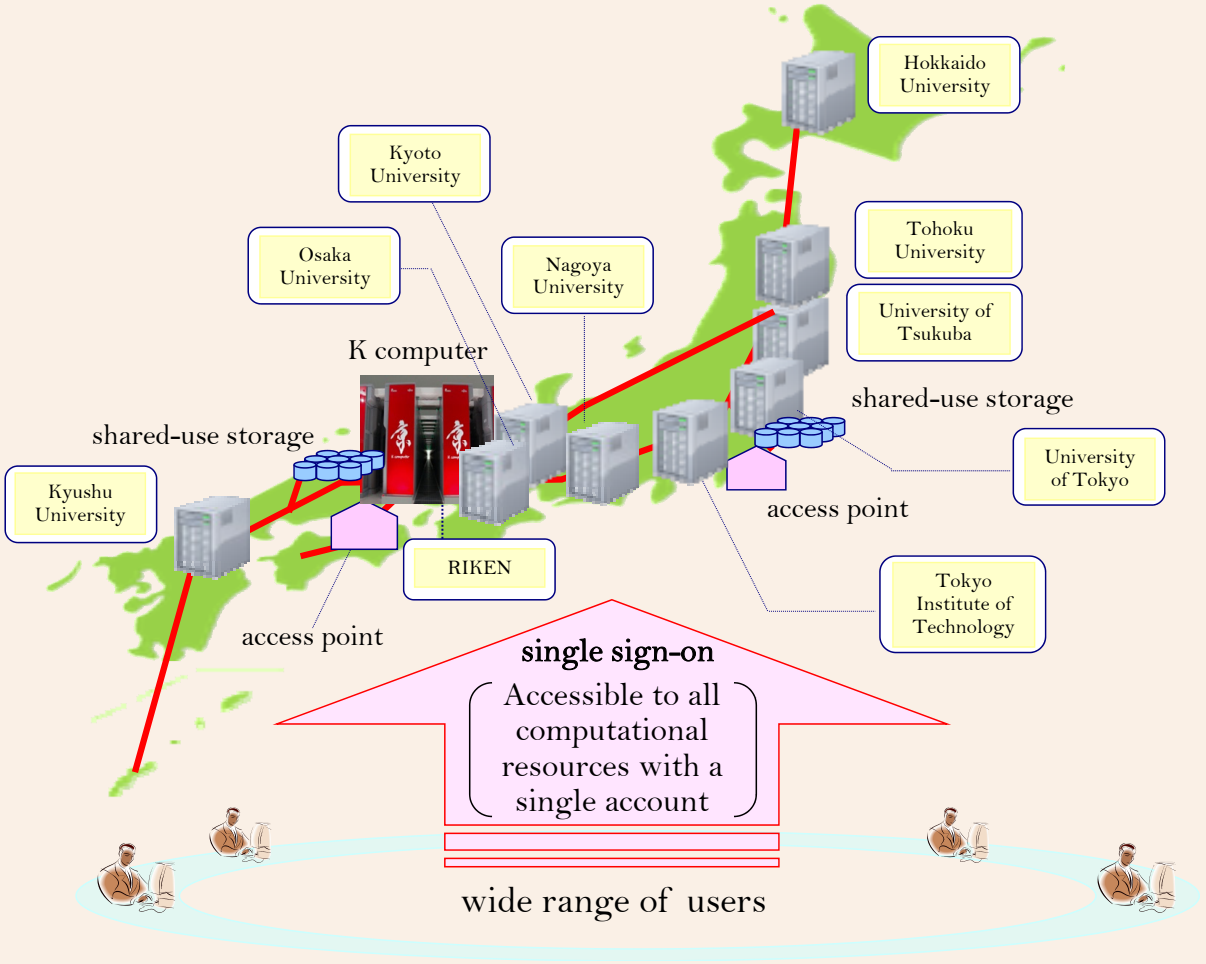
Figure 2-3-5/ Image of Innovative High-performance Computing Infrastructure (HPCI)



