to Tohoku University and AIMR

Susumu Ikeda
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Director of Research Support Division (Administrative Director)

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Tohoku University, Japan

Minerals Tour
Musée de minéralogie MINES ParisTech
Collection of Univ. Pierre et Marie Curie
Muséum national d'Histoire naturelle

My visits to France so far

1998 Orléans (mineralogy conference), Paris (Quartier Latin)

Prof. Motoko Kotani
Director
Pure mathematician (Geometer)

Entrance fee: 6 €

http://collection-mineraux.sorbonne-universite.fr/fr/index.html
Tohoku University

- Founded in 1907 as the 3rd Imperial University in Japan
- “Research First” and “Open-Door” Policy
- The first university which accepted women students, foreign students in Japan

President
Dr. Hideo OHNO

First Women Students in 1913
Tohoku University
Dr. Kotaro HONDA “god of steel”

1917    Invention of **KS Steel**, the strongest magnet in the world
1916-22 Establishment of **Institute for Materials Research (IMR)**
1931-40 President of Tohoku University
1937    First recipient of **Order of Culture**, the Japan’s highest cultural honor

With **Albert Einstein** in 1922 at Tohoku Univ.

**KS Steel**

**Dr. Honda laid the foundation of materials science** of not only Tohoku University but also Japan.
Yagi-Uda Antenna
invented by Prof. Shintaro UDA and Prof. Hidetsugu YAGI in 1926

Invented by Prof. Jun-ichi NISHIZAWA 1926-2018

- Light-focusing Glass Fibers (1964)
- Polarization Fibers (1974)
- Avalanche Photodiode (1952)
- PIN Photodiode (1953)
- Semiconductor Lasers (1957)
- Static Induction Thyristor (1970)

IEEE Jun-ichi Nishizawa Medal was established in 2002 in honor of Jun-ichi Nishizawa's lifetime of outstanding achievements.
Advanced Institute for Materials Research
Missions of WPI Research Centers

to attract excellent researchers from around the world

1. Science: Leading-edge research level
2. Globalization: Realization of an international research environment
3. Reform: Reform of the research organization
4. Fusion: Creation of interdisciplinary domains
Motoko Kotani
Director
Pure mathematician
(Geometer)

Prof. Kotani in a photograph taken at the reception held at Rennes City Hall with Deputy Mayor of Rennes (NanoMat2015). Our Sendai City is a sister city of Rennes.

Toward the predictive materials science based on mathematics-materials science collaboration

History of Math-Mate Collaboration at AIMR

from The Academic Executive Brief - Elsevier

Establishment 2007
Partial fusion 2010
Complete fusion derived by mathematics (the common language for natural sciences)

2007 2009 2011-12 2013 2016 2019
~25% of the AIMR researchers are mathematicians or theoretical physicists
Persistent homology can extract some order hidden in random structures.


A series of monographs for math-mate collaboration “SpringerBriefs in the Mathematics of Materials”

**Vol. 1**

Susumu Ikeda
Motoko Kotani

A New Direction in Mathematics for Materials Science

2015

**Vol. 2**

Akihiko Hirata
Kaname Matsue
Mingwei Chen

Structural Analysis of Metallic Glasses with Computational Homology

2016

**Vol. 3**

Daniel Packwood

Bayesian Optimization for Materials Science

2017

Please refer to these books if you wish to get further information about our math-materials collaboration.
René-Just Haüy (1743–1822)

French mineralogist

"Father of Modern Crystallography"

Discovery of **law of rational indices** in **1784**

Materials (crystals) can be expressed based on the mathematical language “**geometry**”. 

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Workshop franco-japonais nanomatériaux

Five researchers are participating in this NanoMat2019 from Advanced Institute for Materials Research, Tohoku University

Oral speakers from AIMR at NanoMat2019

Assoc. Prof. Hiroshi Yabu
Junior Principal Investigator

Nanocomposite materials based on catechol-containing adhesive and reductive polymers

Assoc. Prof. Akichika Kumatani

Nanoscale Electrochemical Imaging on Energy Materials: From Lithium-ion (De)intercalation Process to Electrocatalytic Reaction

Poster presenters from AIMR at NanoMat2019

Dr. Tang Ma
Assist. Professor

Functional bio-hybrid membranes through self-assembly

Dr. Hiroya Abe
Assist. Professor

Fe Azaphthalocyanine for Realizing Highly Active Oxygen Reduction Reaction (ORR) Catalytic Electrodes

Assoc. Prof. Susumu Ikeda
Administrative Director

Molecular dynamics simulations of organic semiconductor thin film growth
Create predictive materials science based on mathematics-materials science collaboration

Thank you for your attention!
Nicolas Steno (1638–86)
Danish scientist

Discovery of **law of constant angles** in 1669

First discovery of geometrical characteristics of materials. This paved the way for the Haüy’s discovery in 1784.

