

〔 電気情報工学科 〕

〔区 分 A〕

香川 福有

Fault Detection from Bend Test Images of Welding Using Faster R-CNN

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Lecture Notes on Data Engineering and Communications Technologies, vol 118. Springer, pp190-200, (2022. 3)

The human visual inspection to find defects from welding joints is very tough. The examiners have to inspect many bend test fragments carefully. The present study aims to build an automatic detection system capable of finding cracks from bend test fragments. This paper describes the automatic detection method employing Faster R-CNN to detect crack regions. First, we introduce our achievement and explain the focused issue. Second, the structure of the proposed Faster R-CNN is explained, and then the present paper shows the experiment of automatic detection using web-camera working in real-time. Finally, conclusions and future works are discussed.

香川 福有

Evaluation for Angular Distortion of Welding Plate

Shigeru Kato*1, Shunsaku Kume*2, Takanori Hino*3, Fujioka Shota*4, Tomomichi Kagawa*1, Hironori Kumeno*5, Hajime Nobuhara*6

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Lecture Notes in Networks and Systems 294(1), Springer, pp344-354, (2021. 9)

Welding is essential in our life. It is crucial to nurture welding skills in Japan nowadays. The experts have to evaluate the many beginners' welding. Since the experts' burden is critical, a computational assistant for evaluating beginners' welding is required. This paper describes a simple evaluation system of welding plates by beginners. The authors considered four types of beginners' typical defects: lack of welding metal, linear misalignment, welding metal unevenness, and angular distortion. To capture these defects simultaneously, the authors propose an original equipment to photograph the welding plates. The computer extracts only the part of the welding plate using color markers. CNN (Convolutional Neural Network) evaluates the defects. As a first step, the authors addressed evaluating only angular distortion. The angular distortion is one of the typical failures by beginners. In the experiment, the authors conducted the validation of CNN. In the conclusion part, we discuss the experimental result

and future works.

KATO Katsumi

Breakdown Characteristics of Cone-type ϵ -FGM Spacer for Gas Insulated Switchgears

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電気学会論文誌 A, Vol.141, No.10, pp546-551, (2021.10)

Gas insulated switchgears (GIS) are required to be downsized for the cost reduction, global warming mitigation and energy saving. For the downsizing of GIS, a novel electric field grading technique is highly expected. In order to solve this problem, we have been investigating the electric field control and relaxation technique by “functionally graded materials (FGM)” with spatial distribution of permittivity (ϵ -FGM) and/or conductivity (σ -FGM). In our previous works, post-type and truncated cone-type ϵ -FGM spacers were fabricated by “flexible mixture casting method” (FMC method). Compared with the conventional spacers (Uniform spacer) with a uniform permittivity distribution, the electric field grading effects of those ϵ -FGM spacers were simulated based on Volume-Time theory and verified by the measurement of their breakdown voltages.

In this paper, toward the application of ϵ -FGM to the actual GIS spacer, i.e. 30% reduction of spacer diameter or 50% reduction of cross section, we fabricated the 1/4-sized cone-type ϵ -FGM spacer. By grading the mixing ratio of SrTiO_3 ($\epsilon_r=332$) and SiO_2 ($\epsilon_r=4$) fillers in epoxy resin, a cone-type spacer with the diameter of 60 mm was fabricated by FMC method. The breakdown voltage of the ϵ -FGM spacer was measured in a tank filled with SF_6 gas at 0.5 MPa-abs under the negative standard lightning impulse voltage by the step-up method. The maximum breakdown voltage of ϵ -FGM spacer was verified to be higher by 23% than the Uniform spacer with the same configuration and size of the ϵ -FGM spacer, which was also consistent with the simulated value.

KATO Katsumi

Electric Field Simulation of Permittivity and Conductivity Graded Materials (ϵ/σ -FGM) for HVDC GIS Spacers

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IEEE Transactions on Dielectrics and Electrical Insulation, Vol.28, No.2, pp736-744, (2021.4)

This paper discusses the application of the novel technology - functionally graded material (FGM) which combines both spatial permittivity (ϵ) and conductivity (σ) distributions with the aim to control the electric field around DC-GIS spacer. Some distribution types of ϵ and/or σ in the spacer bulk, such as U-type and graded to higher conductivity (GHC) are investigated through electric field simulation, in comparison to the uniform spacer with constant ϵ and σ distributions. The electric field relaxation effect of each distribution type of ϵ/σ -FGM under DC steady state, DC polarity reversal, DC-on, and lightning impulse voltage superimposed on DC steady state condition are obtained. The results show that ϵ/σ -FGM with U-type permittivity and GHC-type conductivity distribution of which low σ is applied near the high voltage side of

the DC-GIS spacer is the most effective in reducing the maximum electric field under all stated conditions.

Shigeru Kato

Fault Detection from Bend Test Images of Welding Using Faster R-CNN

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Shigeru Kato

Crack Detection from Weld Bend Test Images Using R-CNN

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Lecture Notes in Networks and Systems, vol 343. Springer, pp289-298, (2021.10)

The personnel burden is an issue with the visual inspection of welding defects that occur in bend test fragments. This study aims to construct an automatic evaluation system for welding defects that occur in bend test fragments. This paper describes the automatic detection of defective areas from bend test fragments using R-CNN. First, we have described the structure of the proposed R-CNN, followed by the experiments for evaluating R-CNN and their results. Finally, we have provided a conclusion and discussed future issues.

Shigeru Kato

Evaluation for Angular Distortion of Welding Plate

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若林 誠

オンライン型モノづくり講座の実践と協同ミッション：缶サットからモデル CubeSat 製作まで

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 工学教育、第 69 巻 6 号、pp153-158、(2021.12)

Online manufacturing seminars present an attractive means for engineering education. As part of our space engineering education program, an online CanSat production course has been improved annually since 2018. In 2020, we challenged ourselves to have an online production seminar using a more advanced model as “model CubeSat”, which more closely approximates a real spacecraft. While the model CubeSat production course was previously conducted at an in-person training camp, the CanSat and model CubeSat teaching materials in 2020 were enhanced via online instructions. In the seminar, we encouraged students to work on collaborative missions across remote locations. Based on responses to a questionnaire on the production course, we report on the status of teaching material development and course management from CanSat to model CubeSat production.

IMAI Masafumi

Analysis of Whistler-Mode and Z-Mode Emission in the Juno Primary Mission

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Journal of Geophysical Research: Space Physics, 126, e2021JA029885, (2021.11)

At the end of the Juno primary mission, we report observations of whistler mode chorus and Z-mode emission. The Juno orbits are evolving and much better coverage of the whistler mode chorus source region has resulted since the earlier surveys. Bursty chorus emission extending to $\sim 30^\circ$ latitude and to frequencies less than the lower hybrid frequency near the source region imply

high electron energies (>100 keV). Average chorus intensity levels peak at $\sim 10^{-3}$ nT² near M-shell of 8-9 and magnetic latitude of $\sim 5^\circ$. Z-mode emission is identified at higher latitudes generally near and inward of the Io torus with intensity levels as much as two orders of magnitude higher than Z-mode emissions observed at Saturn. Inferred source regions for the Z-mode are consistent with the inner edge of the Io torus and with auroral field lines that may also support Jovian kilometric and decametric emission. Parametric fitting functions are evaluated for both whistler mode chorus and Z-mode, describing wave intensity as a function of frequency, magnetic latitude, and M-shell. Both whistler mode and Z-mode waves may have significant impact on electron scattering and acceleration at Jupiter as recent models indicate.

IMAI Masafumi

Simultaneous UV Images and High-latitude Particle and Field Measurements During an Auroral Dawn Storm at Jupiter

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Journal of Geophysical Research: Space Physics, 126, e2021JA029679, (2021.11)

We present multi-instrument Juno observations on day-of-year 86, 2017 that link particles and fields in Jupiter's polar magnetosphere to transient UV emissions in Jupiter's northern auroral region known as dawn storms. Juno ranged from 42° N to 51° N in magnetic latitude and 5.8-7.8 Jovian radii (1 RJ = 71,492 km) during this period. These dawn storm emissions consisted of two separate, elongated structures which extended into the nightside, rotated with the planet, had enhanced brightness (up to at least 1.4 megaRayleigh) and high color ratios. The color ratio is a proxy for the atmospheric penetration depth and therefore the energy of the electrons that produce the UV emissions. Juno observed electrons and ions on magnetic field lines mapping to these emissions. The electrons were primarily field-aligned, bidirectional, and, at times, exhibited sudden intensity decreases below ~ 10 keV coincident with intensity enhancements up to energies of $\sim 1,000$ keV, consistent with the high color ratio observations. The more energetic electron distributions had characteristic energies of ~ 160 -280 keV and downward energy fluxes (~ 70 -135 mW m⁻²) that were a significant fraction needed to produce the UV emissions for this event. Magnetic field perturbations up to $\sim 0.7\%$ of the local magnetic field showing evidence of upward and downward field-aligned currents, whistler mode waves, and broadband kilometric radio

emissions were also observed along Juno's trajectory during this time frame. These high-latitude observations show similarities to those in the equatorial magnetosphere associated with dynamics processes such as interchange events, plasma injections, and/or tail reconnection.

