Naoki HIRAIWA

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EDUCATION

Kyushu University, Fukuoka, Japan
Advisor: Prof. Mai Bando and Prof. Shinji Hokamoto

Ph.D. Student, Apr. 2022 - Mar. 2025 (expected)

- Visiting Scholar at University of Colorado Boulder, Sep. 2023 - Aug. 2024

M.Eng. in Aeronautics and Astronautics, 2022 GPA 4.00/4.00

- Thesis: "Analysis of Ballistic Transfer Based on Lobe Dynamics"

B.Eng. in Aeronautics and Astronautics, 2020 GPA 3.78/4.00

- Thesis: "Analysis of Orbital Dynamics in the Binary Asteroid System Based on Center Manifold Theory" (in Japanese)

RESEARCH EXPERIENCE

Trajectory Design and Optimization Based on Lobe Dynamics
Apr. 2022 - Current

Doctoral Thesis Research, Kyushu University, Hokkaido University, and Universidade Federal do Rio de Janeiro

- Lobe dynamics can reveal phase space transport of chaotic trajectories.
- Generating chaotic low-energy transfer trajectories in cislunar space based on lobe dynamics

Low-Thrust Trajectory Design with Convex Optimization
Aug. 2021 - Current

Kyushu University

- Designing halo-to-NRHO low-thrust optimal transfer trajectories via successive convex optimization
- Constructing initial guesses from halo orbits based on beam search

Analysis of Chaotic Trajectories Based on Lobe Dynamics
Feb. 2021 - Mar. 2022

Master's Thesis Research, Kyushu University

- Lobe dynamics is used to study phase space transport in chaotic systems such as CR3BP.
- Apply lobe dynamics to trajectory design to leverage chaotic trajectories in the system

Trajectory Design Based on Center Manifold Theory
Apr. 2019 - Mar. 2023

Bachelor's Thesis Research, Kyushu University

- Extended the trajectory design method to remove the symmetry assumption and add the perturbation terms
- Computed quasi-periodic orbits successfully in a binary asteroid system

PUBLICATIONS

Peer-reviewed Journal Publications

First author

1. N. Hiraiwa, M. Bando, I. Nisoli, and Y. Sato: "Designing robust trajectories by lobe dynamics in low-dimensional Hamiltonian systems," Physical Review Research, Vol. 6, L022046, 2024.
2. N. Hiraiwa, M. Bando, and S. Hokamoto: "Halo-to-Halo Low-Thrust Transfer via Successive Convex Optimization with Intermediate Orbit Design," *Journal of Evolving Space Activities*, Vol. 1, Article No. 48, 2023.
3. N. Hiraiwa, M. Bando, and S. Hokamoto: "Trajectory Design in Irregular Gravitational Fields Based on Center Manifold Theory," *Journal of Guidance, Control, and Dynamics*, Vol. 46, No. 8, pp. 1637–1648, 2023.

Co-author

1. S. Yamaguchi, N. Hiraiwa, M. Bando, S. Hokamoto, D. B. Henry, and D. J. Scheeres: "Trajectory Design for Awaiting Comets on Invariant Manifolds with Optimal Control," *Astrodynamics*. (Accepted)
2. K. Ikeda, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Low-Energy Transfer Trajectories from Jupiter to Europa with Ballistic Transfer," *Journal of Evolving Space Activities*, Vol. 1, Article No. 35, 2023.

