第 35 回　アストロダイナミクスシンポジウム（2025 年）アブストラクト集
35th Workshop on JAXA Astrodynamics and Flight mechanics (2025) Abstract

Special Lecture Jul 28th(Mon) Main Room PM(15:00-16:00)

Behçet Açıkmeşe (University of Washington)

Behçet Açıkmeşe is a Professor of Aerospace Optimization and Control in the William E. Boeing Department of Aeronautics and Astronautics and an Adjunct Professor in the Department of Electrical and Computer Engineering at University of Washington, Seattle. He received his Ph.D. in Aerospace Engineering from Purdue University. He was a senior technologist at JPL and a lecturer at Caltech. At JPL, he developed GN&C algorithms for planetary landing, spacecraft formation flying, and asteroid and comet sample return missions. He developed the “flyaway” GN&C algorithms used successfully in NASA’s Mars Science Laboratory and Mars 2020 missions during the landings of Curiosity and Perseverance rovers on Mars in 2012 and 2021. Dr. Açıkmeşe invented a real-time convex optimization based planetary landing guidance algorithm (G-FOLD), which is the first demonstration of a real-time optimization algorithm on a reusable rocket. This novel optimization-based control algorithm proved to be a key development in aerospace GN&C, especially in enabling advanced numerical optimization techniques for autonomous reusable rockets. He is a recipient of the NSF CAREER Award, IEEE Technical Excellence in Aerospace Controls, numerous NASA Achievement awards for his contributions to NASA missions and technology development. He is an associate editor of IEEE Control System Magazine and AIAA Journal of Guidance, Control, and Dynamics. He is a recipient of multiple best paper awards from AIAA and IEEE. He is also a fellow of AIAA and IEEE.

「Optimization-Based Design and Control for Next-Generation Aerospace Systems」

Abstract

Next-generation aerospace systems – from asteroid-mining robots and spacecraft swarms to hypersonic vehicles and urban air mobility – demand autonomy that transcends current limits. These missions require spacecraft to operate safely, efficiently, and decisively in unpredictable environments, where every decision must balance performance, resource constraints, and risk. The core challenge lies in solving complex optimal control problems in real time while: i) *Exploiting full system capabilities* without violating safety limits, ii) *Certifying algorithmic reliability* for critical Guidance, Navigation, & Control (GN&C) systems, iii) *Co-designing hardware and software subsystems* for optimal end-to-end performance. Our solution is *optimization-based autonomy*. By transforming GN&C challenges into structured optimization problems, we achieve provably robust, computationally tractable solutions. This approach has already revolutionized aerospace: reusable rockets land autonomously via real-time trajectory planning, drones navigate dynamic obstacles, and spacecraft perform precision docking – all powered by algorithms that solve optimization problems with complex physics-based equations and inequalities in milliseconds.

Emerging frontiers – such on-orbit satellite servicing, multi-vehicle asteroid exploration, largescale orbital spacecraft swarms, and global hypersonic transport – push these methods further. Yet barriers remain: handling non-convex constraints, ensuring solver resilience, large-scale optimization for decision making and co-design, and bridging the gap between theory and flight-ready systems. This talk explores how real-time optimization is rewriting the rules of autonomy, and how researchers can turn these innovations into practice – propelling aerospace engineering into an era where aerospace systems think, adapt, and perform at the edge of the possible.

Special Lecture Jul 29th(Tue) Main Room PM(12:45-13:45)

上野　誠也（UENO Seiya）

JAXA 航空技術部門/横浜国立大学名誉教授（JAXA Aviation Technology Directorate/ Professor Emeritus of Yokohama National University）

1985 年に東京大学大学院工学系研究科航空宇宙工学専攻博士課程修了. 工学博士. 1985 年より㈱東芝宇宙開発部門において姿勢制御系設計を担当．1988 年に横浜国立大学工学部助教授に採用，主に航空宇宙工学の誘導制御に関する教育研究に従事．2023 年に同大学定年退職後，JAXA 航空技術部門に非常勤職員として採用，将来の航空交通管理に関する研究開発に従事．専門は誘導制御，特に最適制御理論を応用した軌道最適化を主として研究に従事．日本航空宇宙学会第 46 期会長，同学会名誉会員など学会活動にも従事.

「力学から見た最適軌道（Optimal trajectory specific to dynamical system）」

Abstract

最適制御理論から導かれた最適軌道は古くからロケットや探査機の軌道設計に重要な役割を担っていた。最適制御理論で導いた式を誘導則に適用した例も多くみられる。計算機の発達に伴い、最適軌道を搭載計算機で求めることも可能となっている。しかし、最適化の対象は力学システムである。導かれた最適軌道や誘導則には力学の基本原理が含まれていることがある。数値計算で求めた最適軌道を力学システムとして考察する。

Abstracts (Room A)

ASTRO-2025-A001

「小天体近傍における複数特徴点を追尾する軌道設計手法の検討」

「Study of trajectory design with multiple feature points tracking around small body」

* 吉川 健人, 津田 雄一(JAXA)

Abstract:

This presentation discusses trajectory design near celestial bodies for guiding the spacecraft using multiple cooperative targets deployed on the celestial body as precise and stable observational data.

ASTRO-2025-A002

「フロケモードに基づいたソーラーセイルのロバストハロー軌道制御」

「Floquet-Mode-Based Robust Station Keeping around Halo Orbits Using Solar Sails」

* 中条 俊大（科学大）

Abstract:

Thanks to recent technology demonstrations in space, solar sails are becoming more practical. Autonomous guidance and control are essential for practical use, but modeling uncertainties is a major challenge, especially in unstable orbits such as halo orbits. Furthermore, the orbit control input for solar sails is the attitude angle, which has only two degrees of freedom, making the control problem more complicated. To address these challenges, this study presents a new guidance strategy that converts the dynamics into a Floquet-mode-based system and maintains the orbit using sliding mode control that is robust against uncertainties such as control errors.

ASTRO-2025-A003

「小天体フライバイにおける相対軌道運動の解析的多項式近似法の 3 次元定式化」

「Three-Dimensional Formulation of Analytical Polynomial Approximation of Relative Orbit Motion on Small-Body Flyby」

* 鶴谷 柊朔(東大・院), 津田 雄一(JAXA)

Abstract:

Flyby exploration is a promising approach for studying small celestial bodies, and autonomous navigation technology plays a key role in facilitating such missions by enabling

efficient and scalable operations. However, there are many challenges to overcome for implementing autonomous system, including limited onboard computational power and the inadequacy of traditional linearization methods under high-speed flyby conditions. In this research, we propose a novel orbit calculation method that analytically derives approximate polynomial solutions to nonlinear relative motion equations, achieving high accuracy with low computational load. On this presentation, specifically, how to realize three-dimensional formulation are focused on. Simulations under realistic flyby scenarios validate the effectiveness of this new dynamics model.

ASTRO-2025-A004

「はやぶさ 2 トリフネフライバイ最接近フェーズにおけるの小惑星観測姿勢検討」

「Study on Asteroid Observation Attitude during Encounter Phase of the Hayabusa2 Trifune Flyby」

* 岩城 拓弥, 三桝 裕也(JAXA), 平林 正稔(Georgia Tech), 下村 純人, 藤原 正寛, 楠本 哲也(JAXA)

Abstract:

During the flyby of the asteroid Torifune by the asteroid probe Hayabusa2, the scientific observation is conducted by its onboard instruments as the probe passes within a few kilometres of the asteroid. The probe takes a predefined observation attitude during this brief encounter. In this study we identify the constraints that must be satisfied when determining the observation attitude. Under these constraints, the observability of each scientific instrument is evaluated through simulation.

ASTRO-2025-A005

「モデル予測制御による月付近の周期軌道への軌道維持」

「Station-keeping for periodic orbits near the Moon with model predictive control」

* 永井 雄介, 柳尾 朋洋(早大・院)

Abstract:

Recently the study of periodic orbits near the Moon has never been more important because of NASA's Lunar Gateway. This study implements numerical simulations of station-keeping for several periodic orbits near the Moon such as halo orbits, vertical Lyapunov orbits, planer Lyapunov orbits, and near-rectilinear halo orbits. Halo and near-rectilinear halo orbits were obtained from numerical continuation, while the others were from the center manifold

reduction near L1/L2. The main purpose of this study is to evaluate fuel-efficiency of these periodic orbits. For this purpose, the necessary ΔV for 1-month station-keeping along each periodic orbit was computed respectively. The results will provide a practical point of view for the application of periodic orbits and future space missions.

ASTRO-2025-A006

「地球低軌道における超小型ソーラーセイルの姿勢運動の初期解析」

「Preliminary Study on Attitude Dynamics Analysis of Micro Solar Sail in Low-Earth Orbit」

* 川口 雄生(東京科学大・院), 中条 俊大(東京科学大)

Abstract:

This study presents an initial analysis of the attitude dynamics of nanosatellite solar sails in Low-Earth Orbit (LEO). Unlike interplanetary trajectories, LEO subjects a spacecraft to significant disturbances from atmospheric drag and gravity-gradient torque in addition to solar-radiation pressure (SRP). In this preliminary work we therefore model only SRP together with gravity-gradient torque and examine how the periodic component of the gravity-gradient torque alters the attitude response. The objectives are to assess attitude stability, clarify how sail geometry and uncontrolled attitude modes (zero-momentum and spin-stabilized) influence it, and evaluate the ability to maintain an out-of-plane orientation under these disturbance torques for PIERIS, a 30-kg-class solar-sail mission scheduled for launch in 2027.

ASTRO-2025-A010

「軌道上での可変形状機能による外力トルク変化結果」

「On-orbit results of external torque change caused by variable shape function」

* 天木 祐希（科学大・院）, 渡邉 奎, 宮本 清菜（科学大）, 小林 寛之, 小林 大輝, 尾関 優作, 田代 克樹（科学大・院）, 中条 俊大, 中西 洋喜（科学大）

Abstract:

The variable shape function is a method of attitude and orbit control by actively changing the shape of the satellite on orbit. The external torque acting on the satellite, such as gravity gradient and atmospheric drag torque, changes as the satellite shape, which can be used for environmental force estimation and attitude control. This presentation describes the on-orbit experimental results using the variable shape attitude control demonstration satellite “HIBARI” to investigate the external torque changes resulting from changes in satellite shape.

ASTRO-2025-A008

「ソーラーセイル探査機で任意の太陽角を実現する位相角制御」

「Phase-Angle Control Enabling Arbitrary Sun-Pointing Angles in Solar Sail Spacecraft」

* 木村 洸貴, 楠本 哲也, 三桝 裕也, 佐伯 孝尚, 津田 雄一(JAXA)

Abstract:

This study proposes an attitude control method for solar sail spacecraft based on dynamic equilibrium tracking. By adjusting the phase angle around the spin axis, the equilibrium direction is steered to guide the spacecraft toward sustained solar pointing. The control algorithm selects the phase angle that minimizes the predicted pointing error at each step. This approach enables precise attitude control using super-slow spin, where the spin rate is comparable to the timescale of solar radiation pressure effects. Analytical formulation and numerical simulations demonstrate the effectiveness and stability of the proposed method.

ASTRO-2025-A009

「地球-月三体系における宇宙機の軌道・姿勢連成モデルの解析および制御」

「Analysis and Control of Orbit-Attitude Coupled Model for Spacecraft in the Earth-Moon Three-Body System」

* 林 勇太(九大・院), 平岩 尚樹(JAXA) , 坂東 麻衣(九大) , 外本 伸治(九大)

Abstract:

Halo orbits in the Earth-Moon three-body problem are expected to play a key role in future deep space missions, and their importance has been increasing in recent years. In this study, periodic solutions of spacecraft attitude motion under the influence of gravity gradient torque are derived based on a coupled orbit-attitude model considering attitude dynamics in the Earth-Moon three-body problem. Furthermore, we evaluate the stability of the periodic solution and design a control system that simultaneously stabilizes the orbital and attitude motions. This study discusses the possibility of deepening our understanding of spacecraft dynamics as a coupled system and contributing to the efficient design of orbit-attitude control for future long-duration missions.