今井 雅文

オンライン型モノづくり講座の実践と協同ミッション：缶サットからモデル CubeSat 製作まで

徳光政弘*1, 高田 拓*2, 村上幸一*3, 中谷 淳*4, 下垣丞汰朗*1, 今井雅文*5, 若林 誠*5, 上田真也*6

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工学教育, 69(6), 153-158, (2021.12)

〔概要は前掲〕

IMAI Masafumi

Consideration of the Special Course for Assistive Technology Engineer Development in Collaboration with Medical Institutions

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14th International Symposium on Advances in Technology Education, 161-166, (2022.2)

Manufacturing education in collaboration with medical institutions is very important and useful. National Institute of Technology, Niihama College (NIT, Niihama College) is offers a two-year systematic curriculum as the "Special Course for Assistive Technology Engineer Development (AT course)". This is the process of learning the basic knowledge of Medical welfare engineering, and manufacturing based on the needs of clinical field. In the AT course, problems in clinical environment are given as themes, and students take the initiative in working toward solving the issues while receiving advice on fluids, controls, sensors, programming, etc. from teaching staffs. However, it is difficult to imagine the problems in clinical environment, and multifaceted viewpoints, ideas, and knowledge are required to solve the problems. Also, in clinical environment, it doesn't matter who made it. Furthermore, in order to create products that can be used in clinical environment, it is necessary to have "technology" and "strategy" that enable high-quality manufacturing as well as the functions required by users. It is not possible to nurture engineers who can make practical things only by school education, and social implementation education in collaboration with the local community is necessary. Therefore, as the AT course, we built an education system in collaboration with medical institutions. In addition, this system is designed to nurture engineers who can "manufacture with care" and to create an environment where they can learn manufacturing from various perspectives. This report provides an overview of the AT course and examples of actual efforts. Also summarize student efforts and feedback from clinical institutions, consider changes in student awareness before and after taking the course, and describe the benefits of collaborating with medical institutions. As an example of our efforts, we will introduce a proposal for an efficient ventilation method in a rehabilitation room using CFD (Computational Fluid Dynamics).

IMAI Masafumi

A Comprehensive Set of Juno In Situ and Remote Sensing Observations of the Ganymede Auroral Footprint

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Jupiter's satellite auroral footprints are a manifestation of the satellite-magnetosphere interaction of the Galilean moons. Juno's polar elliptical orbit enables crossing the magnetic flux tubes connecting each Galilean moons with their associated auroral emission. Juno's payload allows measuring the fields and particle population in the flux tubes while remotely sensing their associated auroral emissions. During its thirtieth perijove, Juno crossed the flux tube directly connected to Ganymede's leading footprint spot, a unique event in the entire Juno prime mission. Juno revealed a highly-structured precipitating electron flux, up to 316 mW/m², while measuring both a small perturbation in the magnetic field azimuthal component and small Poynting flux, with an estimated total downward current of 4.2 ± 1.2 kA. Based on the evolution of the footprint morphology and the field and particle measurements, Juno transited for the first time through a region connected to the transhemispheric electron beam of the Ganymede footprint.

[区 分 C]

Shigeru Kato

ディープラーニングを用いた溶接外観判定

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溶接技術、69(9)、pp130-131、(2021.9)

初心者が行ったステンレス TIG 溶接の CNN による評価方法について述べた。

〔区 分 E〕

和田 直樹

人工知能を用いた丸太の空洞評価

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第 72 回日本木材学会大会（名古屋、岐阜）、B15-02-1600、(2022.3)

街路樹内部の空洞化による倒木事故が発生しており、安価で簡単な空洞検出装置が期待されている。我々はこの空洞検出に人工知能を用いることを提案している。丸太にドリルで空洞を加工した試験体に振動を与えた時の共振特性を畳込ニューラルネットワーク (CNN) に入力し、空洞の有無や大きさ、空洞の偏心位置の判定を検討した。22 fold の交差検定 10 回の平均で、空洞直径 50 mm の正答率は 85%、30 mm は 40%、15 mm は 40%、空洞無しは 85%、偏心は 90%となった。倒木の恐れがあるような大きな空洞や偏心は CNN 判定で空洞を検知できる可能性がある。

和田 直樹

人工知能を用いた角材の内部割れ評価

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第 72 回日本木材学会大会（名古屋、岐阜）、B15-02-1545、(2022.3)

製材の生産において高温乾燥が導入されているが、条件によってはその工程で内部割れが発生し、接合等の強度を低下させる可能性が指摘されている。一方、我々はこれまで、大きさが異なる空洞を加工した丸太の振動特性から、畳込ニューラルネットワーク (CNN) を用いて、その空洞の有無や大きさが判定できることを確認した。そこで、本手法を製材に応用して、内部割れの大きさを判定できるか検討した。試験の結果、内部割れの状態が異なるスギ製材（105mm 正角、長さ 250mm）を計 70 本用いて検証したところ、内部割れの程度を CNN で判定できる可能性が示唆された。

和田 直樹

丸太振動測定装置における大型加振器の検討

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-9、67、(2021.9)

台風時の街路樹の倒木による事故が発生している。これらは木材内部の腐朽による空洞化が原因である。丸太に空洞を加工した試験体の共振周波数特性を畳込ニューラルネットワーク (CNN) に入力して空

洞を検知できる可能性を示してきた。しかし、小型の試験体を用いたため加振力の小さいボイスコイルを用いていた。そこで、実際の樹木の共振特性を測定するためにより加振力の大きい大型のボイスコイルについて検討を行った。その結果、直径 250mm、長さ 500 mm の試験体の空洞の有無に対応した特徴的な共振ピークを測定できるようになった。

和田 直樹

CNN を用いた丸太の空洞検出

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台風時の街路樹の倒木による事故が発生している。これらは木材内部の腐朽による空洞化が原因である。そこで、ドリルで丸太に空洞を加工した試験体を 80 本製作して、その共振周波数特性からスペクトログラムを作成して畳込ニューラルネットワーク (CNN) に入力し空洞の有無を判定した。20 fold の交差検定を 10 回行った平均で、空洞直径 50 mm の正答率は 88 %、30 mm は 79 %、15 mm は 33 %、空洞無しは 46 %となった。倒木の恐れがあるような大きな空洞のある樹木については、CNN 判定で空洞を検知できる可能性を示すことができた。

和田 直樹

丸太振動測定用携帯型加振受振器の製作

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-4、62、(2021. 9)

台風時の街路樹の倒木による事故が発生している。これらは木材内部の腐朽による空洞化が原因である。丸太に空洞を加工した試験体の共振特性を画像化して畳込ニューラルネットワーク (CNN) に入力し空洞の有無を判定できることを示した。しかし、試験体の振動測定には大型の測定装置を用いていた。そこで、現場で手軽に測定できる安価な携帯型装置の製作を行った。そして、携帯型装置を用いても CNN による空洞の有無を判定できる可能性を示すことができた。

和田 直樹

振動と荷重を用いた柑橘果肉の食感測定

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-3、61、(2021. 9)

愛媛では 15 種類以上の柑橘の味が楽しめる。柑橘の味は酸味や甘味だけでなく食感も重要である。そこで品種による食感の違いを数値化できれば品質評価に利用できる。食用部分のじょうのう内部に針を刺した時の荷重と振動を高感度に測定できる装置を製作した。そして、紅まどんな、温州みかん、伊予柑を測定したところ、それらの食感の微妙な違いに対応した数値データを得ることができた。

皆本 佳計

CONSIDERATION OF THE SPECIAL COURSE FOR ASSISTIVE TECHNOLOGY ENGINEER DEVELOPMENT IN COLLABORATION WITH MEDICAL INSTITUTIONS

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International Symposium on Advances in Technology Education Conference, (2021.8)

Manufacturing education in collaboration with medical institutions is very important and useful. National Institute of Technology, Niihama College (NIT, Niihama College) is offers a two-year systematic curriculum as the "Special Course for Assistive Technology Engineer Development (AT course)". This is the process of learning the basic knowledge of Medical welfare engineering, and manufacturing based on the needs of clinical field. In the AT course, problems in clinical environment are given as themes, and students take the initiative in working toward solving the issues while receiving advice on fluids, controls, sensors, programming, etc. from teaching staffs. However, it is difficult to imagine the problems in clinical environment, and multifaceted viewpoints, ideas, and knowledge are required to solve the problems. Also, in clinical environment, it doesn't matter who made it. Furthermore, in order to create products that can be used in clinical environment, it is necessary to have "technology" and "strategy" that enable high-quality manufacturing as well as the functions required by users. It is not possible to nurture engineers who can make practical things only by school education, and social implementation education in collaboration with the local community is necessary. Therefore, as the AT course, we built an education system in collaboration with medical institutions. In addition, this system is designed to nurture engineers who can "manufacture with care" and to create an environment where they can learn manufacturing from various perspectives. This report provides an overview of the AT course and examples of actual efforts. Also summarize student efforts and feedback from clinical institutions, consider changes in student awareness before and after taking the course, and describe the benefits of collaborating with medical institutions. As an example of our efforts, we will introduce a proposal for an efficient ventilation method in a rehabilitation room using CFD (Computational Fluid Dynamics).

香川 福有

Study on Apple Texture Evaluation with Regard to Product Management

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Proc.of 6th STI-Gigaku, pp29 (2021.10)

Apple intake is good and effective for our health. This study aims to construct a product management system for the detailed analysis of apples. The proposed equipment measures the force and sound of apple flesh using a wedge-formed probe. Two different specimens, A and B, of apples have been examined, and 16 data signals of load and sound are preserved. We constructed a neural network (NN) model, which distinguished specimens A and B. The input of the model is the parameters in load and sound. To validate the proposed NN model, we conducted two cross-validation techniques and obtained an accuracy of 84.5%. In future, we will perform a human sensory test where human subjects would listen to recorded sound.