Source: Created by MEXT

Column 2-5

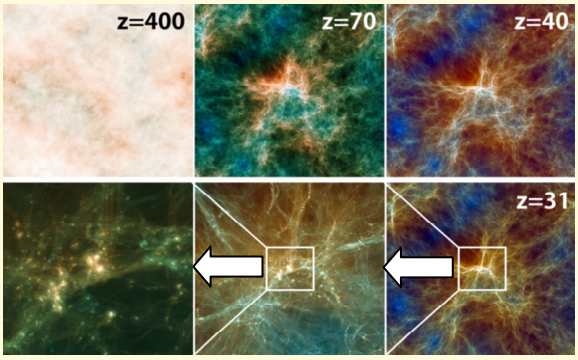
Computation results of the gravitational evolution of dark matter by the K computer awarded Gordon Bell Prizes

At a supercomputer conference in the U.S (SC11) held by the Association for Computing Machinery (ACM) in November 2012, "Simulations of gravitational evolution of two trillions dark matter particles in the early Universe" were reported by a team of Tsukuba University, RIKEN, and Tokyo Institute of Technology; the team was awarded the Gordon Bell Prize, the most prestigious prize in the area of simulations making full use of super computers. It was a splendid achievement as a team from Japan received the award two years in a row.

The group received the award because it performed extremely large simulations with an unprecedentedly high level of efficiency[1]. This is the result of a high evaluation in regard to the effective performance and practical value of the K computer, which has the world's best performance.

Dark matter[2] exists in the Universe at a rate as much as five times that of matter we can usually observe. To reveal the process of the formation of the Universe, it is necessary to understand the gravitational evolution of the dark matter particles. However, if previous computers were used for the simulation of several trillion of dark matter particles, it would take an unrealistic period of time. In this research, the group successfully performed the simulation in only about three days by operating a massively parallel application[3] developed through the TreePM method, an algorithm used to calculate the gravitational interactions among particles at high speed; this was done on the K computer, which realizes super high parallel computing with more than 80,000 CPU and has 10 PFLPS (10^{16} operations per second) (the world's best-class calculation performance). It would take several hundreds of years if a personal computer were used.

As a result, the microstructure of dark matter that exists in various galaxies and its growth process became possible to understand with unprecedented precision. This research contributed to the improvement of dark matter observation methods and to the understanding of dark matter. Also, the creation of innovative scientific research results is expected to shed light on the process of the formation of the Universe's various structures, such as the formation of stars and galaxies.



Note: The brightness shows the space density of dark matters. The bright area has high density. "z" is an index for time and distance used in astronomy. The greater the "z" is, the earlier the universe is. Dark matters concentrate via gravity as the time past since the creation of the universe and form a large structure. (z=400, about two million years after the creation of the universe. z=31, about 100 million years after the creation of the universe (about 13.6 billion years before)

Source: Distribution of dark maters density in the early Universe
Courtesy of University of Tsukuba

4) R&D of nuclear power and fusion

Regarding the R&D of nuclear power, and as a result of the Accident at TEPCO Fukushima Daiichi Nuclear Power Station, efforts were made on R&D and human resources development in order to support

1 The Argonne National Laboratory group of U.S. performed a similar dark matter simulation on Sequoia which has twice as high computational performance (theoretical peak performance 20Pflops) than that of K computer. Tsukuba group was highly evaluated since the calculation speed per one particle is 2.4 times faster than that by the USA group and the group developed extremely advanced application to compute the extremely large simulations as fast as possible.
2 Dark matter particles constitute about 20 % of matter energy and interact via gravity only. The nature of dark matter
3 Massively parallel application is an application program that can run efficiently on a massively parallel computer.

the safety of nuclear power and to aid in the recovery from the nuclear power plant disaster that occurred in FY 2012.

