Department of Earth and Space Science

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The Department of Earth and Space Science, Graduate School of Science of Osaka University, is a unique department established in 1995, aimed at developing a new horizon in the research and education of earth and space science from a physics-based perspective. The principal goals of our department's research activities are to understand the extreme state of matter in space, including even life, and to decipher the many diverse phenomena which occur in space, the planets and the Earth.

The Department of Earth and Space Science consists of four major research areas: (1) Astrophysics and Planetary Science, (2) Earth and Planetary Material Sciences, (3) Extreme Material Science, and (4) Life Science. Related disciplines also covered are theoretical astrophysics, X-ray astrophysics, infrared astronomy, planetary science, geophysics, theoretical and experimental condensed-matter physics, and biophysics. A total of 28 students enroll each year for the Master's Program and 13 for the Doctoral Program.

Our department focuses on fundamental physics as the basis of the earth and space science. This is why we aim to conduct research and education in close collaboration with the Department of Physics at the Graduate School of Science. Our department is always open to talented researchers and students from a wide variety of fields, from physics to astronomy, geophysics, geology, mineralogy, biology, and engineering. Our aim is to go beyond the traditional framework of science and develop a new frontier of interdisciplinary science, while at the same time construct a new, integrated style of the earth and space science. We see our research leading to new perspectives from which to approach the environmental problems the earth faces in the 21st century, and question of the origins of life on earth. Our ultimate aim is to facilitate developments that will change our lives for the better. The following is the list of our faculty members.

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**please add "astro-osaka.jp".

Home Page

http://www.ess.sci.osaka-u.ac.jp/english/index-e.html

Photograph of the entrance lobby. The wall design symbolizes the evolution of life and the birth of new Earth and Space Science from physics in the microscopic world. The floor is covered with Precambrian granite (2.2 billion years old). The wall design employs "stromatolite" formed by cyanobacteria (1.8 billion years old) and "wave-rippled sandstone" (1.2 billion years old). Let us listen to the sound of Precambrian waves.

Department of Earth and Space Science

Theoretical Astrophysics Group

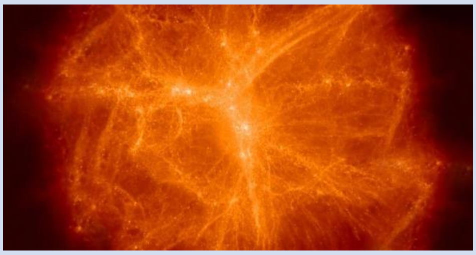
Members Kentaro NAGAMINE (Professor), TBD (Associate Professor), Shinsuke TAKASAO (Assistant Professor), Isaac SHLOSMAN (Visiting Guest Prof.), Luca BAIOTTI (Adjunct Associate Prof.)

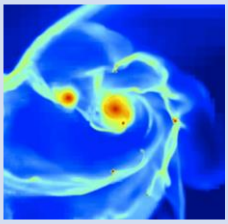
Home Page http://astro-osaka.jp/

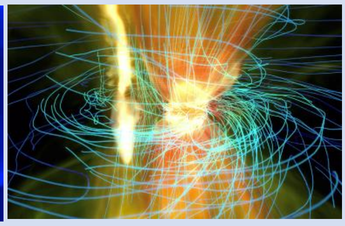
[Research Area]

1) Structure Formation and Cosmology (large scale structure in the Universe, intergalactic medium, galaxy formation, clusters of galaxies, cosmic magnetic fields)
2) Formation of Astrophysical Bodies (planets, stars, galaxies, black holes)
3) Astrophysical plasma, magneto-hydrodynamics, solar physics
4) Gravitational Wave Astronomy

It is widely believed that our Universe was born about 14 billion years ago in Big Bang. As the Universe expanded and cooled, various forms of matter were created, and the structures such as stars and galaxies emerged. Various astrophysical phenomena in extreme conditions take place, such as galaxy formation, supernova explosions, black hole formation, gravitational wave emission, and gamma-ray bursts. We employ multiple research methods, from fundamental theory, astrophysical models, computer simulations, to data analyses. The main objective of our research is to understand various astrophysical processes that took place during the course of cosmic evolution.







