

第 36 回 アストロダイナミクスシンポジウム (2026 年) アブストラクト集
36th Workshop on JAXA Astrodynamics and Flight mechanics (2026) Abstract

Keynote: Aug 4th(Tue) Room A (12:40-13:40)

藤原 正寛 (FUJIWARA Masahiro) *

楠本 哲也 (KUSUMOTO Tetsuya) *

三桝 裕也 (MIMASU Yuya) *

* JAXA 宇宙科学研究所 (JAXA, Institute of Space and Astronautical Science)

「はやぶさ 2 # における小惑星トリフネ超近接フライバイの実現」

「Achieving an Ultra-Close Flyby of Asteroid Torifune in the Hayabusa2 Extended Mission」

講演者情報

藤原 正寛

2023 年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。同年 7 月より JAXA 研究開発部門第一研究ユニット研究開発員として、はやぶさ 2 # プロジェクトに従事し、自律航法誘導アルゴリズムの開発を担当。

楠本 哲也

2024 年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。博士（工学）。2024 年度より、JAXA 宇宙科学研究所宇宙航空プロジェクト研究員として、はやぶさ 2 # プロジェクトに従事。姿勢制御および誘導航法を専門とし、関連する研究開発に取り組んでいる。

三桝 裕也

2011 年九州大学大学院工学府博士課程修了。同年、JAXA プロジェクト研究員として入構。2014 年から同機構の正職員として、小惑星探査機はやぶさ 2 などの研究開発・運用に従事。2025 年度より、はやぶさ 2 拡張ミッションのチーム長。

Abstract

2026 年 7 月 5 日、はやぶさ 2 #（拡張ミッション）では、小惑星トリフネへのフライバイ運用を実施した。本運用には二つの目的があった。一つ目は、元来サンプルリターン用に設計された探査機を用いて、科学的価値の高い近接観測データを取得すること、二つ目は、将来のプラネタリーディフェンスに資する航法誘導技術を獲得することである。これらの目的を両立するため、トリフネ表面から数百 m まで接近して通過することを目標に掲げ、オンボード自律軌道航法・誘導アルゴリズムの新規開発と、地上での軌道決定・軌道誘導に関する入念な事前訓練を行った。これらの取り組みの成果はフライバイで取得された科学観測データが示す通りである。本講演では、トリフネ超近接フライバイの成功に至るまでの開発および訓練の過程と、当日の運用の一端を紹介する。

On July 5, 2026, a flyby of the asteroid Torifune was conducted as part of the Hayabusa2 extended mission. The operation had two primary objectives: to obtain scientifically valuable close-range observation data using the spacecraft, which was originally designed for a sample-return mission, and to acquire navigation and guidance technologies relevant to planetary defense. To achieve both objectives, the team set a target of passing within several hundred meters of Torifune's surface. We developed a new onboard optical navigation and guidance algorithm and conducted extensive operational training in ground-based orbit determination and trajectory guidance. The resulting scientific observations demonstrate the success of the ultra-close flyby. This talk will present selected aspects of the development and training process and describe the operations conducted on the day of the encounter.

Keynote: Aug 5th(Wed) Room A (11:30-12:30)

方 弘毅 (HO Koki)

ジョージア工科大学 (Georgia Institute of Technology)

「Changing the Game in Space Logistics and In-Space Servicing」

Biography

Dr. Koki Ho is the Dutton-Ducoffe Professor, an Associate Professor, and the director of the Space Systems Optimization Group in the Daniel Guggenheim School of Aerospace Engineering at Georgia Tech. His research focuses on developing modeling and optimization methods for rigorous space mission analysis and design. Dr. Ho earned his Ph.D. at MIT and his bachelor's and master's degrees at the University of Tokyo. He is the recipient of the AAS Emerging Astrodynamacist Award, NSF CAREER Award, NASA Early Career Faculty Award, DARPA Young Faculty Award, and the Luigi Napolitano Award. Dr. Ho served as the Chair of the AIAA Space Logistics Technical Committee in 2017-2024.

Abstract

As space missions become increasingly complex, we often need multiple spacecraft coordinated to achieve an overarching objective. This trend creates various new challenging problems in the mission design process for emerging applications such as human lunar/Mars exploration campaigns, in-space satellite servicing/assembly/manufacturing, and mega-scale satellite constellations. In response to those challenges, advanced modeling and optimization techniques have been developed, many of which are inspired by how complex terrestrial logistics challenges have been handled. In this talk, we will discuss the recent progress in logistics-inspired modeling and optimization for space mission design. We will demonstrate several examples of how mathematical modeling and optimization can contribute to complex space applications that involve multiple missions, multiple vehicles, and reusable infrastructure elements.

Abstracts (Room A)

ASTRO-2026-A001

「Unscented Transform を用いた低推力軌道遷移のための確率的 Predictor-Corrector 誘導則」

「Stochastic Predictor-Corrector Guidance for Low Thrust Orbit Transfer using Unscented Transform」

* 伊東 理紗(CU Boulder・院), McMahon Jay(CU Boulder)

Abstract:

Asteroid exploration is one of the most important missions in planetary science and space engineering. Such missions require robustness to cope with the uncertain and stochastic environment of small bodies, as well as computationally efficient autonomous control. In this work, we present a predictor-corrector method that is suitable for onboard implementation with limited computational resources. The proposed approach uses the Unscented Transform to estimate the mean and covariance of the final state, and based on this estimate, a new target is defined to minimize the final error. The effectiveness of the method is demonstrated through a case study of an orbit transfer around the asteroid Bennu, including uncertainties encountered in real missions.

ASTRO-2026-A002

「運用制約を伴わない宇宙機姿勢マニューバ最適化におけるユークリッド NLP 定式化と多様体最適化定式化の比較」

「A Comparison of Euclidean NLP and Manifold Optimization Formulations for Spacecraft Attitude Maneuver Optimization without Operational Constraints」

* 藤本 翔太(帝京大・院), 中宮 賢樹(帝京大)

Abstract:

Spacecraft attitude problems require preserving the $SO(3)$ rotation group's geometric structure. Euclidean NLP formulations treat attitude matrices as $R^{3 \times 3}$ variables, imposing orthogonality and determinant equality constraints. Conversely, manifold optimization directly uses $SO(3)$ as the search space. This study compares both approaches for unconstrained attitude maneuver optimization—excluding operational limits like sensor

field-of-view or asymmetric actuator inputs—under common cost functions , initial states, stopping criteria, and metrics. We evaluate how $SO(3)$ structure handling impacts convergence and numerical stability by tracking cost function histories, iteration counts, $SO(3)$ preservation errors, and attitude error profiles.

ASTRO-2026-A003

「多様体制約を持つ着陸誘導問題における擬スペクトル逐次凸化法」

「Pseudospectral Successive Convexification for Manifold-Constrained Landing Guidance Problem」

* 鳴海 龍哉(東大 (院)) , 坂井 真一郎(ISAS/JAXA)

Abstract:

We investigate a six-degree-of-freedom landing guidance problem whose attitude and pointing variables evolve on nonlinear manifolds. Instead of enforcing these geometric properties as external equality constraints, the proposed method incorporates the manifold structure directly into pseudospectral collocation. The resulting successive convexification scheme preserves unit-quaternion and unit-vector feasibility while reducing the computational burden of the guidance optimization. Simulation results show accurate manifold preservation and faster solution times, supporting the use of the method in time-critical landing scenarios.

ASTRO-2026-A004

「軌道要素を用いた適応スライディングモードによる軌道制御の検討」

「A study on the orbit control using the adaptive sliding mode control based on orbital elements」

* 井本 悠太(阪大), Mancini Mauro, Ruggiero Dario, Capello Elisa(POLITO), 佐藤 訓志(阪大)

Abstract:

This study investigates the orbital element-based adaptive sliding mode control for low-thrust orbital deployment toward small-satellite constellation missions.

Recent advances in electric propulsion have made continuous low-thrust maneuvers feasible for small satellites.

In addition, orbital element-based control is useful for the constellation deployment because

in-plane and out-plane motion can be separately considered.

However, previous orbital element-based low-thrust orbit control methods assume that perturbation forces are known, and a robust orbit control method is needed.

Therefore, we will propose an adaptive sliding mode control approach that is robust and automatically tunes control parameters to the uncertain environment.

ASTRO-2026-A005

「ラグランジュ点軌道における軌道維持のためのモデル予測制御の定式化」

「Nonlinear Model predictive control formulations for station keeping on libration point orbits」

* 嶋根 悠理(UCI)

Abstract:

Along libration point orbits, where the inherent instability of the orbit can lead to rapid divergence of a spacecraft's trajectory from its intended motion, reliable and propellant-efficient guidance is essential to support successful mission operations. While legacy targeting-based techniques have been successfully deployed on past cislunar missions, recent works adopting model predictive control (MPC) techniques, when formulated appropriately, have demonstrated comparative propellant cost and superior tracking performance under the same operational considerations as existing missions. We review and compare several candidate MPC formulations with varying complexities and evaluate their performance.

ASTRO-2026-A006

「拡張 ΔV -law を用いた円軌道遷移における軌道フィードバック制御」

「Orbit Feedback Control for Circular-Orbit Transfers Using an Extended Delta-V Law」

* 島 岳也(MELCO), 山田 克彦(大公大)

Abstract:

This presentation presents a feedback control method for low-thrust circular-orbit transfers. For transfers involving changes in semi-major axis and inclination, the optimal solution is given by Edelbaum's law, which provides an analytical expression for the required ΔV . By modifying the switching timing of the thrust direction, Edelbaum's law can be extended to include changes in the right ascension of the ascending node (RAAN), while retaining an

analytical ΔV solution.

Based on this analytical ΔV expression, an extended ΔV -law is proposed using the squared ΔV as a Lyapunov function candidate. By introducing a modified target semi-major axis, a feedback control law is derived that regulates the semi-major axis, inclination, RAAN, and argument of latitude. Numerical simulations compare the proposed method with representative feedback control approaches, including the Q-law, and demonstrate its effectiveness for low-thrust circular-orbit transfers.

ASTRO-2026-A007

「CubeSat クラス宇宙機の低推力火星エントリ軌道設計における目標点に対する降下軌道の感度解析」

「Target-Point Sensitivity Analysis of Descent Trajectories in Low-Thrust Mars Entry Trajectory Design for CubeSat-Class Spacecraft」

* 倉田 昇祈(東大・院), 大山 聖(JAXA), 樋口 丈浩(横国大)

Abstract:

JAXA has been studying Mars exploration using a micro-scale Mars airplane. To inject this airplane into the Martian atmosphere, a 6U CubeSat-class carrier spacecraft has been considered.

This study focuses on the trajectory design of the carrier spacecraft. A parameter sweep of the target point is performed to conduct a sensitivity analysis of the descent trajectory. Through this analysis, descent trajectories suitable for atmospheric entry are obtained.

