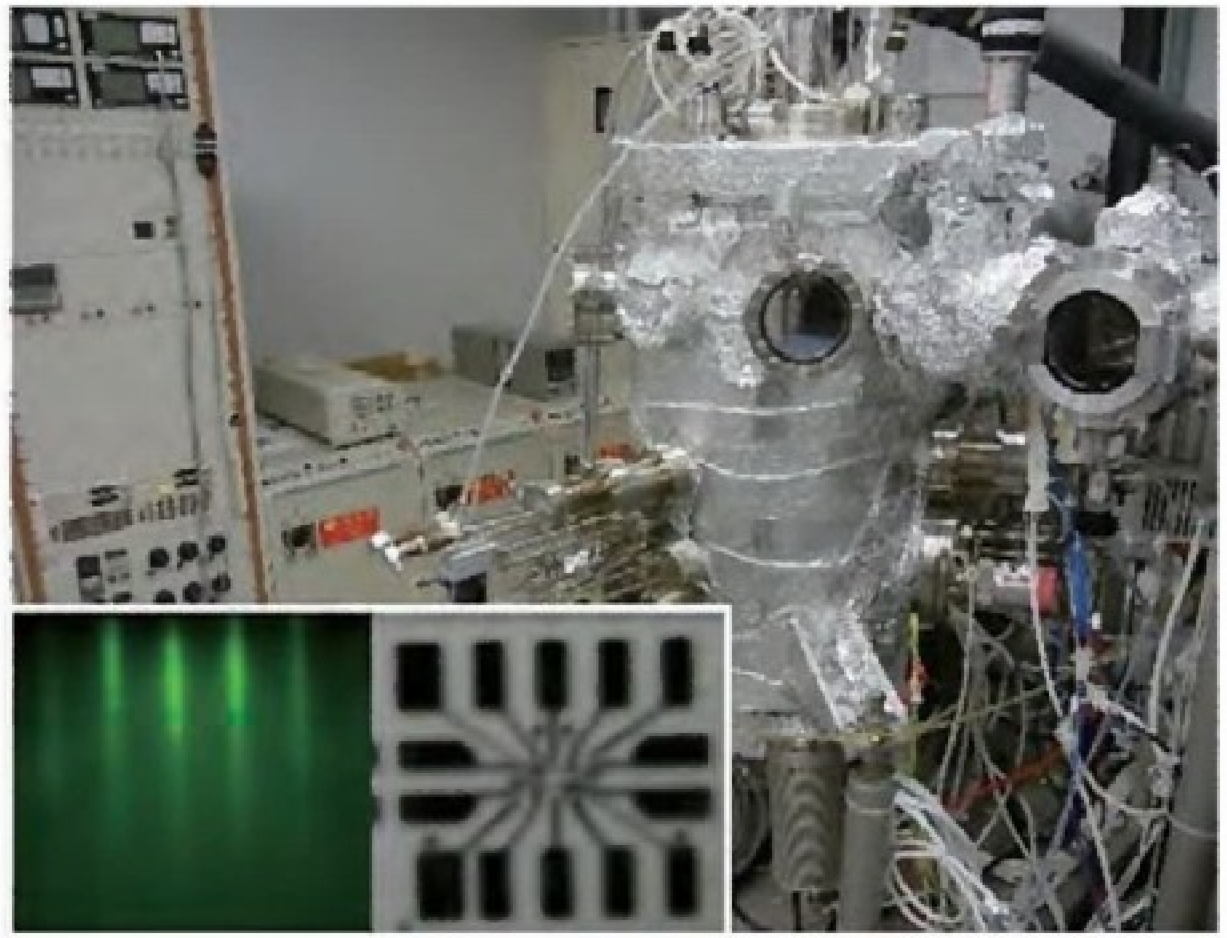
Development of Spintronic Materials and Their Device Applications

Our main research field is **spintronics**, also known as spinelectronics, which has opened up novel applications by utilizing the spin degree of freedom in addition to the charge of electrons. The first spintronics research theme now in progress in our laboratory is using molecular beam epitaxy to grow GeTe-based **diluted magnetic semiconductors** (DMSs). In DMSs, magnetic ions randomly substitute the cation sites of the host semiconductor, which allows for the simultaneous exhibition of ferromagnetic and semiconducting properties. One of the interesting features of DMS is carrier-induced ferromagnetism, which makes it possible to control ferromagnetic order using electric fields or light. We have fabricated spin-based devices such as a magneto-tunneling junction device and a spin-filtering device by using microfabrication techniques. The second theme is the study of the interaction between electron spins and heat currents (**spin caloritronics**). This involves researching spin Seebeck effects and anomalous Nernst effects in ferromagnetic materials. We are also interested in a fabrication technique using **electron beam lithography**.



The molecular beam epitaxy system, the RHEED pattern, and our fabricated device.