Department of Earth and Space Science

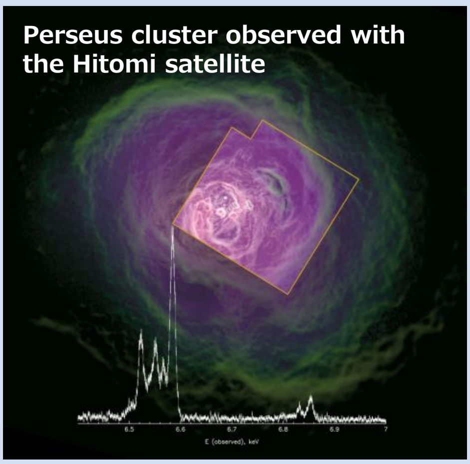
X-ray Astronomy Group

Members Hironori MATSUMOTO(Professor), Kiyoshi HAYASHIDA(Associate Professor), Hirofumi NODA(Assistant Professor)

Home Page http://www.ess.sci.osaka-u.ac.jp/english/english/3_research/

[Research Area]

1) Observational study of high-energy phenomena in the universe
3) Developments of instruments for X-ray astronomy



High-energy phenomena can be seen everywhere in the universe. For example, a star explodes as a supernova at the end of its life, and leaves hot gas of a temperature of a few tens of millions of Kelvins. The hot gas is called a supernova remnant, and it is luminous in X-rays. Black holes and neutron stars are thought to be born in supernovae. The gravity of these compact objects is extremely strong, and they can emit X-rays when they accrete gas. Almost all galaxies harbor a gigantic black hole at their centers. Some of them accrete interstellar gas and emit X-rays as active galactic nuclei. Clusters of galaxies, the largest gravitationally bounded system in the universe, I filled with hot gas, and they can be observed through X-rays.

We are performing X-ray observations of the hot universe using X-ray astronomical satellites in the world such as Suzaku, Hitomi, MAXI, Chandra, XMM-Newton, and so on. We are also developing new X-ray instruments for future applications such as X-ray CCD, multi-image X-ray interferometer, and X-ray mirror.

Department of Earth and Space Science

Planetary Science Group

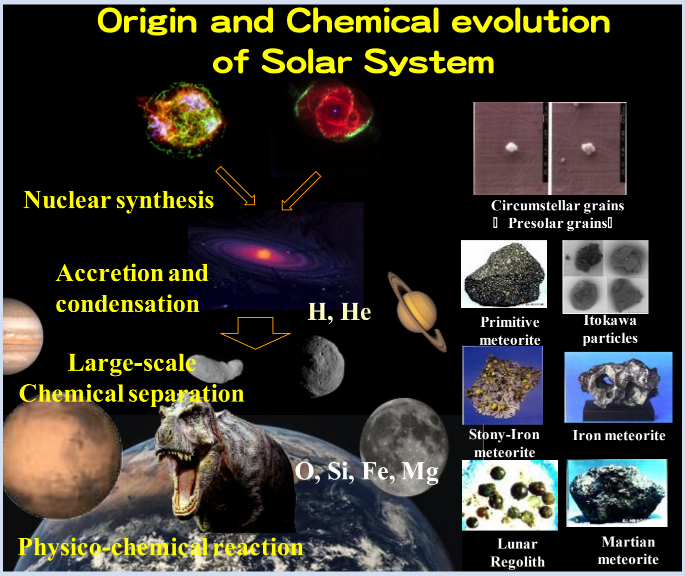
Members Kentaro TERADA(Professor), Chiaki UYEDA(Associate Professor), Chihiro YAMANAKA (Associate Professor), Shoichiro YOKOTA(Associate Professor), Yosuke KAWAI(Assistant Professor)

Home Pages http://planet.ess.sci.osaka-u.ac.jp

［Research Area］

1） Origin and evolution of the Solar System.
2） The magnetic properties of magnetic & weak magnetic planetary materials.
3） Observation of the planetary environment by the laser spectrometry
4） Plasma measurements around planets and moons.
5） Development of the technique/instrument for a new frontier of planetary science.