Regarding FBR cycle technologies, efforts were made to focus on the further improvement of safety and on the maintenance and management of facilities while also considering the direction of the discussions about the review of Japan's nuclear power policies. Also, necessary efforts were made for the R&D of nuclear fusion. Furthermore, the R&D of technologies related to nuclear nonproliferation and nuclear security were also improved. (refer to 1(1) in Part 2 Chapter 2 Section 2 for FBR technologies, refer to 2(2) in Part 2 Chapter 3 Section 3 for technologies on nuclear nonproliferation and nuclear security).

5) Promotion of R&D in regard to information security

The policy entitled "Information Security 2012" (July 2012) was developed at the "National Information Security Policy Council" (chairman: chief cabinet secretary) and was established to promote information security measures by the consolidation of cross-sectional, public-private sectors. The council's project committee developed the "Roadmap for Information Security R&D Strategy" (June 2012, Strategic Technology Project Committee) and the "Immediate Issues for FY 2012 and onward based on the Program for the Development of Human Resources for Information Security" (May 2012, Spreading and Human Resource Development Project Committee), and now promotes the R&D of technologies on active and highly reliable (dependable) information security as well as promoting the development of human resources who will lead R&D in the field of information security.

Based on the information security R&D strategy 2012, and in cooperation with other nations, MIC established an international network to gather intelligence on cyber attacks and malwares[1] with help from both domestic and overseas Internet providers and universities, and MIC is now making efforts on R&D, as well as the verification of technologies that enable both the prediction of cyber attacks as well as a prompt response against cyber attacks when they do occur. Regarding cloud technology, which is useful for securing work continuity when disaster occurs, and because issues related to information security, such as information leakage have been pointed out, MIC is planning the promotion and expansion of this technology and making efforts to research, develop and verify a new information security technology that can prevent information leakage and other issues. METI conducts research to prevent damages related to information security by protecting against new threats and research to enhance the environment and allow people to use IT safely, and by taking actions such as the establishment of a cyber-security test bed[2] which is a security verification site for control systems.

6) Research on the development and upgrading of safety evaluation methods for offshore structures and on the environmental–impact-reduction method

The National Maritime Research Institute conducts the development and upgrading of safety evaluation methods for offshore structures and an environmental-impact-reduction method that is the basis of platform technologies for marine resources and energy development.

1 Malicious software that damages computers and users; for example, computer viruses, worms and spyware.
2 A facility that performs the evaluation and verification of security through simulated cyber attacks against an indispensable control system that controls equipment in a plant.

(2) Establishment of S&T platforms for the development of a new frontier

The government promotes both theoretical and experimental study, as well as R&D including observations and analyses, in order to establish a platform for the development of a new frontier of intelligence, such as the comprehensive understanding and elucidation of oceans, earth and space.

1) Promotion of R&D in maritime fields

Oceans are still a frontier for human beings because of their vast expanse and because of the difficulties in accessing them. Driven by an intellectual desire to understand the unknown, various surveys and research have been conducted on oceans. These efforts have resulted in the discovery of unused energies and mineral resources and in the oceans' involvement in changes to the earth's environment, such as climate change. Thus, it is necessary to seek and understand the theories on various ocean phenomena in order to solve the critical problems that have to do with the future of human beings, such as solutions to global environmental problems, responses to huge trench-type earthquakes, and the development of ocean resources.

(i) Research and development to understand meteorological phenomena in deep seafloor

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) conducts research and surveys focusing on the seas surrounding the Japanese archipelago and the entire Pacific Ocean, through the exploration of crustal structures by using research vessels, including the manned research submersible, "SHINKAI 6500," and unmanned research vehicles. The research and surveys are conducted to understand the mechanics of devastating meteorological phenomena such as massive earthquakes, volcano eruptions, and tsunamis that occur on the deep seafloor. In FY2012, JAMSTEC conducted a seafloor observation in the hypo-central region of an expected Tonankai earthquake using seismometers, and found that ultra low-frequency earthquakes are continually occurring at the boundary of the ocean plate and the continental plate near the trench axis. It was previously thought that the boundary would not generate earthquakes due to its weak anchoring. Also, JAMSETC conducted a geological survey, a rock sample collection, hot water exploration, and the measurement of terrestrial heat flow by using the remotely operated vehicle, "HYPER-DOLPHIN" at the sea-floor volcano located south of Izu Oshima (Omuro-dashi), and found that Omuro-dashi is an active, rhyolitic volcano.