ASTRO-2025-A007

「磁力計のみによる軌道寿命短縮装置ーその方式とデバイス」

「MAGNETOMETER-BASED SELF-LIFE-SHORTENING SCHEME, DYNAMICS AND THE DEVICE」

* Aditya Gopalakrishnan, 川口 淳一郎(ANU)

Abstract:

The debris management system has been awaiting the development of devices that can be attached to spacecraft in an auxiliary manner for shorten-ing the orbital life. This paper presents an innovative scheme for simultaneous orbit and attitude determination based solely on magnetometer, without the use of filters. The system autonomously activates when the bus system malfunctions. Additionally, the paper discusses attitude control and the stability associated with propulsive maneuvers. The results demonstrate the effectiveness and utility of the scheme through its astrodynamics properties with numerical examples.

ASTRO-2025-A011

「高速自転小惑星着陸のための、不確定性を考慮した宇宙機誘導」

「Guiding a spacecraft to land on a rapidly spinning asteroid under uncertainties」

* 石塚 智大(ISAE), 尾崎 直哉(ISAS), 菊地 翔太(NAOJ), 津田 雄一(ISAS), ステファニ リジーデストレ(ISAE)

Abstract:

This study presents the preliminary mission and guidance design to land on the rapidly rotating asteroid 1998 KY26. Due to the significantly faster spin rate compared to other asteroids previously visited, the spacecraft will encounter a centrifugal force stronger than the gravitational force during the terminal descent. Consequently, downward maneuvers will be necessary for the descent. However, the development of the dynamical environment and the spacecraft guidance, navigation, and control (GNC) model is challenges, introducing uncertainties into the mission design. It is revealed that the spacecraft may fail to reach the surface if the uncertainties are not accounted for in the guidance strategy. Therefore, to ensure the reliable and safe touchdown, the guidance strategy incorporating covariance steering is implemented to mitigate the perturbations caused by the uncertainties.

ASTRO-2025-A012

「不整地への安定した着陸のための逆止弁による流量制御付きエアバッグ着陸システム-荷重発生メカニズムの考察- 」

「Flow-controlled airbag landing system with check-valves for stable landing on uneven

terrain -Investigation into the mechanism of load generation-」

* 立澤 快大(静大・院), 丸 祐介, 森 治, 伊藤 琢博, 澤井 秀次郎(JAXA), 能見 公博(静大)

Abstract:

To enable landings on uneven terrain, we propose equipping the lander's legs with airbags incorporating check valves that open when the internal pressure exceeds a certain threshold. The check valves regulate the outflow of gas from the airbags, allowing each airbag to self-adjust and maintain balance. This configuration is expected to suppress the tilting of the lander more effectively compared to conventional methods. In our previous work, we developed a mathematical model describing the ground-contact behavior of the airbags and compared it with experimental results. However, discrepancies were observed between the model and the experiments. Therefore, in this study, we aim to construct a more accurate model by investigating and considering the mechanism by which loads are generated in the airbags.

ASTRO-2025-A013

「火星衛星探査計画 MMX 探査機の着陸安全の動的評価」

「Dynamic Evaluation of Landing Safety of Spacecraft in the Martian Moons Exploration」

* 大槻 真嗣, 馬場 満久, 今田 高峰(JAXA), 高橋 正樹(KU), 姫野 武洋(UT), 前田 孝雄(TUAT), 尾崎 伸吾(YNU), 石上 玄也(KU), 小林 泰三(Rits), 北薗 幸一(TMU), 能見 公博(SU)

Abstract:

This presentation introduces a method of landing safety evaluation based on spacecraft dynamics to surface layer of Phobos in the Martian moons exploration (MMX). In contrast to conventional probes, the MMX spacecraft is intended to remain in the surface layer for several hours following its targeted landing. A distinctive dynamics model is mentioned in this presentation on the basis of low-gravity experimental results, with the capacity to replicate the flexibility of the spacecraft structure, the liquid sloshing, the shock absorption, and the interaction with the surface layer. Subsequently, we also report the spacecraft's unique behaviors for its landing simulation on authentic terrain.

ASTRO-2025-A014

「落下塔実験による薄殻エアロシェルカプセルの姿勢安定性に対する重心位置の影響

評価」
「Evaluation of the Effect of Center of Gravity on the Aerodynamic Stability of a Thin Aeroshell Capsule by Drop Tower Tests」
* 三木 嵩大（早大・院），高澤 秀人，山田 和彦（JAXA），手塚 亜聖（早大）
Abstract:
For future deep space exploration, thin aeroshell capsules with a low ballistic coefficient are investigated. To study the effect of the center of gravity (CG) on attitude stability at low speeds, drop tests were conducted in a drop tower using capsules with varying CG locations. The capsules, with a diameter of 0.4 m and a mass of approximately 560 g, were dropped from a height of 25 m. When the CG was located beyond 37.7% of the capsule diameter from the tip, growth in oscillation amplitude was observed.

ASTRO-2025-A015
「スラスタ噴射による天体表面物体の飛散挙動」
「Dispersal behavior of regoliths by thruster jet」
* 山川 真以子，丸 祐介，澤井 秀次郎(JAXA)，大門 優(ITF)，中島 健賀(RYOYU)，津田 雄一，森 治(JAXA)
Abstract:
This study presents a geometric method to predict the direction and amount of regolith dispersed by thruster jets during spacecraft landing, using crater shape estimation. Experimental and numerical investigations—via simplified one-way DEM-CFD—show that regolith dispersal depends on crater geometry, which varies with jet angle and thrust conditions. Single and multiple thruster configurations were analyzed, revealing how plume interactions and crater wall angles influence regolith trajectories. The findings offer practical guidance on thruster layout and sensor placement to minimize contamination. This approach enables efficient mission planning without two-way DEM-CFD, supporting safer landings on celestial bodies.

ASTRO-2025-A016
「ガスサンプリングシステムにおける、1way DEM-CFD 手法を用いた粒子挙動シミュレーション」
「Particle Behavior Simulation Using a 1-Way DEM-CFD Method in a Gas Sampling System.」

* 髙田 真緒(関学・院), 山川 真以子(JAXA), 中川 雄登(東大・院), 松浦 周二(関学), 森 治(JAXA)
Abstract:
In this study, we simulated the particle behavior in a gas sampling system, in which particles on the regolith surface are blown up by a high-pressure gas jet to collect samples. Axisymmetric velocity and density distributions obtained from a fluid analysis conducted in advance were used, and particle motion was reproduced using a 1-way DEM-CFD method in which fluid drag and wall contact forces were applied to the particles. This method can be used to simulate particle motion and dispersal behavior under gas injection. Based on the simulation results, we examined how surface particles are blown up by the jet and collected as a sample.

ASTRO-2025-A017
「Improving Lunar Descent Guidance and Control through Overshoot Reduction with Smooth Attitude Transitions」
* Duran Fatih(RWTH), Ito Takahiro, Maru Yusuke(JAXA)
Abstract:
In January 2024, JAXA's Smart Lander for Investigating Moon (SLIM) achieved a pinpoint landing with an accuracy of under 100 meters. This level of precision is crucial for future space missions, allowing landers to reach scientifically valuable yet hazardous terrain. During SLIM's powered descent, a known issue was a brief horizontal overshoot when switching thrust directions, caused by limitations in attitude dynamics and abrupt commands. To address this, a smoother attitude transition strategy is introduced. By gradually blending thrust directions, the resulting thrust vector changes more gently, reducing dynamic stress and improving alignment between guidance and control. While SLIM used pulsed-mode thrust, this study also explores throttleable thrusters as an alternative. A guidance law for continuous thrust modulation is being developed, aiming to maintain accuracy while improving fuel efficiency.

ASTRO-2025-A018
「木星エアロキャプチャ用極超音速滑空体の熱解析」
「Theamal Analysis of Hypersonic Glide Vehicle for Jovian Aerocapture」
* 臼杵 智章(東大・院), 津田 雄一(JAXA)

Abstract:
The Jovian aerocapture is effective method for exploring the Jupiter rings. However, when using a high L/D glider, leading edge is exposed to a severe aerodynamic heating environment of 85MW/m2. We analyzed internal temperature of the heat shield during aerocapture by one-dimensional ablation code. As a result, we confirmed that high-density carbon-phenolic material with 80 mm thickness is required for Jovian glide vehicle.

ASTRO-2025-A019
「多様体上の凸最適化による RCS の On/Off を考慮した着陸誘導」
「Landing Guidance with On/Off RCS via Convex Optimization on Manifolds」
* 鳴海 龍哉(東大・院), 坂井 真一郎(JAXA)
Abstract:
This study presents a novel method for handling the on/off switching behavior of a reaction control system (RCS) in landing guidance. The binary nature of the switching introduces significant computational challenges in trajectory optimization. While convex-concave decomposition has previously been used to address such problems, we propose an alternative approach based on manifold optimization. By reformulating the mixed-integer problem as a real-valued relaxation on a manifold, the proposed method offers a structured framework for incorporating binary control inputs into trajectory design.

ASTRO-2025-A020
「固体ロケット推進剤を用いた Touch-and-Go 型サンプリング探査体に関する設計手法」
「Study of Design Methodology for Touch-and-Go Sampling Probe with Solid Rocket Propellant」
* 大木 春仁, 中川 果帆(東大・院), 楠本 哲也, 森下 直樹(JAXA), 山本 輝汰(東大・院), 津田 雄一(JAXA)
Abstract:
For future sample return missions, the concept of sending a Touch-and-Go sampling probe (TAG-SP) that specializes in sample collection from a mother vehicle that functions as a transport vehicle is being considered. For this daughter vehicle, the application of a solid rocket motor (SRM) as propellant is expected as the ultimate system for a lightweight and simple exploration vehicle. So far, we have studied a system that controls the position and attitude by deflecting the thrust vector of four SRMs with a single-axis gimbal. However, the

number of SRMs required, the degree of freedom of control, and the design method of the SRM parameters necessary for Touch-and-Go have not been systematized. Therefore, this study aims to establish a design methodology for TAG-SP that can be extended to various exploration targets and mission scenarios.

ASTRO-2025-A021

「固体推進系を用いたスピン型惑星着陸機の着陸分散解析」

「Landing Dispersion Analysis for Spinning Planetary Lander with Solid Rocket Motors」

* 中川 果帆, 大木 春仁(東大・院), 楠本 哲也(JAXA), 山本 輝汰(東大・院), 津田 雄一(JAXA)

Abstract:

This study considers a spinning planetary lander using two solid rocket motors (SRMs) with thrust vector control, achieving a minimal configuration and soft-landing system. While conventional spacecraft has 6-DoF controllability, this lander controls only vertical acceleration through spin-stabilization. Monte Carlo and covariance analyses evaluate landing dispersion due to separation errors, especially for small celestial bodies. Results highlight trade-offs in system simplicity versus landing accuracy and the potential improvements are discussed.

ASTRO-2025-A022

「未知の小惑星に対する画像航法を用いた安全で効率的な着陸制御則の検討」

「Vision-based Navigation and Path-Planning for Safe, Efficient Landing to Unknown Asteroids」

* 王 方成（東大・院）, 尾崎 直哉, 橋本 樹明（JAXA）

Abstract:

This research addresses autonomous approach and landing technologies for unknown objects in space, essential for asteroid exploration and space debris removal missions. While such missions typically separate into exploration and execution phases, constraints may limit adequate exploration, necessitating real-time safety assessment during execution. The study focuses on developing control laws for safe landing on unknown asteroids by integrating spacecraft-specific dynamics with real-time image-based navigation and terrain evaluation. The proposed approach enables simultaneous landing point safety assessment and guidance control, addressing scenarios where traditional phased mission architectures

are impractical due to operational constraints.