About Researcher

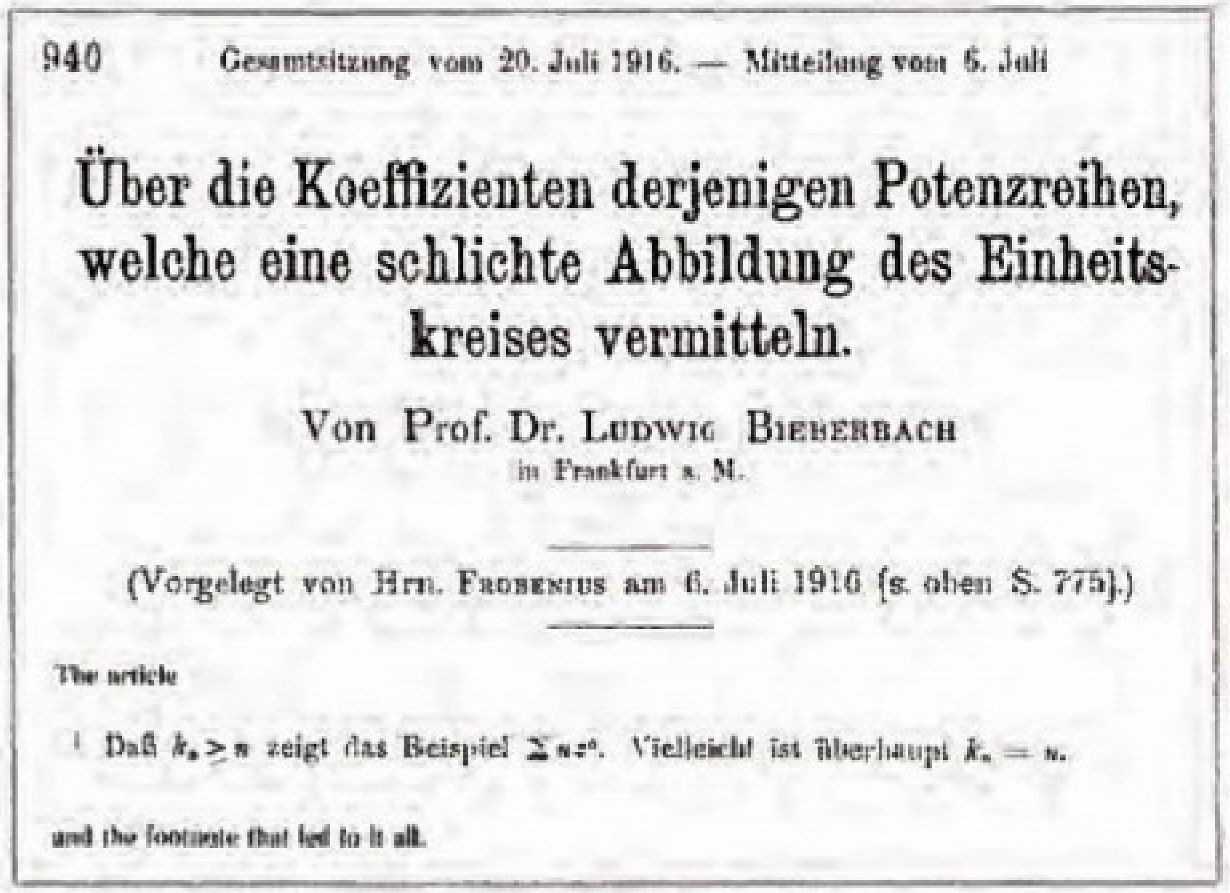
ASADA Hironori, Dr.Eng.

Dr.Eng., 1991, Kyushu University

Conformal Dynamics and Loewner Theory

A primary goal in the natural sciences is to identify common laws of natural phenomena, such as wind flow and fluid dynamics, and to express them mathematically. Differential equation theory plays an important role as a sort of language for describing these phenomena. My primary interest is to investigate a number of problems in complex analysis through the **Loewner differential equations (LDE)**, which uses partial differential equations to describe an expanding flow in a simply connected domain (i.e., a domain consisting of one piece with no holes) in a complex plane. While the basic idea is simple, it can be applied extensively in not only mathematics, but also other fields such as physics and technology.

Recently, LDE theory has been applied to describe the scaling limits of some stochastic processes. This extended version of the LDE is called the **Schramm-Loewner evolution (SLE)**. Recently, the SLE is attracting the attention of many mathematicians, and LDE theory lies at the forefront of modern mathematics.


940 Gesamtsitzung vom 20. Juli 1916. — Mitteilung vom 6. Juli

Über die Koeffizienten derjenigen Potenzreihen, welche eine schlichte Abbildung des Einheitskreises vermitteln.

Von Prof. Dr. Ludwig Bieberbach
in Frankfurt a. M.

(Vorgelegt von Hrn. Frobenius am 6. Juli 1916 (s. oben S. 775).)

The article

[1] Daß $k_n \geq n$ zeigt das Beispiel $\sum n z^n$. Vielleicht ist überhaupt $k_n = n$.

and the footnote that led to it all.

The Bieberbach conjecture, a starting point of Loewner theory, was first posed in a footnote in his paper.

About Researcher

HOTTA Ikkei, Ph.D.

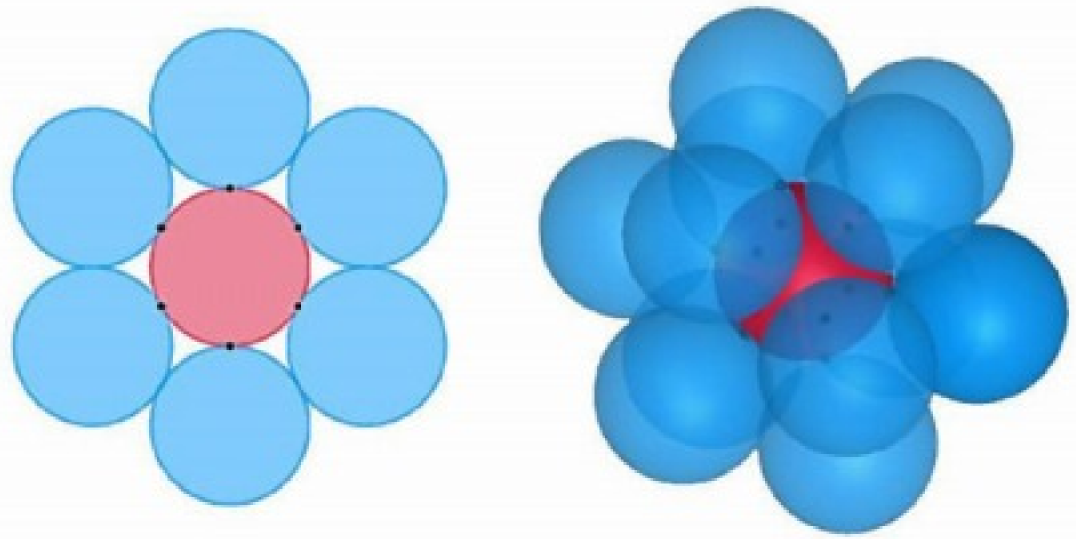
Ph.D., 2010, Tohoku University

WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~ihotta/

Algebraic Combinatorics and Discrete Geometry

Do you know how many unit circles can be placed around a single unit circle without them overlapping? The answer is that you can place six-unit circles without any gaps. In the same way, do you know how many spheres can be placed around a single sphere without them overlapping? By trial and error, it is easy to see that at least 12 spheres can be placed. However, since there is always a gap between the placements of the 12 spheres, there is a possibility that you can place a 13th sphere. Whether or not the 13th sphere can be placed was discussed by Isaac Newton and David Gregory in 1694. In 1953, Schütte and van der Waerden mathematically proved that the 13th sphere could not be placed. In general, it is not easy to mathematically prove something that cannot be done by the senses.