Conference Proceedings

First author

1. N. Hiraiwa, M. Bando, and S. Hokamoto: "Extending Earth–Moon Transfer Based on Lobe Dynamics into the Restricted Four-Body Problem," 25-320, *35th AAS/AIAA Space Flight Mechanics Meeting*, Jan. 2025.
2. N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Earth–Moon Low-Energy Transfers Based on Lobe Dynamics" (in Japanese), 4J07, *68th Space Sciences and Technology Conference*, Nov. 2024.
3. N. Hiraiwa, D. B. Henry, D. J. Scheeres, and M. Bando: "Design of Minimum-Time Low-Thrust Transfer between Quasi-Periodic Orbits," C1.4.8, *75th International Astronautical Congress*, Oct. 2024.
4. N. Hiraiwa, D. B. Henry, M. Bando, and D. J. Scheeres: "Analysis of Dynamical Structures in a Three-Dimensional Volume-Preserving Map," 24-239, *AAS/AIAA Astrodynamics Specialist Conference*, Aug. 2024.
5. N. Hiraiwa, M. Bando, and S. Hokamoto: "Analysis of Transfer Trajectories in Cislunar Space Using Sequences of Lobe Dynamics," C1.9.2, *74th International Astronautical Congress*, Oct. 2023.
6. N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Optimal Low-Thrust Transfer Trajectory for Halo Orbits via Convex Optimization" (in Japanese), 3L05, *66th Space Sciences and Technology Conference*, Nov. 2022.
7. N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Optimal Low-Thrust Orbit-to-Orbit Transfers via Convex Approach," C1.3.6, *73rd International Astronautical Congress*, Sep. 2022.
8. N. Hiraiwa, M. Bando, and S. Hokamoto: "Halo-to-Halo Low-Thrust Transfer via Successive Convex Optimization with Intermediate Orbit Design," *33rd International Symposium on Space Technology and Science*, 2022-d-58, Mar. 2022.
9. N. Hiraiwa, M. Bando, and S. Hokamoto: "Analysis of Ballistic Escape Based on Lobe dynamics," C1.7.10, *72nd International Astronautical Congress*, Oct. 2021.
10. N. Hiraiwa, M. Bando, and S. Hokamoto: "Trajectory Design in the Didymos System Based on the Center Manifold Theory" (in Japanese), 4M10, *64th Space Sciences and Technology Conference*, Oct. 2020.
11. N. Hiraiwa, M. Bando, and S. Hokamoto: "Trajectory Design in the Vicinity of 65803 Didymos Based on the Center Manifold Theory," 20-593, *AAS/AIAA Astrodynamics Specialist Conference*, Aug. 2020. (Published in *Advances in Astronautical Sciences*, 175:4849-4866, 2021)

Co-author

1. Y. Hayashi, N. Hiraiwa, M. Bando, and S. Hokamoto: "Station-Keeping for Earth–Moon Periodic Orbit with Solar Sail based on the Orbit-Attitude Coupled Model," 25-371, *35th AAS/AIAA Space Flight Mechanics Meeting*, Jan. 2025.
2. S. Yamaguchi, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Parking Trajectories to Comets Leveraging Invariant Manifolds with Low Thrust" (in Japanese), 2F02, *67th Space Sciences and Technology Conference*, Oct. 2023.
3. A. Chikusa, N. Hiraiwa, M. Bando, and S. Hokamoto: "Guidance and Control System for Mars Aerocapture Considering Uncertainties" (in Japanese), 1D16, *67th Space Sciences and Technology Conference*, Oct. 2023.
4. S. Hirayama, N. Hiraiwa, M. Bando, and S. Hokamoto: "Optimal Trajectory Design by Adam under Stochastic Disturbing Acceleration," C1.7.2, *74th International Astronautical Congress*, Oct. 2023.
5. N. Pushparaj, N. Hiraiwa, and M. Bando: "Optimal Transfer Trajectories between Relative Quasi-Satellite Orbits," C1.6.10, *74th International Astronautical Congress*, Oct. 2023.
6. S. Yamaguchi, N. Hiraiwa, M. Bando, and S. Hokamoto: "Mission Strategy to Await Comets by Leveraging Manifolds and Low Thrust," C1.6.6, *74th International Astronautical Congress*, Oct. 2023.
7. A. Chikusa, N. Hiraiwa, M. Bando, and S. Hokamoto: "Guidance and Control Algorithm for Mars Aerospace

Considering Uncertainties," C1.3.10, *74th International Astronautical Congress*, Oct. 2023.