ASTRO-2025-A023

「固体ロケットモーターを用いた Touch-and-Go 型サンプリング探査体への SLIM 誘導アルゴリズムの適用」

「Adapting the SLIM Guidance Algorithm to a Touch-and-Go Sampling Probe with Solid Rocket Motors」

* 山本 輝汰, 大木 春仁, 中川 果帆(東大・院), 楠本 哲也, 津田 雄一(JAXA)

Abstract:

A Touch-and-Go Sampling Probe (TAG-SP), a small sample return spacecraft equipped with solid rocket motors (SRMs), is being conceptualized as a future sample return system. One of the key challenges is performing complex landing guidance with limited onboard computational resources. To address this, we adapt the landing guidance algorithm of the Smart Lander for Investigating Moon (SLIM) to TAG-SP, enable trajectory design without numerical optimization. This adaptation presents specific challenges: the uncontrollable thrust and fixed burn duration of SRMs, and the need to account for the curvature of the target celestial body. We consider addressing these issues by modifying SLIM's terminal descent phase division. This approach aims to develop a feasible and efficient guidance method for TAG-SP missions.

ASTRO-2025-A024

「非線形 MPC を用いた CMG 搭載宇宙機の最適姿勢制御」

「Optimal attitude control of CMG-equipped spacecraft using nonlinear MPC」

* 井本 悠太, 中務 雄祐, 佐藤 訓志(阪大)

Abstract:

In this study, a spacecraft attitude control law utilizing nonlinear Model Predictive Control (MPC) is proposed.

In attitude control of spacecraft equipped with CMG, it is common to use steering laws to calculate gimbal angle transitions.

However, steering laws have singularity problems.

Therefore, an attitude control method is needed that directly designs optimal transitions of gimbal angles and gimbal angle accelerations without relying on steering laws.

Therefore, in this study, a nonlinear Model Predictive Control (MPC) approach is employed

for spacecraft attitude control.
The effectiveness of the designed control law is verified through simulations and actual experiments.
Additionally, conditions for controller parameters to ensure stability are also examined.

ASTRO-2025-A025
「直行軸のリアクションホイールを利用した Z 軸 One Wheel Control」
「Z-axis One Wheel Control utilizing Reaction Wheel Mounted on the Transverse Axis」
* 楠本 哲也, 木村 洸貴, 三桝 裕也, 佐伯 孝尚(JAXA)
Abstract:
Hayabusa2 can stabilize its attitude only by a reaction wheel around the z-axis and this one-wheel control mode has been used in the actual mission. This study proposes to utilize a reaction wheel mounted on the transverse axis to broaden the controllability of the z-axis one wheel control. Precession and nutation motion can be changed by the actuation timing of a reaction wheel and the amount of angular momentum. This study explains the usage of the reaction wheel of the transverse axis via simulation and flight data.

ASTRO-2025-A026
「惑星間探査機のための SAP 独立駆動による角運動量制御の検討」
「Study on Angular Momentum Control by Independent SAP Driving for Interplanetary Spacecraft」
* 小坂 岳文, 中川 弘喜, 小澤 祐亮, 保田 誠司(NEC)
Abstract:
Interplanetary spacecraft is exposed to various disturbance torques and they are accumulated as angular momentum in reaction wheels (RWs). For releasing the angular momentum, one possible method is utilizing reaction control system (RCS) thrusters, however, fuel mass consumed by RCS injection has a critical impact on spacecraft mass budget. To reduce fuel consumptions, this study describes an angular momentum unloading algorithm utilizing solar radiation pressure (SRP) torque generated by independent solar array panel (SAP) driving. A relational model between SAP angle and SRP torque is derived and then determination logic of each SAP angle according to direction of unloading torque and momentum control law are constructed. Finally, effectiveness of fuel consumption reduction is verified through numerical simulations assuming interplanetary phase of

DESTINY+ spacecraft.

ASTRO-2025-A027

「デブリ捕獲用ロボットアームのジンバル機構を利用したトルク平衡姿勢誘導」

「Torque Equilibrium Attitude Guidance Using Gimbal Mechanisms of Debris Capturing Robotic Arm」

* 中嶋 哲大（科学大・院），佐々木 貴広（JAXA），中条 俊大（科学大），中村 涼（JAXA），中西 洋喜（科学大）

Abstract:

It is revealed that TEA (torque equilibrium attitude) is effective for ADR (active debris removal) by small satellites. In order to miniaturize the satellites, it is required to realize TEA by smaller attitude actuators equipped with the satellites, such as reaction wheels. In this research, TEA by attitude actuators and gimbal mechanisms of capturing robotic arm is proposed. The proposed attitude guidance algorithms are demonstrated in numerical simulations. Throughout the simulations, it is shown that the proposed algorithms realize TEA by smaller attitude actuators than conventional TEA guidance algorithms.

ASTRO-2025-A028

「ニューラルネットワークを用いた CMG の逆キネマティクス」

「Neural Network-Based Inverse Kinematics for Control Moment Gyroscopes」

* 東山 大輝(MELCO, OMU・院), 下村 卓, 山田 克彦(OMU)

Abstract:

This work proposes a data-driven inverse kinematics approach for control moment gyroscopes (CMGs) using neural networks. Conventional Jacobian pseudoinverse-based steering laws exhibit poor conditioning near kinematic singularities, leading to unbounded gimbal rates. In contrast, the neural network directly approximates the mapping from commanded angular momentum to gimbal angles, inherently bypassing Jacobian inversion. However, solution discontinuities may still occur in the vicinity of singular manifolds. To mitigate this, training datasets are generated with singularity avoidance constraints to ensure feasible transitions. Comparative simulation studies of attitude maneuvers demonstrate the advantages of the proposed method relative to traditional algorithms.

ASTRO-2025-A029

「超小型衛星における永久磁石を使った姿勢制御に関する実験的評価」

「An Estimation of Passive Attitude Control System with Magnetorquer by Permanent Magnet for Ultra-small Satellite」

* 井上 永遠(群馬高専・専攻科), 滝谷 優太, 渡邉 真桜, 長壁　孝太郎(群馬高専・本科), 平社 信人(群馬高専)

Abstract:

In this report, a passive attitude control system with magnetic torquer by permanent magnet for the ultra-small satellite on polar orbit is described. Then to produce a concentrated magnetic field without dispersion for the attitude control system by magnetorquer, some plate type magnets with perpendicular magnetization are arranged circumferentially to adapt the strict condition of such ultra-small satellite. Furthermore, to reveal some functions of the constructed passive magnetorquer, the ultra-small satellite with the magnetorquer has developed as Innovative Satellite Technology Demonstration-2 project planning by JAXA. Then obtained data on orbit of the attitude control experiment are analyzed and evaluated.

ASTRO-2025-A030

「STT 出力の符号制約を考慮した姿勢制御の検討 (第 3 報)」

「Study on the attitude control of spacecraft by taking account of the sign restriction on the STT output (3rd report)」

* 軸屋 一郎（金大）, 西藤 卓矢（金大・院）, 山田 克彦（大公大）

Abstract:

The Euler parameters representing the spacecraft attitude are uniquely determined except the indefiniteness in the sign. This sign indefiniteness is not often considered in the attitude control of satellite. In our previous work, we have pointed out that this sign indefiniteness becomes an obstacle for the conventional quaternion-based proportional derivative (PD) control, and then, proposed three types of control laws for this problem. In this work, we discuss the robustness with respect to the multiplicative measurement noise.

ASTRO-2025-A031

「High Accuracy Analytical Ground Point Velocity Calculation for Remote Sensing Missions」

* Yadav Jeet, Kumar Gaurav, Sateesh Dhanisha, Sivaraman Gowtham(Pixxel)

Abstract:

Precise attitude references are essential for high-quality remote sensing data. As higher ground resolution is pursued, control reference accuracy becomes critical. Understanding projected sensor line-of-sight motion is key to computing the spacecraft's desired attitude profile across various imaging profiles for a variety of remote sensing missions. This paper introduces simple analytical methods to compute effective ground velocity using instantaneous state, imaging geometry, and local surface curvature. After framing the problem and reviewing numerical methods, an algorithm is derived to express the instantaneous ground point velocity in terms of terms of imaging geometry and the satellite state derivative. A framework is also defined to derive quaternion reference profiles based on a parameterized curve on any planetary body. Results show >99% accuracy compared to numerical methods, with significant computational savings. Future applications and scope are also discussed.

ASTRO-2025-A032

「姿勢誤差表現の違いによる制御性能の比較評価」

「Comparative evaluation of control performance with the different attitude error expressions」

* 藤本 翔太(帝京大・院), 中宮 賢樹(帝京大)

Abstract:

Various attitude-error representations based on Euler angles and quaternions are used in spacecraft attitude control, yet their impact on control performance has not been fully quantified. Therefore, this study quantitatively evaluates how different attitude-error representations affect control performance through numerical simulations. To capture global characteristics, the initial attitude error is swept from 0deg. to 360deg. about a fixed axis, and an evaluation function is calculated at each angle. The performance indices obtained for each representation are then compared.

ASTRO-2025-A033

「姿勢制御における外乱オブザーバーを用いたスラスタ誤差の推定とフィードバック則の検討」

「Thruster Error Estimation and Feedback Law during Attitude Control Using a Disturbance Observer」

* 石戸 大智(総研大・院), 坂東 信尚, 森 治, 佐伯 孝尚(JAXA)

Abstract:
In deep space exploration, there is a growing need for missions involving multiple spacecraft, such as the Orbital Transfer Vehicle (OTV). In such missions, Rendezvous and Docking (RVD), which requires precise control, is considered a critical technology. However, when using thrusters for the precise control needed in RVD, output thrust errors present a significant challenge to improving accuracy. These thrust errors, which are a form of model disturbance, cannot be directly observed, and conventional methods have struggled to accurately identify them. Therefore, this study proposes a feedback control framework that utilizes a disturbance observer to accurately estimate thruster errors from observable attitude motion. This method makes it possible to achieve high-precision attitude control with thrusters.

Abstracts (Room B)

ASTRO-2025-B001

「MMX の探査機オンボード航法系」

「Spacecraft on-board navigation system for Martian Moons eXploration」

* 渡邉 泰之, 上野 竜雄, 渡辺 健太郎, 杉田 幹浩(MELCO), 宮井 太士(MESW), 松本 祐樹, 木村 洸貴, 岡田 尚基, 竹尾 洋介, 吉川 健人, 巳谷 真司(JAXA)

Abstract:

The MMX spacecraft has an on-board navigation system which precisely estimates its position and velocity relative to Phobos. The estimation is realized by an extended Kalman filter, which integrates acceleration obtained from a gravity model and an inertial measurement unit and measures position with an optical camera and a laser altimeter. This system is applied to navigation for descending to Phobos and partially to on-board orbit determination in quasi-satellite orbits. In this presentation, the composition and processing of the navigation system is introduced and simulation results of navigation and guidance descending to Phobos are shown as numerical examples.

ASTRO-2025-B002

「生成モデルを用いたシスルナ空間非協力物体のマヌーバ推論」

「Generative Maneuver Inference for Non-cooperative Objects in Cislunar Space during Optical Blackouts Using Diffusion Models」

* 荒井 俊哉(総研大・院), 尾崎 直哉(JAXA)

Abstract:

In cislunar space, multi-body gravitational dynamics and limited opportunities for optical observation—due to solar interference and other factors—make it challenging to detect orbital changes of non-cooperative objects based solely on angle-only tracklet measurements.