ASTRO-2026-A008

「ローブダイナミクスを活用した推力噴射失敗にロバストな地球-月圏の軌道設計」

「Trajectory Design Based on Lobe Dynamics for Resilience Against Missed Thrust Events in Cislunar Space」

* 大井 駿太(東大・院), 川端 洋輔(名大), 平岩 尚樹(横国大), 五十里 哲, 船瀬 龍(東大)

Abstract:

In trajectory transfers for cislunar missions, robust trajectory design is required to maintain the ability to reach the target orbit with limited fuel even after missed thrust events (MTEs). However, conventional methods require numerical optimization to design recovery trajectories for many MTE cases, resulting in high computational cost. This study proposes an efficient trajectory design method that is robust against MTEs based on lobe dynamics in dynamical systems theory. The proposed method first extracts promising transfer trajectories using lobe dynamics and represents their connectivity as a weighted directed graph. It then rapidly designs a nominal trajectory and recovery trajectories for MTEs through path search on the graph. The effectiveness of the method is demonstrated through an application to a LEO-to-LLO transfer.

ASTRO-2026-A009

「Coupled Aero-Orbital Mission Analysis of an Atmosphere-Breathing Electric Propulsion Orbiter in the Rarefied Atmosphere of Titan」

* Kuteesa Dion(UoS, Undergraduate)

Abstract:

This study models an Atmosphere-Breathing Electric Propulsion (ABEP) spacecraft in Titan's thermosphere. To address coupled aerodynamic drag and orbital decay, a framework links rarefied gas dynamics with low-thrust mechanics. Molecular flow solvers are scripted to map drag coefficients across transition and free-molecular regimes. These lookup tables integrate into a 1D non-Keplerian orbital simulator to solve equations of motion and identify the optimal altitude corridor for long-term orbit maintenance.

ASTRO-2026-A010

「軌道姿勢連成ダイナミクスに基づく小惑星周りにおけるソーラーセイルの周期解と安定性解析」

「Periodic Solutions and Stability Analysis of a Solar Sail Around an Asteroid Based on Coupled Orbit-Attitude Dynamics」

* 林 勇太(九大・院), 菊地 翔太(NAOJ), Daniel Scheeres(CU Boulder), 坂東 麻衣, 外本 伸治(九大)

Abstract:

Solar sails are propulsion systems in which attitude and thrust direction are inherently coupled, making orbit-attitude dynamics inseparable. This study constructs exact 12-dimensional periodic solutions for a solar sail orbiting an asteroid through numerical computation — solutions that have not previously been obtained. By performing eigenvalue analysis of the monodromy matrix, we reveal that as the degree of orbit-attitude coupling increases, the instability mode transitions from a real saddle point to a complex saddle point. These findings provide new insight into the nonlinear dynamics of solar sails in asteroid proximity operations.

ASTRO-2026-A011

「Effect of rarefied flow field on aero-thermodynamics of small aerobraking spacecraft」

* ベルテ マックスミリアン (大学)

Abstract:

We evaluate the impact of rarefied flow field effects on the aero-thermodynamic characteristics of a small aerobraking spacecraft. Simulations are conducted using the DSMC method, and compared with a free-molecular local surface inclination method. Effects of particle-particle collisions in the flow field around the spacecraft on the aerodynamic forces, torques, and heating are assessed and discussed.

ASTRO-2026-A012

「姿勢履歴に基づく Touch-and-Go 型サンプリング探査体の着陸軌道設計」

「Landing Trajectory Design for a Gimbaled Solid-Rocket Touch-and-Go Sampling Probe Based on Attitude Profiles」

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

Abstract:

Precision landing with a solid rocket motor is challenging because thrust magnitude and burn duration cannot be continuously adjusted. This research develops a reduced-order trajectory design framework for a gimbaled touch-and-go sampling probe. The descent motion is represented by several attitude-transition segments, whose durations and angular rates serve as design variables. These variables are determined to satisfy terminal position,

velocity, and attitude requirements. The required gimbal motion is subsequently reconstructed from the prescribed attitude trajectory and rotational dynamics. Numerical simulations are conducted to examine trajectory feasibility, terminal accuracy, attitude excursion, and actuator requirements under representative motor, initial-state, and timing uncertainties during descent operations.

ASTRO-2026-A013

「ガスサンプリングシステムに向けた複雑配管・狭小空間における粒子輸送挙動解析および DEM シミュレーション構築」

「Analysis of particle transport behavior in complex piping and confined spaces, and construction of DEM simulations for gas sampling systems.」

* 高田 真緒(関学・院), 山川 真以子(JAXA), 大藤 勇亮(関学・院), 相子 康彦, 佐伯 孝尚(JAXA), 松浦 周二(関学), 森 治(JAXA)

Abstract:

This study investigated particle transport behavior in a gas sampling system that collects sample particles by ejecting high-pressure gas to lift them from the surface of a small celestial body. As next-generation asteroid explorers become smaller, sample collection mechanisms may become narrower and more complex. Therefore, understanding particle behavior along narrow and complex paths is essential. In this study, experiments were conducted to evaluate particle transport under such conditions, and a discrete element method (DEM)-based simulation was developed to reproduce and analyze particle behavior. The applicability of the proposed method to sample transport by gas ejection was also examined.

ASTRO-2026-A014

「探査機による太陽光遮蔽を利用した小惑星粒子の三次元軌道推定」

「Three-Dimensional Orbit Estimation of Asteroidal Particles Based on Spacecraft-Induced Shadowing」

* 菊地 翔太(NAOJ), Scheeres Daniel(コロラド大)

Abstract:

Estimating the trajectories of asteroid particles ejected by natural processes or spacecraft-

induced disturbances is important for both scientific interpretation and spacecraft safety. Conventional image-based angle-only orbit determination of such particles relies on orbital nonlinearity and parallax to infer three-dimensional trajectories from two-dimensional observations. However, for observations with short tracking durations or limited viewing-geometry variation, orbit determination based solely on image data becomes extremely challenging. To address this limitation, we propose an image-based method for three-dimensional orbit estimation that exploits geometric constraints imposed by spacecraft-induced shadowing.

ASTRO-2026-A015

「膜面エアロシェルの積極的な抗力制御による月-地球低軌道間のエアロキャプチャ」
「Active Drag-Modulation Aerocapture using a Deployable Membrane for Cislunar-to-LEO Orbital Transfer」

* 齊藤 拓実, 栗原 聡文(東北大)

Abstract:

Aerocapture is a promising, resource-efficient orbital transition technology, but conventional rigid blunt-body spacecraft suffer from degraded aerodynamic deceleration in the upper atmosphere where the Knudsen number exceeds 0.10. To achieve sufficient drag, they must penetrate deeper atmospheric layers, drastically narrowing the entry corridor and increasing re-entry risks. To overcome this limitation, this study proposes an aerocapture guidance strategy using a deployable thin-membrane aeroshell. By actively controlling the deployment shape to modulate the ballistic coefficient, the proposed strategy enables efficient drag utilization even within the highly rarefied atmosphere, significantly expanding the permissible entry corridor for reliable aerobraking.

ASTRO-2026-A016

「宇宙機のセーフモード発動に起因する突発的推進停止の確率モデリングとロバスト軌道設計への応用」

「Modeling Missed-Thrust Events Caused by Safe Mode and Its Application to Robust Trajectory Optimization」

* 渋谷 雅人(総研大・院), 小山 慎介(ISM), 尾崎 直哉(JAXA)

Abstract:

Spacecraft safe-mode events can induce intermittent thrust interruptions, referred to as missed-thrust events, which degrade trajectory performance. Conventional robust trajectory design typically addresses such events using heuristic assumptions regarding the timing and duration of safe-mode occurrences, often resulting in overly conservative fuel margins.

To incorporate safe mode uncertainties into trajectory optimization, we develop a stochastic optimal control framework that combines: (i) stochastic scenario generation using a Markov jump process whose transition probabilities are derived from the alternating renewal process model, (ii) trajectory optimization that accounts for the probabilistic occurrence of missed-thrust events, and (iii) arbitrary polynomial chaos expansion to propagate uncertainty and reduce computational cost.

The proposed framework provides a unified approach for trajectory optimization under discrete event-driven uncertainties..

ASTRO-2026-A017

「低推力推進輸送機の惑星遷移における汎用時刻表『Generic Bacon Plot』の構築 — Regularized Multiple Shooting Method の応用」

「The Concept of Generic Bacon Plots for Planetary Low-Thrust Missions - Application of Regularized Multiple Shooting Method」

* 武井 悠人(JAXA)

Abstract:

Lower-cost planetary missions in the 2030s are motivating space tug concepts that can carry multiple deployable and onboard payloads. Chemical tugs offer shorter transit times, whereas solar electric propulsion (SEP) provides higher specific impulse and larger payload capability. While pork-chop plots serve as general transfer timetables for near-impulsive chemical missions, existing bacon plots for SEP depend strongly on specific spacecraft designs. This paper proposes a Generic Bacon Plot (GBP) to map planetary transfer opportunities using reduced spacecraft-dependent parameters, simplified thrust and launch-vehicle models, and representative mission constraints. Using Earth-to-Mars transfers as a representative case, this study adopts a regularized multiple shooting method to solve the resulting nonlinear trajectory optimization problems and generate GBPs,

enabling rapid comparison of SEP and chemical tug mission options.

ASTRO-2026-A018

「位相拡張グラフに基づく多重重力アシスト軌道設計」

「Phase-Augmented Graph Framework for Multiple Gravity-Assist Trajectory Design」

* 重松 雅明(東大・院), 津田 雄一(JAXA)

Abstract:

Multiple gravity-assist (MGA) trajectory design, which utilizes the gravitational fields of multiple planets to gain velocity, is a complex combinatorial optimization problem involving numerous design variables, including planetary encounter sequences, encounter epochs, flight times, and the magnitudes and timings of ΔV maneuvers. In this study, a graph structure augmented with phase information is constructed based on the Tisserand Graph, which is commonly used to evaluate energetic accessibility between planetary encounters. The MGA trajectory design problem is then formulated as a path-finding problem on the graph, and the effectiveness of the proposed approach is investigated.

ASTRO-2026-A019

「円制限三体問題における月衝突軌道の解析」

「Analysis of the Lunar Collision Orbits in the Circular Restricted Three-Body Problem」

* 進 聡一郎(九大・院), 潘 珊珊, 坂東 麻衣, 外本 伸治(九大)

Abstract:

This study investigates the phase space structure of orbit families emanating from the three-dimensional lunar collision orbit in the Earth-Moon circular restricted three-body problem (CR3BP). The Kustaanheimo-Stiefel (KS) regularization is applied to the spatial CR3BP to completely remove the collision singularity at the Moon, extending the planar analysis of Oshima et al. (2017) to three dimensions. Since the Levi-Civita regularization used in the planar case cannot be extended to three dimensions due to Hurwitz's theorem, the KS transformation is employed instead. Backward propagation from the lunar singularity is performed for several values of the Jacobi constant, and the preliminary results reveal a rich family of three-dimensional orbits whose structure depends strongly on the energy level.