My research is to investigate **"good" point arrangements** in various spaces from a broad range of perspectives. I am also investigating the mathematical properties of these "good" point arrangements. This research field is called **algebraic combinatorics** or **discrete geometry**.



Arrangements of six-unit circles and of 12 spheres

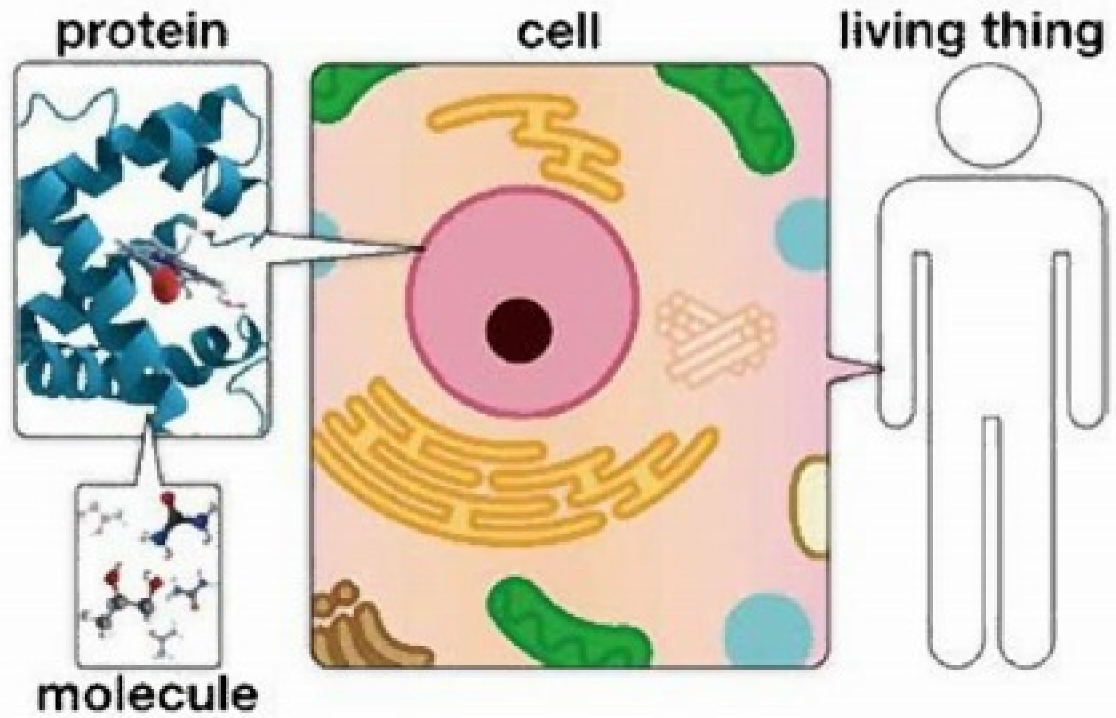
About Researcher

KURIHARA Hirotake, Ph.D.

Ph.D., 2011, Tohoku University

The Physics of Hierarchical Structures

A **hierarchical structure** is a layered arrangement of things such as objects, values, and categories. In nature, as with [living thing - cell - protein - molecule] in biology, hierarchies spontaneously emerge along with spatial and temporal scales. More developed abilities are then achieved in higher layers. Although many studies have been carried out by focusing on a single temporal-spatial scale, complex phenomena consist of **nonlinear interactions** that affect the other scales. Improvements in computational power and nanoscopic-scale experiments are triggering a rise in the study of complex phenomena dominated by nonlinear interactions.
I have studied several nonlinear phenomena such as glass transition, turbulence, economics, and self-organization in honeycomb construction. My studies are based on the ideas of **statistical physics**, using theoretical analysis and numerical simulation. I am particularly interested in why hierarchies appear in nature, and what functions emerge from them.



An example of a hierarchical structure: Living things are composed of cells. Cells consist of proteins, which are aggregations of molecules.

About Researcher

NARUMI Takayuki, Ph.D.

Ph.D., 2010, Tohoku University

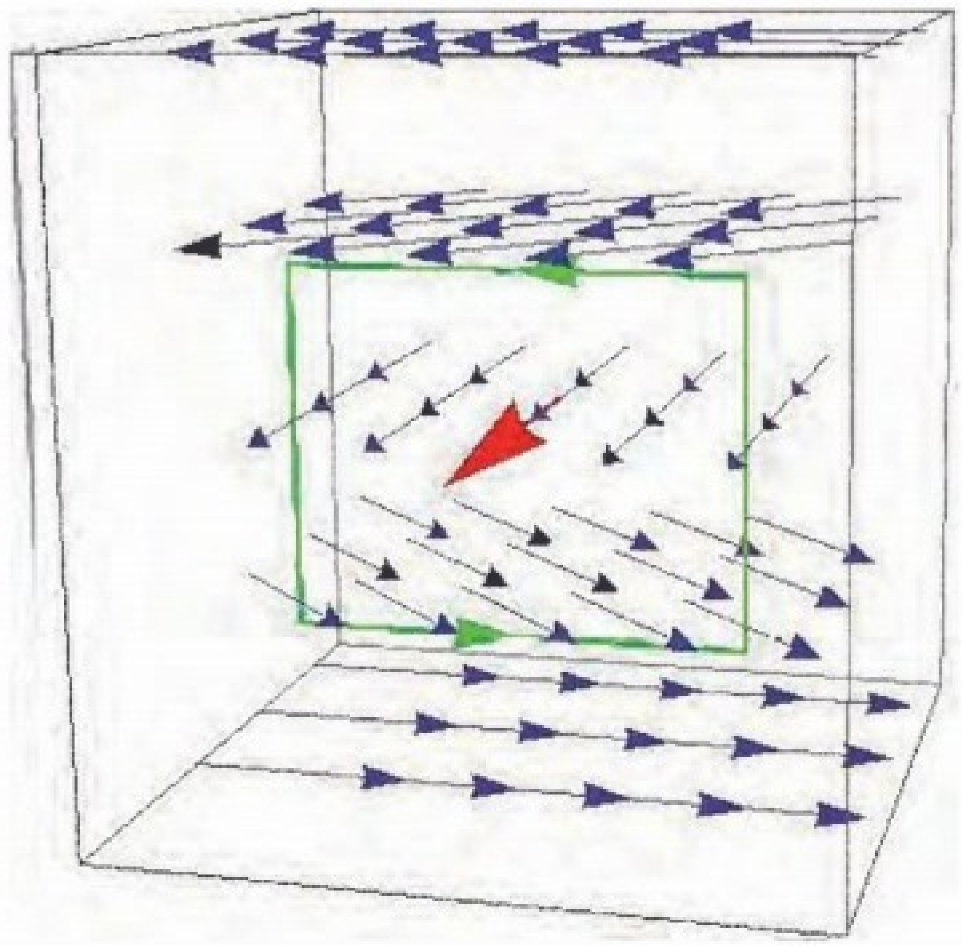
WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~tnarumi/lang-en/