This study proposes a probabilistic method that simultaneously infers both the maneuver profile during periods of optical blackout and the measurement-to-object association for multiple non-cooperative objects in cislunar space.

The method utilizes Conditional Diffusion Probabilistic Models and is based solely on sparse angle-only tracklets obtained after the blackout period.

Simulation results show that, in scenarios where the measurement-to-object association is unknown, the proposed conditional diffusion model successfully recovers the maneuver as

a well-resolved multimodal probability distribution.

ASTRO-2025-B003

「彗星尾方向を用いた彗星同定アルゴリズムのパラメータチューニング手法の検討」

「Study of parameter tuning methods for comet identification algorithms using comet tail directions」

* 都筑 大樹(東大・院), 藤原 正寛, 坂谷 尚哉, 佐々木 貴広, 尾崎 直哉, 伊庭 遼, 船瀬 龍, 橋本 樹明(JAXA)

Abstract:

The success of a comet exploration mission depends on the ability to identify the target comet from images that also contain stars and noise. To date, algorithms have been proposed that utilize the characteristic of comets' tails extending in the opposite direction from the sun to identify comets from a single image. However, there has been the challenge of experimentally determining the threshold parameters. In this study, we propose a method for tuning the threshold parameters based on prior information about the probe and the comet. In this presentation, we report on the results of our investigation of the proposed method.

ASTRO-2025-B004

「測角航法による超小型サンプリングプローブの初期軌道決定」

「Angles-only initial orbit determination of an ultra-compact sampling probe」

* 川﨑 歩, 久島 明洋, 天川 海音(東大・院), 津田 雄一(JAXA)

Abstract:

In recent years, functionally separated small celestial body sample return missions, which divide roles between an orbital transfer vehicle and a mission vehicle, have attracted increasing attention. One key challenge is the initial orbit determination of an ultra-compact sampling probe launched from the surface of the small celestial body. This study addresses angle-only initial state estimation by sequentially capturing images from the orbital transfer vehicle stationed above the target body. To reflect the real mission environment, a high-fidelity dynamical model incorporating perturbations such as the body's non-uniform gravity and SRP is developed to evaluate the feasible region in the observation condition space where reliable estimation is possible. Simulation results show that conventional MAP estimation assuming linear dynamics is sensitive to prior uncertainty, whereas leveraging

the nonlinear dynamics of the environment improves estimation robustness.

ASTRO-2025-B005
「深宇宙探査における推進装置を持たないサンプルコンテナに対する着陸機に支援された相対航法」
「Lander-aided relative navigation for unpropelled sample containers for deep-space exploration」
* 久島 明洋, 川﨑 歩, 天川 海音(東大・院), 杉原 アフマッド清志, 津田 雄一(JAXA)
Abstract:
For future sample return missions, a small lander-sampler is proposed to land on the target body on behalf of the Orbit Transfer Vehicle (OTV) and return a sample container to the OTV. The container transmits radio signals to enable the OTV to direction-find the container and capture it. However, this angles-only approach requires a complex rendezvous sequence for range estimation, while placing a ranging instrument on the container is challenging due to size and power limitations. To address this dilemma, we explore the possibility of using the stationary lander to aid with navigation, where a reflector or a transponder is placed on the lander, enabling the OTV to obtain range or range-rate information.

ASTRO-2025-B006
「はやぶさ２＃のトリフネ近接フライバイに向けたオンボード画像航法の高精度化検討」
「Improvement of Onboard Image Navigation for the Proximal Flyby of Torifune by Hayabusa2#」
* 尾川 順子, 楠本 哲也（JAXA）, 淡野 敏, 松久 孝志（SEC）, 山田 学（千葉工大）, 湯本 航生, 三桝 裕也（JAXA）
Abstract:
はやぶさ２＃のトリフネ近接フライバイにおいては，トリフネをオンボードで光学的に認識することが計画されているが，既存の小惑星トラッキング（AIT），ターゲットマーカトラッキング（TMT）よりも高精度な認識が求められている．本発表では既存のトラッキング手法の高精度化検討について紹介する．

ASTRO-2025-B007

「シスルナ圏ミッションのための GNSS-AOWR ハイブリッド航法装置」

「GNSS-AOWR Hybrid Navigation Device for Cislunar Mission」

* 西本 慎吾(ANU・院), 川口 淳一郎(ANU)

Abstract:

A navigation technique in cislunar space that is independent of space agencies is essential for enabling advanced space exploration in the region. However, the poor geometry of GNSS satellites at cislunar distances degrades observability and poses challenges to positioning accuracy. This study proposes a hybrid navigation device using GNSS and Asynchronous One-Way Ranging (AOWR) to address these observability issues and demonstrates its effectiveness through hardware-in-the-loop simulation. The scheme operates without relying on sophisticated ground facilities, enabling participation in lunar exploration by universities and the private sector.

ASTRO-2025-B008

「はやぶさ２＃：超小型小惑星への光学航法に関する考察」

「Hayabusa2#: Investigation of the Optical Navigation to the Ultra-small Asteroid」

* 三桝 裕也(JAXA)

Abstract:

After return to Earth on December 6th, 2020, Hayabusa2 departed from Earth to start its new journey to the deep space. The next rendezvous target was selected as the asteroid 1998 KY26, which is a very small object with a diameter of about 30m and its rotation period is very fast about 10min. It is believed that the centrifugal force on the surface of the asteroid will be larger than gravity assumed from its size. In that special dynamical field, it is challenging for Hayabusa2 to perform touchdown operation without an artificial ground control point, target marker. In this paper, consideration of the optical navigation for this mission is introduced.

ASTRO-2025-B009

「単眼カメラの時系列画像におけるターゲットサイズ変化を利用した宇宙機の相対軌道決定」

「Spacecraft Relative Orbit Determination Using Target Size Variation in Monocular Time-Series Images」

* 髙田 侍郎, 青野 郁也(東大・院), 相子 康彦, 津田 雄一(JAXA)
Abstract:
In this presentation, we propose a method for spacecraft relative orbit determination using time-series images from a monocular camera. Unlike conventional methods such as moving stereo vision or feature-based approaches, this method calculates the relative distance from the temporal change in the target's size in the image. An Extended Kalman Filter (EKF) is applied to estimate the state, exploiting the target's size and center in the binarized image as observations. We will detail the theoretical background and the estimation algorithm, present the results of numerical simulations, and discuss the future work of this research.

ASTRO-2025-B010
「新規クレーター環境における恒星食を利用した月面自己位置推定の拡張検証」
「Extended Validation of Lunar Self-Localization via Star Occultation in a New Crater Environment」
* 水沼 健人(東大・院), 橋本 樹明(JAXA)
Abstract:
Precise self-localization is critical for rovers in lunar Permanently Shadowed Regions (PSRs). We validate a robust method using Star Occultation; the technique identifies the match for an observed star occultation pattern within a pre-computed templates. Each template, derived from a Digital Elevation Model (DEM) and star catalogs, corresponds to a specific rover position. Building upon our previous single-crater study, we extend the validation by applying the identical methodology in a new lunar environment. This work reconfirms the method's wide applicability and provides quantitative performance insights under different topographical conditions, aiding future mission planning.

ASTRO-2025-B011
「深宇宙探査用の超小型 RF ToF センサの実験的検証と SDR を用いた新規検討」
「Experimental Validation and New Investigation with SDR of an Ultra-Compact RF ToF Sensor for Deep Space Exploration」
* 芝田 朋世（都立大・院），杉原 アフマッド清志（JAXA），鳥阪 綾子（都立大），鳥居 航, 冨木 淳史, 竹内 央, 森 治（JAXA）
Abstract:
In recent years, missions involving multiple small/ultra-small spacecraft, such as formation

flying and rendezvous docking, have gained increasing importance in deep space. In deep space exploration missions, the Global Navigation Satellite System (GNSS) is not available. Therefore, inter-spacecraft ranging techniques that do not rely on GNSS and can be implemented on small/ultra-small platforms are essential. The authors have proposed an extremely compact, lightweight, and low-power RF ToF (RF Time-of-Flight) sensor with a simple architecture that fits within a 5?10 cm class housing, and its feasibility has been demonstrated through experiments and analysis. Furthermore, for longer range, a RF ranging sensor algorithm based on SDR (Software-Defined Radio) is analytically investigated.

ASTRO-2025-B012

「ベイズ最適化を用いた能動的外乱除去制御による柔軟構造衛星の姿勢制御」

「Attitude Control of Flexible Satellites Using Bayesian-Optimized Active Disturbance Rejection Control」

* 俵谷 裕紀（防大・院）, 山﨑 武志, 髙野 博行（防大）

Abstract:

Large space structures (LSSs) behave as flexible—rather than rigid—bodies, making it intrinsically difficult to capture their complete dynamics with analytical models. This study therefore employs model-free Active Disturbance Rejection Control (ADRC) for the attitude control of LSSs, moving beyond conventional system-identification approaches. Controller parameters are tuned automatically through Bayesian optimization, enabling high tracking accuracy and robust stability with comparatively few trial evaluations. Numerical simulations on a flexible-satellite model demonstrate smooth attitude maneuvers, effective suppression of residual-mode excitations, and stability preservation under variations in modal parameters.

ASTRO-2025-B013

「軽量薄膜太陽電池パドルの動特性」

「Dynamic Characteristics of Lightweight Thin-Film Solar Array Paddles.」

* 小野 弘幸, 福永 桃子(CB), 宮崎 康行(JAXA)

Abstract:

Extremely lightweight solar array paddle is required to enable deep space exploration using micro spacecraft. The author's team is developing an ultra-lightweight thin-film solar array

paddle (SAP) consisting of triangular membrane structure and two deployable booms, which will be used for the outer planet exploration mission "OPENS-0". This paper reports the dynamic characteristics of the SAP by the modal analysis and deployment analysis of the SAP.

ASTRO-2025-B014

「小型土星探査機 OPENS の多粒子法における膜展開解析」

「Analysis of membrane deployment behavior in the Multi-Particle Method for the small saturn explorer OPENS」

* 米田 大晟(青学・院), 楠本 哲也, 杉原 アフマッド清志(JAXA), 菅原 佳城(青学), 森 治(JAXA)

Abstract:

In spacecraft, thin-film structures are used for solar sails and other applications because they are extremely lightweight and can cover a large area. The small space probe OPENS is also equipped with a lightweight thin-film structure with power generation and antenna functions. However, thin-films are very flexible and their behavior can easily become unstable, so it is necessary to simulate their deployment behavior on the ground. This study will analyze the deployment behavior of the thin-film structure of OPENS using Malti Particle Method and compare the deployment behavior with that of the actual machine.

ASTRO-2025-B015

「軽量膜展開構造物 HELIOS-R の膜展開・展張解析」

「Membrane-Deployment analysis of HELIOS-R: Lightweight Membrane Deployment Structure」

* 浜付 一輝（都立大・院）, 杉原 アフマッド清志, 楠本 哲也（JAXA）, 鳥阪 綾子（都立大）, 森 治（JAXA）

Abstract:

HELIOS-R is a lightweight membrane deployment structure with power generation and antenna functions, will be a mission component on RAISE-4. The membrane structure with functional devices is deployed by the boom extension into a triangular configuration, but the lightweight membrane structure is very flexible and their behavior under zero-g encironment must be understood. Therefore, it is necessary to simulate both their deployment behavior and the tensioned shape in advance. In this study, we will analyze the deployment behavior

of the membrane structure of HELIOS-R using Multi-Particle Method (MPM), and predict the final tensioned shape. The purpose of this presentation is to predict both the deployment behavior and the tensioned shape, contributing to improved operational reliability.