To decipher the history of the Solar System, we focus on the origin, evolution and current environment of our solar system based on various experimental approaches. Mainly, we carry out precise isotopic analyses from hydrogen to uranium in Apollo samples, other various meteorites and circum-stellar dusts. We also conduct in-situ plasma observation including mass analyses by spacecraft to study the environments around planets and moons. The three-dimensional non-destructive analysis using "muon" is developed for the planetary science.



Department of Earth and Space Science

Earth and Planetary Materials Science Group

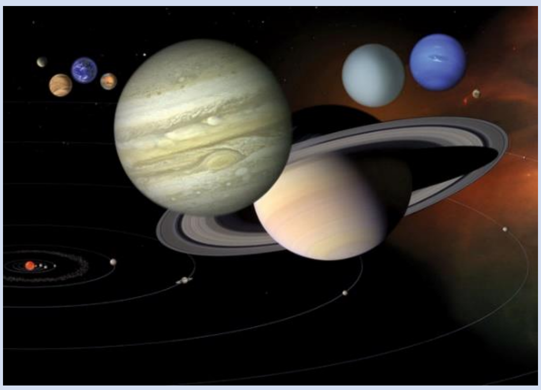
Members Sho SASAKI (Professor), Osamu OHTAKA (Associate Professor), Kazuto SAIKI (Associate Professor), Jun KIMURA (Assistant Professor)

Home Page http://www.astroboy-jp.com/

[Research Area]

1) Formation and evolution processes of solid planets, satellites, and solar system small bodies.
2) Phase transitions and physical properties of the Earth's deep interior (Ultra-high pressure experiments using synchrotron radiation on the Earth's interior materials and their simulants).
3) Developments of apparatus and techniques (e.g., in-situ observations under high pressure, hyperspectral imager, three-dimensional image analysis and space weathering apparatus, etc.).
4) Dynamic process for geologic activity on planetary bodies.
5) Material sciences and instrument developments in space missions (e.g., HAYABUSA-2, SLIM, MMX, JUICE).

The Earth, planets, satellites and other objects in the Solar System have wide varieties in surface environments and interior structures. Differentiation of materials along with planetary thermal evolution played a crucial role in the present state of these solar system bodies. Using spacecrafts and ground observations, theoretical simulations and experimental methods, we investigate the origin and evolution of various solar system bodies from dust particle to planets.



Department of Earth and Space Science

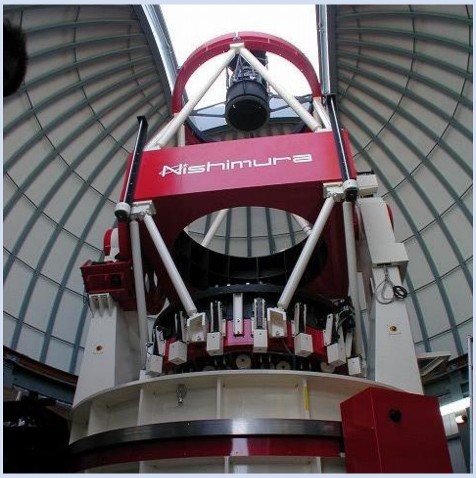
Infrared Astronomy Group

Members Takahiro SUMI (Professor), Kento MASUDA (Assistant Professor)
Daisuke Suzuki (Assistant Professor)

Home Page http://www-ir.ess.sci.osaka-u.ac.jp/index_e.html

[Research Area]

1)Observational study of Exoplanets
2)Astrobiology
3)Observation of gravitational wave event
4)Galactic structure and dark matter



We study various astrophysical phenomena by using ground and space telescopes in infrared and develop related instruments. Especially, we focus on the formation of exoplanets and aim to find a bio-signature in exoplanets in future. We also conduct optical follow-up observations of gravitational wave events, studies of the Galactic structure and dark matter.