Mathematical Approach to Hydrodynamics and Electrodynamics

Hydrodynamics and **electrodynamics** deal with very different phenomena in our surroundings. However, their fundamental equations—Navier-Stokes equations and Maxwell equations—are transformed into the same form under certain assumptions. For example, irrotational incompressible fluid flows and static electric or magnetic fields in two dimensions have a mathematical analogy explained by using complex analysis.

One research subject of mine is the mathematical analysis of a rotational (or vortical) fluid flow and a time-varying electric or magnetic field that have an analogy in a sense.

What I am now most interested in is to apply **Beltrami flow** to **electromagnetic waves**. This flow, defined by a divergence-free vector field parallel to its own curl, has been investigated in hydrodynamics and plasma physics since the work of Beltrami in the 19th century. In these areas of research, however, such flow is difficult to realize and control. By contrast, in electrodynamics, it can be realized by using circularly polarized electromagnetic waves. From both theoretical and practical viewpoints, Beltrami flow seems to have unknown potential for applications of electromagnetic waves.



A simple example of Beltrami flow (blue arrows), which is parallel to its own curl (red arrow)

About Researcher

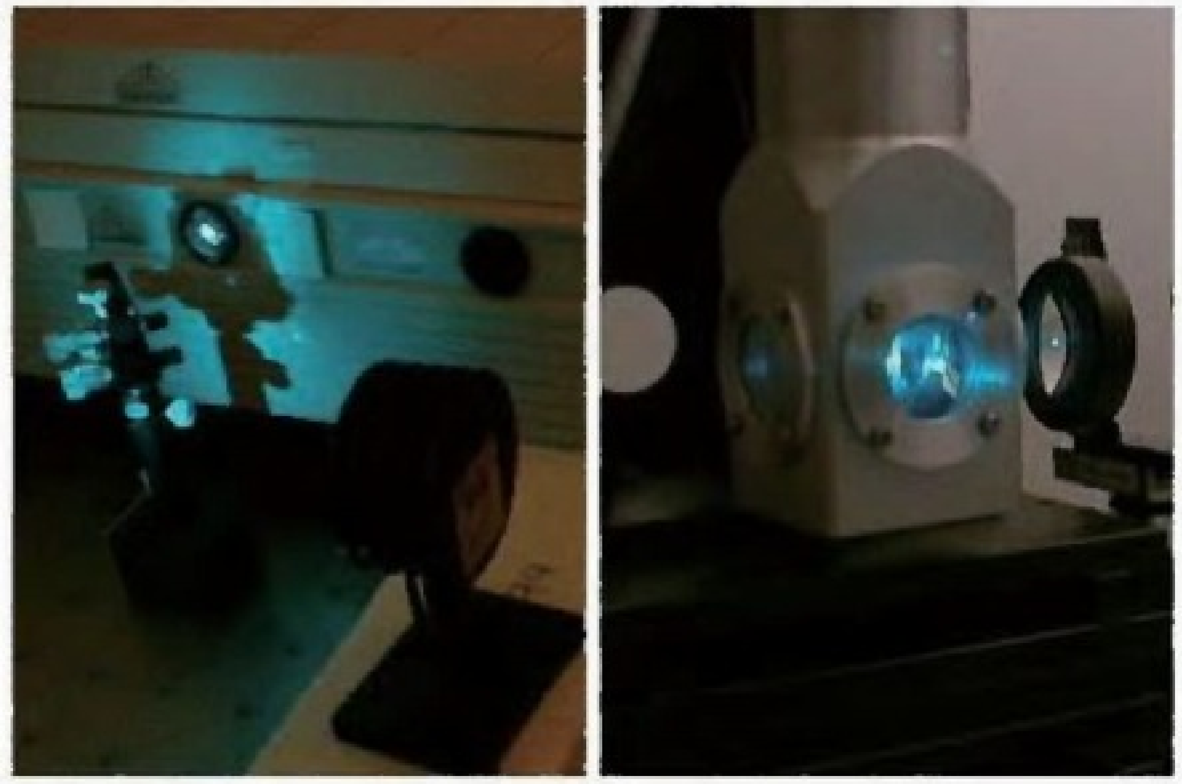
NISHIYAMA Takahiro, Ph.D.

Ph.D., 1996, Keio University

Study of Defect Luminescence and Light-Induced Effects in Hydrogenated Amorphous Silicon

Our research interest is in **light-induced effects** in amorphous semiconductors, especially the light-induced creation of defects in **hydrogenated amorphous silicon** (a-Si:H). Dangling bonds of silicon are dominant defects in a-Si:H and cause degraded performance in a-Si:H-based devices such as solar cells. Therefore, it is desirable to suppress the light-induced creation of defects in a-Si:H. However, the mechanism of defect creation in a-Si:H has not been well understood in spite of many studies over the course of more than 30 years.

We are interested in radiative defects that give rise to **defect luminescence**. The radiative defects differ from the dangling bonds of silicon, which act as non-radiative recombination centers. The light-induced creation of radiative defects has been also observed in a-Si:H as an increase of defect luminescence in intensity. We are studying light-induced effects in a-Si:H extensively by measuring the intensity and lifetime of defect luminescence for a-Si:H films after illumination with intense pulsed light.



Pulsed light from a YAG-OPO laser system (left) illuminating an a-Si:H film in a cryostat (right) at low temperature

About Researcher

OGIHARA Chisato, Ph.D.