香川 福有

Development of Graduation Research in Food Texture Estimation

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Proc. of 14th International Symposium on Advances in Technology Education (ISBN 978-952-216-795-8) part.2, pp52-57, (2021.8)

This paper describes a suitable graduation research subject that makes students interested in AI (Artificial Intelligence). Food is familiar to us. Therefore, we built up a research topic related to food. The objective of the proposed subject is to design an intelligent system, which can recognize foods' textures. In the proposed research, AI estimates food texture from sound and load signals. Our original equipment measures these signals when the food is compressed or cut. The authors applied CNN (Convolutional Neural Network) to classify various texture type. CNN is one of the NN (Neural Network) models and regarded as one of the latest beneficial AI (Artificial Intelligent) techniques. The input of CNN is an image representing the load and sound signals when the food is cut or compressed by the equipment. The output is the estimated classification value of the food. In the research process, the students are required to figure out the electric sensors, such as load cells and the sound sensors, and learn the usage of the individual amplifier of the sensors. In the experiment stage, to collect signal data of the foods, the students have to measure the size of the food samples and memorize the experimental conditions as detailed as possible in the notebook. In this way, they can take advantage of their experience writing reports in student engineering experiments in their lower grades. Besides, the students should construct an information system using Matlab. By using Matlab, they can address building intelligent information systems quickly. They have to analyze the physical features of load and sound strength by calculating the mean and standard deviation (STD). Furthermore, they are required to comprehend the result of FFT (Fast Fourier Transform) and STFT (Short Time Fourier Transform) of the sound signal. The first half of the present paper shows the texture classification experiment of three kinds of snacks performed by a student. The latter half shows the experiment in apples' texture. Finally, conclusion and future work are discussed.

香川 福有

振動と荷重を用いた柑橘果肉の食感測定

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令和3年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-3、61、(2021.9)

〔概要は前掲〕

KATO Katsumi

Inverse Analysis of Optimum Permittivity Distribution for FGM Spacer in Consideration with Multiple Objective Functions in Gaseous Insulation System

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International Symposium on High Voltage Engineering 2021, online/offline, Xian, PR-China, Nov.21-25 (2021), No.401.

For relaxation of electric field (E-field) stress around solid insulation spacer in HV-GIS (Gas Insulated Switchgears), we have proved the effectiveness of an application of functionally graded materials (FGM) with spatial distribution of permittivity (ϵ -FGM). For this purpose, we have proposed a technique for inverse analysis of the permittivity distribution in an ϵ -FGM spacer. The technique can provide us optimum permittivity distribution with the maximum E-field stress relaxation with less computation time.

In this paper, we developed the new technique of the inverse analysis under the consideration of multiple objective functions on the insulation performances. In our study, we focus on three kinds of functions: (a) dielectric strength in SF₆ gas gap, (b) dielectric strength on the spacer surface, and (c) dielectric strength on the embedded electrode/epoxy spacer interface. Under the consideration of three objective functions, the optimum permittivity distribution in ϵ -FGM spacer are modified full-automatically.

Through the application results to GIS spacer, we obtain the inverse analysis of optimum permittivity distribution by only 11 times of iterations. As a result, we obtained 25% improvement of insulation performance around ϵ -FGM spacer compared with the conventional spacer with uniform permittivity distribution.

KATO Katsumi

Flashover Voltage Estimation of Cone-type GIS Spacer with Permittivity Graded Materials (ϵ -FGM) by Volume-Time Theory in Consideration with Conductor Surface Roughness in SF₆ Gas

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International Symposium on High Voltage Engineering 2021, online/offline, Xian, PR-China, Nov.21-25 (2021), No.705.

Toward the compact gas insulated switchgears (GIS) and transmission lines (GIL), we have been investigating a novel electric field grading technique around the GIS spacer by “functionally graded materials (FGM)” with spatial distribution of permittivity (ϵ -FGM). We have already designed and fabricated the cone-type ϵ -FGM spacer samples with the relative permittivity distribution between 10 and 4 for 245 kV class GIS and obtained the higher flashover voltage (FOV) than that of the spacer samples with uniform permittivity. In this paper, in order to verify the estimated FOV of the ϵ -FGM spacer samples, we estimated the theoretical discharge inception voltage (TDIV50) by the analytical approach with the extended Volume-Time theory in consideration with the conductor surface roughness. The estimated TDIV50 of the ϵ -FGM spacer sample was verified to be consistent with the measured FOV and higher by 28 % in SF₆ gas at 0.6 MPa-abs than that of the conventional spacer sample.

KATO Katsumi

Breakdown Characteristics of Cone-type ϵ -FGM Spacer for Gas Insulated Switchgears Application of SiC-filled Permittivity and Conductivity Graded Material (ϵ/σ -FGM) in HVDC GIS Spacer

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The size reduction of HVDC GIS is needed for reduction of SF₆ gas use. The challenge concerning the insulating material in HVDC GIS is to reduce the high electric field strength in gas around the solid insulators (spacers). Our previous works have shown the effectiveness of the functionally graded material (FGM) with graded permittivity (ϵ) and conductivity (σ) in controlling the high electric field strength under various DC operating conditions. However, ϵ/σ distributions were independent of each other. For practical implementation of FGM to HVDC GIS, the flexible mixture casting (FMC) method so far allows us to create a material whose ϵ/σ distributions are interdependent. In this paper, based on the measured dependence between ϵ and σ in SiC-filled epoxy composites, the electric field relaxation effect is evaluated under three different ϵ/σ distributions (U-type, grading-to-higher conductivity (GHC)-type and grading-to-lower conductivity (GLC)-type) applied to a 320 kV HVDC GIS spacer model. The results show that GLC-type ϵ/σ -FGM has effectively and constantly reduced the maximum electric field strength under the time-varying voltage application from DC-on to DC-steady state and against temperature differences between the high voltage and ground sides up to 70 K. For the downsizing of gas insulated switchgears (GIS), a novel electric field grading technique is highly expected. In order to meet this demand, we have been investigating the electric field control and relaxation technique by "functionally graded materials" with the spatial distribution of permittivity (ϵ -FGM). In this paper, we fabricated the 1/4-sized cone-type ϵ -FGM spacer for 245 kV-class GIS and verified its breakdown voltage improvement effect by both experiment and simulation.

KATO Katsumi

Distinctive Downsizing of Cone-Type Insulating Spacer for 245 kV Class GIS by Functional Insulating Materials

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In order to investigate the possibility of downsizing of a cone-type insulating spacer of GIS, flashover voltage (FOV) characteristics by standard lightning impulse (LI) voltage in the SF₆ gas were studied by fabricating mini-model spacers applying nano-micro composite (NMC)

materials and/or permittivity (ϵ) functionally graded materials (ϵ -FGM). Furthermore, by applying ϵ -FGM technique, an insulation spacer of actual the size reduction by 30% in diameter compared with that used in conventional 245 kV class GIS was achieved, and withstand LI voltage characteristics were verified.

For NMC materials, epoxy resin with SiO₂ micro-filler (MC) was filled with 1 vol % of nanofiller (SiO₂, TiO₂, SrTiO₃, Al₂O₃) to fabricate a 1/4 size cone-type spacer model. For the ϵ -FGM, a 1/4 size cone-type insulating spacer was also fabricated, and the FOV was measured.

After that, for the ϵ -FGM, an actual size cone-type insulating spacer of 245 kV class GIS was fabricated, and the FOV was measured. The permittivity distribution of the ϵ -FGM spacer was optimized by an inverse calculation technique with a newly developed electric field analysis method.

Finally, the FGM spacer with distributed permittivity of $\epsilon_r=10^{-4}$ using SrTiO₃ and SiO₂ fillers was fabricated. Under negative standard LI voltage with 0.5 MPa-abs, the FOV of FGM spacer was to be 21-29 % higher than that of Uniform spacer with $\epsilon_r=4$. In addition, as a result of withstanding voltage test of LI ± 1050 kV 15 times which was a type test of standard LI voltage with 0.6 MPa-abs, of 245 kV class GIS regulated in IEC 606944, there was no flashover, and the standard requirement was satisfied.

The progressive development of HVDC transmission system has urged us to develop a novel technique in supporting the performance of DC power apparatus. Functionally Graded Materials (FGM) are one of the techniques that allows us to control electric field within the DC insulation system. This paper investigates the applicability of the combination of spatial permittivity and conductivity graded materials (ϵ/σ -FGM) in DC power apparatus. ϵ/σ -FGM are revealed to be more effective in suppressing maximum electric field as well as more uniformly distributed electric field against the increase of temperature distribution under polarity reversal, DC-on, and impulse superimposed on DC condition.

KATO Katsumi

Theoretical Investigation on Discharge Inception Voltage Improvement of SiC-filled Permittivity and Conductivity Graded Material (ϵ/σ -FGM) for HVDC GIS

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第 52 回電気電子絶縁材料システムシンポジウム (オンライン) No. C-7, (2021.9)

Functionally graded material (FGM) with graded permittivity (ϵ) and/or conductivity (σ) uses electric field grading concept to enhance the insulation performance of solid insulators (spacers) in GIS/GIL. It was experimentally verified that an application of ϵ -FGM to 245 kV class AC GIS spacer using flexible mixture casting (FMC) method can improve the breakdown voltage by 25% compared to a conventional spacer. In order to approach the actual impact of FGM technology, this paper discusses the application of ϵ/σ -FGM on a 320 kV HVDC GIS spacer based on the measured σ and ϵ characteristics of SiC-filled epoxy composites. The insulation performance of ϵ/σ -FGM spacers are evaluated through electric field relaxation effect under various DC operating conditions and theoretical discharge inception voltage (TDIV) improvement effect.