We search for exoplanets by using the 1.8m MOA-II telescope with the gravitational microlensing technic. We also construct the 1.8m telescope in South Africa to conduct the microlensing exoplanet search in infrared. We are exploring Earth-mass exoplanets. We are planning to join to NASA's WFIRST mission to carry out the space microlensing exoplanet search. We are also studing the observational plan to detect the biosignature in exoplanets for future space missions.

Department of Earth and Space Science

Theoretical Condensed-Matter Physics Group

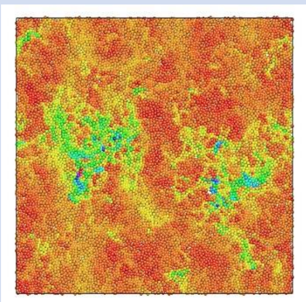
Members Takahiro HATANO (Professor),
Satoshi YUKAWA(Associate Professor), Kazushi AOYAMA(Assistant Professor)

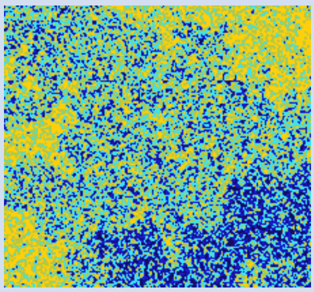
Home Page http://noneq.ess.sci.osaka-u.ac.jp/

[Research Area]

1) Physics of friction, fracture, and earthquakes: Time series analyses and statistical aspects of fracture and its potential applicability for earthquake forecast. Mechanical models for fracture and earthquakes. Physics of friction across the scales.
2) Dynamics of nonequilibrium phenomena in earth and planetary sciences: Heat conduction, spin flux, granular flow, etc. Phenomena where fluxes, diffusion, and phase transitions are interrelated. Such phenomena are investigated from the viewpoint of nonequilibrium statistical mechanics.
3) Statistical physics of frustrated spin systems: Ordering and defects in pyrochlore and triangular lattices.

We study dynamics, statistics, and their universality in various natural phenomena on the Earth and planets as well as in condensed matter, brazing a new trail in "cooperative phenomena in many-body systems". Our approaches are based on statistical mechanics (either equilibrium or nonequilibrium), nonlinear dynamics, stochastic processes, and computational physics.





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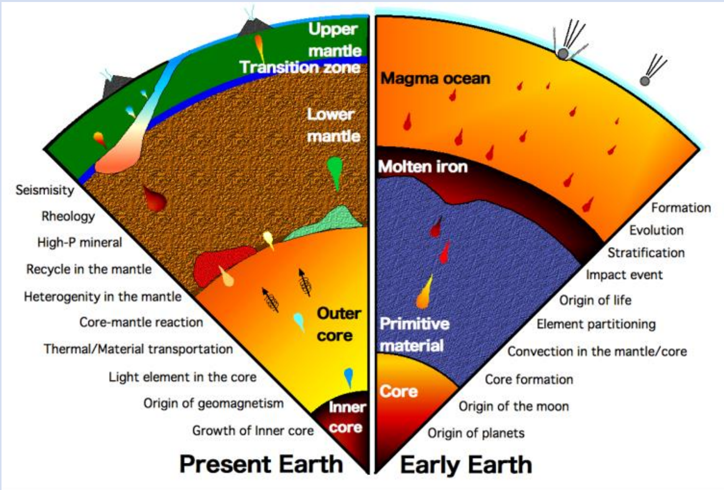
High-pressure Material Physics Group

Members Tadashi KONDO (Professor), Toshifumi TANIGUCHI (Associate Professor), Tatsuhiro SAKAIYA(Assistant Professor)

Home Page http://anvil.ess.sci.osaka-u.ac.jp/intro/English/index.html

[Research Area]
1) Phase transition and mineral physics in the mantle.
2) Formation, light elements, physical properties of the core.
3) Early Earth & planets, satellite and their evolution.
4) In-situ observation under High P-T condition.
5) Development of High P-T generation & measuring.