ASTRO-2026-A020

「整数計画法による $p:q$ 共鳴軌道を用いた月航法コンステレーション設計」

「Lunar Navigation Satellite Constellation Design via Integer Programming with Cislunar Resonant Periodic Orbits」

* 小松 龍世（総研大・院），Ho Koki（Georgia Tech），川勝 康弘（JAXA）

Abstract:

Growing interest in lunar navigation satellite systems has motivated extensive research on lunar constellation design, but prior work restricts orbits to two-body or a few three-body families and relies on metaheuristics with no optimality guarantee. We formulate the design problem as a mixed-integer linear program over a substantially expanded space of resonant periodic orbits in the circular restricted three-body problem. Periods commensurate with the Earth-Moon synodic period bound the evaluation window, and a linear surrogate replaces the nonlinear geometric dilution of precision. Solving recovers the Pareto front between total dry mass and navigation accuracy with certified optimality gaps, and high-fidelity analysis confirms accuracy-requirement compliance.

ASTRO-2026-A021

「火星輸送を対象とした電気推進型深宇宙軌道間輸送機の設計最適化」

「Multidisciplinary Design Optimization of Deep-Space Orbital Transfer Vehicles with Electric Propulsion for Mars Exploration」

* 遠藤 優太（横国・院），高尾 勇輝（横国），張 科寅，月崎 竜童（JAXA）

Abstract:

Deep-space exploration increasingly requires flexible and reusable transportation systems capable of supporting diverse missions while reducing development cost. Deep Space Orbital Transfer Vehicles (DSOTV) with electric propulsion are promising candidates because of their high propellant efficiency, although their long transfer times and strong coupling between trajectory, power, payload, and thermal design remain challenging. This study conducts a multidisciplinary design optimization of Earth-to-Mars DSOTV using direct collocation with nonlinear programming. Several propulsion systems, thruster numbers, and launch masses are evaluated. Pareto-front analysis reveals trade-offs between transfer time and propellant consumption. The results clarify suitable propulsion choices and provide

design guidelines for electric-propulsion DSOTV.

ASTRO-2026-A022

「逐次凸計画法を用いた確率的な推力喪失にロバストなシスルナ領域における軌道最適化」

「Robust Cislunar Trajectory Optimization under Missed-Thrust Events via Sequential Convex Programming」

* 関根 啓貴(東大・院), 川端 洋輔(名大), 小栗 健士朗 (Purdue University), 五十里 哲, 船瀬 龍(東大)

Abstract:

This study presents a low-thrust cislunar trajectory optimization framework designed to handle missed-thrust events. Unlike traditional worst-case methods that often yield overly conservative trajectories, the proposed approach incorporates a probabilistic missed-thrust model to balance fuel efficiency with mission success probabilities. This study further makes three contributions to improve computational stability and optimality: Kustaanheimo-Stiefel transformation for removing lunar singularity, adaptive-mesh sequential convex optimization, and stochastic search based on entropy maximization. Numerical simulations demonstrate that this methodology significantly enhances mission reliability while maintaining computational tractability for complex cislunar transfers.

ASTRO-2026-A023

「Bi-Circular Restricted Four-Body Problem における月脱出解空間の解析」

「Analysis of Lunar Escape Solution Space in the Bi-Circular Restricted Four-Body Problem」

* 紫原 聖之 (東大・院), ハウエル キャサリン (Purdue University), 川勝 康弘 (JAXA)

Abstract:

This study investigates the solution space of lunar escape trajectories in the Bi-Circular Restricted Four-Body Problem (BCR4BP), where solar gravity introduces explicit time dependence into the Earth-Moon system. While invariant manifolds provide useful transport structures in the Circular Restricted Three-Body Problem (CR3BP), their time-invariant counterparts do not directly persist in non-autonomous models. To characterize escape dynamics under solar perturbations, Lagrangian Coherent Structures (LCS) extracted from

Finite-Time Lyapunov Exponent (FTLE) fields are combined with periapsis-based trajectory analysis. The resulting framework is applied to escape trajectories through both the L1 and L2 gateways, enabling a systematic description of lunar escape in a non-autonomous multi-body environment.

ASTRO-2026-A024

「ベジエ曲線に基づく初期軌道解析による低推力ミッション設計空間の網羅的探索」

「Systematic Exploration of Low-Thrust Mission Design Space via Bezier Curve-Based Initial Trajectory Analysis」

* 平野 敬大(静大・院), 船木 一幸(JAXA), 松井 信(静大)

Abstract:

In low-thrust trajectory optimization, numerical approaches like direct methods incur massive computational costs and often suffer from solution divergence. To address this, we propose a rapid initial trajectory generation technique using a Bezier curve shape-based method. This approach produces kinematically smooth trajectories without relying on computationally heavy optimization solvers. Applying this framework to deep-space Solar Electric Propulsion (SEP) missions, we stably derive feasible solutions that strictly satisfy thrust constraints. Consequently, this enables an extensive mapping of the mission design space through the efficient generation of Bacon plots.

ASTRO-2026-A025

「太陽-地球-月系における EML2 領域と SEL2 領域を結ぶ弾道サイクラー軌道」

「Ballistic Cyclor Trajectories between EML2 and SEL2 in the Sun-Earth-Moon System」

* 小町 咲葵(ANU・院), 川口 淳一郎(ANU), 大島 健太(諏訪理科大)

Abstract:

This paper demonstrates the existence of maneuver-free ballistic cyclor trajectories connecting the Earth-Moon Lagrange point 2 (EML2) and Sun-Earth L2 (SEL2) regions in the bicircular restricted four-body problem.

The objective is to investigate whether perpetual cyclor trajectories can exist between these two regions and to identify the conditions required for the existence.

The reverse ballistic lunar transfer and two lunar swing-bys are employed to generate initial

guesses for one-way transfers from EML2 to SEL2.

These solutions are optimized using the multiple-shooting method. Several ballistic trajectories are obtained and extended to cycler trajectories using symmetry time-reversal symmetry.

ASTRO-2026-A026

「Performance Evaluation of Multi-Orbit Lunar Navigation Satellite Constellations」

* チュティビカイ ビビッド(東北大・院), 齊藤 拓実, 栗原 聡文(東北大)

Abstract:

The increasing global interest in lunar exploration has led to a growing demand for a Lunar Navigation Satellite System (LNSS) capable of supporting high-precision, real-time Positioning, Navigation, and Timing (PNT) services. This study aims to analyze the performance of the proposed LNSS architecture. The characteristics of lunar constellations composed of satellites from multiple orbits, including frozen orbits and Libration Point Orbits (LPOs) such as Distant Retrograde Orbits (DRO) and halo orbits, are analyzed in terms of Dilution of Precision (DOP) and DOP availability. These metrics are used to evaluate the performance under the requirements of various mission scenarios.

ASTRO-2026-A027

「確率的不変集合を用いた NRHO 軌道維持のロバスト性解析」

「Robustness Analysis of NRHO Station-keeping Leveraging Probabilistic Invariant Sets」

* 平岩 尚樹(横国), 尾崎 直哉(JAXA)

Abstract:

Long-term missions around the reference orbit require station-keeping robust against uncertainties. While the deterministic stability can be evaluated via the monodromy matrix of the linearized controlled system, the robust stability analysis under uncertainties remains challenging. This study evaluates the robustness of station-keeping with a feedback control policy using probabilistic invariant sets (PISs), applied to a near-rectilinear halo orbit in the Earth-Moon system. Feedback gains are designed via a periodic discrete-time LQR, and the resulting PIS quantifies station-keeping robustness and collision-avoidance margin with the Moon. Preliminary results extending this approach to part of the L2 halo family are also

presented.

ASTRO-2026-A028

「Assessment of a Moon-Grazing Retrograde Periodic Orbit as a Staging Node for Rapid-Response Deep-Space Missions」

* ベレッティ ダリオ (PoliMi・院), 大島 健太(諏訪理大)

Abstract:

This work investigates the use of a Moon-grazing retrograde periodic orbit (RPO) of the Earth-Moon A1 family as a staging orbit for rapid-response deep-space missions. The selected orbit is reconstructed and characterized in the CR3BP, and its stability, accessibility, and transfer properties are assessed. A trajectory-design method combining RPO departures, lunar encounters, Earth-return arcs, and a powered Earth flyby is developed and refined through multiple-shooting optimization. Applications to Venus and Mars escape trajectories, reachability analyses, stationkeeping, and a simplified Comet Interceptor-like assessment suggest that the RPO is a promising staging node for future rapid-response missions.

ASTRO-2026-A029

「ラグランジュ点近傍周期軌道間の不変多様体遷移におけるポアンカレ断面位置の影響評価」

「Influence of Poincare Section Placement on Invariant-Manifold Transfers Between Periodic Orbits Near Lagrange Points」

* 小林 柚夢 (東大・院), 川勝 康弘 (JAXA), 吉村 浩明 (早大)

Abstract:

This study investigates the influence of Poincare section placement on the delta-V/ToF characteristics of invariant-manifold transfers between periodic orbits around libration points. Conventional approaches often search for connection points on a fixed Poincare section, which limits the set of feasible transfer candidates. In this study, the Poincare section location is introduced as a design variable, and a multi-objective optimization is performed under multiple energy conditions. The proposed approach enables the evaluation of optimal section locations and changes in the delta-V/ToF trade-off structure for different

energy levels, demonstrating its effectiveness for trajectory design using invariant manifolds.

ASTRO-2026-A030

「超低高度軌道の宇宙機のための J2 項と大気抵抗力を考慮したクープマン作用素に基づく線形化軌道モデルの予備的評価」

「Preliminary Evaluation of a Koopman-Based Linear Orbital Model for Spacecraft in Very Low Earth Orbit under J2 and Atmospheric Drag Perturbations」

* 尾関 優作（東京科学大学・院），中西 洋喜，中条 俊大（東京科学大学）

Abstract:

Very low Earth orbit (VLEO) has attracted attention for missions for ground applications, such as high-resolution Earth observations and low-latency communications. Spacecraft in VLEO are primarily affected by atmospheric drag and J2 perturbations. For operating VLEO spacecraft and constellations, a computationally efficient and accurate linear orbital model is useful for prediction, design, and optimization. This study constructs a Koopman-based linear orbital model under atmospheric drag and J2 perturbations using deep learning trained on numerical simulation data. In this presentation, we describe the model construction method and provide a preliminary evaluation of the resulting linear model's prediction accuracy.

ASTRO-2026-A031

「KL 正則化最適制御問題に基づくカオス輸送の最小燃料制御と宇宙機軌道設計への応用」

「Minimum-Fuel Control of Chaotic Transport Based on a KL-Regularized Optimal Control Problem and Its Application to Spacecraft Trajectory Design」

* 小田切 勇樹(九大・院), 坂東 麻衣, 外本 伸治(九大)

Abstract:

This paper proposes a sample-based optimal control framework for minimum-fuel trajectory design in nonlinear systems with chaotic transport. Starting from a Kullback-Leibler-regularized variational problem, a Laplace prior is introduced to induce an L1-type control cost, enabling sparse control without backward propagation or prescribed input bounds. The method is applied to an Earth-Moon periapsis Poincare map approximated using SINDy.

The control inputs are concentrated at transitions, producing a trajectory from the Earth region to the lunar vicinity. The trajectory reaches the Moon's vicinity in approximately 148 days with a total Δv of 375 m/s and follows the system's dynamical transport structures.