KATO Katsumi

Discharge Inception Voltage Calculation of HVDC GIS with Graded Permittivity and Conductivity (ϵ/σ -FGM) Spacer

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電気・電子・情報関係学会東海支部連合大会, No. A5-6, (2021.9)

The electric field relaxation effect of functionally graded materials with graded permittivity and conductivity (ϵ/σ -FGM) on HVDC GIS spacer has been evaluated. This paper calculates the theoretical discharge inception voltage (TDIV) of HVDC GIS with ϵ/σ -FGM spacers based on Volume-Time theory.

加藤 克巳

放電開始条件を考慮した FGM 絶縁スぺーサの誘電率分布逆求解計算

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令和4年電気学会全国大会、オンライン、No. 6-002、(2022.3)

筆者らは、SF₆ガス／固体複合絶縁系からなる高電圧機器のコンパクト化を目的として、誘電率傾斜機能材料 (ϵ -FGM) の適用を目指している。本発表では、ガス中の放電開始条件と固体絶縁物の絶縁特性の両者を考慮し、両者のバランスをとりながら最適な誘電率分布を与える逆求解計算技術を開発した。

加藤 克巳

実器サイズ GIS 用 ϵ -FGM スぺーサにおける絶縁破壊特性の理論的検討

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令和4年電気学会全国大会、オンライン、No. 6-003、(2022.3)

筆者らは、ガス絶縁開閉装置 (GIS) の小型化と、SF₆ガス削減に向けて、誘電率傾斜機能材料 (ϵ -FGM) を用いたスぺーサの実用化を目指している。これまでに導体表面粗さを考慮した Volume-time 理論による放電開始電圧 (TDIV) の推定と実験的検証を行ってきた。本発表では、 ϵ -FGM スぺーサにおける TDIV の SF₆ ガス圧力依存性を理論的に検討した。

加藤 克巳

ϵ -FGM 適用 245kV 級 GIS スぺーサの長期 V-t 特性

増井秀好*1、岡本健次*1、柳瀬博雅*1、早川直樹*2、小迫雅裕*3、加藤克巳*4、大久保仁*5、大澤直樹*6、井上智裕*7、足立和郎*8、高橋俊裕*8、

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令和4年電気学会全国大会、オンライン、No. 6-004、(2022.3)

筆者らは、絶縁スぺーサの電界制御によるガス絶縁開閉装置 (GIS) の小型化 (直径 30%、断面積 50%) のために、誘電率傾斜機能材料 (ϵ -FGM) を適用した絶縁スぺーサの実用化に取り組んでいる。これまでに、 ϵ -FGM を適用し、直径を 30%小型化した実サイズの 245kV 級 GIS スぺーサを試作して、SF₆ガス中の雷イン

パルス破壊電圧評価を行ってきた。本発表では、長期 V-t 試験を実施したので報告する。

KATO Katsumi

Discharge Inception Voltage Improvement by Application of Permittivity and Conductivity Graded Materials (ϵ/σ -FGM) to HVDC GIS Spacer

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令和 4 年電気学会全国大会, オンライン, No.6-005, (2022.3)

The application of permittivity graded materials (ϵ -FGM) to cone-type spacer for a 245kV-class AC GIS has been confirmed to have field relaxation and breakdown voltage improvement than a conventional spacer. On the other hand the electric field analysis has been performed on a HVDC GIS spacer with combined permittivity and conductivity graded materials (ϵ/σ -FGM) to reduce not only AC but also DC fields that occur under various DC operating conditions. Toward experimental verification, this paper investigates theoretical discharge inception voltage (TDIV) improvement for a scaled model of DC ϵ/σ -FGM spacer by Volume-Time theory.

Shigeru Kato

Genetic Algorithm Based Automatic Layer Selection of Transfer Learning for Object Detection

Ryuji ITO*1, Hajime NOBUHARA*1, Shigeru KATO*2

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Proc.of IWACIII 2021, pp1-6, (2021.11) (発表賞受賞・査読付き)

FPN (Feature Pyramid Neural Network) の CNN 層から得られる特徴マップについてどの層からの特徴を組み合わせることで、物体検出が最もよく求められる手法を、遺伝的アルゴリズムで最適化した。進化に伴いより精度よく、物体検出を行うことができることが確認された。

Shigeru Kato

Study on Apple Texture Evaluation with Regard to Product Management

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Proc.of 6th STI-Gigaku, pp29, (2021.10) (査読付き)

Apple intake is good and effective for our health. This study aims to construct a product management system for the detailed analysis of apples. The proposed equipment measures the force and sound of apple flesh using a wedge-formed probe. Two different specimens, A and B, of apples have been examined, and 16 data signals of load and sound are preserved. We constructed a neural network (NN) model, which distinguished specimens A and B. The input of the model is the parameters in load and sound. To validate the proposed NN model, we conducted two cross-validation techniques and obtained an accuracy of 84.5%. In future, we will perform a human sensory test where human subjects would listen to recorded sound.

Shigeru Kato

Development of Graduation Research in Food Texture Estimation

Shigeru Kato*1, Tomomichi Kagawa*1, Naoki Wada*1, Takanori Hino*2, Hajime Nobuhara*3

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Proc. of 14th International Symposium on Advances in Technology Education (ISBN 978-952-216-795-8) part. 2, pp52-57, (2021.8) (査読付き)

This paper describes a suitable graduation research subject that makes students interested in AI (Artificial Intelligence). Food is familiar to us. Therefore, we built up a research topic related to food. The objective of the proposed subject is to design an intelligent system, which can recognize foods' textures. In the proposed research, AI estimates food texture from sound and load signals. Our original equipment measures these signals when the food is compressed or cut. The authors applied CNN (Convolutional Neural Network) to classify various texture type. CNN is one of the NN (Neural Network) models and regarded as one of the latest beneficial AI (Artificial Intelligent) techniques. The input of CNN is an image representing the load and sound signals when the food is cut or compressed by the equipment. The output is the estimated classification value of the food. In the research process, the students are required to figure out the electric sensors, such as load cells and the sound sensors, and learn the usage of the individual amplifier of the sensors. In the experiment stage, to collect signal data of the foods, the students have to measure the size of the food samples and memorize the experimental conditions as detailed as possible in the notebook. In this way, they can take advantage of their experience writing reports in student engineering experiments in their lower grades. Besides, the students should construct an information system using Matlab. By using Matlab, they can address building intelligent information systems quickly. They have to analyze the physical features of load and sound strength by calculating the mean and standard deviation (STD). Furthermore, they are required to comprehend the result of FFT (Fast Fourier Transform) and STFT (Short Time Fourier Transform) of the sound signal. The first half of the present paper shows the texture classification experiment of three kinds of snacks performed by a student. The latter half shows the experiment in apples' texture. Finally, conclusion and future work are discussed.

加藤 茂

人工知能を用いた丸太の空洞評価

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第72回日本木材学会大会(名古屋、岐阜)、B15-02-1600、(2022.3)

[概要は前掲]

加藤 茂

人工知能を用いた角材の内部割れ評価

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第 72 回日本木材学会大会（名古屋、岐阜）、B15-02-1545、(2022. 3)

〔概要は前掲〕

加藤 茂

丸太振動測定装置における大型加振器の検討

眞鍋京佑*1、山口雄太郎*1、堀内優也*1、塩貝一樹*1、和田直樹*1、加藤茂*1、玉置教司*2、櫻井直樹*3

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-9、67、(2021. 9)

〔概要は前掲〕

加藤 茂

CNN を用いた丸太の空洞検出

堀内優也*1、山口雄太郎*1、川人直也*1*4、塩貝一樹*1、和田直樹*1、加藤茂*1、玉置教司*2、櫻井直樹*3

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-8、66、(2021. 9)

〔概要は前掲〕

加藤 茂

丸太振動測定用携帯型加振受振器の製作

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-4、62、(2021. 9)

〔概要は前掲〕

加藤 茂

振動と荷重を用いた柑橘果肉の食感測定

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令和 3 年度電気・電子・情報関係学会四国支部連合大会講演論文集、7-3、61、(2021. 9)

〔概要は前掲〕

若林 誠

Three-year Achievements in Human Resource Development Program in Space Engineering

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33rd International Symposium on Space Technology and Science, 10th Nano-Satellite Symposium & 14th IAA Low-Cost Planetary Missions Conference, (2022. 3)

In this paper, we report an achievement of Human Resource Development Program for student of National Institute of Technology (KOSEN). This program is aimed to cultivate an ability of the aerospace engineering in non-space major students. The program consists of three parts of sub-programs: (1) KOSEN Space Academia which is a remote hands-on seminar using video conference system (2) KOSEN Space Camp which is a four-days camp-style workshop held in Niihama city, and (3) KOSEN-1 project which is an actual development of 2U size CubeSat. A total of 263 students and 78 faculty members participated in this program for three years from 2017 to 2019.

若林 誠

Cultivation of Space Human Resources Using Nationwide KOSEN1 Online Lectures and Idea Contests to Develop Mission Planning Ability

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33rd International Symposium on Space Technology and Science, 10th Nano-Satellite Symposium & 14th IAA Low-Cost Planetary Missions Conference, (2022. 3)

This paper describes the space related human resources development project conducted by KOSENs in 2020. Satellite development is effective for practical education in KOSENs. As such, KOSEN Space Collaboration Group have held boot-camp style education programs for KOSEN students since 2015 and online lectures on space science and technology since 2018. Herein, we have proposed a new contest called the All KOSEN space contest to cultivate satellite mission planning skills. To evaluate the efficiency of this proposed contest, we conducted a pre-contest in 2020 and researched the educational benefits of this pre-contest. From the results, we were able to extract useful insights to guide the planning of the main contests with potential to bridge the gap between our previous educational programs and actual satellite development. Consequently, the result of this study indicates that the satellite development skills of KOSEN students can be further improved.

