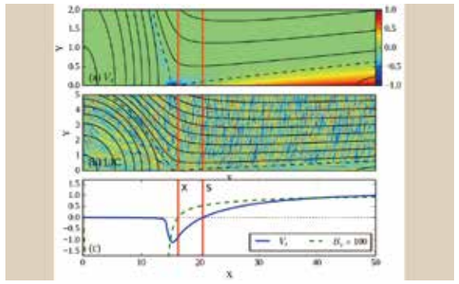
1st ISEE Award ceremony

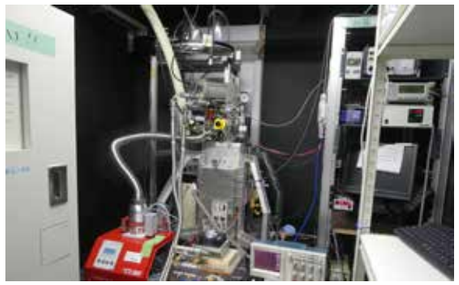


Computer simulation of non-steady Petschek-type reconnection (see p.25)

Group photograph at the inauguration of the SCT prototype on Jan 17, 2019 (Image credit: Deivid Ribeiro, Columbia University)

Radio telescope for IPS observations at Kiso

Aurora observation at Nain, Canada (September 11, 2018)



Millimeter-wave radiometer installed in Tromsø, Norway

A hydroclimatological study launched around the Rolwaling area of the Himalayas

Geologic field excursion at Mt. Apoi, Hokkaido – A window into the mantle

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Annual Report FY2018

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

FY2018

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

April 2018–March 2019

Foreword

The Institute for Space-Earth Environmental Research (ISEE), as a representative institute of Nagoya University, actively continues research and education. ISEE was established in October 2015 by merging three institutes of Nagoya University: the Solar Terrestrial Environment Laboratory, the Center for Hydrospheric Atmospheric Research, and the Center for Chronological Research. The mission of ISEE is to clarify the mechanisms and mutual relationships of the Earth, the Sun, and cosmic space, treating them as a seamless system, and to benefit humanity by resolving issues in the global environment and contributing to the advances of space exploration. To this end, ISEE has continued to promote the development of new science fields in cooperation with various related communities. Its role as the Joint Usage/Research Center is one of its most important tasks. As the Joint Usage/Research Center, we operate various programs for the International Joint Research, Workshop and Symposium, high-performance computing, database management, and chronological analysis. In FY 2018, we conducted the joint research programs of 208 titles.

As this year is in the middle of the third-phase medium term of Japanese national universities, we conducted external evaluations of all ISEE activities by inviting the following world-leading scientists as the External Review Committee members: Prof. Daniel Baker (University of Colorado), Dr. Nat Gopalswamy (NASA), Prof. Feng Sheng Hu (The University of Illinois at Urbana-Champaign), Dr. Teruyuki Nakajima (JAXA), and Prof. Tuneyoshi Kamae (The University of Tokyo & Stanford University). Through this review, the ISEE activities are highly evaluated as follows:

> It is a clear and deeply held view of the External Review Committee that ISEE is performing at a remarkable level. The Institute comprises committed individuals who are not only passionate in their individual roles but also highly collegial in what they do. The leadership of ISEE is effective and enlightened in all key respects. The Institute and its members are successfully pursuing a wide range of space science, geophysical, and astronomical research themes in a highly integrative fashion. It is the Committee's consensus view that ISEE—even now at the midway of its six-year nominal lifetime—has already achieved the objective of interdisciplinary research on an impressive scale with strong international dimensions. The individual divisions and programs are synergistic and the whole of ISEE is much greater than the sum of its parts. The scope of their endeavors in space and Earth sciences is exceptional for an academic institute, putting Japan in a strong position to compete in this broad research arena on the global stage.

In FY 2018, the mid-term evaluation of the Joint Usage/Research Centers by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) was also conducted, and ISEE received rank-A evaluation, as ISEE is expected to contribute to the related communities through the integrated research linking space science and Earth science.