ASTRO-2025-B016

「柔軟構造物の簡易モデルを用いた固有値解析手法」

「Eigenvalue Analysis Method Using a Simplified Model of Flexible Structures」

* 河原 寛奈(青学大・院), 久保 勇貴(神戸大), 森 治(JAXA), 菅原 佳城(青学大)

Abstract:

The use of membrane structures equipped with thin-film devices for spacecrafts has been extensively studied in recent years. While such membrane structures enable weight reduction and enhanced functionality, evaluating the vibration characteristics influenced by the placement of devices remains a significant challenge. In particular, eigenvalue analysis is typically performed by constructing mathematical models and conducting finite element method (FEM) simulations; however, this approach becomes time-consuming when validating a large number of device configuration patterns. In this study, we propose a method to estimate the eigenvalues of flexible membranes with thin-film devices using an effective simplified model without relying on FEM analysis, which enables time-efficient survey of membrane configurations.

ASTRO-2025-B017

「深宇宙サンプルリターンのための自動囲い込み式ドッキング機構の宇宙環境適合に向けた双安定性機構の検討」

「Design Study of a Bistable Self-Caging Docking Mechanism for Deep Space Sample Return Missions」

* 吉田 英生, 徳安 彰大, 田中 友悠(科学大・院), 五十嵐 岳(科学大), 中西 洋喜(科学大・院)

Abstract:

To expand mission flexibility and reduce risks in deep space exploration, a parent-child type sample return mission has been proposed. A key requirement for this mission is a docking and release mechanism operable in deep space. We have proposed a claw-type docking system that completes the capture process upon initial contact, even under large misalignment tolerances. However, ensuring mechanical reliability and operability in the

harsh space environment remains a challenge. This presentation discusses the development of a new bistable mechanism to address this issue, aiming to maintain structural stability without continuous actuation. The design enhances feasibility of autonomous docking and release operations in deep space missions.

ASTRO-2025-B018

「アルキメディアンスクリュを用いた 4 輪独立 Push Pull Locomotion 型月・惑星探査ローバの軟弱斜面横断に関する研究」

「Study on Traveling across Loose Soil using Lunar and Planetary Exploration Rover with function of Push Pull Locomotion with Independently adjustable Wheelbases and Archimedean Screw」

* 奥田 誠(芝工大・院), 藤原 大佑(諏訪理科大), 飯塚 浩二郎(芝工大)

Abstract:

In recent years, conventional wheel type rovers have been adopted for lunar and planetary exploration. However, wheeled rovers experience many problems with slipping behavior on the loose slopes of lunar and planetary terrains. When traversing slopes, lateral slipping may occur which can lead to a decline in exploration efficiency, so it is necessary to address side slip performance. Previous studies have verified the effectiveness of the 4WAPPL rover function of Push Pull Locomotion for reducing slippage. The screw wheels used in this study have the shape of an Archimedean spiral revolved about a cylinder. In this study, the effect of reducing slippage of 4WAPPL type rovers equipped with Archimedean screw wheels will be experimentally verified.

ASTRO-2025-B019

「複数の小型軽量協調移動ローバを用いた斜面横断走行時の横滑り抑制に関する研究」

「A Study on Skidding Suppression during Travelling Across Slopes Using Multiple small light Collaborative Locomotion Rovers」

* 亀川 廉(芝浦工大・院), 藤原 大佑(諏訪東京理科大), 飯塚 浩二郎(芝浦工大)

Abstract:

Some organizations, such as JAXA and NASA, plan to explore the moon with many small-sized rovers called swarm rovers. A two-wheeled rover is adopted for lunar swarm rovers. However, wheel-type vehicles have a problem skidding on a loose slope of the lunar surface. Previous research proposed a collaborative locomotion using the supporting force of the

stopped wheel. This method improves the driving ability of wheeled vehicles on loose terrain. In addition, the sideways coupling of vehicles to each other could suppress skidding when crossing a loose slope. However, skidding still occurs when the attitude angle of vehicles is lowered. This study proposes a method of recovering attitude by using a stopped wheel. Moreover, the authors conduct driving tests. The result indicates the proposed method is effective in suppressing skidding and improves the crossing abilities.

ASTRO-2025-B020

「探査ロボットの移動性能向上に向けた複数移動モードの検討」

「Multi-Modal Locomotion Strategies for Improving Mobility Performance of Exploration Robots」

* 井上 弘貴(東大・院), 橋本 樹明(JAXA)

Abstract:

Exploration robots play a vital role in space missions, as they can investigate environments that are difficult or dangerous for humans to access and collect scientifically valuable data. These environments are typically composed of rough terrain with rocks and loose soil, requiring robots to possess high mobility and navigation capabilities. One promising approach to enhancing mobility is to equip robots with multiple locomotion modes. In this study, we consider a robot with such capability and investigate how its mobility performance can be improved by appropriately switching between modes according to the environment.

ASTRO-2025-B021

「宇宙機の相対加速度を利用した空中捕獲法の挙動解析」

「Behavior Analysis of Free Space Capture Method Using Spacecraft Relative Acceleration」

* 中川 雄登（東大・院）, 森 治, 佐伯 孝尚, 津田 雄一（JAXA）

Abstract:

This study aims to establish a design guideline for a material transfer method called Free Space Capture by analyzing the motion of an object within a horn-shaped structure. Unlike conventional docking-based methods that rely on canceling relative velocities, the Free Space Capture method achieves capture through collisions between the horn and the object. However, without intervention, the object is prone to escaping from the horn after successive impacts. To address this, we explore the effect of spacecraft-generated acceleration on maintaining the object's position within the horn. The findings from this study can be applied,

for example, to sample transfer between mother and daughter spacecraft in deep-space sample return missions.

ASTRO-2025-B022

「危険度最小経路に対するマニピュレータ軌道追従制御」

「Manipulator trajectory tracking control for a safety path that minimizes the "degree of danger"」

* 相子 康彦, 津田 雄一(JAXA), 上野 誠也(横国大)

Abstract:

Manipulators are expected to be used in future space missions. A variety of missions are proposed in many future visions, including crew support in space stations or capturing scientific samples for space explorers and so on. These missions, manipulators must be made autonomous to reduce the crew's workload and improve operability from the ground. Current trajectory generation for space manipulators results in discontinuous trajectories at the motion profile switching points. In this presentation, we propose a control law that tracks trajectories that consider the hardware performance of the actual manipulator by using only the target trajectory of the manipulator without setting a motion profile for the trajectory generated when the manipulator is operated.

ASTRO-2025-B023

「月面・軌道上における壁面自走型の電子ビーム溶接ロボットによる
金属・レゴリス材料の革新的接合技術」

「Innovative Joining Technology for Metals and Regolith Using a Wall-Climbing Electron Beam Welding Robot on the Lunar Surface and in Orbit」

* 南 尚吾(SQ), 大西 正悟(SQ・CEO), 高橋 宗徳(SQ・COO)

Abstract:

Our company is developing a compact, lightweight, high-efficiency electron beam welding system and integrating it into a proprietary small-scale cooperative robot platform to enable in-space welding and assembly. These wall-climbing robots operate while adhering to construction panels, allowing precise relative positioning and welding even in microgravity. By launching these robots and structural panels aboard satellites, we aim to realize full-scale on-orbit construction. Furthermore, we are extending this orbital electron beam welding technology to the lunar surface. A major challenge in lunar construction is the high

transportation cost—estimated at 200 million yen per kilogram. To overcome this, we are pioneering a world-first method of solidifying and joining lunar regolith with electron beams for use as local construction material.

ASTRO-2025-B024

「月面基地内利用パートナーロボットのダンスパフォーマンスのステップ創出」

「Creation of Steps for a Dance Performance of a Partner Robot Used in the Moon Base」

* 井上 海斗(関東学院大・院), 耿 直(元関東学院大・院), 小松 督(関東学院大)

Abstract:

With the Artemis program at its core, long-term human habitation on a planetary base is soon to become a reality. However, planetary bases are closed systems, creating an environment that imposes significant psychological stress on humans. To address this, performance robots, already proven to reduce stress both on Earth and aboard the ISS, are expected to play a role for this situation with conversation, song and dance. However, in low-gravity environments such as the Moon, dance performances executed by robots are significantly affected. To investigate how low gravity influences performance, we conducted a comparative analysis of numerical simulations and two types of hardware simulators designed to replicate lunar gravity conditions on Earth. The results of hardware simulators revealed that the inclined-plane method proved to be the more effective approach.

ASTRO-2025-B025

「サンドフィッシュスキンク模擬ロボットを用いた軟弱地盤地中移動に関する研究」

「Subsurface Locomotion in Loose Soil using a Sandfish Skink-inspired Robot」

* 溝口 友海, 大塚 慧, 藤生 翔太(芝浦工大・院), 田中 大陸(芝浦工大・学), 飯塚 浩二郎(芝浦工大)

Abstract:

Lunar exploration rovers face significant limitations in mission duration and operational range due to extreme temperature fluctuations on the lunar surface. To address this, a concept for a rover that travels beneath the lunar regolith, which exhibits excellent thermal insulation properties, has been proposed. A prototype rover capable of subsurface locomotion by mimicking the undulatory motion of the sandfish skink has been developed. However, during forward movement, the rover occasionally emerges from the sand, reducing its subsurface mobility. This study aims to clarify the cause of this phenomenon by

experimentally investigating the relationship between the rover's undulatory motion and the resulting movement of the surrounding regolith.

ASTRO-2025-B026

「単眼カメラによる推定を用いた小型飛翔体捕獲のためのマニピュレータ軌道最適化手法」

「A Manipulator Trajectory Optimization Method for Capturing Free-Flying Small Objects via Single Camera-Based Estimation」

* 青野 郁也, 髙田 侍郎（東大・院）, 相子 康彦, 津田 雄一（JAXA）

Abstract:

Small object capture is an essential technology for future space missions such as deep space sample return and debris removal. To realize the capturing technology in space, the following elements are required: autonomous control, multi-capture capability, and minimal equipment. The proposed method optimizes manipulator trajectories for capturing small free-flying objects based on estimation using only a monocular camera. Generally, estimating depth from angles-only measurements is challenging. Hence, the estimation variance at the terminal point is constrained within the capture region through stochastic optimization. Numerical examples are provided to demonstrate the effectiveness of the proposed method.

ASTRO-2025-B027

「不確実な質量・慣性を有する対象物に対する軌道上ロボットの適応制御手法」

「Adaptive Control for On-Orbit Robotic Manipulation of Objects with Uncertain Mass and Inertia」

* 高橋 健一郎(科学大・院), 中条 俊大, 中西 洋喜(科学大)

Abstract:

This study proposes an adaptive control strategy for on-orbit robotic manipulation of space debris and other objects with uncertain mass and inertia. Due to limited prior knowledge in space environments, accurate modeling of target dynamics is difficult. To address this, we design a control law that adaptively estimates inertial parameters during manipulation. The proposed method is being tested through numerical simulations to evaluate its performance under various uncertainties. This work aims to contribute to the development of autonomous and robust control methods for future on-orbit servicing and debris removal missions.

ASTRO-2025-B028

「AstroFlex: A Mobile, Multi-Nodal Platform for In Situ Characterisation of Small Bodies within the REMORA Framework」

ヒックモット ウィリアム, * ソルディーニ ステファニア, ヘットゲス カイ(Uni. of Liverpool)

Abstract:

AstroFlex is a surface-based exploration platform developed within the UKRI-funded REMORA project (REndezvous Mission for Orbital Reconstruction of Asteroids), which envisions a fleet of CubeSats for tracing and tagging asteroids. AstroFlexs are a swarm of mobile, electrostatically actuated robots that adhere to and traverse small body surfaces. These nodes perform Radio-Frequency Tomographic Imaging (RTI), reconstructing internal structures by dynamically forming transmission paths. Using shared electrodes for actuation, adhesion, and impedance spectroscopy, AstroFlex enables efficient near-surface material characterisation. The platform supports fault-tolerant, persistent science operations in irregular, low-gravity environments, enhancing REMORA's orbital data with ground-truth measurements. Simulations and early hardware tests confirm viability for surface mobility, adhesion, and tomographic imaging.