Ph.D., 1988, The University of Tokyo

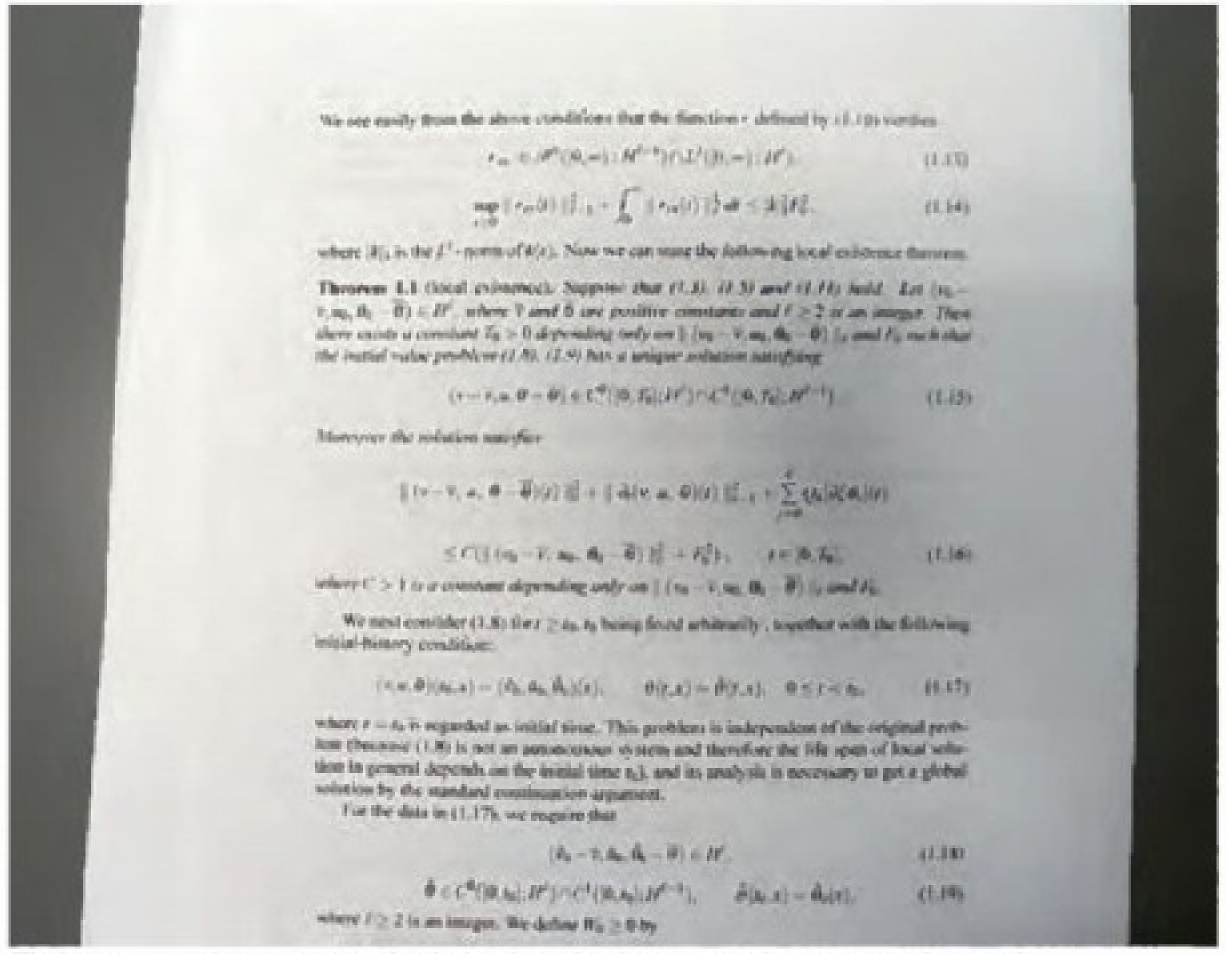
Free Boundary Problems for Compressible Gases and Vacuums

Our research involves nonlinear partial differential equations. Currently, we are studying initial-boundary problems, particularly free boundary problems.

First, we consider **the initial-history value problem** for the one-dimensional equation of thermoelsticity with fading memory.

If the initial data are smooth and small, then a unique smooth solution exists globally in time and converges to the equilibrium as time goes to infinity, provided that the kernel is strongly positive definite. Our proof is based on a standard energy method that makes use of properties of strongly positive definite kernels considering the linearized problem relative to the original problem.

Next, we study a free boundary problem for the equation of **spherically symmetric motion** of a viscous gas surrounding a mass point. Under certain assumptions that are imposed on the initial data, we want to obtain the global existence and uniqueness of the weak solution and give some uniform bounds with respect to the time of the solution. Moreover, we are interested in some stabilization of the solution.



Existence theorem of global solutions to the equation of thermoelasticity with fading memory

About Researcher

OKADA Mari, Ph.D.

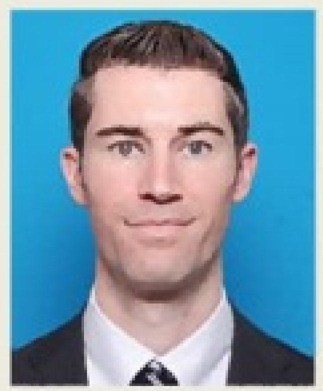
Ph.D., 1988, Kyoto University

Peer Review in the Content and Language Integrated Learning (CLIL) Classroom

Content and Language Integrated Learning (**CLIL**) is a pedagogical approach to **foreign and second language teaching** that incorporates both linguistic and domain specific content into the coursework, allowing students to utilize their language skills to learn about subjects related to their major. It is particularly advantageous for students with highly specialized yet globally oriented majors such as Engineering students, who benefit from exposure to scientific topics being presented in natural English. My area of research concentrates specifically on how **peer review**, an activity where students assess the work of their classmates, can be conducted in a CLIL classroom. Peer review as a learning activity has been employed in a variety of tertiary education contexts for its positive effect on student cognitive and metacognitive development. In my present research, I study student feedback to identify tendencies and patterns in student communication to better inform classroom instruction and thereby maximize the efficacy of the activity.