Abstracts (Room B)

ASTRO-2026-B001

「スピン型高アスペクト比膜構造物に対する太陽輻射圧を用いた姿勢マヌーバおよびニュートーション抑制手法の検討」

「Attitude Maneuvering and Nutation Suppression of Spin-type High-aspect-ratio Membrane Structures Using Solar Radiation Pressure」

* 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:

Phased array antennas often require apertures exceeding 10 m depending on their application, which are difficult to realize with conventional space structures. To address this challenge, this study proposes a spin-type high-aspect-ratio membrane structure equipped with a one-dimensional interferometer. Because of its flexibility, the membrane deforms and exhibits dynamic behavior that differs from that of a rigid body. This study develops an attitude maneuvering and nutation suppression strategy based primarily on solar radiation pressure, controlled by switching liquid crystal devices attached to the membrane, while thrusters are also considered. A comparison with a rigid-body model identifies the membrane-specific behavior and assesses the feasibility of solar-radiation-pressure-based attitude control.

ASTRO-2026-B002

「HELIOS-R における単眼カメラによる膜形状推定の軌道上実験結果報告」

「On-Orbit Demonstration of Membrane Shape Reconstruction Using a Monocular Camera in the HELIOS-R Mission」

* 高尾 勇輝(横国大), 鶴谷 柊朔, 天川 海音, 久島 明洋(東大・院), 高田 真緒(関学大・院), 高田 侍郎(東大・院), 田口 純也(青学大・院), 浜付 一輝(都立大・院), 中川 雄登(東大・院), 石戸 大智(総研大・院), 川崎 歩(東大・院), 仙場 淳彦(名城大), 佐藤 泰貴(JAXA), 渡邊 秋人(サカセ), 松下 将典(防衛大), 森 治(JAXA)

Abstract:

This study presents on-orbit demonstration results for membrane shape reconstruction using a monocular camera in the HELIOS-R mission. The deployable membrane of HELIOS-R has retroreflective markers on its surface. A multi-particle model is applied to connect these markers via springs and represent a three-dimensional shape of the membrane. Shape reconstruction becomes possible by detecting these markers in an on-orbit image

captured by a monocular camera. We conducted various experiments such as membrane deployment, boom extension and retraction, and shape memory polymer actuation to observe on-orbit behavior of the membrane, for which several interesting results have been obtained through our analysis.

ASTRO-2026-B003

「ブーム展開型三角膜のリンクリング解析」

「Wrinkling Analysis of Boom-Deployable Triangular Membrane」

* 平本 望(東海大・院), 清水 隆貴(元青学・院), 森 治(JAXA), 中篠 恭一(東海大)

Abstract:

This paper deals with boom-deployable triangular flexible membrane structures designed to enhance spacecraft functionality. While these lightweight structures effectively deploy large surface areas from a compact launch configuration, their inherent thinness makes them susceptible to wrinkling and undesired deformation. These wrinkles are particularly critical as they can induce unexpected torque due to solar radiation pressure (SRP). In this study, we perform finite element analysis using the MITC4 shell element to investigate the wrinkles occurred on a boom-deployable triangular membrane. Specifically, we investigated the relationship between wrinkles and tension when forced displacements are applied to the upper-left and upper-right sides of the membrane. Through this numerical analysis, we clarified the characteristics of the resulting wrinkle patterns.

ASTRO-2026-B004

「ガウス過程回帰を用いた能動的外乱除去制御による大型宇宙構造物の 3 軸姿勢変更に関する一考察」

「Three-axis Attitude Maneuver of Large Space Structures Using Gaussian Process Regression-Based Active Disturbance Rejection Control」

* 俵谷 裕紀 (防大・院), 山崎 武志, 高野 博行 (防大)

Abstract:

Large space structures (LSS) behave as flexible bodies, exhibiting elastic vibrations, cross-axis coupling, and parameter variations caused by solar-array rotation, which complicate accurate three-axis attitude control. This study applies linear active disturbance rejection control (LADRC) to estimate and compensate for these effects as a total disturbance. Gaussian process regression efficiently searches the LADRC design parameters to improve

tracking performance while satisfying the required multi-loop input disk margin (MMI). A trajectory profile generator (TPG), designed from the optimized control bandwidth, smooths the reference command and suppresses flexible-mode excitation. Numerical simulations demonstrate accurate attitude maneuvers, vibration suppression, and robust stability.

ASTRO-2026-B005

「軽量膜展開構造物 HELIOS-R の軌道上膜展開の事前・事後解析」

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

* 浜付 一輝(都立大・院), 鳥阪 綾子(都立大), 杉原 アフマッド清志, 楠本 哲也, 森 治(JAXA), 松下 将典(防衛大), 宮崎 康之, 佐藤 泰貴(JAXA), 高尾 勇輝(横国大), 渡邊 秋人, 堀 利行, 伊藤 裕明(サカセ・アドテック), 中川 雄登, 大木 春仁, 中川 果帆, 鶴谷 柊朔, 重松 雅明, 天川 海音, 久島 明洋, 川崎 歩, 高田 侍郎, 山本 輝汰, 大島 凜太郎, 金沢 侑紀(東大・院), 河原 寛奈, 田口 純也, 横堀 颯希(青学・院), 進藤 颯(青学・学), 石戸 大智, 小林 伶士, 鳥谷 陽樹, 名取 千夏(総研大・院), 高田 真緒, 大藤 勇亮(関学・院), 平本 望(東海大・院), 駒場 啄舞(科学大・院)

Abstract:

This study reports on the deployment and configuration of the multifunctional membrane structure “HELIOS-R,” which was mounted on RAISE-4 and successfully demonstrated in-orbit deployment. First, we performed pre-deployment predictions and post-deployment analyses of the membrane deployment using a Multi-Particle Method and confirmed good agreement with flight data. Furthermore, we conducted a retraction experiment in which the boom was reversed from the deployed state. We report on the image data acquired after the retraction experiment and the results of a comparative verification of the membrane surface inclination estimated using thin-film solar cells, 5G antennas, and an Interferometer.

ASTRO-2026-B006

「デバイス配置と境界条件を考慮した多機能膜の効率的な固有振動数推定手法の提案」

「Proposal of an Efficient Natural Frequency Estimation Method for Multifunctional Membranes Considering Device Placement and Boundary Conditions」

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

Abstract:

In recent years, membrane spacecraft equipped with multifunctional membranes have been

extensively studied. These membranes consist of lightweight films integrated with thin-film devices such as solar cells and antennas, enabling both weight reduction and enhanced functionality. However, evaluating how device placement and boundary conditions affect dynamic characteristics remains a significant challenge. Typically, eigenvalue analysis relies on FEM simulations, but validating numerous configurations using this approach is extremely time-consuming. In this study, we propose an efficient method to estimate the natural frequencies of flexible membranes, accounting for diverse device placements and boundary conditions. By eliminating the need for repeated FEM simulations, this approach accelerates the design of multifunctional membranes through the utilization of thin-film devices.

ASTRO-2026-B007

「What Will the Comet Interceptor Mission See? Image Generation and Challenges for Navigation and Attitude Determination」

* マチューカー パーブロー, スターク デリック, アーラルダズ バーラン(SDSU)

Abstract:

The ESA-JAXA Comet Interceptor mission will flyby an unknown long period comet. Unprecedented challenges are expected for several subsystems, and this work focuses on optical navigation and attitude determination. Core detection, on the one hand, will be diffculted by the uncharacterized properties of the comet, including core radius, shape, and dust environment activity. Star tracking, on the other hand, will be hindered by dust particles polluting and traveling across the field of view. This work attempts to provide insights into what SCB1's narrow-angle camera and star tracker will observe as SCB1 approaches the comet and within the dust environment. The image generation process for an unknown comet is presented, the modeling approach is described, and results are validated. Ongoing efforts on image processing for centroiding and attitude determination are discussed, and how this work can support the development and validation of SCB1's on-board algorithms.

ASTRO-2026-B008

「ドップラ観測量を用いた小天体内部構造モデリングに基づく高精度重力場推定手法の検討」

「Study on a High-Precision Gravity Field Estimation Method Based on Internal Structure Modeling of Small Bodies Using Doppler Data」

* 松本 祐樹, 巳谷 真司(JAXA), 松本 晃治(NAOJ)

Abstract:

For landing missions on small bodies, constructing a high-precision gravity field model is essential for the safe descent and landing operations of spacecraft. However, deep-space exploration of small bodies faces significant challenges: prior information is often scarce, and observation data can only be acquired from limited trajectories, such as equatorial orbits, due to onboard propellant constraints. In this study, we propose a method to efficiently estimate spherical harmonic coefficients using Doppler measurements obtained from an equatorial orbit around a small body. Furthermore, since the error of the spherical harmonic expansion increases near the surface, we introduce an approach to inversely estimate the internal structure model of the small body. We demonstrate that this proposed method improves the accuracy of gravity field estimation near the surface compared to a uniform-density polyhedron model.

ASTRO-2026-B009

「相対論効果を考慮した、実時間での測距同時時刻同期法について」

「CONSOLIDATED REAL-TIME RANGE AND CLOCK SYNCHRONIZATION SCHEME TAKING THE RELATIVISTIC EFFECTS INTO ACCOUNT」

* 川口 淳一郎, 西本 慎吾, 小町 咲葵(ANU)

Abstract:

There have been many studies on range measurement. However, range measurement has traditionally been considered independently of clock synchronization, even though phase difference information inherently encompasses both aspects. The authors have worked with the Asynchronous One-Way Range (AOWR) scheme for several years. This scheme performs well and has been applied in device development. However, the method by which relativistic effects are incorporated has not yet been disclosed. This paper reveals the actual processing scheme in the AOWR for the first time. Based on the light cone constraint, the scheme provides a closed-form solution for simultaneous range measurement and clock synchronization. It performs effectively and accurately accounts for relativistic effects. The paper presents numerical examples and discusses and demonstrates the outcomes of real-time closed-form processing.

ASTRO-2026-B010

「小天体探査に向けた非同期片方向測距による測位システムの開発—ドローン飛行実証と数値解析—」

「Development of a Positioning System Using Asynchronous One-Way Ranging for Small-Body Exploration: Drone Flight Demonstration and Numerical Analysis」

* 西本 慎吾 (ANU・院), 川口 淳一郎 (ANU)

Abstract:

This paper presents an asynchronous one-way ranging (AOWR) positioning system for autonomous navigation during small-body exploration missions. The proposed system employs radio markers deployed on the surface to provide simultaneous ranging and clock synchronization without an external infrastructure, enabling robust positioning near the small-body. The positioning performance during the landing phase is demonstrated through a drone-based experiment, validating the feasibility of the proposed navigation architecture. Furthermore, numerical simulations are conducted for a rendezvous scenario to investigate the applicability of the same positioning framework to proximity operations. The results demonstrate the potential of the proposed system for supporting both autonomous landing and rendezvous around small bodies.

ASTRO-2026-B011

「大気抵抗を補償したポート・ハミルトン系の姿勢軌道統合制御による高精度宇宙機編隊飛行」

「Attitude-Orbit Coupled Control for Spacecraft Formation Flying Based on Port-Hamiltonian Systems with Atmospheric Drag」

* 矢部 俊典(阪大・院), 佐藤 訓志(阪大)

Abstract:

In this study, a formation tracking method based on attitude-orbit coupled control is proposed within the port-Hamiltonian framework. Spacecraft formation flying requires integrated control of both relative attitude and orbit. The coupled attitude-orbit dynamics, including gravity and atmospheric drag, are formulated based on the port-Hamiltonian systems. An error system for a time-varying reference attitude and orbit is constructed based on generalized canonical transformations. Finally, a controller is designed to render the resultant error system uniformly asymptotically stable. The effectiveness of the proposed method is demonstrated through numerical simulations.