We are actively working to promote international joint research, and in this year, we have invited 219 foreign researchers to conduct joint research and seminars. In particular, we organized the 1st ISEE International Symposium on "Recent Progress in Heliospheric Physics by Direct Measurements of Unexplored Space Plasmas" from February 25 to 29, 2019, at Nagoya University. The ISEE International Symposium is the frag-ship meeting of more than 50 scientific meetings convened by ISEE every year. In addition, the ISEE International Workshop program produces various new international joint papers and books through the collaboration and discussion of experts from all over the world for each scientific subject, and the ISEE International Joint Research Program led by established scientists from various countries successfully continues.

Aiming to develop space−earth environmental research, promoting interdisciplinary research, and exploring the new discipline of space−earth environmental research, we established the ISEE Award for a prominent research activity that is based on the ISEE Joint Research Program. The first ISEE Award was awarded to Professor Hisao Takahashi of the National Institute for Space Research (INPE), Brazil, for his great contribution to space−earth environmental research through studies of ionospheric disturbances in the equatorial region. The award ceremony and memorial lecture were held on February 27, 2019. We hope that the ISEE Award will further help the development of space−earth environmental research in the future.

ISEE is organized by basic research divisions comprising seven research groups and three centers: the Center for International Collaborative Research, the Center for Integrated Data Science, and the Center for Orbital and Suborbital Observation. ISEE is currently promoting four interdisciplinary research projects: the Project for Solar-Terrestrial Climate Research, the Project for Space–Earth Environmental Prediction, the Project for the Interaction of Neutral and Plasma Atmosphere, and the Project for Aerosol and Cloud Formation. These projects are being carried out in cooperation with the following nationwide collaborative research: “Project for Solar-Terrestrial Environment Prediction (PSTEP) (PI: Kanya Kusano), “Study of Dynamical Variation of Particles and Waves in the Inner Magnetosphere using Ground-based Network Observations (PWING) (PI: Kazuo Shiokawa), “Tropical Cyclones-Pacific Asian Research Campaign for Improvement of Intensity Estimations/Forecasts (T-PARCII) (PI: Kazuhisa Tsubkoki), and “Changing Climate and Resident-Environment in the Migrations and Expansions of Homo Sapiens across the Continent of Asia” (PI: Hiroyuki Kitagawa), which are supported by the Grant-in-Aid for Scientific Research program of MEXT.

ISEE strives to nurture young minds through new perspectives and integrated and international partnerships. In particular, ISEE cooperates with the Graduate School of Science, Graduate School of Engineering, and Graduate School of Environmental Studies of Nagoya University to offer a unique educational opportunity in which graduate students from the three graduate schools collaborate on research of mutual interest. Through ISEE, these students also participate in international research activities.

At ISEE, we are actively working on outreach programs to promote public awareness of our research and contribute to science education. In FY 2018, we held an open lecture and conducted an open laboratory at the University Festival (Meidai-Sai) in June. In September, we conducted a public lecture in cooperation with the Council for Research Institutes and Centers of Japanese National Universities. In addition, we organized an open seminar on "Internationalized Astronomy Research” in conjunction with the Graduate School of Science, a summer school for elementary-school students in the Tokai region to learn about the history of the Earth, as well as an open house at the Kiso Observatory. We gave a presentation at the Nagoya University Homecoming Day event in October, and cooperated with organizers in presenting the Science Festival for Young People in the city of Tarumizu, Kagoshima Prefecture (the location of ISEE Observatory) in December. We created a video to explain ISEE research for the ISEE homepage and YouTube viewing, and distributed postcards providing information about video access to ISEE research, as well as scientific booklets for high-school students in Aichi Prefecture.

Modern society is undergoing drastic changes and civilization is rapidly evolving in an unprecedented manner at a global scale. ISEE views the Sun, Earth, and space as a seamless system because it is crucial to understand the delicate balance and mechanisms of this system to sustain humanity and develop mankind spreading throughout the solar system. ISEE will, therefore, continue with its mission to help resolve global issues and advance space exploration. We hope that this annual report can help you understand the recent ISEE activities.

Kanya Kusano
Director

ISEE Award

The first award ceremony and memorial lecture was held on Feb.27, 2019.

Establishment of ISEE Award

Aiming to develop space-earth environmental research, promoting interdisciplinary research, and exploring the new discipline of space-earth environmental research, the ISEE is presenting an ISEE Award to a prominent research activity that is based on the ISEE Joint Research Program.

