forestry)	Indonesia
14	Indonesian Institute of Sciences (LIPI) (Research and Development Unit for Biomaterials)	Indonesia
15	Chulalongkorn University (Faculty of Science)	Thailand
16	College of Forest and Environmental Sciences, Kangwon National University	Korea
17	The Research Institute for Human Settlements Agency for Research and Development Ministry of Public Works – Indonesia	Indonesia
18	Faculty of Civil Engineering and Planning, Islamic University of Indonesia	Indonesia
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Research Institute for Sustainable Humanosphere (RISH), Kyoto University
Gokasho, Uji, Kyoto 611-0011, Japan
Tel: +81-774-38-3601, Fax: +81-774-38-3600/31-8463
http://www.rish.kyoto-u.ac.jp/

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