8. S. Hirayama, N. Hiraiwa, M. Bando, and S. Hokamoto: "Optimal Transfer by Stochastic Gradient Descent Algorithm Adam," *34th International Symposium on Space Technology and Science*, 2023-d-43, Jun 2023.
9. S. Yamaguchi, N. Hiraiwa, M. Bando, and S. Hokamoto: "Feasibility Study of the Comet Observation Mission Using Sun-Earth-Moon Four-Body Problem" (in Japanese), JSASS-2022-S009, *Annual Meeting of Japan Society for Aeronautical and Space Science Western Branch*, Nov. 2022.
10. K. Ikeda, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Satellite Tour Trajectories Using Poincaré Maps in Multibody Dynamics of Jovian System" (in Japanese), P051, *66th Space Sciences and Technology Conference*, Nov. 2022.
11. S. Hirayama, N. Hiraiwa, M. Bando, and S. Hokamoto: "Trajectory Optimization by Stochastic Gradient Descent Algorithm Adam" (in Japanese), P053, *66th Space Sciences and Technology Conference*, Nov. 2022.
12. S. Yamaguchi, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Transfer Trajectories to Comets for Nano-Satellites Based on the Concept of Comet Interceptor" (in Japanese), P057, *66th Space Sciences and Technology Conference*, Nov. 2022.
13. A. Chikusa, N. Hiraiwa, M. Bando, and S. Hokamoto: "Analysis of Mars Aerocapture Trajectories Considering Disturbances for Guidance System" (in Japanese), P061, *66th Space Sciences and Technology Conference*, Nov. 2022.
14. K. Ikeda, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Satellites Tours Using Periapsis Poincaré Map in Multibody Dynamics of Jovian System," C1.8.8, *73rd International Astronautical Congress*, Sep. 2022.
15. K. Ikeda, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Low Energy Transfer Trajectories from Earth to Europa with Ballistic Capture," *33rd International Symposium on Space Technology and Science*, 2022-d-23, Mar. 2022.
16. K. Ikeda, N. Hiraiwa, M. Bando, and S. Hokamoto: "Design of Low Energy Transfer Trajectories to Europa Using Periapsis Poincaré Map" (in Japanese), P36, *65th Space Sciences and Technology Conference*, Nov. 2021.

Seminars and Talks

1. N. Hiraiwa: "Dynamical Structures of Lobe Dynamics for Spacecraft Trajectory Design," at *Dynamics Days Sapporo 2024*, Dec. 2024.
2. N. Hiraiwa: "Design of Chaotic Transfers Based on Lobe Dynamics," at *33rd Workshop on JAXA Astrodynamics and Flight Mechanics*, Jul. 2023.
3. N. Hiraiwa: "Analysis of Chaotic Trajectories Based on Lobe Dynamics," at *32nd Workshop on JAXA Astrodynamics and Flight Mechanics*, Jul. 2022.

HONORS and AWARDS

Individual

Chiyoda Foundation Scholarship Apr. 2018 - Mar. 2020

Dean's Award for Freshman (Top 2% GPA), Kyushu University Jul. 2017

Fellowships

Kyushu University SPRING program, from Japan Science and Technology Agency [URL]

- Total support up to ~$16,000/year Apr. 2022 - Mar. 2023

JSPS Research Fellowships for Young Scientists (DC2), from Japan Society for the Promotion of Science [URL]

- Total support up to ~$16,000/year Apr. 2023 - Mar. 2025

Research Grants

Grants-in-Aid by SPRING program (**FY2022**), from Japan Science and Technology Agency. Total budget is up to ~$3,400/year.

Grants-in-Aid for Scientific Research <KAKENHI> (**FY2023, 2024**), from Japan Society for the Promotion of Science. Total budget is up to ~$12,000/2 year.

PRESS RELEASES

- Kyushu University and Hokkaido University: "Successfully developed a novel methodology of spacecraft trajectory design based on chaotic orbits in the Earth–Moon system" (in Japanese, [URL]), based on the paper Phys. Rev. Res. 6, L022046 (2024), May 30th, 2024.

SKILLS

Language: Japanese (native), English (fluent)
Programming: MATLAB (proficient), C/C++ (intermediate), LaTeX(proficient)