若林 誠

高専間で連携した実践的宇宙人材育成

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高等専門学校電子制御工学科、*4 岐阜工業高等専門学校機械工学科、*5 群馬工業高等専門学校機械工学科、*6 徳山工業高等専門学校機械電気工学科、*7 東京都立産業技術高等専門学校ものづくり工学科、*8 九州工業大学宇宙システム工学研究系、*9 香川高等専門学校高松キャンパス電気情報工学科
第 65 回宇宙科学技術連合講演会、(2021. 11)

This paper reports the space education program for KOSEN students by means of online lectures and competition held in 2020. Our program focuses on developments and operations of CubeSat which has been tried to be built in KOSEN campuses since 2011. The “KOSEN-1” satellite has been developed and expected to be launched in 2021 as a most outstanding result of our activity. We aim to develop the follow-up series of satellites with providing suitable education for KOSEN students. To enhance mission planning ability of KOSEN students, we held the brand-new mission idea contest in 2020. Nowadays, every KOSEN student can participate in the developments of actual satellites through our program.

若林 誠

高専間で連携した宇宙人材育成の取り組み

若林誠*1, 今井雅文*1, 徳光政弘*2, 中谷淳*3, 今井一雅*4, 平社信人*5, 池田光優*6, 高田拓*7, 北村健太郎*8, 村上幸一*9, 高専スペース連携

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2021 年度 宇宙教育シンポジウム、(2021. 6)

「高専スペース連携」は宇宙理工学の研究分野を持つ高専教員からなるグループで、2014 年頃から「国立高専で連携した人工衛星開発」と、「衛星開発・運用に携わることができる人材育成」を目標として活動を続けてきた。従来から行ってきたオンライン講座である「高専スペースアカデミア」と、合宿・対面型の「高専スペースキャンプ」に加え、ミッション企画力をオンラインで育成する「全国高専宇宙コンテスト」を新たに計画し、2020 年度にプレ大会を実施した。地理的に離れた複数高専間で連携した取り組みには、オンラインツールの活用が有効であり、人工衛星開発をテーマにした教育コンテンツについての実施事例を報告する。

若林 誠

高専宇宙人材育成における気球実験の取り組みと将来像

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2021 年度 大気球シンポジウム、(2021. 11)

人工衛星の開発は、機械・電気電子・情報・材料といった複数の分野にまたがる知識・技術が必要であり、また「宇宙」というキーワードは高専等の「ものづくり教育」の現場において、ものづくりへの興味関心を高める上で有効である。「高専スペース連携」は宇宙理工学の研究分野を持つ高専教員からなるグループとして、高専における宇宙関連の教育を推進する目的で 2011 年に発足した。2014 年頃からは「国立高専の連携による人工衛星開発」と、「衛星開発・運用に携わることができる人材育成」を具体的な目標として掲げ、現在まで活動を続けてきている。「高専スペース連携」の特徴的な取り組みとして、2015 年から実施している合宿型教育プログラム「高専スペースキャンプ¹⁾」、2017 年からオンラインで全国の

希望者に宇宙理工学講座を配信している「高専スペースアカデミア²⁾」等がある。宇宙工学の専門学科を持たない国立高専の学生がハンズオン形式で宇宙理工学、特に超小型人工衛星開発と運用に関する知識・技術を身に付けられる環境を整えてきている。並行して、我々が提案した 2U サイズの超小型人工衛星「KOSEN-1」は、JAXA の革新的衛星技術実証プログラム 2 号機に採択され、2021 年度の打ち上げ機会を得るに至った。また、「KOSEN-1」に続いて開発中の「KOSEN-2」は、革新的衛星技術実証 3 号機に採択され、2022 年度の打ち上げ機会を得ている。

本発表においては、高専スペース連携で実施している宇宙人材育成の取り組みの中で、高専スペースキャンプで行われている気球実験の事例及び、2021 年度から本格開催される「全国高専宇宙コンテスト」に関連した気球実験の将来像について紹介する。

IMAI Masafumi

New understanding on Jupiter' s lightning in the atmosphere as revealed by Juno

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Japan Geoscience Union Meeting 2021, (2021.6)

Since 5 July, 2016, the Juno spacecraft has toured Jupiter in a 53-day eccentric polar orbit. During each perijove, Juno has monitored a copious amount of Jupiter' s lightning at the radio, optical, and ultraviolet wavelengths with five onboard instruments. The radio and plasma wave (Waves) instrument has recorded two kinds of low-frequency electromagnetic waves related to the lightning. The first is comprised of Jovian low-dispersion whistlers observed at frequencies below 20 kHz. These radio signals may possibly propagate up to several thousand kilometers horizontally away from lightning strokes below the ionosphere before ultimately escaping into the inner magnetosphere, but their direct vertical propagation cannot be excluded. The second kind consists of dispersed millisecond pulses called Jupiter dispersed pulses (JDPs), observed at frequencies below 150 kHz but above the maximum plasma frequency encountered during the wave propagation through the ionosphere. JDPs propagate directly from lightning strokes but can leak into the inner magnetosphere only where ionospheric density is low. The high-temporal observations of either whistlers or JDPs by Waves showed variations of lightning-related processes on the order of submilliseconds. Another type of the lightning-induced radio signature is the ultrahigh frequency (UHF) sferics recorded at 600 MHz and 1.2 GHz by the Microwave Radiometer (MWR). The UHF sferics freely traverse the ionosphere from the source lightning strokes as straight-line propagation. In addition to three kinds of radio signatures, clouds illuminated from below by nightside lightning have been captured by two navigation cameras (Stellar Reference Unit (SRU) and Advanced Stellar Compass (ASC)), while the ultraviolet spectrograph (UVS) discovered Transient Luminous Events in the upper stratosphere, thought to be associated with tropospheric lightning. Imaging data from the Hubble Space Telescope have

been instrumental in associating many of these phenomena with actively convecting regions, especially cyclonic vortices. In the theoretical domain, Juno team members proposed a new precipitation mechanism involving ammonia-water “mushballs,” potentially explaining both the deep depletion of ammonia detected by the MWR, as well as the shallow lightning seen with the SRU. In this presentation, we report an overview of the recent observations of Jupiter’s lightning in the atmosphere as revealed by Juno.

IMAI Masafumi

Simultaneous UV Images and High-latitude Particle and Field Measurements During an Auroral Dawn Storm at Jupiter

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Magnetospheres of the Outer Planets, (2021.7)

We present Juno observations between 03:00 to 06:00 UT on day-of-year 86, 2017 that link particles and fields in Jupiter’s polar magnetosphere to transient UV emissions in Jupiter’s auroral region known as dawn storms. Juno ranged between 42°N – 51°N in magnetic latitude and 5.8 – 7.8 jovian radii (1 RJ ~ 71,400 km) during this period. These dawn storm emissions consist of two separate, elongated structures which extend into the nightside, rotate with the planet, and have high color ratios and enhanced brightness (up to at least 1.4 megaRayleigh). Juno observed electrons, ions and magnetic and electric fields on magnetic field lines mapping to these emissions. The electrons are field-aligned, bi-directional, and, at times, exhibit sudden intensity depletions below ~10 keV coincident with intensity enhancements up to energies of ~1000 keV, consistent with the high color ratio observations. These energetic electron distributions have characteristic energies of ~120 – 250 keV and downward energy fluxes (~40 – 140 mW/m²) that are a significant fraction of those required to produce the UV emissions for this event. The ions have similar energy distributions as the electrons. Whistler mode auroral hiss waves and magnetic field perturbations up to ~0.7% of the local magnetic field (~1500 – 3700 nT) are also observed along Juno’s trajectory. These high latitude observations are a result of dynamic processes in the equatorial magnetosphere that trigger the generation these dawn storm emissions.

IMAI Masafumi

Loss processes of energetic ring current ions in Jupiter' s inner and middle magnetosphere

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Magnetospheres of the Outer Planets (2021.7)

The low-altitude-accessing, polar orbit of Juno, allows the Jupiter Energetic Particle Detector Instrument (JEDI to view into, and resolve, the loss cone of the energetic ions that comprise the low-altitude extension of Jupiter' s ring current populations. For a region that extends from just inside Ganymede, to regions well beyond Ganymede, energetic ions (> 50 keV H⁺, >130 keV Oxygen and Sulfur ions) are strongly scattered into the loss cone at the “strong diffusion limit” at essentially all times. In analyzing the causes of this scattering, we have eliminated the hypothesis that the ions are scattered by the small radii of curvature of the magnetic field lines. We have concluded that the magnetic Alfvénic turbulence documented by Saur et al. (2003) likely causes the scattering. Scattering is weak or non-existent near the orbits of the moons Europa and Io, except for the regions just downstream of the co-rotating plasmas. For Io, we observe moderately strong scattering within roughly 20° in azimuth from the moon' s position, and fairly weak scattering within up to 60° downstream. The scattering near Io' s orbit is never fully at the level of the strong diffusion limit. Significantly, scattering is weak or non-existent just upstream of Io' s position, a finding that discriminates against a role for neutral gas pickup, and the associated generation of electromagnetic ion cyclotron waves, as the immediate cause for the scattering. A very preliminary accounting of the total scattering losses in the vicinity of Io' s orbit yields loss rates no larger than several percent of the strong diffusion limit. Given the new role that Smith et al. (2019) has assigned to cool plasmas as the sources of electrons for charge exchange interactions, charge exchange losses in the vicinity of Io may be an order of magnitude larger than traditionally calculated. We conclude that charge exchange losses are at minimum competitive with scattering losses for energetic ions in the vicinity of Io' s orbit.