Fostering interpersonal communication, productive learning outcomes, and human resource development through Peer Review

About Researcher



ROBERTSON Zachary,MA TESL/TEFL

MA TESL/TEFL, 2015, Birmingham University

Translation Studies from a Cognitive Linguistic Perspective

My research theme centers on **Cognitive Linguistic** analysis pertaining to translations between English and Japanese, focusing on the mental mechanisms behind the rendition of **figurative expressions**.

I have studied several rhetorical expressions from a Cognitive Linguistic perspective including transferred epithets (*with nervous fingers*; *落ち着かない指で*), synaesthetic metaphors (*a sweet smell*; *甘い香り*), oxymora (*a little giant*; *小さな巨人*), and tautologies (*A rule is a rule*; *規則は規則だ*) in English and Japanese.

Based on those linguistic analyses, several questions related to translation studies have emerged. For instance, why is it that some figurative expressions can be simply translated from one language to the other just word for word, while others cannot? What is the nature of so-called cultural backgrounds in both languages to support those figurations? Does it have to do with Venuti's (1995) domestication and foreignization in translation? If so, how? What is the **translatability** in the first place?

I have been tackling these questions not only by observing other translators' works but also by practicing rendition myself between the two languages.

[原文]

番頭：　おいおい、何をしているんです、定吉。バカ。鼻の穴に火箸を突っ込んで、２本ぶら下げて、首を振って、チャリンチャリン音をさせて。何がおもしろいんです、え？ およしなさい、店先で、本当に。<u>頭を</u>きれいに拭いときなさいよ。お前の頭じゃあないよ。火箸の頭ですよ。本当にしょうがないねえ。

（落語『百年目』より、下線筆者）

[訳文]

Head Clerk: Oy, what do you think you're doing, Sadakichi? You dummy. Putting a pair of iron-sticks into your nostrils, hanging 'em, and shaking your head to clink 'em. What's the fun, huh? Never do such a foolish thing at the shop. And be sure to wipe <u>the heads</u> clean. Not yours, fool! The heads of the sticks, of course! You're really hopeless.

（Translated by Sadamitsu, underline added）

Unsuccessful translation: the English version fails to convey the punch line in the original

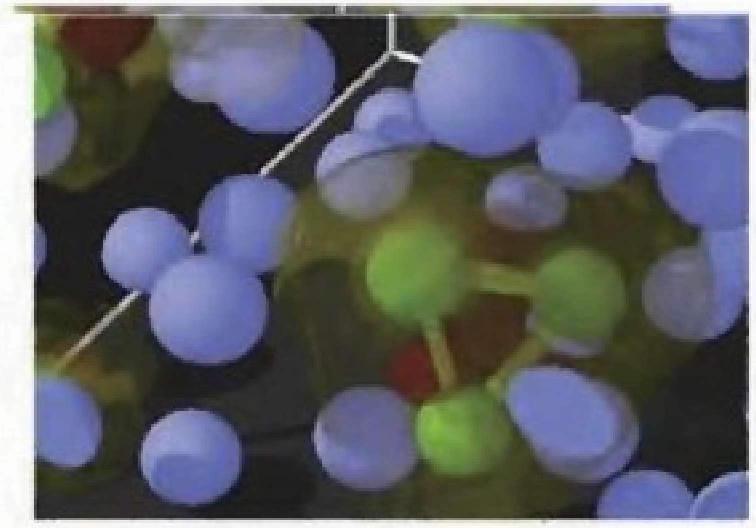
About Researcher

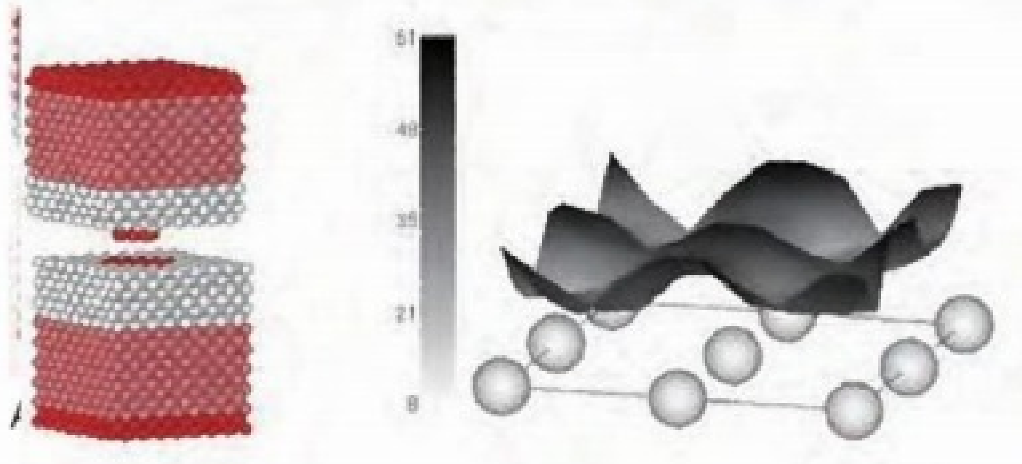
SADAMITSU Miyagi

MA,1999, Osaka University

Computer Simulation of Materials

All materials around us are composed of atoms and molecules, which provide characteristic and useful properties of those materials. My research is focused on calculating the motion of individual atoms using **computer simulation** and to understand the properties and mechanisms of the materials from a microscopic point of view. The top figure below illustrates the ionic structure of a liquid alloy composed of different atoms at high temperature. It was first found by means of this simulation that some atoms come together such that clusters of atoms exists in the liquid alloy. The bottom figure illustrates the results of a computer simulation of an experimental system for observing the surface of a material. Based on this simulation, it is possible to reveal the microscopic mechanisms of this experimental system. There remain many unclear natural phenomena around us and challenging issues, even in cutting-edge fields of technology. I am interested in solving these challenges using computer simulation.