Our research interests are in the change of materials under ultra-high pressure and high/low temperature corresponding to the planetary interiors. Most materials change their physical and chemical properties drastically in such extreme conditions. For example, crystal structure, density, elastic properties, electrical and magnetic properties, bonding nature and chemical reaction with coexisting phase are important clues for the geophysical modeling and understanding the evolution of the planets. We generate various P-T fields in the laboratory by using various techniques of high-pressure generation (both static and dynamic), with various in-situ observations and recovery analysis. Through these laboratory-based experiments, we aim to understand comprehensively planetary system and components from the point of view of material science.



Interesting issues in the present Earth and early Earth

Department of Earth and Space Science

Soft Matter Earth & Planetary Science Group

Members Hiroaki KATSURAGI (Professor), Osamu HISATOMI (Associate Professor), Tetsuro HIRONO (Associate Professor),Makoto KATSURA (Assistant Professor), Noriko NAKAYAMA (Assistant Professor)

Home Page http://life.ess.sci.osaka-u.ac.jp/

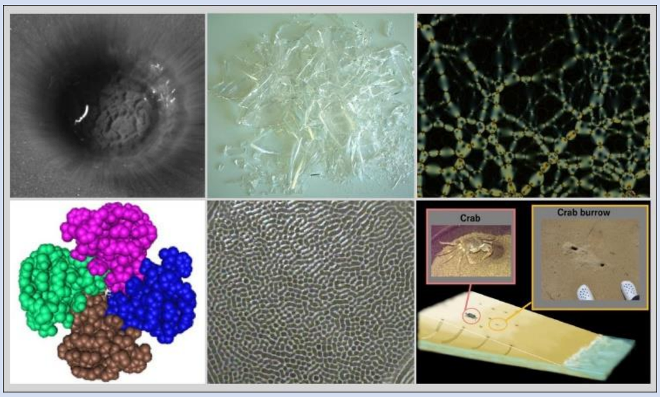
[**Research Area**]

1) Physics of granular matter and its geophysical application (impact, fracturing, pattern formation etc.)

2) Biophysics

3) Material sciences of earthquakes and faults

4) Measurement methods for soft matter characterization and environmental study



Various complex phenomena occurring on the surface of the Earth and planetary bodies result from the complicated combinations of material behaviors such as fluidization, solidification, and self organization. We are striving to reveal the fundamental processes governing these natural complex phenomena. Examples include, planetary surface terrain, origin of life, earthquake rupture dynamics. Development of the measurement techniques and experimental apparatus for various soft materials is also investigated in this group.

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Laser Astrophysics Group (Institute of Laser Engineering)

Members Mitsuo NAKAI（Professor）, Youichi SAKAWA (Associate Professor)

Home Page https://www.ile.osaka-u.ac.jp/research/lap/home_e.html

[Research Area]

1) Astrophysical (collisionless) shock and particle acceleration (cosmic ray acceleration)
2) Relativistic plasma physics
3) Explore the frontier of nuclear science with ultra-intense lasers

Astrophysics studies the variety of astrophysical phenomena using the physics knowledge experimentally obtained on Earth. Since most of the astrophysical phenomena are in the non-equilibrium / multi-hierarchy complex systems and occur under extremely high-energy-density environments, such phenomena have never been accessible in the laboratories before.

By realizing extremely high temperatures, densities, and intense fields in national and international laser facilities through international collaboration, we mimic the conditions of astrophysical phenomena to understand the underlying physics.

High-energy GEKKO XII (right) and ultrahigh-intensity LFEX (left) laser systems at ILE, Osaka University.