ASTRO-2026-B012

「相対位置センサを用いた大規模衛星群向けの分散協調航法フィルタ」

「Decentralized Cooperative Navigation Filter for Large Satellite Swarm using Relative Position Sensors」

* 若尾 大輔(総研大), 坂井 真一郎(JAXA)

Abstract:

This study proposes a decentralized cooperative navigation filter for estimating the pose of large-scale satellite swarms, including positions and attitudes, using relative-position sensors. Distributed space systems can improve mission performance and robustness, and they require decentralized onboard navigation methods. Relative-position sensors are attractive because they require fewer resources than relative-pose sensors. However, their observability cannot be characterized solely by individual observation relationships; instead, it depends on the structure of the observation graph. To address this issue, we construct observability-guaranteed subsets and design a Kalman filter to estimate pose within each subset. This method enables decentralized cooperative navigation with resource-constrained satellites.

ASTRO-2026-B013

「分散型宇宙システムにおける磁気フォーメーションフライトとワイヤレス電力伝送の同時運用提案と影響検討」

「Simultaneous Operation for Electromagnetic Formation Flight and Wireless Power Transfer in Distributed Space Systems」

* 江藤 歩(総研大・院), 坂井 真一郎(JAXA)

Abstract:

In distributed space systems composed of small satellite swarms, we investigate the feasibility of the simultaneous operation of Electromagnetic Formation Flight (EMFF) using low-frequency alternating current (AC) and Wireless Power Transfer (WPT) using high-frequency AC. The aim of this integration is to simultaneously achieve propellant-free attitude and relative position control alongside flexible power distribution within the swarm. As an initial study, we investigated how the magnetic field fluctuations associated with power transfer affect the EMFF. In this presentation, we report an overview of the concept and discuss its feasibility based on the investigation results.

ASTRO-2026-B014

「非線形モデル予測制御を用いた制約付き深宇宙ランデブードッキング誘導手法」

「A Constrained Deep-Space Rendezvous and Docking Guidance Method Using Nonlinear Model Predictive Control」

* 鳥谷 陽樹（総研大・院），佐伯 孝尚，森 治，坂東 信尚，横田 健太郎（JAXA）

Abstract:

In deep space exploration, missions involving multiple spacecraft are currently being devised. Such missions require rendezvous and docking (RVD) technology. RVD in deep space demands high autonomy and robustness against disturbances. Furthermore, it is characterized by numerous constraints, such as field-of-view limitations during rendezvous and upper bounds on thrust. Therefore, this study proposes a method to generate trajectories that satisfy these RVD constraints by utilizing nonlinear model predictive control, which is robust to disturbances and can explicitly handle constraints.

ASTRO-2026-B015

「相対軌道要素を用いた宇宙機近傍運用の安全制約制御」

「Constraint-Based Control for Spacecraft Proximity Operations Using Relative Orbital Elements」

* 大嶋 俊之，松本 祐樹(JAXA)

Abstract:

Spacecraft rendezvous and proximity operations (RPO), including fly-around phases, require safety even after control-system failures or maneuver aborts. This study investigates a constraint-based control approach using relative orbital elements (ROE) to support passive safety during proximity operations. The proposed framework exploits the geometric interpretation of the ROE representation, particularly the projected shape of relative motion, to formulate safety constraints with respect to a keep-out region. Numerical simulations for representative low-Earth-orbit scenarios, including J2 perturbations, are used to evaluate the resulting safety margins and to discuss the applicability and limitations of the proposed approach.

ASTRO-2026-B016

「線形時不変な相対軌道要素を用いた制御則の基礎検討」

「Preliminary Study of a Control Approach Based on Linear Time-Invariant Relative Orbital

Elements」

* 横田 健太郎, 佐々木 貴広 (JAXA), 前 匡鴻 (東大), 坂井 真一郎 (JAXA)

Abstract:

Relative orbital elements (ROEs) are widely used to describe spacecraft relative motion because they provide an intuitive geometric interpretation of relative-orbit configurations. However, conventional ROE-based continuous-control models include a time-varying input matrix, which complicates the direct application of standard control design methods. To address this issue, a phase-synchronized set of ROEs obtained by rotating the relative eccentricity and inclination vectors with the orbital phase is proposed. The proposed formulation preserves the geometric insight of conventional ROEs while yielding a linear time-invariant (LTI) representation for unperturbed relative motion. Based on this representation, a simple control law exploiting the LTI structure is derived. Numerical simulations demonstrate the effectiveness of the proposed formulation for relative-orbit reconfiguration.

ASTRO-2026-B017

「初期分離条件と差動大気抗力を考慮した CubeSat 編隊の到達可能領域評価」

「Reachability Assessment of CubeSat Formation Deployment Using Separation Conditions and Differential atmospheric Drag」

* 田中 啓太, 稲守 孝哉 (名大)

Abstract:

This study evaluates the reachability of CubeSat formation deployment using initial separation conditions and differential atmospheric drag. In CubeSat formations launched in a connected configuration, the relative velocity generated during on-orbit separation strongly determines the subsequent relative orbit. Differential atmospheric drag provides a propellant-free control mechanism, but it is a weak input that mainly affects in-plane relative motion. A reachable-region assessment is formulated using separation velocity magnitude, separation direction, formation time, and ballistic parameters as design variables. Numerical propagation with J2 perturbation is used to evaluate terminal relative orbital element and identify feasible preliminary deployment-design regions.

ASTRO-2026-B018

「小天体近傍における衛星コンステレーション維持のための自律航法誘導制御」

「Autonomous Guidance, Navigation, and Control for Station Keeping of Satellite Constellation around Small Bodies」

* 佐久間 広和（横国大・院），高尾 勇輝（横国大）

Abstract:

This study develops an autonomous Guidance, Navigation, and Control system for maintaining a satellite constellation in the vicinity of a small asteroid. Because small-body environments are strongly affected by solar radiation pressure, irregular gravity, and communication delays from Earth, satellites must estimate and control their states autonomously. Frozen orbits considering these perturbations are selected as target orbits. A feedback controller based on the State-Dependent Riccati Equation method is designed, and an Extended Kalman Filter integrates inter-satellite ranging, line-of-sight velocity, and optical navigation. Numerical simulations show that the proposed system can maintain the constellation, while an absolute reference satellite is essential for stable operation.

ASTRO-2026-B019

「拡大画像列を用いた深宇宙ランデブー・ドッキングのための航法誘導制御」

「Guidance, Navigation, and Control for Deep Space Rendezvous and Docking Using Expanding Image Sequence」

* 高田 侍郎, 大島 凜太郎（東大・院），相子 康彦, 津田 雄一（JAXA）

Abstract:

This presentation proposes a novel Guidance, Navigation, and Control (GNC) method for deep space rendezvous and docking using the target's magnification rate from monocular camera images and maneuvers. In particular, we focus on an approach that simultaneously achieves robustness against severe optical environment changes in deep space and lightweight computation, thereby ensuring high navigation accuracy. Furthermore, we explain the theoretical background of the proposed GNC law and present numerical simulation examples to verify its effectiveness.

ASTRO-2026-B020

「Free Space Capture 法における 3 次元運動に関する検討」

「Preliminary Analysis of Three-Dimensional Motion in Free Space Capture」

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

Abstract:

A simple material transfer method is required for resource-limited environments such as deep space. The authors have proposed the Free Space Capture method, which captures a spherical container using contact motion with a horn-shaped capture mechanism. This study presents a three-dimensional motion analysis of the capture motion in Free Space Capture and discusses its design process. The effects of the coefficients of restitution and friction, as well as the initial conditions, on the capture motion are investigated.

ASTRO-2026-B021

「深宇宙探査機間の光学航法における航法輝点の識別同定への複比の利用」

「Application of Cross Ratio for the Identification and Recognition of Navigation Markers in Optical Navigation between Deep-Space Probes」

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

Abstract:

Deep-space exploration using multiple spacecraft is currently under consideration, and deep-space rendezvous and docking (DS-RVD) is a key technology for this. In DS-RVD, retroreflective markers and cameras are used to perform highly reliable relative state estimation in real time. Although methods such as RANSAC have been proposed for estimation problems using such feature points, they involve loop processing using the least-squares method, resulting in long computation times. Therefore, we reduce computation time by dividing the process into feature-based identification and sequential estimation. In this study, we compare the accuracy and computation time when using scale factors invariant to changes in position and orientation as features.

ASTRO-2026-B022

「測角航法を用いた自律ランデブーのための誘導航法の同時最適化」

「Onboard Simultaneous Optimization of Guidance and Navigation for Autonomous Rendezvous with Angles-only Navigation」

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

For rendezvous against non-cooperative targets, angles-only navigation is the most widely applicable and cost-effective way of relative orbit determination. However, in linear dynamics, angles-only navigation lacks information along line of sight and guidance law is associated with navigation accuracy. Our proposed method determines the navigation accuracy that minimizes the stochastic sum of guidance and navigation errors, and obtains the control

inputs required to achieve the desired accuracy by solving a quadratic optimization problem. This method enables autonomous approach to non-cooperative targets with significant uncertainties under conditions where ground support is difficult or unavailable, such as deep-space missions.

ASTRO-2026-B023

「宇宙機の編隊飛行における衛星相対運動を考慮した効率的レーザー走査手法の提案」
「Efficient Laser Scanning Method Considering Satellite Relative Motion for Spacecraft Formation Flying」

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

Abstract:

Future space observation missions, such as space interferometer missions, require high-precision formation flying by multiple spacecraft. To achieve this, it is necessary to establish laser links between spacecraft. In the initial acquisition phase, the uncertainty region in which the target spacecraft may be located must be scanned with a laser beam.

However, the detectable region is extremely small compared with the overall scan region. In addition, the target spacecraft has relative motion, which may significantly increase the acquisition time depending on the scanning method. Therefore, this study investigates an efficient laser scanning method that accounts for the relative motion of the target spacecraft.

ASTRO-2026-B024

「宇宙科学ミッションのための慣性座標系における複数衛星の相対軌道維持に必要な ΔV 解析」

「Delta-V Analysis for Relative Orbit Maintenance of Multiple Satellites in an Inertial Reference Frame for Space Science Missions」

* 瀬戸山 義昭(崇城大・院), 伊藤 琢博, 丸 祐介, 澤井 秀次郎(JAXA), 下田 孝幸(崇城大)

Abstract:

This study investigates the control velocity (Delta-V) required to maintain a two-satellite formation aligned with a specific observation target. In space science missions, situations arise where multiple spacecraft must be precisely aligned with an observation target in an inertial reference frame. Although critical, this configuration degrades over time due to

perturbations. Here, this study the relative dynamics in the inertial frame satisfying the three-body alignment condition and evaluate the required control inputs against perturbations. The final Delta-V requirements are then analyzed as a function of orbital altitude, target direction, and mission duration. This study contributes to realizing space science missions that depend on aligned inertial formation flight.