The first ISEE Award was given to Professor Hisao Takahashi of the National Institute for Space Research (INPE), Brazil, for his great contribution to space–earth environmental research through studies of ionospheric disturbances in the equatorial region. The award ceremony and memorial lecture was held as below.

Date: February 27, 2019, 16:00–17:30

Venue: ES hall of the ES building in the Nagoya University Higashiyama Campus

Title of the Award Lecture: Our Concern for Space Weather - Equatorial Ionospheric Plasma Bubbles

ISEE Award 2018

Winner : **Dr. Hisao Takahashi**

Professor of post-graduate course
INPE, Brazil

Title : **Contribution to Space-Earth Environmental Research through Studies of Generation and Development of Equatorial Ionospheric Plasma Bubble**

Citation: Dr. Takahashi has shown, for the first time, using GNSS data over South America that atmospheric waves launched from tropospheric convection are propagated to an altitude of 300 km, generating a wavy structure of the ionospheric plasma. He suggested that such waves can trigger plasma bubbles after sunset. During his visit to ISEE, Nagoya University, in 2016 as a visiting professor, he organized an international workshop and led a global discussion on the generation and development of plasma bubbles. The results of the workshop have been published in 13 scientific papers in a special issue of the international journal, Progress in Earth and Planetary Sciences.

Carrier of the winner: Dr. Takahashi received his Master of Science at Niigata University in 1970, and then received his PhD degree in INPE, Brazil, in 1980. Since then, he has been working at INPE as a research staff of Aeronomy Division, Head of Aeronomy Division, and General manager of Space weather Program of INPE. He has been carrying out measurements of Aurora and Airglow to study atmospheric waves and their impacts on the Earth's upper atmosphere.

Fig.1

Aircraft observation of supertyphoon Trami

Supertyphoon Trami caused a huge disaster over central Japan at the end of September 2018. The T-PARCII team performed an aircraft observation of Trami on September 25, when the storm was categorized as a supertyphoon. We penetrated the eye of Trami and made dropsonde observations successfully. The observation showed a central pressure of 918.8 hPa and the thermodynamic structure of the eye. The aircraft observation continued until September 28 and the time evolution of the storm was observed.

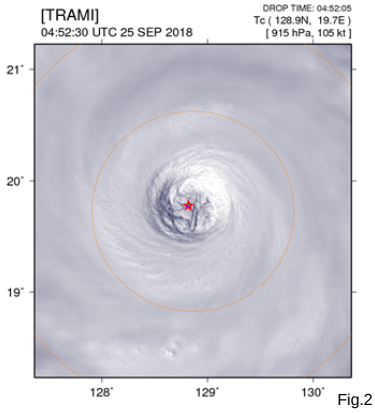

Fig.2

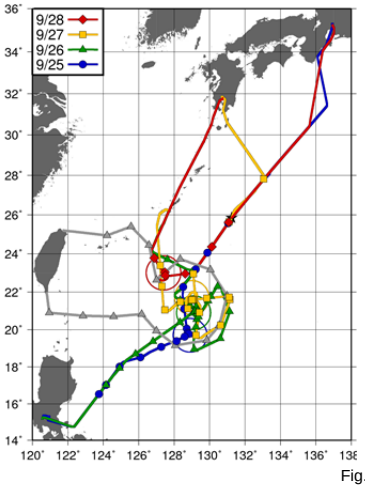

Fig.3

Since typhoon intensities are now estimated using satellite cloud images, there is a large uncertainty in the intensity data of a very intense typhoon, such as a supertyphoon. Accurate data and forecasts of typhoon intensity are very important for disaster prevention. The T-PARCII project aims to improve typhoon intensity estimations and forecasts. We performed aircraft observations of two supertyphoons in 2017 and 2018. The penetration observations provided accurate data of typhoon central pressure and thermodynamic structure of the typhoon's inner core. The assimilation of dropsonde data improved the track and intensity forecasts. In 2018, dropsonde data were successfully transmitted in real time to all forecast organizations in the world and contributed to operational forecast of a typhoon.