IMAI Masafumi

Consideration of the Special Course for Assistive Technology Engineer Development in Collaboration with Medical Institutions

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Manufacturing education in collaboration with medical institutions is very important and useful. National Institute of Technology, Niihama College (NIT, Niihama College) is offers a two-year systematic curriculum as the "Special Course for Assistive Technology Engineer Development (AT course)". This is the process of learning the basic knowledge of Medical welfare engineering, and manufacturing based on the needs of clinical field. In the AT course, problems in clinical environment are given as themes, and students take the initiative in working toward solving the issues while receiving advice on fluids, controls, sensors, programming, etc. from teaching staffs. However, it is difficult to imagine the problems in clinical environment, and multifaceted viewpoints, ideas, and knowledge are required to solve the problems. Also, in clinical environment, it doesn't matter who made it. Furthermore, in order to create products that can be used in clinical environment, it is necessary to have "technology" and "strategy" that enable high-quality manufacturing as well as the functions required by users. It is not possible to nurture engineers who can make practical things only by school education, and social implementation education in collaboration with the local community is necessary. Therefore, as the AT course, we built an education system in collaboration with medical institutions. In addition, this system is designed to nurture engineers who can "manufacture with care" and to create an environment where they can learn manufacturing from various perspectives. This report provides an overview of the AT course and examples of actual efforts. Also summarize student efforts and feedback from clinical institutions, consider changes in student awareness before and after taking the course, and describe the benefits of collaborating with medical institutions. As an example of our efforts, we will introduce a proposal for an efficient ventilation method in a rehabilitation room using CFD (Computational Fluid Dynamics).

IMAI Masafumi

Enhancing KOSEN Education in Planetary Radio Science through the Development of KOSEN-1 CubeSat

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The 4th NIT-NUU Bilateral Academic Conference, (2021.9)

The planetary radio science covers the investigations of the natural radio emissions in our solar system and beyond. In our solar system, the Sun and Jupiter are two major radio sources to produce natural radio emissions at the decameter wavelength. On Earth, such radio emissions are reachable at the frequency above 10 MHz (the limit frequency of the terrestrial ionosphere), while the observable frequency range on the spacecraft is limited by on-board receiver capability. The students and professors at 10 colleges of the National Institute of Technology (Kochi, Gunma, Tokuyama, Gifu, Kagawa, Yonago, Akashi, Niihama, Kagoshima, and Tomakomai) have been developing the first 2-U CubeSat. This CubeSat called KOSEN-1 is planned to be launched by a JAXA Epsilon rocket in FY 2021, targeting the science object of observing the radio emissions around 20 MHz from Jupiter (and possibly the Sun). Among the various roles for the development of KOSEN-1 CubeSat, Niihama College is responsible for designing the onboard radio receiver system. Additionally, this radio receiver system has been improved for installing a ground-

based radio observatory in support of KOSEN-1 CubeSat. As a part of the graduation project at KOSEN, this unique education allows students to improve various kinds of skills not only on the electrical engineering and the information science but also the planetary radio science. We present the recent efforts on this KOSEN education through the development of KOSEN-1 CubeSat.

IMAI Masafumi

Development of Jupiter Radio Receiver System with LWA-Japan in Support of KOSEN-1 CubeSat

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The 4th NIT-NUU Bilateral Academic Conference, (2021.9)

A 2U CubeSat, called KOSEN-1, is planned to be launched by a JAXA Epsilon rocket in FY 2021 as a part of JAXA's innovative satellite technology demonstration program. KOSEN-1 is the first collaborative CubeSat developed by 10 colleges of the National Institute of Technology in Japan. Its scientific mission is to observe Jupiter's decametric (DAM) radiation in conjunction with ground-based radio observatories around the world. Jupiter's DAM radiation is known to be sporadic emissions in a wide frequency range of a few MHz through 40 MHz. We propose a new small-size radio observatory called LWA-Japan, consisting of a couple of the bowtie dipoles in the Shikoku Mountains. Here we report on the current status of the development of Jupiter Radio Receiver System installed in LWA-Japan as following the hierarchy of the same system onboard KOSEN-1.

IMAI Masafumi

Planetary Radio Observation CubeSat: Current Step on Earth to Next Step on Moon

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ISAS Planetary Exploration Workshop 2021, (2021.9)

The planetary radio science covers the investigations of the natural radio emissions in our solar system and beyond. In our solar system, the Sun and Jupiter are two major radio sources to produce natural radio emissions at the decameter wavelength. Because the ground-based radio reception is sensitive down to 10 MHz, there are several long-baseline interferometer studies for Jupiter and Sun radio observations in understanding their source size and radio beaming structure. However, the length of the baseline in a usable pair on the ground is physically limited by the diameter of Earth and the U-V coverage is biased due to a sparse low-frequency radio telescope network. Expanding the baseline provides a benefit to further constrain the radio source size and radio beaming thickness.

KOSEN-1 is the first 2-Unit CubeSat developed by 10 colleges of the National Institute of

Technology (abbreviated as KOSEN in Japanese) in Japan. This CubeSat is ready to be launched from the Uchinoura Space Center in Japan on 1 October, 2021. KOSEN-1 is one of nine satellites in the Innovative Satellite Technology Demonstration-2 carried by a JAXA Epsilon-5 Launch Vehicle. KOSEN-1 includes three key technologies to (1) demonstrate a high-accuracy attitude control system, (2) utilize an on-board computer with a Linux microcomputer board, and (3) deploy a 6.6-m long dipole antenna from the CubeSat for Jupiter radio observations. The scientific target is to capture Jovian millisecond short-bursts (S-bursts) in collaboration with ground-based radio telescopes to better understand Jupiter's decametric radio beaming structure. KOSEN-1 has a software-defined radio receiver that can monitor the electric fields of the waves around 20 MHz by means of a 6.6-m long dipole antenna. Once it is launched, KOSEN-1 will maintain its polar orbit around Earth, freely observing Jovian decametric radiation. We take place a global KOSEN-1 supporting observation campaign with ground-based radio telescopes from October through December 2021. As a next step, this kind of CubeSat near the Lunar orbit would be well suited to test if the Jovian radio beaming thickness is larger than the angular resolution of $\sim 130''$, about 30 times higher than that measured from the KOSEN-1 and ground-based radio telescope pair. In this presentation, we will review the scientific background of the planetary radio science from the ground-based and space-born observers, and show the current step of KOSEN-1 CubeSat for Jupiter radio observations and a future plan of the planetary radio observation CubeSat in the orbit of Moon.

IMAI Masafumi

KOSEN-1 Jupiter radio observation campaign with ground-based radio telescopes

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SGEPSS Fall Meeting 2021, (2021.11)

Jupiter produces auroral radio emissions at frequencies below 40 MHz from both north and south polar regions of the planet. The highest frequency radio component is called decametric (DAM) radiation covering in a broad frequency range of a few through 40 MHz. Jovian DAM radiation is partially controlled by the Jovian moon Io, thereby being called Io-related DAM (Io-DAM) emissions. The Io-DAM comprises of millisecond-varying bursts called short-bursts or S-bursts. Because the ground-based radio reception is sensitive down to 10 MHz, there are several long-baseline interferometer studies for Jovian S-bursts in understanding the radio beaming structures with thickness of beaming. According to the previous studies, the minimum thickness of the DAM emissions is estimated at least larger than a $2.75''$ east-west size (Imai et al., 2016, 2019) and a $1.8''$ north-south size (Lynch et al., 1976) using several radio telescopes (including LWA1). However, the length of the baseline in a usable pair on the ground is physically limited by the diameter of Earth and the U-V coverage is biased due to a sparse low-frequency radio telescope network. Expanding the baseline provides a benefit to further constrain the size of the S-burst beam thickness. KOSEN-1 is the first 2U CubeSat developed by 10 colleges

of the National Institute of Technology (NIT) in Japan. This CubeSat is equipped with a software-defined radio (SDR) receiver that can monitor the electric fields of the waves around 20 MHz by means of a 7-m long dipole antenna. The SDR receiver can provide both waveforms and spectra in a 2-MHz bandwidth depending upon the available telemetry to the ground, while the timing of the records is synchronized with the GPS 1 Pulse-Per-Second. Since its launch in 2021 fiscal year, KOSEN-1 will have maintained its polar orbit around Earth, freely observing Jovian DAM radiation. We propose to observe a total of 16 Io-DAM S-burst events with KOSEN-1 and ground-based radio telescopes, including LWA1 and LWA-Seville. Also, additional ground-based support is planned with the Deployable Low-band Ionosphere and Transient Experiment (DLITE; Helmboldt et al., 2021) in New Mexico, Maryland, and Florida, as well as, Radio JOVE citizen scientist observers. These multibaseline observations would give a new way of probing the Jovian S-burst beam thickness. In this presentation, we will review the radio observation system onboard KOSEN-1 and show the plan of KOSEN-1 Jupiter radio observation campaign with the ground-based radio telescopes in 2021 fiscal year.