Apparatuses to measure an angle which two faces form
230 space groups

Group theory

mathematical means to describe the regularities
- point symmetries
- periodicities (translation symmetries)

Évariste Galois
(1811–32)

M. Sophus Lie
(1842–99)

Proof of the classification of the 230 space groups (in 3D)

was independently established by two mathematicians and one crystallographer.

mathematician
E.S. Fedorov
in 1890

mathematician
A.M. Schoenflies
in 1891

crystallographer
W. Barlow
in 1894

Clearly, mathematics is contributing significantly to the development of materials science.
Quasicrystals

In 1982, Daniel Shechtman observed pentagonal symmetry in the electron diffraction pattern of an aluminum alloy sample.

his experimental notebook

10-fold electron diffraction pattern (from Shechtman’s presentation file)

Daniel Shechtman (Lecture at Tohoku University)

Zn-Mg-Dy quasicrystals, courtesy of the late Prof. An-Pang Tsai, Tohoku University

Penrose tiling (Wikimedia Commons)
Mineralogy
Crystallography
Metallurgy
Ceramics
Semiconductor
Solid State Physics
Spintronics

1669
Steno
Newton
Leibniz
Gauss
Turing
Connes

Mathematics
Euclidean Geometry
Linear Algebra
Modern Geometry

Materials science
Symmetry
Periodicity
Wave of electrons
Bloch's theorem

Electronic properties
Density functional theory (DFT)

Phase separation
Cahn-Hilliard equation

1600
1700
1800
1900
2000
2100

Earthenware
Mineralogy
Crystal
Space Group
Group Theory

Cultural evolution

1600
Earthenware
Metal ware

1700
Mineralogy
Crystallography

1800
Metallurgy
Ceramics

1900
Solid State Physics
Spintronics

2000
Surface Science
Device engineering

2100

Advanced Geometry
Noncommutative geometry

Advanced numerical techniques

Level set methods

Quantum Hall effect

Osher

Shechtman

Quasi crystals
Topological insulator

Surface Science

Phase separation

Cahn-Hilliard equation

Advanced Geometry

Materials science

Symmetry

Periodicity

Wave of electrons

Bloch's theorem

Electronic properties

Density functional theory (DFT)

Self organization

Pattern formation

Turing

Connes

Level set methods

Quantum Hall effect

Advanced numerical techniques

Noncommutative geometry

Materials science
Research groups
Materials Physics
Soft Materials
Non-equilibrium Materials
Device / System
Mathematical Science

Management
Director: M. Kotani
Deputy Director: S. Orimo
Adm. Director: S. Ikeda
Deputy Adm. Director: M. Funada

Executive Advisor
Masaru Tsukada
Yasumasa Nishiura

International Advisory Board
J.G. Bednorz, IBM Zurich
1987 Physics Nobel laureate
H. Gleiter, Karlsruhe Inst. Tech.
V. Narayanamurti, Harvard Univ.
E. Negishi, Purdue Univ.
2010 Chemistry Nobel laureate
S. Mori, Kyoto Univ.
1990 Fields Medalist

Materials Physics
K. Tanigaki (AIMR)
T. Fukumura (AIMR)
T. Sato (AIMR)
Y. Ikuhara (U Tokyo)
E. Saitoh (U Tokyo)

Non-equilibrium Materials
H. Suito (AIMR)
A.L. Shluger (UCL)
Q.-K. Xue (Tsinghua U)

Mathematical Science
Y.P. Chen (Purdue U)
T. Dietl (Polish Acad Sci)
A.L. Greer (U Cambridge)

Device/System
S. Orimo (AIMR)
S. Mizukami (AIMR)
S. Samukawa (AIMR)
S. Fukami (AIMR)

Soft Materials
A. Hirano (AIMR)
T.P. Russell (UMass Amherst)

G Leader
H. Yabu (AIMR)