Fig. 1: Photograph of the eye of supertyphoon Trami from the aircraft at a height of 14 km on September 25, 2018: lower clouds and eye-wall cloud (Prof. H. Yamada of Univ. Ryukyus).
Fig. 2: Visible satellite image of Trami and dropsonde launching point on September 25, 2018.
Fig. 3: Flight passes of the aircraft observation during September 25–28, 2018. The gray line indicates the flight pass of Taiwan DOTSTAR. The circles indicate the position of the storm core.

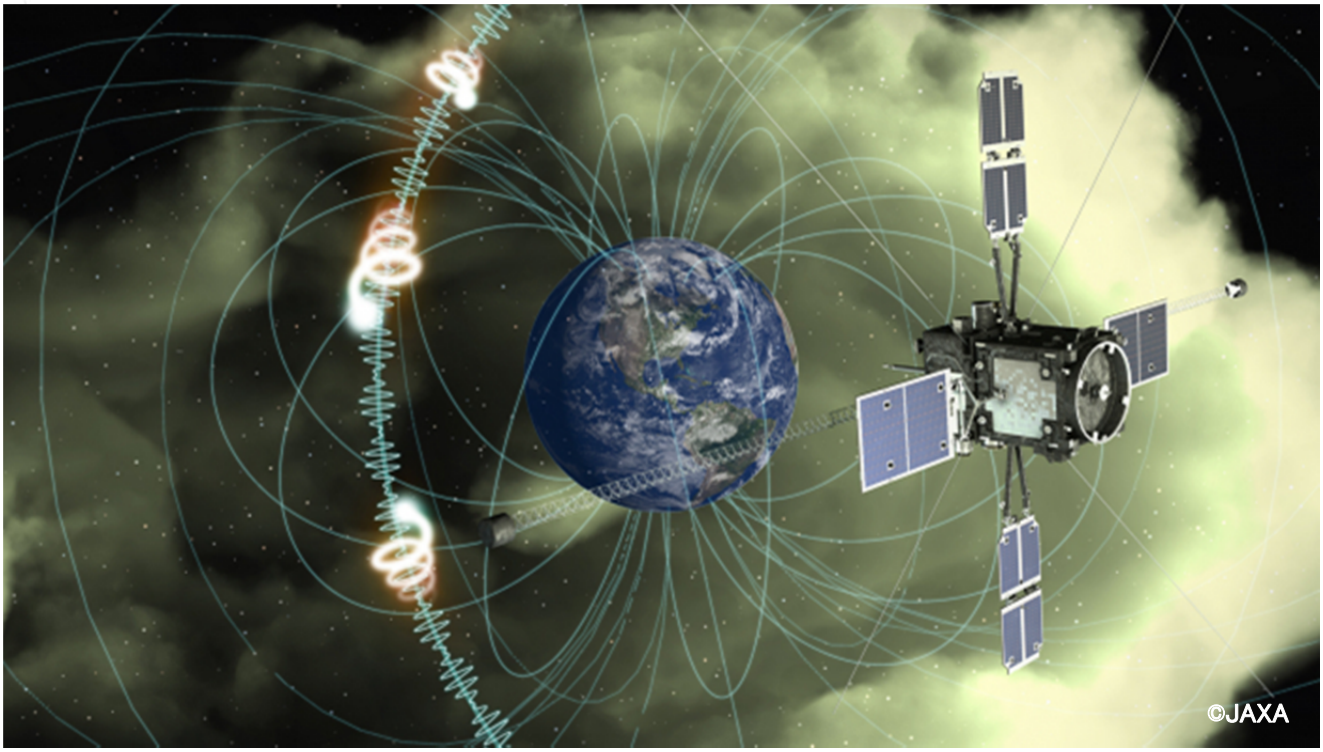

Fig.1

Direct observations of energetic electron accelerations by chorus waves

Dr. Satoshi Kurita and Prof. Yoshizumi Miyoshi of CIDAS and colleagues have analyzed the plasma waves and electron data from the Arase satellite and identified a rapid acceleration of energetic electrons by chorus waves.

Cross-energy coupling is a key concept for understanding the dynamical evolutions of the geospace, where plasma/particles with different energy ranges interact each other through wave−particle interactions. Accelerations of energetic electrons by plasma waves are one of the key processes in cross-energy coupling. Although it had been supposed that the day-order time scale is necessary to accelerate electrons, the new observations from Arase showed tens of keV of electron accelerations within 30 s after the enhancement of chorus waves, which is much shorter than that predicted in the traditional diffusion theory. This result was published in Geophysical Research Letters, American Geophysical Union. This study uses the data files and analysis software distributed by the ERG-Science Center, operated by ISAS/JAXA and ISEE.