(ii) Development of ocean resource survey and exploration technology

MEXT conducts the development of advanced and fundamental technology required to perform observations and surveys of ocean resources and uses the developed technology for surveys and research. Under the "Ocean-resource Use Promotion Technology Development Program," MEXT has been developing technologies such as sensors since FY 2008 in order to more efficiently and accurately understand the amount of available ocean mineral resources located over a wide area; this is also done by utilizing the knowledge gained by universities. In FY 2012, MEXT started a field test on the deep seafloor and has been verifying the practicality and effectiveness of actual exploration.

In order to conduct wide-area surveys of ocean resources, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has conducted performance evaluation tests of the autonomous underwater vehicles (AUV), "YUMEIRUKA," "JINBEI," and "OTOHIME;" all of these tests were done in the ocean

as opposed to in a laboratory setting. Also, JAMSTEC developed a new unmanned remote-operated vehicle (ROV) with the maximum operating depth of 7,000m. In FY2012, the survey using the AUV "URASHIMA" found the possible existence of a previously undiscovered area where hot water is spewing in at the North Knoll of the Iheya Ridge, Okinawa Trough; furthermore, they successfully scanned a surface image of the mud volcano containing methane hydrate that is located off of Tanegashima. JAMSTEC has also conducted a sampling survey in order to find the distribution of sediments, including rare-earths. The research and surveys were conducted in order to discover the components of ocean resources.

Newly developed autonomous underwater vehicle
Newly developed autonomous underwater vehicle "OTOHIMI," "JINBEI," and "YUMEIRUKA" (from left)
Courtesy of JAMSTEC

(iii) Development of interior-earth exploration technology

In order to understand the subsurface biosphere of microorganisms and the triggering mechanisms of ocean-trench earthquakes, JAMSTEC conducts the development of drilling technology using the deep-sea drilling vessel, "CHIKYU," and it also uses real-time observation technology consisting of an underwater cable network. Other research and surveys are also practically implemented by using those technologies. In FY 2012, JAMSTEC connected a long-term, borehole observatory with earthquake and tsunami observation and monitoring systems (DONET) that were deployed in Kumano, Nada, off of the Kii Peninsula, which is the expected hypo-central region of the Tonankai Earthquake; this was done in order to realize real-time observations of micro-crustal deformations. Also, under the Integrated Ocean Drilling Program (IODP), JAMSTEC conducted drilling surveys using "CHIKYU" in the hypo-central region of the 2011 Off-the-Pacific-Coast of Tohoku Earthquake. JAMSTEC also collected and analyzed geological samples of plate-boundary faults, and found that large-scale slippage could occur at the faults near the trench axis when they accumulate energy. This finding overturns the conventional theory. Furthermore, JAMSTEC has conducted drilling surveys off the coast of Hahinohe, Shimokita Peninsula, in order to understand the activities of subterranean microorganisms which involve the generation of natural gases and methane hydrate; geological samples from the beneath the seabed were also collected. The point at which the survey took place was the deepest depth ever achieved in scientific ocean drilling (2,466m below the seabed).

(iv) Development of technology to secure marine organism resources

Recently, it has become obvious that marine organisms are influenced by human activities, such as global warming, the environmental destruction of oceans, and overhunting. Therefore, research that contributes to the preservation of marine biodiversity and to the realization of the sustainable use of resources is increasingly important. To meet this requirement, MEXT conducts the Ocean Resource Use Promotion Technology Development Program, which includes R&D that can lead to innovative production by understanding the physiology of marine organisms, and R&D to comprehensively understand ecological systems. MEXT also conducts the R&D of observation/monitoring technology as