ASTRO-2025-B029

「宇宙機搭載用ブーム展開型多角形柔軟膜構造におけるリンクリング解析と薄膜デバイス配置位置検討」

「Wrinkling Analysis of Boom-Deployable Polygonal Flexible Membrane Structures for Spacecraft and Investigation of Thin-Film Device Placement」

* 清水 隆貴（青学・院），森 治（JAXA），中篠 恭一（東海大）

Abstract:

This paper presents research on boom-type polygonal flexible membrane structures for enhanced spacecraft functionality. While these lightweight structures efficiently deploy large surfaces from a compact launch state, their inherent thinness leads to wrinkling and deformation. This was evident in a prior demonstrator, where membrane wraping caused unexpected solar radiation pressure(SRP), leading to attitude control issues and significant propellant consumption. Through FEM analysis with two type finite elements, Tension

Field Membrane Element and MITC Shell Element, this research shows wrinkle generation regions. In additon, it explores optimal placement for thin-film devices on the membrane, minimizing the impact of wrinkles. This approach aims to enhance the design and functionality of future spacecraft, particularly in deep space exploration missions.

ASTRO-2025-B030

「非干渉化参照モデルを用いた柔軟構造をもつ宇宙機の姿勢制御と制振」

「Attitude Control and Vibration Suppression of Spacecraft with Flexible Structure Using a Decoupled Reference Model」

* 山本 悠登(大公大・院), 金田 さやか, 下村 卓(大公大)

Abstract:

One of the problems of spacecraft with flexible structures is that vibrations are generated in the flexible structure due to the demand of attitude control of the spacecraft, and the vibrations affect the performance of the attitude control. Furthermore, flexible structures have higher-order modes which cannot be treated as controlled modes, and those modes can make the spacecraft unstable. In this paper, a two-degree-of-freedom (2DOF) control using the decoupled plant as a reference model is developed. It is shown that both attitude control and vibration suppression including higher order modes are achieved by the 2DOF control. Moreover, the attitude control is achieved simultaneously across all three axes by considering a feedback virtual input to compensate for the error relative to reference states.

ASTRO-2025-B031

「薄膜太陽電池におけるバイメタル効果による反りが太陽光圧下でのバイアスモーメンタム姿勢運動に与える影響の評価」

「Evaluation of the Effect of Warping Caused by the Bimetal Effect in Thin-Film Solar Cells on Momentum-Biased Attitude Motion under Solar Radiation Pressure」

* 横堀 颯希(青学・学), 久保 勇貴(神戸大), 森 治(JAXA), 菅原 佳城(青学)

Abstract:

In outer planetary exploration, solar cells are attracting attention as a safer alternative to RTGs but the resulting increase in mass poses a challenge. Therefore, a membrane solar array paddle with lightweight thin-film solar cells is considered promising.

However, in such environments, a temperature difference of 200?300°C causes significant warping in multilayer solar cells due to the bimetal effect. Under attitude motion dominated

by solar radiation pressure, this local warping may affect system stability.
This study evaluates the effect of such warping on momentum-biased attitude motion under solar radiation pressure. Previous studies introduced the nine parameters determined by optical properties and surface geometry, which represent the characteristics of attitude motion around the equilibrium through linearization. The effects of cell warping on the nine parameters of the linear model are evaluated, and their validity is verified through nonlinear attitude simulations.

ASTRO-2025-B032
「薄膜太陽電池パドルの柔軟振動が太陽光圧下でのバイアスモーメンタム姿勢運動に与える影響の評価」
「Evaluation of Flexible Oscillation of Membrane Solar Array Paddles on Momentum-biased Attitude Motion under Solar Radiation Pressure」
* 久保 勇貴(神戸大)
Abstract:
Spinning and momentum-biased attitude motions under solar radiation pressure have been inclusively formulated and validated through on-orbit demonstrations by JAXA's IKAROS, Hayabusa, and Hayabusa2 missions. These studies assumed time-invariant local deformation of the sunlit surface and successfully described the averaged, long-period attitude motion around the equilibrium. In this presentation, a new formulation of momentum-biased attitude motion under solar radiation pressure, which incorporates the effect of time-varying flexible oscillations, is presented. Through numerical simulations with possible spacecraft parameters, the differences from the previous models and their effects are discussed.

ASTRO-2025-B033
「スピン型高アスペクト比膜構造物の地球指向姿勢制御下における動的挙動の評価」
「Evaluation of Dynamic Behavior of Spin-type High-aspect-ratio Membrane Structures under Earth-Pointing Attitude Control」
* 田口 純也(青学・院), 杉原 アフマッド清志, 森 治(JAXA), 菅原 佳城(青学)
Abstract:
Synthetic aperture interferometry using multiple antennas arranged in a planar configuration is a promising method for high-resolution Earth observation but scaling increases mass and

launch constraints. To address this, this study proposes a deployable, spin type high aspect ratio membrane structure equipped with a one dimensional interferometer. Continuous rotation enables two dimensional aperture synthesis, but the membrane's flexibility causes shape deformation which, in turn, affects observation performance and attitude control. As a foundational investigation, this study targets the membrane alone as the subject of analysis and applies thruster based attitude control. The deformation and vibration induced by thruster firings are analyzed, and the dynamic behavior under various control conditions is evaluated.

Abstracts (Room C)

ASTRO-2025-C001

「Decoder-Only 時系列トランスフォーマーモデルによる低エネルギーな月近傍軌道設計」

「Low-Energy Lunar Trajectory Design by Decoder-Only Time Series Transformer」

* 畠山 祥(総研大・院), 柳瀬 利彦(PFN), 尾崎 直哉(JAXA)

Abstract:

Designing low-energy trajectories in the cislunar region poses significant challenges due to the nonlinear dynamics of the three-body problem, where classical approaches like Lambert's problem are not applicable. This study introduces a decoder-only time series Transformer model that generates initial guess trajectories by learning from numerically propagated orbital data. By encoding initial and terminal conditions as prefix tokens, the model infers full trajectories without directly solving boundary value problems. Trained on a diverse set of lunar flyby trajectories, the proposed method demonstrates strong potential for efficient and flexible mission design in complex gravitational environments.

ASTRO-2025-C002

「低推力多重スイングバイ軌道の多段階ハイブリッド型最適化」

「Multi-Stage Hybrid Optimization of Low-Thrust Multiple Swing-by Trajectories」

* ハ ギョンロク（京大・院）, 藤本 健治, 丸田 一郎（京大）

Abstract:

This study proposes a novel multi-stage hybrid optimization framework for designing low-thrust, multiple gravity-assist (MGA) trajectories. The approach combines a new perturbed conic model for accurately representing both thrusting and coasting arcs with a global genetic algorithm and a Newton-based local optimization method (GALLOP-NM). The proposed model significantly reduces the total ΔV compared to conventional shape-based approximations. Numerical simulations demonstrate that the perturbed conic leg improves modeling flexibility, and the hybrid approach achieves high-fidelity trajectory solutions. This framework offers a practical and computationally efficient solution for interplanetary mission design using solar electric propulsion systems.

ASTRO-2025-C003

「はやぶさ 2 の計画変更による小惑星 2024 YR4 の地球衝突確率低減の可能性について」
「Possibility of reducing Earth Impact probability of 2024 YR4 utilizing in-space asset Hayabusa2」
* 津田 雄一, 竹内 央, 佐伯 孝尚, 吉川 真(ISAS/JAXA)
Abstract:
In early 2025, the asteroid 2024 YR4 was reported to have a non-negligible Earth impact probability in December 2032. Although Earth impact probability has now been reduced to almost zero, we conducted a quick hypothetical study to "rescue" Earth by changing the destination of the in-space Hayabusa2 to 2024 YR4 for orbit deflection by spacecraft impact, instead of visiting the original rendezvous target 1998 KY26, when the risk to Earth was still high. This presentation shows its results and discusses contributions to the field of planetary defense.

ASTRO-2025-C004
「火星衛星探査計画 MMX におけるコンティンジェンシー軌道設計」
「Contingency Trajectory Design for Martian Moons eXploration」
* 岩渕 真和, 西村 和真 (FDNS), 中野 将弥 (FUJITSU), 池田 人, 大木 優介 (JAXA)
Abstract:
In this paper, recovery trajectories are designed as contingency plans in case that a maneuver cannot be executed as planned due to unforeseen circumstances such as spacecraft failure. Specifically, assuming that a failure occurs during MOI1, which is executed at the time of Mars orbit insertion, this paper examines the case where corrective maneuvers are executed immediately afterwards and the case where corrective maneuvers are executed one Martian year later. For MOE3, which is executed at the time of Mars orbit escape, the return trajectory that optimizes the required ΔV amount is designed, considering the possibility of re-executing MOE3 after one Mars orbit.

ASTRO-2025-C005
「ロバストな軌道保持のための確率的不変集合の活用」
「Probabilistic Invariant Set for Robust Station-Keeping」
* 平岩 尚樹, 尾崎 直哉（JAXA）
Abstract:
Robust station-keeping is crucial for operating spacecraft in the long term under chaotic

dynamics and uncertainties. One of the conventional strategies is the covariance steering, which guides the mean state to the reference orbit and reduces the state covariance at the terminal time to a predetermined level. On the other hand, this study aims to investigate the state covariance resulting from the given feedback control law by leveraging the probabilistic invariant set. The probabilistic invariant set determines the reachable set with a given probability under the feedback control law and uncertainties, and this set can be understood as the state covariance with a chance constraint. The detailed formulation of the stochastic optimal control problem with the probabilistic invariant set is explained, and a numerical example with a simple toy model is presented.

ASTRO-2025-C006

「AL-iLQR による CubeSat クラス宇宙機の火星大気突入用低推力軌道設計」

「Low-Thrust Optimal Trajectory Design for Mars Entry of a CubeSat-class Spacecraft using AL-iLQR」

* 倉田 昇祈(東大・院), 大山 聖(JAXA), 樋口 丈浩(横国大)

Abstract:

A novel Mars exploration method using a micro Mars airplane is being investigated. This approach requires a spacecraft equipped with an aeroshell entry system to deliver the airplane to Mars and initiate atmospheric entry. This study focuses on designing the trajectory for orbital altitude reduction from a Mars elliptical orbit into the Martian atmosphere after separation from an Orbital Transfer Vehicle (OTV), employing low-thrust propulsion. The Augmented Lagrangian iterative Linear Quadratic Regulator (AL-iLQR) method is used for optimization.

ASTRO-2025-C007

「Analysis of Fuel-Optimal Periodic Orbits in Hill3BP」

* パン シャンシャン, 坂東 麻衣（九大）

Abstract:

This work investigates the design and analysis of fuel-optimal low-thrust trajectories within the Hill three-body problem (Hill3BP), a simplified dynamical model often used to approximate motion near a secondary body in a restricted three-body system. Emphasis is placed on identifying and characterizing periodic orbits that minimize propellant consumption, leveraging optimal control theory to derive necessary conditions for fuel

efficiency. The study provides insights into the structure and behavior of such orbits under continuous low-thrust propulsion, offering a foundation for long-duration mission planning in multi-body gravitational environments.