ASTRO-2026-B025

「可観測性と物理的制約を考慮した深宇宙マニピュレータによる小型飛翔体の捕獲軌道最適化手法」

「A Trajectory Optimization Method for Small Flying Object Capture by Deep Space Manipulators under Observability and Physical Constraints」

* 青野 郁也(東大・院) / (MELCO), 高田 侍郎(東大・院), 相子 康彦, 津田 雄一(JAXA)

Abstract:

This paper proposes a trajectory optimization method for capturing uncooperative small flying objects using a deep space manipulator with an eye-in-hand monocular camera. Monocular vision requires active manipulator motion to ensure observability, resulting in a trade-off with physical constraints. To resolve this, trajectory generation is formulated as a nonlinear programming problem that directly incorporates estimation uncertainty via an Extended Kalman Filter. By setting the terminal estimation error covariance as a constraint, the solver autonomously generates optimal trajectories ensuring required precision. Numerical simulations and 6-DOF manipulator ground experiments demonstrate the method's effectiveness and robustness under real-world noise.

ASTRO-2026-B026

「深宇宙における空中捕獲機構実現に向けた単眼マニピュレータカメラによる小型飛翔体の運動推定」

「Motion Estimation of a Small Flying Body Using a Monocular Manipulator Camera Toward the Realization of an In-Flight Capture Mechanism in Deep Space」

* 名取 千夏(総研大・院), 森 治, 相子 康彦, 津田 雄一(JAXA), 青野 郁也(東大・院), 関晃仁(東芝)

Abstract:

For the Next-Generation Sample Return mission, a multi-spacecraft exploration mission

using an Orbital Transfer Vehicle (OTV) and a lander is planned. In deep space, the OTV must autonomously capture sample containers released by ultra-compact-sampling probe. In this study, to realize the Free Space Capture method, we developed a method for estimating position and distance by imaging a spherical container with a monocular manipulator camera and enabling imaging of the sphere from multiple points by moving the manipulator. We also used this method to estimate the timing of arrival at the capture point.

ASTRO-2026-B027

「多面型液晶デバイスの光学特性評価とミッション検討」

「Evaluation of the Optical Properties of Multi-Faceted Reflectivity Control Device and Mission Analysis」

* 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:

We developed and evaluated the optical characteristics of a multi-faceted reflectivity control device that converts solar radiation pressure into control force and torque, focusing on concept verification.

In this presentation, based on the evaluation results, we will examine the missions that can be achieved with this device and demonstrate its effectiveness and prospects.

ASTRO-2026-B028

「超電導磁気浮上機構を用いた宇宙望遠鏡の協調指向制御」

「Cooperative Pointing Control of Space Telescopes Using Superconducting Magnetic Levitation Mechanisms」

* 川本 稜生(東大・院), 坂井 真一郎(JAXA)

Abstract:

Achieving both high agility and precise pointing is a critical challenge for next-generation space telescopes. This study proposes a cooperative pointing control strategy that integrates primary bus-side actuators with innovative superconducting magnetic levitation mechanisms leveraging the flux pinning effect. While the bus attitude control system handles large-angle maneuvers, the electromagnetically controlled levitation mechanisms compensate for residual pointing errors and suppress disturbances simultaneously. By independently adjusting the levitation position of each unit, these mechanisms can regulate

the three-axis pointing angles of the payload. This paper describes the coupled dynamics of the spacecraft bus and the levitated optical payload, demonstrating the feasibility and performance of the proposed cooperative control law through numerical simulations.

ASTRO-2026-B029

「深宇宙 RVD における外乱オブザーバを用いたスラストインパルス誤差の逐次推定および補償則」

「Sequential Estimation and Compensation Law for Thruster Impulse Errors Using a Disturbance Observer in Deep Space RVD」

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

Abstract:

Precise 6-Degree-of-Freedom control is critical for deep space rendezvous and docking. However, Reaction Control System thruster inaccuracies, including steady thrust degradation and transient tail-off, severely compromise control performance. This study proposes a real-time estimation and compensation method for thruster impulse errors using a disturbance observer. By introducing an input-axis switching strategy for observability and a stepwise Recursive Least Squares algorithm based on an impulse integral model, the method successfully isolates highly correlated error parameters. Numerical simulations demonstrate that this approach significantly improves position and attitude accuracy, minimizes limit cycles, and reduces thruster firing frequency, ensuring reliable proximity operations.

ASTRO-2026-B030

「2 対の電磁石を用いた二次元の超小型人工衛星の相対位置・姿勢制御」

「Relative Position and Attitude Control of a Two-Dimensional Microsatellite Using Two Pairs of Electromagnets」

* 中山 隼希(都立大・院), 鳥阪 綾子(都立大)

Abstract:

We propose an integrated system that combines relative position and attitude control using green and permanently reusable electromagnets with a docking, holding, and release mechanism completed by a unidirectional driving force. The electromagnets used in this system perform two functions: providing the driving force for a docking, holding, and release mechanism installable in a 1U CubeSat, and generating attractive and repulsive forces

during multi-pair operation. The electromagnets were implemented in the docking, holding, and release mechanism, and experiments demonstrated that the mechanism can operate with a 2 A power resource. Furthermore, assuming extension to multi-pair operation, the feasibility of implementing a control law based on Legendre approximation was investigated.

ASTRO-2026-B031

「分散宇宙アンテナの故障回復に向けた衛星群再構成」

「Satellite Swarm Reconfiguration for Fault Recovery in Distributed Space Antennas」

* 沈 慧央（総研大・院），高橋 勇多（東科大・院），宇佐美 尚人，坂井 真一郎（JAXA）

Abstract:

Distributed space antennas synthesize a large aperture by coordinating many small satellites, but element failures degrade beamforming performance and require reconfiguration under orbital dynamics constraints. This study proposes a satellite guidance framework for fault recovery in a distributed space antenna. After detecting failed elements, the framework updates target relative positions based on an array performance objective and generates feasible trajectories considering relative orbital motion and actuation limits. The guidance law suppresses sidelobes while minimizing control effort. Numerical simulations for a low Earth orbit scenario demonstrate that the proposed method enables reconfiguration and improves antenna performance despite unavailable elements.

Abstracts (Room C)

ASTRO-2026-C001

「月・惑星探査ロボットアームへの適用に向けた超音波モータの適応制御」

「Adaptive Control of Ultrasonic Motors for Robotic Arms in Lunar and Planetary Exploration」

* 鈴木 圭吾（東大・院），吉光 徹雄（JAXA）

Abstract:

For future planetary exploration, Traveling-Wave Ultrasonic Motors (TWUSMs) are promising candidates for driving robotic arms due to their high torque-to-mass ratio and intrinsic zero-power holding torque. However, their performance is highly sensitive to extreme space environments, which shift the resonant frequency and trigger several non-linear behaviors. This study focuses on the adaptive control of a TWUSM unit as a critical technical foundation for future robotic arm integration. Based on the identification of

fundamental motor characteristics, we are currently constructing a control law that explicitly incorporates the internal operational dynamics.

ASTRO-2026-C002

「月面探査ローバーにおける STT-IMU 天文航法のバックアップ利用とそのキャリブレーション方法」

「Backup Use of STT-IMU Celestial Navigation for a Lunar Exploration Rover and Its Calibration Method」

* 巳谷 真司, 河合 優太(JAXA)

Abstract:

A pressurized rover capable of sustained crewed and uncrewed lunar exploration over more than a decade is currently under development. While navigation is primarily planned using lunar positioning satellites, alternative techniques are required during periods of limited satellite visibility. This paper investigates the feasibility of celestial navigation using onboard Star Tracker (STT) and Inertial Measurement Unit (IMU) as a backup solution. We present an overview of the STT-IMU integrated navigation method and evaluate its expected accuracy. In addition, alignment techniques between STT and IMU, as well as calibration methods for IMU accelerometer biases using lunar positioning data, are discussed.

ASTRO-2026-C003

「UWB 通信を用いた静的環境におけるロボットの相対位置姿勢推定」

「Relative Pose Estimation of Robots in a Static Environment Using UWB」

* 小林 知磨（東大・院），吉光 徹雄（JAXA）

Abstract:

This study focuses on relative position and attitude estimation between multiple robots using ultra-wideband (UWB) communication. In GPS-denied environments such as lunar lava tubes or underground spaces, robots must estimate their locations without relying on external infrastructure. Each robot obtains inter-robot distance and angle information through UWB communication and estimates the relative position and orientation of other robots in a static state. This approach enables a group of robots to share spatial relationships and supports cooperative exploration in unknown environments. The proposed method is expected to contribute to robust multi-robot exploration under limited visibility and communication conditions.

ASTRO-2026-C004

「不整地順応性を持たせた 4 輪独立 PPL 型ローバの斜面横断性能の実験的検証」

「Experimental verification of the Slope-crossing performance of a four wheel independent PPL-Type Rover designed for Adaptability to uneven terrain」

* 藤川 薫(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:

This study experimentally evaluates a four-wheel independent push-pull locomotion (4WPPL) lunar rover with a passive rocker-link suspension that maintains four-wheel ground contact on uneven, soft sandy slopes. Using an Intel RealSense depth camera, researchers scanned and aligned the sand terrain to create reproducible uneven conditions across four cases: uphill embankment, downhill embankment, uphill valley, and downhill valley. Lateral slip and vertical wheel-load distribution were measured with and without suspension during both 4WPPL and conventional driving. Results show that the suspension stabilizes load distribution and generally reduces lateral slip.

ASTRO-2026-C005

「月面地形による星の掩蔽を用いた月面ローバ測位の観測モデルと位置識別性解析」

「Observation Models and Position Identifiability for Lunar Rover Localization Using Star Occultation by Lunar Terrain」

* 水沼 健人(東大・院), 橋本 樹明(JAXA)

Abstract:

Navigation in unlit lunar environments requires passive absolute position cues. This study formulates star occultation by lunar terrain as a rover localization measurement, using the angular margin between apparent stellar elevation and the DEM-derived terrain horizon. Binary visibility, angular-margin, and event-timing observations are compared through Fisher information and grid-based posterior distributions. Synthetic terrains are used to identify degenerate geometries, including flat terrain, single-ridge constraints, and globally ambiguous skyline patterns. The analysis clarifies when local identifiability is achieved, when posterior multimodality remains, and how the resulting observation model can support subsequent sequential filtering and smoothing for lunar rover navigation.

ASTRO-2026-C006

「前後の車輪荷重バランスに着目した Push-Pull Locomotion 型月・惑星探査ローバの移動性能に関する研究」

「Study on the Mobility of a Push-Pull Locomotion Planetary Rover Focusing on Front-Rear Wheel Load Balance」

* 何 青澤, 船川 敬秀, 村田 峻一, 竹内 琉晟(芝浦工大・院), 飯塚 浩二郎(芝浦工大)

Abstract:

Push-Pull Locomotion (PPL) is a mobility method that improves rover traversability on loose terrain by periodically varying its wheelbase. During this motion, changes in wheelbase alter the wheel load distribution, which can affect mobility performance. This study investigates the influence of wheel load distribution on the mobility of a PPL rover using an active center-of-gravity control mechanism. Slope traversal experiments were conducted under different load distribution conditions, and mobility was evaluated using travel reduction. The results indicate that appropriate load redistribution can improve rover mobility by reducing slip and enhancing traction. These findings demonstrate the importance of wheel load management for improving the performance of PPL rovers on sloped terrain.