About Researcher

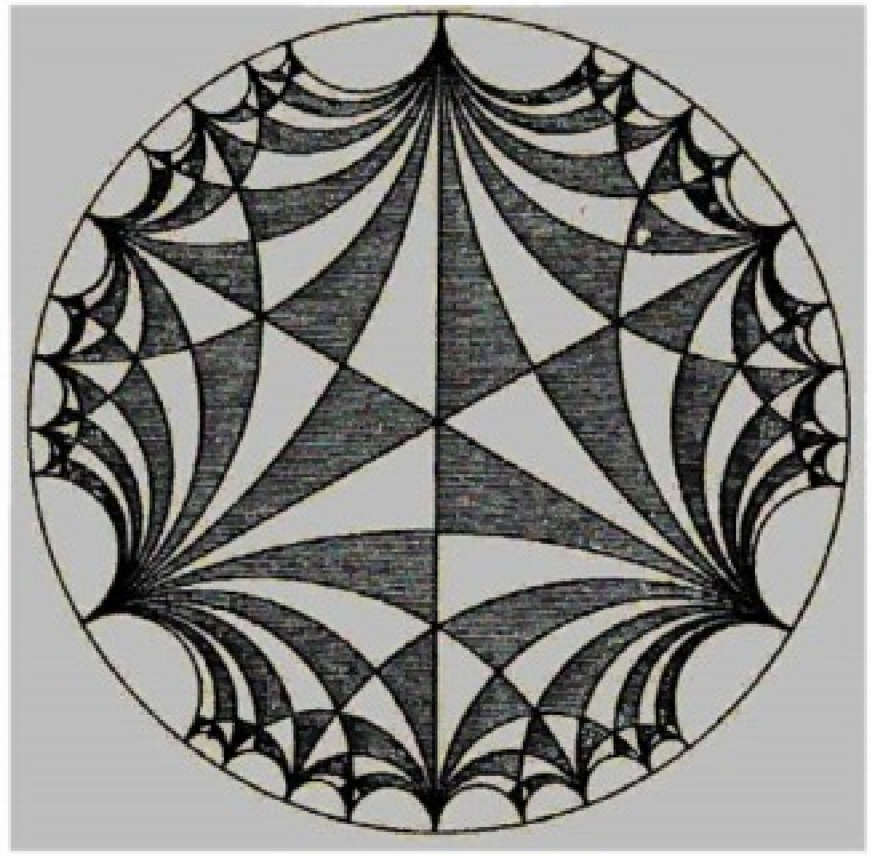
SENDA Yasuhiro, Ph.D.

Ph.D., 2000, Hiroshima University

Real and Complex Hyperbolic Geometry

Non-Euclidean geometry is seemingly a scientific revolution in the history of science. Hyperbolic geometry is one important kind of the two most common non-Euclidean geometries. Within an Euclidean plane, for any given line l and a point p not on the line, it is well known that there is only one line through p which is parallel with l. However, this is not true for the hyperbolic plane. There are infinitely many lines through p that do not intersect with the line l. Our research mainly started from our interest in **hyperbolic geometry**.

Complex hyperbolic plane can be constructed in a similar way to the hyperbolic plane. It is related to hyperbolic plane but there are some differences between them, since the section curvature is not constant but pinched between -1 and -1/4. One project in our research considers the geometry presentations of the complex hyperbolic plane under the action of discrete subgroups of its **holomorphic isometry group**. Recently, we have been trying to analyze the geometric structures of bisectors of two points in the complex hyperbolic plane.



A tiling of the Poincare hyperbolic disk by hyperbolic triangles (R. Fricke, F. Klein 1890)

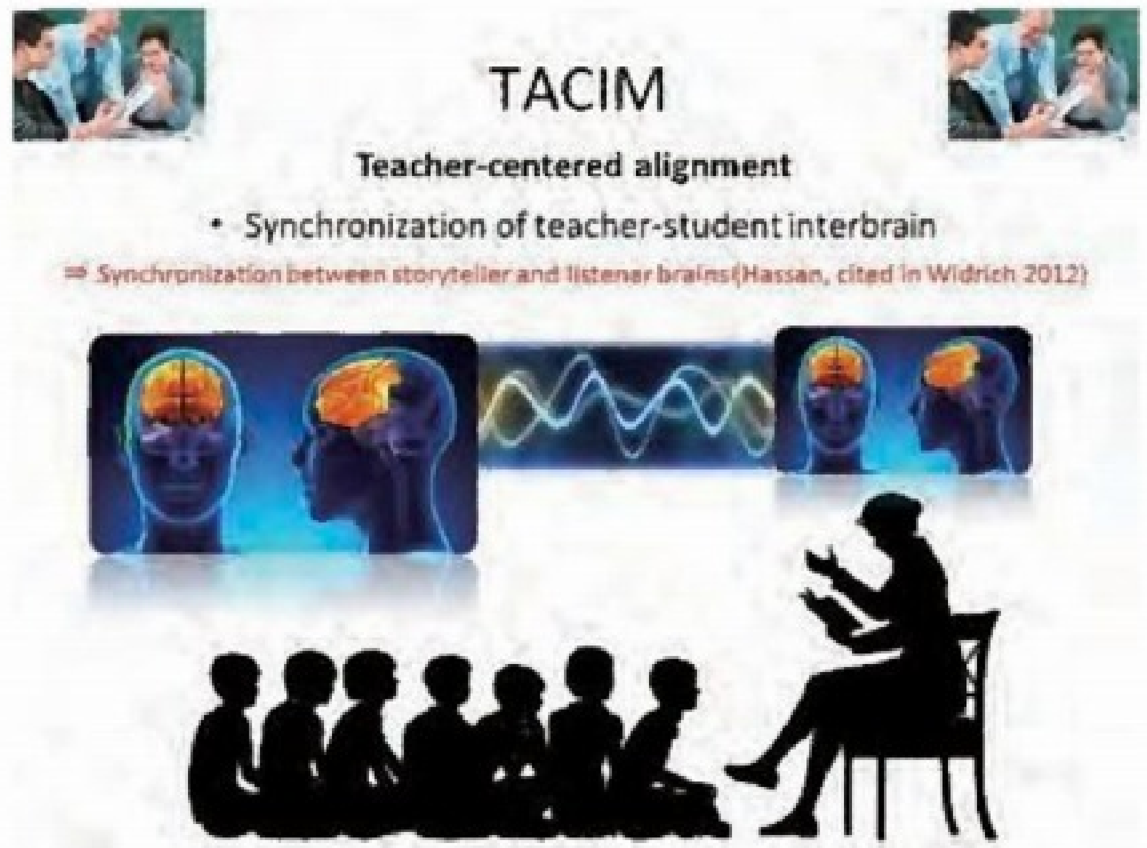
About Researcher

SUN Lijie

Ph.D., 2016, Tohoku University

Content and Language Integrated Learning (CLIL) and neuroELT: Exploring CLIL from a neuroscientific perspective