今井 雅文

省コストで行える歩行解析システム

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第5回日本リハビリテーション医学会秋季学術集会、(2021. 11)

【目的】理学療法 of 歩行解析において、筋電図を活用した手法が用いられる。しかし、そのような商用の特化した歩行解析ソフトウェアは、高価であるため、臨床の現場において容易に導入することは困難であった。本研究では、理学療法士が簡単に扱える、省コストの歩行解析ソフトウェアを提案する。【方法】汎用性に長ける、無償の Java ベース Autoplot を用いて、歩行解析プログラムを作成する。このソフトウェアでは、事前に測定した歩行時の筋電図データを CSV 形式で取り込み、データ内のノイズ処理や歩行周期に対する時間・振幅の正規化を行い、最後の出力結果は 5 から 6 歩行周期の平均値を表示する。【結果・考察】一側下肢 二箇所、両側下肢合わせて四箇所の筋電図データを、最大努力値を基準とした踵部地センサのオンオフ間隔により歩行周期を割り出し、一周期のグラフを表示した。また、必要に応じて画像ファイルを保存することもできた。ソフトウェアを立ち上げてから計算処理が完了し、グラフが表示されるまでは 1 分強であった。本研究で開発した歩行解析ソフトウェアは Windows、Mac OS、Linux の全ての OS に対応しているため、理学療法士の通常使用しているパソコンで動かせる、臨床現場での導入も容易である。さらに、現場からの新たな工学的なフィードバックを受けて、より良いソフトウェアに改善することも期待される。

IMAI Masafumi

A Comprehensive Set of Juno In Situ and Remote Sensing Observations of the Ganymede Auroral Footprint

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American Geophysical Union (hybrid) meeting, (2021.12)

Jupiter’ s satellite auroral footprints result from the interaction between the co-rotating iogenic plasma and the Galilean moons. Since its arrival at Jupiter in 2016, Juno continues to revolutionize the field of moon-magnetosphere interaction by providing, for each perijove, multi-instrument datasets combining in-situ and remote-sensing measurements of the magnetic fluxtubes connecting each satellite with their auroral footprints. So far, the Juno measurements favor an Alfvénic acceleration mechanism generating both the main auroral footprint spots and the footprint tail emissions. This work focuses on the Ganymede fluxtube crossing of PJ30 (8 Nov 2020), where Juno transited through a region connected to Ganymede’ s leading auroral spot measured at 411 +/- 42 kR by Juno-UVS, while Juno-JADE recorded a highly structured downward precipitating electron energy fluxes peaking up to 327 mW/m². We present a multi-instrument characterization of this event combining the remote and in-situ instruments on Juno. Based on the Ganymede footprint spot morphology and inter-spot distance evolution by Juno-UVS, we conclude that Juno transited through the fluxtube connected with Ganymede’ s Main Alfvén Wing footprint.

IMAI Masafumi

Electromagnetic evidence of stepwise extension of the Jovian lightning channels

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American Geophysical Union (hybrid) meeting (2021.12)

During all 33 scientific perijove passes of the prime mission of the Juno spacecraft, its radio and plasma wave (Waves) instrument detected numerous submillisecond lightning signals, called Jupiter dispersed pulses (JDPs). They occur at frequencies below 150 kHz, being able to propagate directly from causative lightning, and reaching Juno thanks to localized low density holes in the Jovian ionosphere. We found dispersed pulses within more than three thousands of

16.384 ms long waveform snapshots, out of the total number of 326466 available snapshots acquired below 5.5 Jovian radii from August 2016 to June 2021.

In order to analyze characteristics of JDP sequences, we selected snapshots containing at least three JDPs and focused on their time separations. Our data set consists of 375 snapshots with groups of three to twenty pulses separated by a total number of 2092 inter-pulse intervals. The separation of pulses within individual pulse groups varied from the shortest separation which we were able to detect in inspected electric field spectrograms (0.3 ms) to 12.8 ms with an average value of 1.6 ms. To avoid grouping of unrelated pulses to particular pulse trains we considered only snapshots containing more than four pulses with a regular distribution in time. The resulting dataset consists of 126 snapshots and 843 inter-pulse intervals. Their distribution exhibits a broad peak centered at 1 ms, and about 400 μ s wide.

We compare the inter-pulse time intervals found within Jovian pulse trains with characteristics of electromagnetic pulse sequences detected routinely by radio receivers during the evolution of terrestrial lightning. If lightning discharges at Jupiter propagate in the water clouds at a similar velocity of 105–106 m/s as the terrestrial lightning leaders, then extensions of lightning channels within Jovian thunderclouds would be happening in steps of several hundreds to a thousand meters. These steps are at least 5–10 times longer than steps observed during the initial breakdown stage of the terrestrial lightning flashes and about 20–50 times longer than steps of downward-moving stepped leaders in the terrestrial cloud-to-ground lightning strokes. This indicates that Jovian lightning is indeed initiated at a different spatial scale compared to processes in the Earth's atmosphere.

IMAI Masafumi

Juno Waves Observations of Long Dispersion Lightning Whistlers associated with the Io torus
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American Geophysical Union (hybrid) meeting, (2021.12)

The detection of lightning whistlers by the Voyager spacecraft provided the first conclusive proof of atmospheric lightning at Jupiter. The lightning whistlers detected by Voyager had dispersive curves with time scales of a few seconds, and the shape and time scale of the dispersion provided estimates of the density profile of the Io torus between ~ 5 and 6 Jovian radii. The Juno spacecraft, with its multiple polar orbits around Jupiter provides a new opportunity to examine Jovian lightning generated emissions, and the density characteristics of the plasma they propagate through. During most perijove passes, the Waves instrument on Juno detects lightning emissions with extremely short dispersion. Below 20 kHz, both electron and ion whistlers are detected with dispersive curves with time scales of a few ms to a few tens of ms. At higher frequencies (~ 20 to 150 kHz), a lightning related emission consisting of dispersed millisecond pulses named Jupiter dispersed pulses (JDPS) is often detected. These emissions have dispersion curves much shorter than the Voyager observations, suggesting a much shorter propagation path through a rarefied plasma between the lightning source and the spacecraft,

which has been verified using ray-tracing analysis. As the Juno mission has progressed, the Juno orbit has changed such that the spacecraft is often at lower latitudes near the Io torus. During some of these periods, when Juno is on magnetic field lines that pass through the Io torus, longer dispersion (many seconds) lightning whistlers have been detected. We will discuss the conditions that these emissions are detected, the properties of the emissions, and examine the density profile of the Io torus needed to produce the observed spectral characteristics of these longer dispersion whistlers.

IMAI Masafumi

Jupiter' s magnetic field and the generation and control of decameter radiation observed by the Juno spacecraft

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American Geophysical Union (hybrid) meeting, (2021.12)

Decametric radio emissions (DAM) originating in Jupiter' s polar magnetosphere ought to originate on magnetic field lines at the local electron gyrofrequency. The Io-related DAM have received the most attention since the 1980' s. The maximum frequency of these emissions ought to be bounded by the maximum magnetic field strength above the footprint of the instantaneous Io Flux Tube (IFT). However, there remains a lack of agreement between the frequency extent of Io-related decameter radiation and the frequency extent predicted by Jovian magnetic field models. Here, we analyze peak frequencies and source locations of Io and non-Io-related DAM observed by Juno from May 2016 to May 2021 (~10,600 events) and show how the latest magnetic field model (JRM09) can accommodate and control Io-DAM. We note that the observed peak frequencies appear to be truncated at 37 MHz although the magnetic field in the northern hemisphere would allow events to 55 MHz at some longitudes. Lower frequencies than the ones allowed by the magnetic field are consistently observed for most of the Io' s longitude. To reconcile this discrepancy, we analyze the upper electron density limit distribution along the magnetic field lines, the possible existence of plasma cavities and the locations in the magnetosphere where the extraordinary mode is not longer achieved. For this, we make use of beaming angles of Io-DAM and the geometry of the Jovian magnetic field.

今井 雅文

高専連携技術実証衛星 KOSEN-1 について (3)

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第 65 回宇宙科学技術連合講演会, (2021. 11)

Our CubeSat project organized by 10 colleges of the National Institute of Technology in Japan was selected as a CubeSat candidate for JAXA's Innovative Satellite Technology Demonstration-2. This 2U CubeSat, named KOSEN-1, is planned to be launched by a JAXA Epsilon Launch Vehicle on October 1st, 2021. KOSEN-1 will demonstrate three new spaceborne technologies for the CubeSat system: (1) a performance of the dual reaction wheel, (2) a usage of the Raspberry Pi CM1 based OBC, and (3) an expansion of a 6.6-m long dipole antenna. Furthermore, KOSEN-1 will observe Jupiter's decametric radio emissions to investigate the beaming characteristics.

今井 雅文

LPWA (LoRa) モジュール搭載 2U キューブサットによる山間および洋上防災データの収集技術実証の提案

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第 65 回宇宙科学技術連合講演会, (2021. 11)

The probability of a Nankai Trough giant earthquake is 70% -80% within 30 years, and the damage is expected to spread over a wide area such as Shikoku, Kinki, and Tokai region. To reduce this damage, it is effective to install various sensors for disaster prevention such as tilt sensors and offshore buoys. In addition, long-distance communication using LPWA (LoRa) is useful in areas where the mobile phone network is inadequate, in the mountains and offshore. However, while LPWA (LoRa) communication realizes long-distance in-line communication, it has the disadvantage of being weak against non-line-of-sight communication. Therefore, in this project, we will use a 2U (20cm x 10cm x 10cm) size CubeSat to relay these data. We will also demonstrate communication technology that receives LPWA (LoRa) data from a small artificial satellite and then downlinks it to the ground using amateur wireless communication in the 430 MHz band from the satellite.