ASTRO-2025-C008

「データ駆動型アプローチを利用した三体問題と二体問題の切り替えに基づく宇宙機の軌道設計」

「A Data-Driven Approach to Spacecraft Trajectory Design Based on Switching between Three-Body and Two-Body Problems」

* 重松 雅明(東大・院), 吉村 浩明(早大)

Abstract:

Recently, trajectory design based on many-body problems, which leverages dynamical systems theory such as tube dynamics, has gained attention as an alternative to conventional two-body approaches. Although low-energy trajectories offer advantages, they often require impractically long transfer times. In such cases, switching to a two-body model becomes effective; however clear criteria for model transition have not been sufficiently established. In this study, we apply the HAVOK framework, a time-series-based method for detecting abrupt dynamical changes, to identify regions in the planar circular restricted three-body problem exhibiting two-body-like behavior. Finally, we introduce a sphere of influence that is adjusted to enable rational integration of distinct dynamical models.

ASTRO-2025-C009

「拡散モデルに基づく平面円制限三体問題における月間遷移軌道の解探索手法」

「Diffusion Model-Based Framework for Moon-to-Moon Transfers in the Planar CR3BP」

* 岡田 博嵩(東大・院), 川端 洋輔(東大), 尾崎 直哉, 平岩 尚樹(JAXA), 五十里 哲, 船瀬 龍, 中須賀 真一(東大)

Abstract:

Recent initiatives like NASA's Commercial Lunar Payload Services have increased demand for advanced lunar trajectory designs involving multiple gravity assists. These techniques adjust hyperbolic excess velocities relative to the Moon, enhancing flexibility under tight thrust constraints. Unlike simple two-body problems with analytic solutions, the planar circular restricted three-body problem (CR3BP) lacks closed-form solutions and exhibits more pronounced multimodal behavior. We propose a diffusion model-based framework for

solving two-point boundary value problems in the planar CR3BP, demonstrated through Moon-to-Moon transfers. Results highlight the multimodal nature of feasible trajectories, confirming the proposed framework's effectiveness and potential for autonomous, fuel-efficient cislunar mission design.

ASTRO-2025-C010

「Bi-Circular Restricted Four-Body Problem における月脱出軌道の設計手法に関する検討」

「Design of Escape Trajectory from the Moon in the Bi-Circular Four-Body Problem」

* 紫原 聖之（東大・院）, Kathleen Howell (Purdue University), 川勝康弘(JAXA)

Abstract:

Escape mechanisms from a secondary body are essential for designing escape trajectories in both Sun?planet and planet?moon systems. Dynamical structures in the vicinity of the Lagrange points in the Circular Restricted Three-Body Problem (CR3BP) hold the key to understanding escape mechanisms. In non-autonomous models, however, these structures—while still existing instantaneously—are no longer time-invariant as in the CR3BP. In this study, we propose a method that employs Finite Time Lyapunov Exponents (FTLE) in the Bi-Circular Four-Body Problem (BCR4BP). In this method, we exploit the inherent time dependence in these systems to explicitly identify the set of initial conditions that permit escape even when the neck region is initially closed.

ASTRO-2025-C011

「摂動論と特異点論による制限 3 体問題の解析とその応用」

「A Study of the Dynamical Structure of the Restricted Three-Body Problem via Perturbation Theory and Singularity Analysis」

* 柴山 允瑠(京大)

Abstract:

本研究では、摂動論および特異点解析の手法を用いて制限 3 体問題を解析し、特に接近遭遇や衝突といった特異構成付近での軌道の振る舞いに着目する。また，そのプラネタリーディフェンスへの応用についても述べる。

ASTRO-2025-C012

「Optimising Interplanetary Trajectories using Particle Swarm Optimisation」

* Kuteesa Dion(UoS, Undergraduate student)

Abstract:

Efficient interplanetary trajectory design remains a critical fundamental research and technology issue for deep-space exploration. This ongoing study explores the novel application of Particle Swarm Optimization (PSO), a swarm intelligence algorithm, for identifying near-optimal interplanetary transfer trajectories. Using a simplified orbital mechanics model, initial investigations demonstrate PSO's effectiveness in converging on feasible low-ΔV solutions. This work highlights PSO's potential to efficiently explore complex design spaces, offering a promising alternative to traditional methods. Future research will incorporate more complex physics into the model and validate performance, contributing to advanced autonomous mission planning capabilities.

ASTRO-2025-C013

「インパルスΔVを用いたNRHO-SEL2間およびSEL2-火星間遷移軌道の設計」

「NRHO-to-SEL2 and SEL2-to-Mars Impulsive Transfer Trajectory Design」

* 大島 健太（諏訪理大），川口 淳一郎（ANU）

Abstract:

The first part of this work explores low-energy transfer between a 9:2 synodic resonant lunar near rectilinear halo orbit (NRHO) and an artificial small halo orbit around the Sun-Earth L2 (SEL2) point. The orbital sequence uses the solar tidal force and lunar swing-bys to fill the energy gap between the orbits and adopts pseudo-manifold trajectories to shorten the flight time. The obtained solutions are near-ballistic multi-flyby trajectories leveraging the solar tidal force. The second part studies the escape scenario from the small halo orbit toward Mars using a powered Earth swing-by. Orbital sequences with or without lunar swing-bys will be presented and the associated trade-off will be discussed.

ASTRO-2025-C014

「Virtual Swarm Methodに基づくハイブリッド推進を用いたセーフモードイベントにロバストな軌道設計」

「Robust trajectory design for safe mode events using hybrid propulsion based on the Virtual Swarm Method」

* 荒井 湧介(東京科学大・院), 中条 俊大(東京科学大)

Abstract:
Low-thrust propulsion is essential for deep-space missions but is highly vulnerable to missed thrust events, such as those caused by safe-mode transitions, which can critically affect mission success. While the Virtual Swarm Method has been previously proposed as a technique for robust trajectory design, this study presents its novel application to hybrid propulsion systems that combine solar electric propulsion and solar radiation pressure. Focusing specifically on robustness against safe-mode events, the method simulates multiple virtual spacecraft to evaluate and improve trajectory resilience without relying on exhaustive failure-case enumeration. Applied to a one-year synchronous orbit, the proposed approach successfully increased the target arrival success rate from 40% to 80%. These results highlight the potential of the Virtual Swarm Method in enabling efficient and robust trajectory design for long-duration interplanetary missions employing hybrid propulsion.

ASTRO-2025-C015
「セーフモード発動を考慮したロバスト軌道設計に関する研究」
「Trajectory Optimization under Safe Mode Uncertainty」
* 渋川 雅人(総研大・院), 尾崎 直哉(JAXA)
Abstract:
Deep-space missions employing low-thrust propulsion face significant risks from unexpected safe mode events, which can interrupt thrust operations and jeopardize mission objectives. Traditional trajectory designs rely on conservative fixed-margin heuristics, often leading to inefficiencies due to their inability to model the stochastic nature of safe mode behavior. This study proposes a novel trajectory optimization framework that incorporates the discrete and non Gaussian uncertainty associated with safe mode events using Stochastic Differential Dynamic Programming (SDDP) enhanced with Polynomial Chaos Expansion (PCE).

ASTRO-2025-C016
「リアプノフ軌道と不変トーラス間のヘテロクリニック接続の解析」
「Analysis of Heteroclinic Connection between Lyapunov Orbits and Invariant Tori」
* 進 聡一郎（九大・院）, 潘 珊珊, 坂東 麻衣, 外本 伸治（九大）
Abstract:

Heteroclinic connections, which connect invariant manifolds of orbits near different equilibrium points, provide a tool to enable transfers between equilibria without thrust. While previous studies on heteroclinic connections have primarily focused on orbits with the same dimension, our research expands this framework to connect orbits of different dimensions. In this study, we first analyze the dimension of intersection of heteroclinic connections between orbits with different dimensions. Then, we numerically computed heteroclinic connections in the circular restricted three-body problem between orbits with different dimensions. These connections facilitate transitions between orbits of different dimensions near distinct equilibrium points without requiring thrust.

ASTRO-2025-C017

「スイングバイを利用した土星衛星タイタンへの軌道の検討」

「Trajectory study of Saturn's moon Titan using a swing-by」

* 瀬戸山 義昭（崇城大・院），下田 孝幸（崇城大）

Abstract:

In recent years, deep space exploration of Jupiter, Saturn, and their moons has been actively conducted. Among them, Saturn's moon Titan is known to contain organic compounds and liquids, which are elements that indicate the possibility of life being present, and is attracting particular attention because it may be possible to find traces of extraterrestrial life. In order to investigate this, it is necessary to send a probe equipped with many observation instruments to Titan. In this paper, we will discuss an orbit that reduces the amount of propellant allocated to carry many observation instruments and uses a swing-by to reach Titan

ASTRO-2025-C018

「拡張 Edelbaum 則による円軌道間の低推力軌道遷移」

「Low-Thrust Transfers Between Circular Orbits Using an Extension of the Edelbaum Method」

* 島 岳也(三菱電機), 山田 克彦(大阪公立大学)

Abstract:

In this presentation, we investigate orbit transfers between circular orbits using low-thrust propulsion. An extended version of the Edelbaum method is considered, in which both the angle β between the orbital plane and the thrust direction, and the switching timing γ of

the thrust direction, are treated as control variables. By neglecting the effects of the J2 perturbation during thrusting, an analytical solution for the optimal control that achieves the desired final semi-major axis, inclination, and right ascension of the ascending node, as well as the required velocity increment ΔV, can be derived. Numerical simulations are performed to validate the analytical solution and compare it with orbit transfers based on the conventional Edelbaum method.

ASTRO-2025-C019

「深層学習による小惑星マルチフライバイ軌道最適化」

「Asteroid multi-flyby trajectory optimization using deep neural networks 」

* 柴北 碧(九大・院), 高尾 勇輝(横国), 坂東 麻衣, 外本 伸治(九大)

Abstract:

This study investigates an asteroid flyby sequence optimization problem aiming to minimize fuel consumption when a spacecraft performs flybys while bound for the main belt region from the Earth. This problem involves flyby sequence optimization and trajectory optimization. The latter requires expensive computational costs and must be performed each time the combination changes. This makes the problem complex when the number of target asteroid is large. To address this problem, this study employs a deep neural network (DNN)-based surrogate model to predict transfer trajectories. A key contribution is the use of a low-dimensional input representation that encodes only the positional relationship between departure and target asteroids, excluding velocity information.This simplification reduces the input space of the DNN and enables accurate predictions even with a limited number of training samples.

ASTRO-2025-C020

「マルチスイングバイ軌道設計最適化における事前知識活用のためのモデル化と評価」

「Modeling Framework for Leveraging A Priori Knowledge for Multi Gravity Assist Trajectory Design」

* 安福 亮(東大・院), 尾崎 直哉, 川勝 康弘(JAXA)

Abstract:

Multi-gravity assist (MGA) trajectory design is typically optimized individually for each mission, lacking a unified knowledge base for broader reuse. This results in high computational cost and limited utilization of past design experience. Prior studies have

explored low-fidelity trajectory models to build such databases, but the model selection is often arbitrary, and the impact of fidelity on optimization remains unclear. This study investigates how different trajectory abstractions—phase-free models ignoring planetary positions and phase-aware models considering orbital phases—affect the utility of precomputed knowledge bases in MGA trajectory optimization.

ASTRO-2025-C021

「深宇宙軌道間輸送機と超小型ソーラーセイル群を用いた小天体コンステレーション探査」

「Constellation around small bodies using nano-solar sails aboard a deep-space orbital transfer vehicle」

* 高尾 勇輝(横国大), 松浦 隆晶, 島内 智希(九大・院), 杉原 アフマッド清志(JAXA), 熊本 篤志(東北大)

Abstract:

This study presents a novel concept of satellite constellation around small bodies. A cluster of nano-solar sails, deployed from a deep-space orbital transfer vehicle (DSOTV), are inserted into various periodic orbits around a small body. This concept allows for advanced exploration techniques such as high-resolution global mapping and radar tomography exploration by the nano-solar sails, while ensuring the safety of the DSOTV. To achieve this, we first developed a dynamical theory on artificial frozen orbits via solar sailing. These orbits are employed to form a satellite constellation comprising various orbital geometries. Two scenarios, namely, high-resolution global mapping and radar tomography observations are addressed as potential applications, demonstrating that the proposed concept could realize efficient and comprehensive exploration of both the surface and internal structures of small bodies.