Content and Language Integrated Learning (CLIL) is a foreign language teaching and learning approach that is aimed at developing both a learner s subject knowledge and foreign language competency equally. It is thought that CLIL is an effective pedagogy, especially for students who require highly speci c expert knowledge, such as engineering students, because it is designed to facilitate both subject/topic and English learning. CLIL classes also bridge general communicative EFL classes and more domain-speci c English medium instructions conducted by engineering teachers. My research concentrates on exploring how CLIL pedagogy can be optimally implemented using findings from neuroscience motivated by an emergent interdisciplinary field called neuroELT. NeuroELT focuses on classroom applications of English language teaching and learning based on studies in Mind, Brain and Education originating at the Harvard Graduate School of Education. In my present research, I am pursuing a classroom application of learner prediction and the brain, the aha moment and the brain and three types of assessments (self-, peer-to-peer and teacher student assessments) and the brain in the Japanese tertiary CLIL context.



Teacher student inter-brain synchronization
(presentation slide from an international neuroELT conference).

About Researcher

UEMURA Takashi, MA in TESL/TEFL

MA in TESL/TEFL, 2015,
University of Birmingham, UK

Covering Properties of Analytic Functions

We have been studying the covering properties of analytic functions in the unit disk,
that is, topics involving Picard's theorem and the **Bloch and Landau constants**. In order to research these topics, we employ Nevanlinna theory, conformal mapping theory, **geometric function theory, quasiconformal mapping**, singular integral operators, and variational methods. I am particularly interested in extremal problems related to these topics.
Lars Ahlfors, one of the greatest professors in complex analysis, often spoke of his excitement of as a young student listening to R. Nevanlinna's lecture on the new theory of meromorphic functions. It was his first exposure to mathematics as a living thing. It is almost surely impossible to offer you such an excellent experience, but I will try to show you a mathematics that is alive and warm.

The most complex and lengthy calculation I have ever solved

About Researcher

YANAGIHARA Hiroshi, Ph.D.

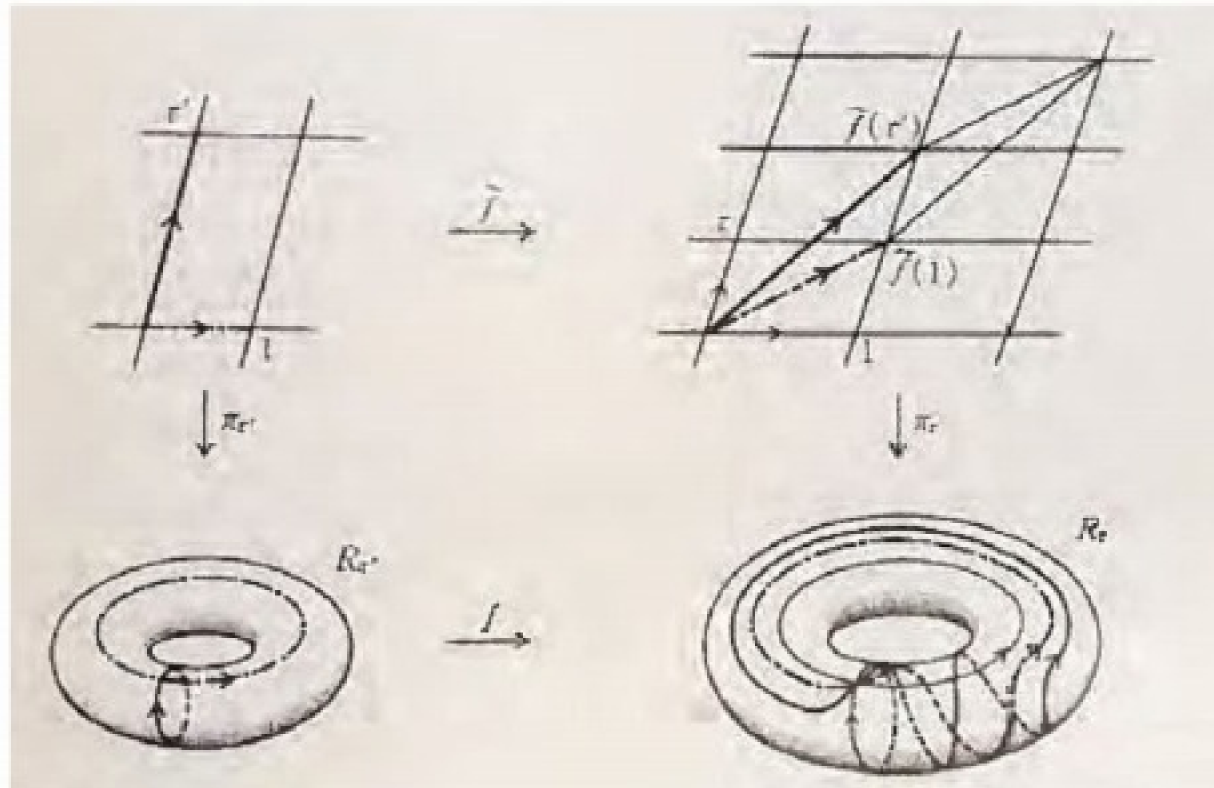
Ph.D., 1987, Tokyo Institute of Technology

WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~hiroshi/

Deformation Theory of a Riemann Surface

What do you imagine when you think about the deformation of shapes? For example, a triangle is different from a circle. However, if we curve each side of the triangle like an arc, we can transform a triangle into a circle. We are interested in the deformation theory of a type of surface called a **Riemann surface**. We study this theory in terms of **complex analyses**. Here, we take not only the shape but also the pattern of the surface into account as criteria of the deformation, which is called a **quasiconformal deformation**. The advantage of this deformation is that we can restore the deformation from data of the dilatation of the pattern at each point on the surface. This feature is used primarily in computer graphics and is applied in many fields, such as engineering and medical science.

While such applications are not included in our current research, we would like to develop them in the future.



Two tori that have the same shape but different patterns.

About Researcher

YANAGISHITA Masahiro, Ph.D.

Ph.D., 2015, Waseda University