今井 雅文

高専連携技術実証衛星 2 号機「KOSEN-2」の軌道上実証と宇宙工学技術者育成

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第 65 回宇宙科学技術連合講演会, (2021. 11)

We develop KOSEN-2 of a CubeSat for a program of Innovative Satellite Technology Demonstration-3 by JAXA. One of the two missions on KOSEN-2 is to demonstrate collecting data from sea observation devices by a beam antenna with high-accuracy altitude control by a dual reaction wheel. Furthermore, our second mission is to establish a human resource development scheme for space engineers through a networked development in KOSENs. We inherit various kinds of designs,

software, and the know-how obtained in KOSEN-1 development since the satellite development of KOSEN-2 is a successive attempt from KOSEN-1. We report the progress of the satellite development of KOSEN-2 and the education of space engineers in the KOSEN-2 project.

今井 雅文

高専間で連携した実践的宇宙人材育成

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第 65 回宇宙科学技術連合講演会, (2021. 11)

This paper reports the space education program for KOSEN students by means of online lectures and competition held in 2020. Our program focuses on developments and operations of CubeSat which has been tried to be built in KOSEN campuses since 2011. The “KOSEN-1” satellite has been developed and expected to be launched in 2021 as a most outstanding result of our activity. We aim to develop the follow-up series of satellites with providing suitable education for KOSEN students. To enhance mission planning ability of KOSEN students, we held the brand-new mission idea contest in 2020. Nowadays, every KOSEN student can participate in the developments of actual satellites through our program.

今井 雅文

コンベックス材を活用した超小型衛星のダイポールアンテナの展開機構に関する実験的研究

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第 65 回宇宙科学技術連合講演会, (2021. 11)

In this report, a 7.2m dipole antenna deployment system for 2U-size Cubesat to observe for Jupiter's decametric radio emission as Innovative-2 is conducted. The authors propose the innovative antenna deployment system as passive mechanism by using plate spring of the convex tape type which the restoring force of the plate spring is brought as expansion force. Then to confirm the effectiveness of the constructed antenna deployment system, some test are executed. At the result, it is achieved that the proposing antenna deployment with plate spring can deploy with reduction for equipment space and electric power supply as the cubesat.

今井 雅文

高専宇宙人材育成における気球実験の取り組みと将来像

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2021 年度大気球シンポジウム, (2021. 11)

人工衛星の開発は、機械・電気電子・情報・材料といった複数の分野にまたがる知識・技術が必要であり、また「宇宙」というキーワードは高専等の「ものづくり教育」の現場において、ものづくりへの興味

関心を高める上で有効である。「高専スペース連携」は宇宙理工学の研究分野を持つ高専教員からなるグループとして、高専における宇宙関連の教育を推進する目的で 2011 年に発足した。2014 年頃からは「国立高専の連携による人工衛星開発」と、「衛星開発・運用に携わることができる人材育成」を具体的な目標として掲げ、現在まで活動を続けてきている。「高専スペース連携」の特徴的な取り組みとして、2015 年から実施している合宿型教育プログラム「高専スペースキャンプ 1)」、2017 年からオンラインで全国の希望者に宇宙理工学講座を配信している「高専スペースアカデミア 2)」等がある。宇宙工学の専門学科を持たない国立高専の学生がハンズオン形式で宇宙理工学、特に超小型人工衛星開発と運用に関する知識・技術を身に付けられる環境を整えてきている。並行して、我々が提案した 2U サイズの超小型人工衛星「KOSEN-1」は、JAXA の革新的衛星技術実証プログラム 2 号機に採択され、2021 年度の打ち上げ機会を得るに至った。また、「KOSEN-1」に続いて開発中の「KOSEN-2」は、革新的衛星技術実証 3 号機に採択され、2022 年度の打ち上げ機会を得ている。本発表においては、高専スペース連携で実施している宇宙人材育成の取り組みの中で、高専スペースキャンプで行われている気球実験の事例及び、2021 年度から本格開催される「全国高専宇宙コンテスト」に関連した気球実験の将来像について紹介する。

IMAI Masafumi

2U-CubeSat KOSEN-1 Technology Demonstration for Jupiter Radio Observation

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33rd ISTS, (2022.3)

Our CubeSat project organized by 10 colleges of the National Institute of Technology in Japan was selected as a CubeSat candidate for JAXA's Innovative Satellite Technology Demonstration-2. This 2U CubeSat, named KOSEN-1 (Figure 1), is planned to be launched by a JAXA Epsilon Launch Vehicle (Figure 2 and 3) on October 1st, 2021. KOSEN-1 will demonstrate three new spaceborne technologies for the CubeSat system: (1) a performance of the dual reaction wheel, (2) a usage of the Raspberry Pi CM1 based OBC, and (3) an expansion of a 6.6m long dipole antenna. The scientific target is to capture Jupiter's millisecond short-bursts (S-bursts) in collaboration with the ground-based radio telescopes in understanding the radio beaming structures with thickness of beaming [1]. Like the RadioJOVE receiver, KOSEN-1 has a software-defined radio (SDR) receiver that can monitor the electric fields of the waves around 20 MHz by means of a 6.6m long dipole antenna. The SDR receiver can provide both waveforms and spectra in a 2MHz bandwidth depending upon the available telemetry to the ground, while the timing of the records is synchronized with the GPS 1 Pulse-Per-Second. Since its launch, KOSEN-1 will have maintained its polar orbit around Earth, freely observing Jovian DAM radiation. We propose to observe a total of 16 Io-related S-burst events with KOSEN-1 and ground-based radio telescopes, including LWA1 and LWA-Sevilleta.

IMAI Masafumi

Cultivation of Space Human Resources by Nationwide KOSEN Online Lectures and Idea Contest to Develop Mission Planning Ability

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33rd ISTS, (2022.3)

In order to provide the characteristic educations of space science and technology among “KOSEN” colleges in Japan, we established “Space collaboration group” in 2011. Since 2015, we have held boot camp style education programs of aerospace, called “KOSEN space camp” [1]. We also promoted online-based educational program of “KOSEN space academia” [2]. The participants in the camp and academia programs could learn the basics of satellite development processes by using CanSat kits and model CubeSat kits. On average, about 35-40 students participate in our educational program every year.

In parallel, we are now developing two original CubeSats (not mock-up) named “KOSEN-1” and “KOSEN-2”, which are both expecting to be launched from Uchinoura Space Center. We aim to develop a follow-up series of satellites built by KOSEN students and staffs in the near future. In keeping the developments of KOSEN satellite series, further improvements of our education are needed, which lead KOSEN students to closely involve the KOSEN satellites developments. It is important to have not only knowledge and technical skills but also mission planning ability. In order to meet this requirement, we proposed the brand-new contest among the KOSEN students. It is called “all KOSEN space contest”. In this contest, participants propose and examine an actual satellite mission using “KOSEN-X simulator” (Fig.1). This simulator has 2-U mission space and the same bus system as the KOSEN-1 satellite. The participants can freely draw up a practical idea in space by using this simulator. The participants give online presentations (Fig.2), which are evaluated by several space scientists and engineer of JAXA and space laboratories in universities. As a part of the contest, the participants can also obtain feedback from these professionals.

We positioned our first contest held in early 2021 as a trial. As a part of this pre-contest, we held a guidance workshop of KOSEN-X simulator at NIT, Niihama College on 7-8 November, 2020. The participants learned about a general method to use the simulator at the workshop. About two month later, our online pre-contest was held with 7 student teams and 5 judges on 11 January, 2021.

In this trial pre-contest, there were a few unique proposals that were useful to apply for actual satellite development and operation in space. From the participant’s questionnaire, it was found that our contest provided an excellent opportunity for KOSEN students to contact space scientists and engineer. In this presentation, we report about the pre-contest and evaluate the effectiveness to reinforce our student’s mission planning skills and interest in satellite developments.

IMAI Masafumi

A Preliminary Study on Attitude Detection System with Capturing Omni-directional Image for Ultra-Small Satellite on Orbit

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SAMCON2022, (2022. 3)

In this report, an attitude detection system with capturing omni-directional image for ultra-small satellite on orbit is described. To detect the attitude angle for ultra-small satellite called as “Cubesat”, the authors conduct omni-directional camera system to specify relative direction for sun and center of the Earth from the satellite on orbit. Then pixel grid of capturing image for the omni-directional camera with strong distortion is formulated as direction vector to analyze some fixed points from the satellite. In this report, to specify the satellite attitude on orbit, it is possible that solar and center of the Earth relative direction from the satellite are determined by capturing image with omnidirectional camera even if the figure of the sun and the Earth is not appeared directly on the image. Then the solar and center of the Earth direction are introduced by the calculation of the Earth outline of capturing image, it is possible that an attitude angle of the satellite is calculated by relationship between the satellite position on orbit and these two fixed points consisted of the solar and center of the Earth direction. To conduct the proposing attitude detection system, a numerical analyzing for the attitude detection by using a sample image with including Earth outline model is calculated, moreover capturing image from launched small satellite on orbit is analyzed.

IMAI Masafumi

A Preliminary Study on Attitude Control System with Magnetorquer by Jacobian Matrix for Ultra-Small Satellite

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SAMCON2022, (2022. 3)

In this report, an attitude control system with magnetic torquer for ultra-small satellite called as “cubesat” is described. To construct the 3-axes attitude control system for geomagnetic field on orbit, the authors propose rate attitude control system with magnetic sensor and torquer with Jacobian matrix, moreover the attitude control method on polar orbit is treated. Then the attitude control system brought COTS to adapt strict conditions for equipment space and electric power supply is treated as Innovative-2 project. To verify the constructing attitude control system for the cubesat, some preliminary experiments to obtain the characteristics of constructing magnetic torquer are executed. As a result, it is considered that the proposing attitude control system with magnetic torquer is effectiveness for the cubesat.