ASTRO-2026-C007

「LiteBIRD スピン衛星の Lie Group Variational Integrator に基づく姿勢運動定式化とニューテーション制御」

「Lie Group Variational Integrator-Based Attitude Dynamics Formulation and Nutation Control for LiteBIRD Spin-Stabilized Spacecraft」

* 神谷 俊夫(明星大)

Abstract:

Spin-stabilized spacecraft such as LiteBIRD exhibit rotational dynamics characterized by a fast spin cycle and a much slower nutation cycle. Conventional numerical integration methods require small time steps to accurately resolve the high-frequency spin motion, leading to a significant computational burden in long-duration simulations and attitude control studies. To address this issue, this paper presents a Lie Group Variational Integrator (LGVI) formulation for the attitude dynamics of a spinning spacecraft. The proposed method directly propagates the attitude on $SO(3)$, preserving the geometric structure of rotational motion and improving long-term numerical consistency. Based on the developed model, a nutation control scheme using impulsive external momentum actuation is investigated. Numerical results suggest that the LGVI framework can reduce the computational effort

required for high-spin spacecraft simulations while maintaining sufficient accuracy for nutation control analysis.

ASTRO-2026-C008

「非干渉化最適サーボによる柔軟宇宙機の姿勢制御と制振」

「Attitude Control and Vibration Suppression of Flexible Spacecraft via Decoupling Optimal Servo」

* 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 flexible spacecraft is that vibrations are generated in the flexible structure during maneuvers, and the vibrations degrade 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, decoupling optimal servo (DECOPS) control system is developed. It is shown that both three-axis attitude control and vibration suppression including higher order modes are achieved by the DECOPS method.

ASTRO-2026-C009

「スピン安定固体ロケットの形状検討」

「Oblate geometry for spin stablized solid rocket lander」

* 入尾野 智紀(九大・院), 坂東 麻衣, 外本 伸治(九大)

Abstract:

This study investigates the geometry of a solid rocket lunar lander. Prior research assumed that the lander spins as fast as 1 Hz to ensure passive attitude control. However, this fast spin rate prevents the lander from reorienting itself for guidance to the target area once the lander is dispatched from the mother ship.

To achieve guidance toward the target, reducing the spin rate would allow the lander to alter its attitude by actuating the solid rocket motors in synchronization with the spin.

Therefore, this study introduces an oblate geometry is introduced to maintain baseline stability at significantly reduced spin rates by increasing the moment of inertia about the principal axis.

ASTRO-2026-C010

「宇宙デブリの渦電流デタングリングの長時間軌道最適化」

「Long-Horizon Trajectory Optimization for Eddy-Current Detumbling of Space Debris」

* 佐藤 裕成アレックス（東大・学），坂井 真一郎（JAXA），五十里 哲（東大），中須賀 真一（立命館）

Abstract:

This study investigates long-horizon trajectory optimization for eddy-current detumbling of space debris. A chaser satellite uses a high temperature superconducting (HTS) coil mounted on a robotic end effector to apply a large magnetic field to conductive sections of the debris, producing eddy-current forces and torques. The optimal control formulation uses magnetic tensor models to analytically compute the eddy-current force and averages the debris's fast rotation to facilitate the optimization. Numerical simulations show that geomagnetic torque acting on the HTS coil can be exploited to reduce the chaser's control effort.

ASTRO-2026-C011

「Optimally Uniform Free Rigid-Body Tumbling」

* McMullan Kyle(Curtin・Graduate Student), Paxman Jonathan, Howie Robert(Curtin)

Abstract:

Pointing control is often not suitable in safe operating modes and within the stringent constraints of very small spacecraft, as it demands precise attitude determination and actuation. To address this, an angular momentum-only control strategy is presented which suitably meets mission objectives that would otherwise require pointing control. In particular, the passive tumbling strategy that most uniformly explores the pointing space with body-fixed vectors is derived and characterised. This control strategy is realisable in practice using a previously derived polhode control law for both control-affine actuators and magnetorquers. Applied to maximising solar power generation, this optimally uniform strategy outperforms all other tumbling strategies and is demonstrated as a viable replacement for pointing control across a range of spacecraft architectures.

ASTRO-2026-C012

「はやぶさ2のワンホイール制御における不規則歳差運動の原因検討」

「Assessment of the Possible Causes of Irregular Attitude Precession during One-Wheel

Control of Hayabusa2]

* 久保 勇貴(神戸大), 楠本 哲也, 木村 洸貴, 三桝 裕也(JAXA)

Abstract:

In Hayabusa2, semi-passive attitude-stabilization operations referred to as one-wheel control (OWC) have been conducted, which combines the actuation of a single reaction wheel with solar radiation pressure torque. In past OWC operations, it has been observed that the angular momentum vector, which normally traces a spiral-like ellipse, exhibits irregular motion as it approaches the equilibrium point. This presentation enumerates possible sources of the anomalous disturbance torque, provides quantitative estimates for each candidate, and narrows down the most likely cause.

ASTRO-2026-C013

「ジンバル駆動型太陽電池膜による太陽光圧トルク特性の解析」

「Analysis of solar radiation pressure torque characteristics of gimbal-driven thin-film solar membranes」

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

Abstract:

In recent years, large-area and lightweight solar membranes have attracted attention in outer planet exploration, and their application is expected to enable the realization of smaller spacecraft than before. In particular, in deep space exploration by small spacecraft, there are constraints on the propulsion system, fuel amount, and number of thrusters that can be installed, so there is a need for a reaction wheel unloading method that does not consume propellant and generates as little translational disturbance as possible. In this study, we will examine the relationship between the angle of the solar membrane changed by the gimbal mechanism and the torque generated by solar radiation pressure in a small spacecraft with two wings equipped with a single-axis gimbal. We will also clarify the correspondence between the solar radiation pressure torque characteristics and the average membrane shape.

ASTRO-2026-C014

「対称性を利用した逆キネマティクスにおける境界条件に関する考察」

「Boundary Conditions in Symmetry-Aware Inverse Kinematics for Control Moment Gyroscopes」

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

Abstract:

This presentation considers the role of symmetry in inverse kinematics for control moment gyroscopes (CMGs). By using symmetry, the inverse kinematics problem can be formulated and learned within a limited fundamental region, while the obtained solution can be extended to the full angular momentum space when applied in practice. This is useful for reducing the domain that must be directly treated. At the same time, it raises questions about how solutions should be represented and connected across the boundaries of symmetric regions. We discuss possible formulations of such boundary conditions and their implications for learning-based inverse kinematics, aiming to provide a basis for future symmetry-aware CMG control methods.

ASTRO-2026-C015

「深宇宙ランデブードッキングにおけるスラストとリアクションホイールを用いた姿勢制御系の検討」

「Analysis of Hybrid Attitude Control System Using Thrusters and Reaction Wheels for Deep-Space Rendezvous and docking」

* 山根 勇祐 (東大・院), 坂東 信尚, 橋本 樹明 (JAXA)

Abstract:

During close-proximity RVD, relative attitude must be accurately controlled using actuators such as thrusters and reaction wheels. Thrusters consume propellant and face minimum-thrust and discrete-operation limits. Reaction wheels provide continuous, high-precision control, but angular momentum saturation is problematic. This study proposes a hybrid attitude control method combining both actuators. Simulink simulations compare thruster-only, reaction-wheel-only, and hybrid control during thruster-based translation. The results show that the proposed method reduces attitude error and propellant consumption while suppressing angular momentum accumulation in the reaction wheels.

ASTRO-2026-C016

「超小型衛星における八木アンテナ通信のための姿勢補償」

「Study on YAGI antenna communication system with attitude compensation for ultra-small satellite」

* 徳光 政弘, 串田 海人, 渡邊 真桜, 小池 亮悟, 岡田 志織, 園田 琉惺, 平社 信人(群馬高専)

Abstract:

In this report, an attitude control system with high accuracy for 2 U-size ultra-small satellite with directional antenna is conducted. To adapt the ultra-small satellite with strict environment such as electric power supply and implemental space being scarce, an expandable YAGI antenna and an attitude compensation system by using COTS are conducted, then constructing these functions are implemented to 2U-size satellite as Innovative-4 project. To clarify some performances of the proposed YAGI antenna acquiring system with attitude compensation for the ultra-small satellite, some experiments on ground and on orbit are executed and obtained results are evaluated.

ASTRO-2026-C017

「光学異方性のあるシートを用いた受動的太陽指向姿勢制御の地球低軌道における実証可能性評価」

「Feasibility Study of Passive Solar Homing Technology in Low Earth Orbit Using a Sheet with Incident-Angle-Dependent Reflectance」

* 吉田 英生, 木村 洸貴, 辻 真次郎(JAXA)

Abstract:

This study aims to establish a methodology for evaluating the feasibility of on-orbit demonstration of passive solar homing technology using a "Novel Incidence-dependent Nonpropulsive Janiform Attitude-control (=NINJA) mirror" in low Earth orbit (LEO). In LEO, disturbance torques arising from aerodynamic drag, gravity-gradient effects, and geomagnetic interactions significantly affect spacecraft attitude control. This study focuses on the estimability of SRP torque induced by angle-dependent optical property variations of the NINJA mirror and investigates evaluation metrics that incorporate both attitude control performance and orbital environmental conditions. The proposed framework is expected to provide design guidelines for selecting suitable orbital and attitude conditions for future demonstrations.

ASTRO-2026-C018

「太陽光圧下における二軸リアクションホイール衛星の姿勢運動解析」

「Attitude Dynamics Analysis of a Two-Axis Reaction Wheel Satellite under Solar Radiation

Pressure]

* 楠本 哲也, 木村 洸貴, 三桝 裕也(JAXA)

Abstract:

This presentation describes the attitude dynamics of a spacecraft equipped with dual-axis reaction wheels (RWs) under the influence of solar radiation pressure. The study demonstrates that appropriate attitude selection enables effective momentum unloading without additional actuators. By exploiting environmental torques, the system can maintain operational stability while reducing onboard control effort. Furthermore, the analysis shows that, under certain conditions, three-axis attitude stabilization can be achieved using only two reaction wheels. These results highlight a practical and efficient control strategy, contributing to reduced system complexity and improved sustainability in long-duration missions.

ASTRO-2026-C019

「制御バリア関数による CMG の特異点回避を考慮した姿勢制御」

「Control Barrier Function-Based Attitude Control with CMG Singularity Avoidance」

* 池田 裕一(湘南工大)

Abstract:

In spacecraft missions demanding rapid and large-angle attitude maneuvers, Control Moment Gyroscopes (CMGs) are often preferred over reaction wheels due to their ability to provide tens of times higher torque. However, CMGs suffer from singularities where torque cannot be generated in specific directions, making singularity avoidance a critical requirement for control system design. This study proposes an attitude control approach that addresses CMG singularity avoidance via Control Barrier Functions (CBFs).

