

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 at 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

1. 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*, 2023.
2. N. Hiraiwa, M. Bando, and S. Hokamoto : "Trajectory Design in Irregular Gravitational Fields Based on Center Manifold Theory," *Journal of Guidance, Control, and Dynamics*, 2023.
3. 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*, 2023.

Conference Proceedings

First author

1. 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.
2. 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.
3. 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.
4. 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.
5. N. Hiraiwa, M. Bando, and S. Hokamoto : “Analysis of Ballistic Escape Based on Lobe dynamics,” C1.7.10, *72nd International Astronautical Congress*, Oct. 2021.
6. 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.
7. 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. 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.
2. 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.
3. 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.
4. N. Pushparaj, N. Hiraiwa, and M. Bando : “Optimal Transfer Trajectories between Relative Quasi-Satellite Orbits,” C1.6.10, *74th International Astronautical Congress*, Oct. 2023.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. 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.

14. 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.
15. 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.

PRESENTATIONS (ORAL)

1. N. Hiraiwa : "Analysis of Transfer Trajectories in Cislunar Space Using Sequences of Lobe Dynamics," at 74th International Astronautical Congress, Oct. 2023.
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 : "Design of Optimal Low-Thrust Transfer Trajectory for Halo Orbits via Convex Optimization" at 66th Space Sciences and Technology Conference, Nov. 2022.
4. N. Hiraiwa : "Design of Optimal Low-Thrust Orbit-to-Orbit Transfers via Convex Approach," at 73rd International Astronautical Congress, Sep. 2022.
5. N. Hiraiwa : "Analysis of Chaotic Trajectories Based on Lobe Dynamics," at 32nd Workshop on JAXA Astrodynamics and Flight Mechanics, Jul. 2022.
6. N. Hiraiwa : "Halo-to-Halo Low-Thrust Transfer via Successive Convex Optimization with Intermediate Orbit Design," at 33rd International Symposium on Space Technology and Science, Mar. 2022.
7. N. Hiraiwa : "Analysis of Ballistic Escape Based on Lobe dynamics," at 72nd International Astronautical Congress, Oct. 2021.
8. N. Hiraiwa : "Trajectory Design in the Didymos System Based on the Center Manifold Theory" at 64th Space Sciences and Technology Conference, Oct. 2020.
9. N. Hiraiwa : "Trajectory Design in the Vicinity of 65803 Didymos Based on the Center Manifold Theory," at AAS/AIAA Astrodynamics Specialist Conference, Aug. 2020.

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 [\[URL\]](#)
• Research grant, Total support up to ~\$24,000/year Apr. 2022 - Mar. 2023
JSPS Research Fellowships for Young Scientists (DC2), from Japan Society for the Promotion of Science [\[URL\]](#)
• Research grant for two years, Total support up to ~\$24,000/year Apr. 2023 - Mar. 2025

SKILLS

Language: Japanese (native), English (fluent)

Programming: MATLAB (proficient), C/C++ (intermediate), \LaTeX (proficient)