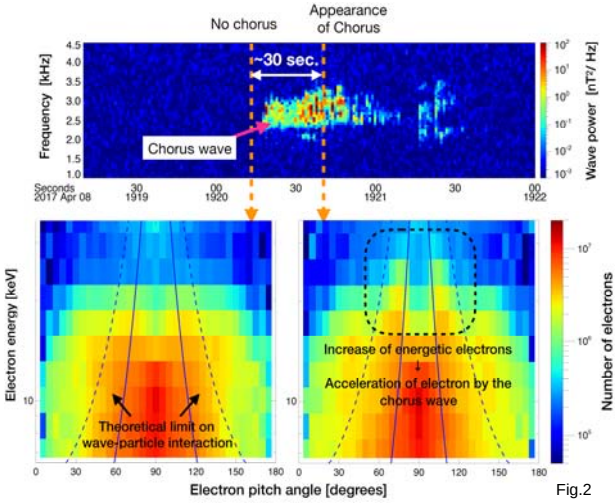

Fig.2

Fig.1: Arase satellite in Geospace.
Fig.2: Frequency-time diagram of chorus waves observed by Arase. (b) Energy spectrum of energetic electrons just before enhancements of chorus waves. (c) Same as (b) but after enhancements of chorus waves. Horizontal axis is the pitch angle, and the vertical axis is energy.

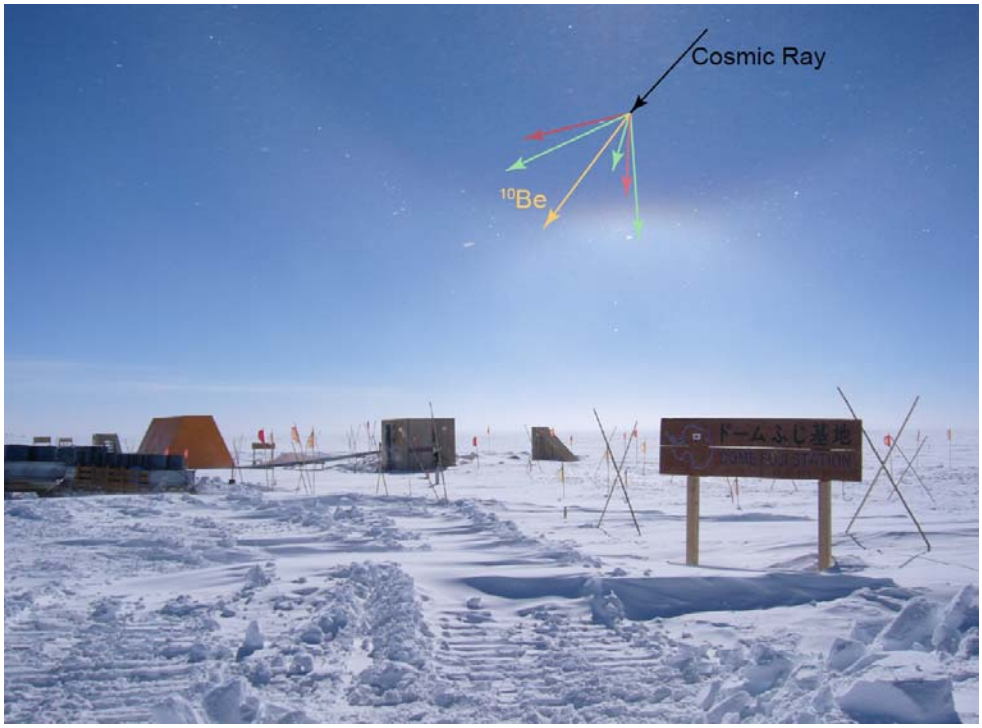

Fig.1

Origin of cosmic ray event confirmed by ^{10}Be analysis of ice cores

Miyake et al. analyzed ^{10}Be concentrations in the Antarctic Dome Fuji ice core with a high time resolution and showed that the origin of the cosmic ray event in 994 CE is consistent with an extreme Solar Proton Event (SPE). A signature of an extreme SPE, whose scale far exceeds the historically recorded events, was found in 775 CE; therefore, it is possible that such extreme SPEs occurred several times in the past.