ASTRO-2026-C020

「駆動可能な太陽電池パドルによる太陽光圧トルクの可制御性について」

「On the Controllability of Solar Radiation Pressure Torque using Drivable SAP」

* 小坂 岳文, 巳谷 真司(JAXA)

Abstract:

Recently, attitude control methods to reduce fuel consumption of chemical propulsion systems are actively discussed for miniaturization and extending life of spacecraft. Active control of solar radiation pressure (SRP) torque generated by drivable solar array panels

(SAPs) is one of the promising approaches. However, conventional methods assume that SAPs are completely symmetrical configuration and center of mass (CM) lies at geometric center position, or relied on numerical solutions, since torque model is nonlinear and inverse problem for drive angles cannot be solved analytically, when considering CM error or arbitrary center of pressure on SAPs. From perspective of onboard implementation, the authors focus on linear model with Jacobian matrix of SRP torque and investigate its controllability when spacecraft has two gimbaled SAPs. Then, an angular momentum control law with Jacobian is developed. Finally, effectiveness of the algorithm through numerical simulation is demonstrated.

ASTRO-2026-C021

「スピン型燃料フリーソーラーセイル中間軸姿勢制御理論の構築」

「Development of an Intermediate-Axis Attitude Control Theory for Spin-Type Propellant-Free Solar Sails」

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Abstract:

This study proposes a novel attitude control strategy for spin-type solar sails that actively modulates inertial mass along the spin axis to induce an intermediate-axis state, triggering controlled instability. Traditionally considered inferior due to large spin-induced inertia, spin-type sails are shown through numerical simulations to achieve propellant-free 180-degree attitude reversal by leveraging the Zhebennikov effect, enabling effective use of solar radiation pressure in low Earth orbit. A Lyapunov-based control law is under investigation to stabilize the transition and utilize precessional impulse. These findings challenge the prevailing paradigm of solar sail control and open a new pathway toward highly efficient, fully propellantless attitude dynamics for deep-space missions.

ASTRO-2026-C022

「低重力環境における衝撃加速度応答に基づく地盤剛性の測定」

「Impact acceleration-based estimation of ground stiffness under low gravity」

* 大槻 真嗣(JAXA), 前田 孝雄(TUAT), 小林 泰三(Rits)

Abstract:

In the context of planetary exploration, it is imperative to predict the mechanical properties

of surface layer of celestial body; however, it necessitates instruments with substantial resources such as measuring leg reaction forces, capturing images of pad penetration, or direct measurement with onboard tools. In this study, we propose a methodology to estimate the mechanical properties using only a triaxial accelerometer and present test results on dynamic pad penetration conducted in a microgravity environment. The results showed that the modulus of subgrade reaction calculated from acceleration data was equivalent to that derived from measurements of force and sinkage quantities.

ASTRO-2026-C023

「推力方向制御を伴うスピン安定着陸機のための地上模擬飛翔試験系の開発」

「Development of Ground-Based Flight Test System for Spin-Stabilized Lander with Thrust Vector Control」

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

Abstract:

This study develops a quadcopter-based flight test framework for a spin-stabilized lander using thrust vector control with a fixed-thrust propulsion system. The framework is intended to emulate the key characteristics of a solid rocket motor with gimbal control, while enabling repeated ground-based flight tests. A separation mechanism and a launch platform are developed to conduct ascent and hovering tests of the experimental vehicle. Preliminary tests have confirmed the basic flight capability of the system, although disturbances during separation and vibration induced by pre-separation spin remain important technical challenges. This presentation reports the experimental concept, system configuration, preliminary observations, and remaining issues.

ASTRO-2026-C024

「垂直離着陸再使用ロケットの着陸脚先端への車輪適用に関する研究 -車輪の回転方向が機体挙動と着陸衝撃に与える影響評価-」

「Application of Wheels to the Landing Leg Tips of Reusable Rocket - Evaluation of the Effect of Wheel Rotation Direction on Vehicle Dynamics and Landing Impact-」

* 会田 湧太(静大・院), 森 治, 伊藤 琢博, 河野 太郎, 丸 祐介, 澤井 秀次郎(JAXA), 能見 公博(静大)

Abstract:

In recently developed reusable rockets, reducing friction between the landing leg tips and the ground is known to improve tip-over resistance during landing. To achieve this, equipping wheels on the landing legs has been proposed. However, vehicle dynamics and landing impacts when combining wheels with shock-absorbing mechanisms remain insufficiently studied. Additionally, the wheel type and mounting method can induce post-landing inclination and rotation of the vehicle axis. Therefore, this study evaluates how wheel installation affects vehicle dynamics and landing impacts in a reusable rocket utilizing honeycomb crushers, aiming to investigate its potential application to actual flight vehicles.

ASTRO-2026-C025

「固体ロケットモーターの点火タイミング調整によるスピン安定型火星着陸方式の検討」

「Study on a Mars Landing Method Using Spin Stabilization with Solid Rocket Motors」

* 金沢 侑紀, 大木 春仁, 中川 果帆, 山本 輝汰 (東大・院), 楠本 哲也, 森下 直樹, 岩渕 頌太, 津田 雄一 (JAXA)

Abstract:

This study investigates a novel terminal deceleration method after atmospheric entry with a deployable aeroshell, using a solid rocket motor (SRM) within a simplified spacecraft structure. While an SRM cannot be throttled once ignited and thrust variations cause attitude tilt, we address these challenges via optimal ignition timing adjustment and spin-stabilization for attitude maintenance. This method aims to reduce both axial rotation and ground velocity for landing, by utilizing two pairs of SRMs for spin-up and spin-down at appropriate timings.

ASTRO-2026-C026

「不整地着陸を実現する着陸機姿勢安定化手法の2自由度着陸脚モデルによる検討」

「Attitude Stabilization of a Lander for Landing on Uneven Terrain: A Study Using a Two-DoF Landing Gear Model」

* 岩渕 頌太, 峯杉 賢治 (JAXA)

Abstract:

To expand the accessible exploration area for lunar and planetary landing missions, attitude stabilization must be achieved while satisfying constraints such as the limited leg range of motion on terrains with uncertain geometry and properties. To achieve this, an optimal

control-based approach is applied and evaluated through numerical simulations of landing dynamics using a two-DoF landing gear model, focusing on attitude stabilization capability and impact acceleration mitigation. The results of numerical simulations under initial conditions with tilted attitude and horizontal residual velocities are presented, and the feasibility of the proposed control approach is discussed.

ASTRO-2026-C027

「ベント付き複合エアバッグを有する惑星着陸機の 6 自由度低次元着陸応答モデル」

「Six-Degree-of-Freedom Low-Order Landing Response Model for a Planetary Lander with Vented Combined Airbags」

* 廣瀬 有貴(東大・院), 橋本 樹明(JAXA)

Abstract:

This study aims to develop a six-degree-of-freedom low-order modeling framework for a planetary lander equipped with vented combined airbags. The lander is treated as a rigid body, while the airbags are represented using lumped quantities such as contact state, volume change, internal pressure, vent flow, reaction force, and friction. The model couples these quantities with translational and rotational motion to investigate touchdown response under varying landing conditions. Numerical examples are used to examine vertical cushioning, rebound, attitude motion, and asymmetric airbag responses. Further model refinement and quantitative validation are planned.

ASTRO-2026-C028

「群知能アルゴリズムを用いた超小型衛星 GNSS データに基づく地球超低軌道の衛星寿命予測」

「Satellite Lifetime Prediction in Very Low Earth Orbit Based on CubeSat GNSS Data Using Swarm Intelligence Algorithm」

* 保坂 望, 若林 駿(北大・院), 高橋 裕介(北大), 玉川 徹(理研), 榎戸 輝揚(京大), 岩切 渉(千葉大), 北口 貴雄, 三原 建弘(理研), 武田 朋志(広大), 大田 尚享, 青山 有未来, 岩田 智子(理科大), 喜多 豊行(千葉大), 高橋 拓也, 山崎 楓, 土屋 草馬, 中野 遥介(理科大), 一番ヶ瀬 麻由(立教大)

Abstract:

CubeSat missions in Very Low Earth Orbit (VLEO, 100-400 km) provide enhanced observation resolution but experience significant atmospheric drag, necessitating accurate

orbital lifetime prediction for mission planning. CubeSats, however, face constraints in sensor capability and data availability, complicating reliable lifetime estimation. This study addresses atmospheric density estimation using GNSS data from the NinjaSat CubeSat as an inverse problem: an orbit consistent with observations is reconstructed using Gaussian Process Regression and compared against Special Perturbations analysis, while aerodynamic coefficients are determined by DSMC and attitude-derived projected areas are calculated based on attitude data of NinjaSat. Optimal parameters are identified through Particle Swarm Optimization. These processes enable reliable lifetime prediction from sparse observational data.

ASTRO-2026-C029

「影の境界を利用した宇宙機のポーズ推定の研究」

「Study on Vision-Based Spacecraft Pose Estimation Using Shadow Boundaries」

* 都筑 大樹(東大・院), 橋本 樹明(JAXA)

Abstract:

This study proposes a physically model-based image navigation algorithm that actively utilizes shadow boundaries as observable shape features rather than noise. The proposed method consists of three processes. First, it calculates the theoretical geometric boundary of the shadow at the current estimated pose based on the target's 3D shape model and the known solar azimuth vector. Next, it extracts high-brightness gradient regions from the captured image using an edge detection algorithm to identify shadow boundary candidates. Finally, it performs pose optimization to minimize the distance between the predicted shadow boundary and the observed edges. This approach enables robust attitude information extraction even in areas where surface texture is lost, leveraging the correlation between the target's geometric shape and lighting conditions.

ASTRO-2026-C030

「速度ノルム制約を用いた超小型サンプリングプローブの視線角観測による初期軌道決定」

「Angles-Only Initial Orbit Determination of Micro Sampling Probe Near Small Bodies Using Speed-Norm Constraint」

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

Abstract:

Functionally distributed sample-return architectures are increasingly considered for small-body exploration, in which a micro sampling probe is deployed to the small-body surface for sampling and subsequently re-ejected toward the mother spacecraft for recovery. The mother spacecraft observes the probe over only a short arc immediately after re-ejection via line-of-sight (LOS) angle measurement; the limited observation window severely constrains range observability, making reliable recovery challenging. This study proposes an angles-only initial orbit determination method that leverages the known re-ejection speed magnitude as a constraint to mitigate the range uncertainty, contributing to relative navigation design for future distributed small-body missions.

ASTRO-2026-C031

「はやぶさ 2 号の小惑星トリフネフライバイにおける OP-NAV 地上軌道決定について」
「Simultaneous Orbit Determination of Hayabusa2 and the Asteroid Torifune」

* 竹内 央, 杉本 理英, 楠本 哲也(JAXA), 山田 学(千葉工大), 浦川 聖太郎(松江高専), 黒田 大介(JSGA), 岩城 拓弥, 三桝 裕也(JAXA)

Abstract:

We report the results of the simultaneous orbit determination of Hayabusa2 and the asteroid Torifune by combining optical observations of Torifune obtained with ground-based optical telescopes and cameras aboard Hayabusa2 with radio tracking data of Hayabusa2 acquired using large ground-based antennas.