ASTRO-2025-C022

「軌道間輸送機の共通化が輸送経済性に与える影響」

「The Effect of Orbital Transfer Vehicle Standardization on Transportation Economics」

* 大久保 岳留(東大・院), 野中 聡, 丸 祐介(JAXA)

Abstract:

Standardization of Orbital Transfer Vehicle (OTV) is one of the key approaches toward reducing the cost and increasing the frequency of space transportation. Although it would

be ideal to be able to use the common OTV for every destination, it is not realistic from the standpoints of economics. To achieve OTV commonality, it is necessary to define the coverage range of its destinations. This study focuses on the impact of standardizing OTVs on payload mass and mission cost by examining multi-destination transportation scenarios using common OTVs.

ASTRO-2025-C023

「確率微分動的計画法による種々の不確定性を考慮した軌道最適化」

「Uncertainty-Aware Spacecraft Trajectory Optimization via Stochastic Differential Dynamic Programming」

* 藤原 正寛(JAXA)

Abstract:

This paper presents an uncertainty-aware trajectory optimization framework that explicitly models maneuver, dynamical, and orbit-determination uncertainties. The problem is formulated in an augmented state space that couples the nominal state with estimation and prediction covariances, thereby capturing first-order stochastic effects. A stochastic differential dynamic programming (SDDP) scheme then computes the nominal control sequence and its linear feedback gains, while keeping the covariance-augmented dynamics tractable by decomposing them into independent local quadratic subproblems. Numerical demonstrations on a linear benchmark, an Earth-to-Mars transfer, and an autonomous rendezvous scenario show reduced final dispersion relative to deterministic baselines.

ASTRO-2025-C024

「楕円軌道における宇宙機のフォーメーション再構成のための幾何的特徴に基づく凸最適化」

「Spacecraft Formation Reconfiguration in Elliptical Orbits via Geometrically-Informed Convex Optimization」

* 佐々木 貴広, 村上 尚美(JAXA)

Abstract:

With the increasing demands of scientific observations and the growing payload mass for space missions, there is a rising need for formation flying and rendezvous docking technologies in elliptical orbits. Establishing control methodologies tailored to the unique dynamics of elliptical orbits is a critical challenge for such missions. This study proposes a

novel approach for constructing a convex polytope for the linear parameter-varying system in the context of the rendezvous problem in elliptical orbits. Numerical simulations demonstrate that the proposed method enhances control performance.

ASTRO-2025-C025

「可変形状機能を利用した軌道要素フィードバックと最適形状決定アルゴリズムに基づく相対軌道制御手法」

「Relative orbit control method based on orbital elements feedback and optimal shape determination algorithm using variable shape function」

* 大坪 恵人（科学大・院），中条 俊大，中西 洋喜（科学大）

Abstract:

The aerodynamic relative orbit control method has advantages over thruster-based methods, such as not requiring propellant consumption and imposing less load on the satellite bus. However, many conventional aerodynamic relative orbit control methods rely on changing the satellite's attitude. This leads to inconsistencies between the attitude required for orbit control and that required for observation missions. To address this issue, this study proposes an aerodynamic relative orbit control method based on shape change using aerodynamic control paddles. The presentation will cover a control method that sets the target control acceleration using an orbital elements feedback control law, along with an optimization algorithm to determine the optimal satellite shape to achieve it.

ASTRO-2025-C026

「宇宙機フォーメーションフライトのためのポート・ハミルトン系に基づく姿勢軌道統合制御」

「Attitude-Orbit Coupled Control of Port-Hamiltonian Systems for Spacecraft Formation Flying」

* 矢部 俊典(阪大・院), 佐藤 訓志(阪大)

Abstract:

This study proposes a coupled attitude and orbit control based on port-Hamiltonian systems for spacecraft formation flying (FF). Missions such as the space gravitational wave telescope DECIGO, the space infrared interferometer LIFE, and the ultra-precision FF demonstrator SILVIA require continuous and precise control of relative attitude and orbit. The previously modeled nonlinear attitude and relative orbital motion of port-Hamiltonian systems are

integrated. An error system for a time-varying reference attitude and orbit is constructed using generalized canonical transformations preserving the port-Hamiltonian structure. A controller is designed for the resultant error system to guarantee that the origin of the closed-loop system is uniformly asymptotically stable. The reference attitude and orbit for an equilateral triangle formation are designed, and the effectiveness of the proposed method is verified through numerical simulations.

ASTRO-2025-C027
「フォーメーションフライトにおける
衛星間スキャン手法の探索性能に関する基礎的検討」
「Fundamental Analysis of Inter-Satellite Scanning Performance in Formation Flight」
* 土岐 爽和(静大・院), 伊藤 琢博, 丸 祐介, 森 治, 澤井 秀次郎(JAXA), 能見 公博(静大)
Abstract:
In future space observation missions, precise formation flight of spacecraft will be essential. To achieve this, scanning techniques using lasers to detect other satellites play a critical role. However, if the scanning method is not selected appropriately for the mission conditions, efficient scanning may be hindered, and in the worst case, the scanning may fail altogether. Therefore, this study conducts a fundamental investigation into the search performance of various scanning methods as a first step toward establishing design guidelines for selecting suitable methods based on specific mission requirements.

ASTRO-2025-C028
「地球周回における低外乱環境でのフォーメーションフライトの検討」
「A Study on Formation Flight in Low-Disturbance Environments in Earth Orbit」
* 永田 楓馬(崇城大・院), 下田 孝幸(崇城大)
Abstract:
In recent years, spacecraft formation flight technology has attracted attention for its potential applications in advanced space observation missions, such as astronomical observations. The realization of such missions requires the selection of either extra-terrestrial or Earth orbits, each of which has its own advantages and disadvantages. Previous studies have reported on formation flight in low Earth orbits, emphasizing the importance of selecting a low-disturbance environment suitable for the mission.

This study focuses on formation flight in low-disturbance environments, examining the significance and feasibility of stable formation maintenance. Based on a review of previous research, the effects of low-disturbance environments on formation maintenance and the improvement of orbital stability are summarized.

ASTRO-2025-C029

「仮想ポテンシャル場を用いた回転する非協力ターゲットへの接近のための誘導制御」

「Guidance and control for approching an uncooperative tumbling target using artificial potential field」

* 大屋 悟士(東北大, 院), 来原 聡文(東北大)

Abstract:

This study proposes a guidance and control method using an artificial potential field to approach to an uncooperative, tumbling target. Synchronizing rotational motion is a significant challenge for achieving accurate proximity operations. This research presents a method that synchronizes both translational and rotational motions by leveraging the relationship between thrust force and centripetal force. In this method, the chaser approaches the target and synchronizes with the target's rotation only after centripetal force is less than thrust force. The findings contribute to rendezvous and docking technologies for active debris removal.

ASTRO-2025-C030

「多面型可変反射率デバイスの基本設計とフォーメーションフライングの軌道制御への適用」

「Preliminary Design of Multi-Faceted Reflectivity Control Devices and Application to Formation Flying」

* 小林 伶士（総研大・院）, 杉原 アフマッド清志, 伊藤 琢博, 佐伯 孝尚, 森 治(JAXA)

Abstract:

To maintain the formation flying of a spacecraft, a continuous and low-thrust orbit and attitude control device is necessary.

As a control device, we focus on a “Reflectivity Control Device (RCD)” that utilizes solar radiation pressure.

The RCD is a device that controls the magnitude of solar radiation pressure acting on a spacecraft by changing its surface reflectance characteristics and has been demonstrated

in space by JAXA, which successfully controlled the angular velocity of the spacecraft.
On the other hand, the RCD cannot change the direction of solar radiation pressure because the device changes the force magnitude of solar radiation pressure.
Therefore, a Multi-Faceted RCD (MFRCD) was proposed to actively change the direction of solar radiation pressure.
This paper describes the magnitude and direction of forces that the MFRCD can generate and the materials assumed.
Numerical simulations of orbit control of formation flying using the MFRCD are then performed.

ASTRO-2025-C031
「分散アレイアンテナの磁気力による衛星軌道設計」
「Satellite Trajectory Design Using Magnetic Force for Distributed Array Antennas」
* 沈 彗央 (総研大・院), 高橋 勇多 (東科大・院), 宇佐美 尚人, 坂井 真一郎 (JAXA)
Abstract:
This study proposes a method for achieving beamforming for distributed array antennas (DAA) composed of multiple palm-sized satellites, utilizing magnetic forces for relative position control. DAA in low Earth orbit offers the advantage of forming large-scale antenna apertures, overcoming the physical limitations of monolithic antennas. This capability is expected to be a key enabler for direct-to-cell (D2C) applications, contributing to the realization of Beyond 5G/6G communication networks. However, maintaining the desired beamforming performance presents a significant challenge, as the formation is susceptible to changes caused by orbital disturbances and satellite failures. To address this, our research evaluates beamforming performance within a passively stable orbit. Furthermore, we define a trajectory of satellites based on Movable Antenna design theory and propose a feasible and free-fuel system that employs magnetic forces to achieve and maintain the required beamforming.

ASTRO-2025-C032
「簡略化磁場モデルと特異点を考慮した軌道計画を統合した EMFF 近傍制御手法」
「An Integrated Framework for Proximity EMFF Control: Combining a Simplified Model with Singularity-Aware Trajectory Planning」
* 吉門 秀樹(東大・院), 坂井 真一郎(JAXA/ISAS)

Abstract:
This study presents a high-reliability framework for proximity Electromagnetic Formation Flight (EMFF), addressing the dual challenges of model fidelity versus computation and control singularities. Our core approach is an online controller that combines a simplified magnetic model with a disturbance observer to achieve both computational efficiency and high fidelity. This controller is designed for real-time trajectory tracking while reactively avoiding encountered control singularities. However, we identified that this online-only, reactive method fails when a maneuver path must cross a singular region. To address this limitation, we also introduce an offline mission planning stage. This stage determines an optimal fixed target current beforehand, guaranteeing a mission trajectory that is free from singularities. By integrating these approaches, the online controller executes a pre-vetted safe path, enabling the completion of complex maneuvers impossible for a purely reactive system.

ASTRO-2025-C033

「差動抗力と Angle Only Navigation を用いた近接マヌーバに関する研究」

「A Study on Proximity Maneuvering Using Differential Drag and Angle-Only Navigation」

* 渡邉 奎, 中条 俊大, 中西 洋喜, 谷津 陽一(科学大), 高橋 健一郎, 天木 祐希, 安田 萌恵, 小林 大輝, 荒井 湧介, 川口 雄生, 吉田 英生, 正木 青空, 山田 直優, 及川 恵太, 座間味 栄馬, 田代 克樹, 尾関 優作(科学大・院), 宮本 清菜(科学大), 片岡 淳, 田中 香津生(早大), 小笠原 聖純(早大・院), 山本 一毅(早大・学)

Abstract:
In recent years, there has been a growing demand for relative orbit control of small satellites, particularly for missions such as space debris removal and space situational awareness. However, small satellites often face severe resource constraints, leaving little room for additional hardware such as thrusters or LiDAR. This study investigates the feasibility of approaching non-cooperative objects using differential drag control and angle-only navigation based on images captured by star trackers (STTs). Numerical simulations are conducted to validate the proposed approach.