A sudden increase in cosmic ray intensity was discovered in 993–994 CE from ^{14}C analyses of tree rings; however, its origin was not identified. It is important to analyze multiple cosmogenic nuclides such as ^{14}C and ^{10}Be to determine the origin of the event. We obtained quasi-annual ^{10}Be concentrations in Southern Hemisphere ice core for the first time and detected a ^{10}Be increase similar to that observed in the Northern Hemisphere (Greenland). This result supports a solar proton origin and indicates the occurrence of extremely large-scale SPEs at ~993–994 CE. We also proposed a method for detecting cosmic ray signals using Na ion data of the same ice core. It is expected that this will lead to a further search for cosmic ray events using ^{10}Be on a scale of hundreds of thousands of years in the future.

Fig.2

Fig.1 : Dome Fuji station and an image of ^{10}Be production through an interaction between a cosmic ray and an atmospheric atom (Picture taken by Prof. Motoyama).
Fig.2: Ice core sample used for the analysis.

Paper information
Journal： Geophysical Research Letters, Vol.46(1), 11-18
Authors： F. Miyake, K. Horiuchi, Y. Motizuki, Y. Nakai, K. Takahashi, K. Masuda, H. Motoyama, and H. Matsuzaki
Title：^{10}Be signature of the cosmic ray event in the 10th century CE in both hemispheres, as confirmed by quasi-annual ^{10}Be data from the Antarctic Dome Fuji ice core
DOI： 10.1029/2018GL080475

Fig.1

Rarefaction of the solar wind associated with weakening of solar activity

The current solar cycle (Cycle 24) is the weakest in 100 years. From long-term observations of interplanetary scintillation conducted at ISEE, Nagoya University, it has been revealed that the solar wind emanating from the Sun is significantly rarefied in Cycle 24.

Radio sources with a compact apparent size undergo “twinkling” by scattering of the solar wind plasma. This phenomenon is called interplanetary scintillation (IPS) and is used as a ground-based method for observing the solar wind. The division for heliospheric research of ISEE has been conducting multi-station IPS observations since 1980s using large radiotelescopes developed by them. The global properties of the solar wind and its response to solar activities have been investigated, being based on the IPS data. As a result, the occurrence of a rarefied solar wind is found to significantly increase in association with the weakening of the recent solar activity. This tendency is observed prominently for the slow solar wind with a speed of less than 350 km/s. The solar wind is known to consist of a fast stream with a low density and a slow stream with a high density. The fact revealed from the IPS observations suggests violation of this relation. While the cause for rarefaction of the slow solar wind by weakening of the solar activity remains an open question, it is considered to provide a clue to elucidate the unsettled mechanism of the solar wind formation.

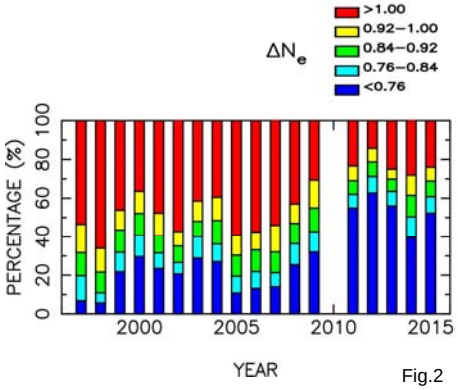

Fig.2

Fig.1 : Radiotelescope dedicated for IPS observations at Toyokawa (SWIFT).
Fig.2 : Percentage bar graph of the density occurrence of the solar wind at a speed of <350 km/s. Blue and red areas denote occurrence rates of low and high densities, respectively. As shown here, the occurrence rates of the low density have increased recently (cited from Tokumaru et al., 2018).

Paper information
Journal： Journal of Geophysical Research – Space Physics, Vol. 123, 2520-2534
Authors： M. Tokumaru, T. Shimoyama, K. Fujiki, and K. Hakamada
Title： Rarefaction of the very-slow (<350 km/s) solar wind in Cycle 24 compared with Cycle 23
DOI： 10.1002/2017ja025014

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