



SUBARU TELESCOPE OBSERVATIONS OF TRANS-NEPTUNIAN OBJECTS TO SUPPORT THE NEW HORIZONS MISSION



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Abstract

Objective

- Establish a procedure for rotational period analysis

Methods

- JAXA Detection System
- HSC pipeline
- Lomb-Scargle method

Results

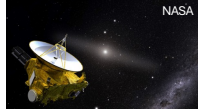
- Preliminary development of a period-analysis procedure
- Rotation periods estimated for 3 main-belt asteroids

Future Work

- Improve period-analysis accuracy using all 12 observation nights
- Apply advanced blending mitigation in star-rich regions

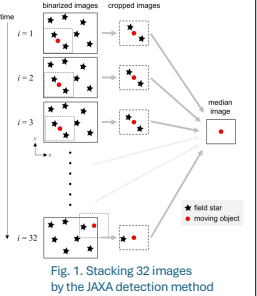
What is the New Horizons (NH) mission?

- To study the unexplored regions of the solar system, the dwarf planet Pluto and its moons, as well as other objects within the Kuiper Belt, a region where traces of the early stages of planetary formation remain.
 NASA launched the NH spacecraft in 2006, investigated the Pluto system in 2015⁽¹⁾⁽²⁾, Arrokoth (2014 MU69) in 2019.
- The extended mission was started in 2016.
 The main purpose : (1) Flyby another KBO
 (2) Observe as many KBOs as possible from the spacecraft.
- In 2020, a series of survey observation for the extended mission began using the Subaru Telescope + HSC and is still ongoing.
 Analysis results from data acquired between 2020 and 2023 have already been reported⁽³⁾⁽⁴⁾.



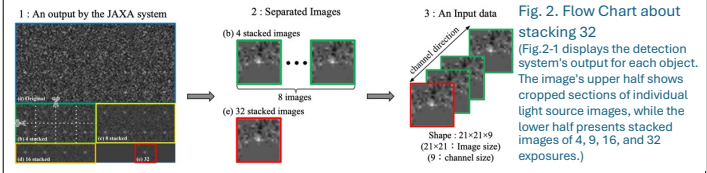
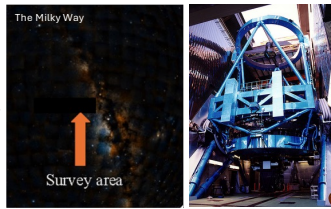
How do we identify Moving Object in HSC images?

- The NH main team performed the primary image processing.
- Chose 32 images taken at equal time intervals from images obtained during one night of observation and then input them into JAXA's moving object detection system.
- JAXA's system superimposes 32 images in all directions at various assumed KBO velocities.
- Our team developed a machine learning program that classified objects as real or spurious and extracted genuine KBO candidates (Please refer to the poster by Shibukawa+, P. 10).
- This procedure was performed for each night's data, and then the KBO candidate detections from all nights were combined and examined for continuous orbital solutions.
- We will report objects with orbits connected over two or more nights to the Minor Planet Center.



Dataset

- Observation DATE : May 28, 2020
 ※Additional datasets containing detected moving objects are available for 12 observing nights from May 2020 to June 2021.
- Exposure Time per Image : 90 seconds
- Number of shot : 80
- Filter : r2

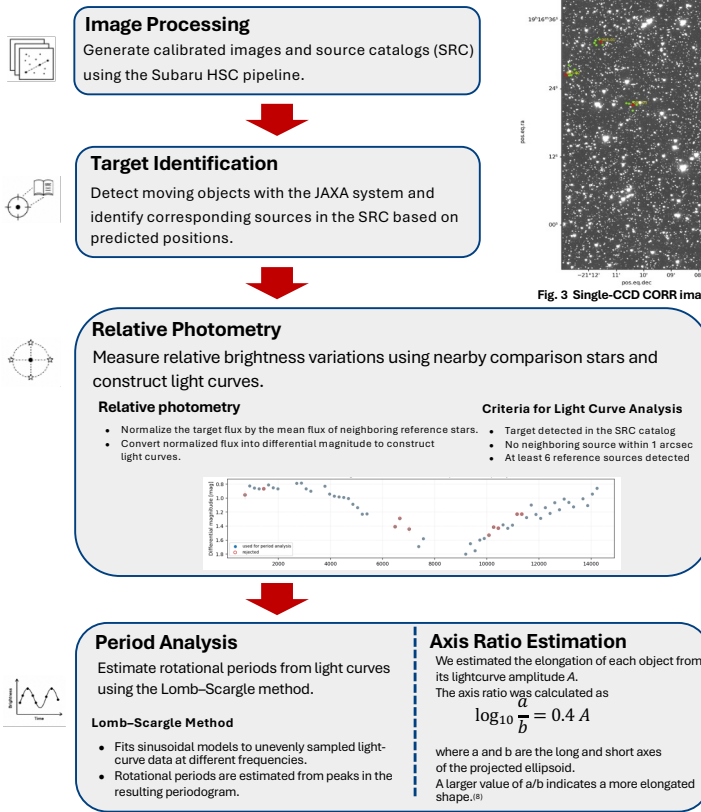


Rotation Period Analysis

Motivation

- The rotation and shape of small bodies reveal the history of impacts they have experienced.
- This information provides clues about the formation and evolution of these bodies.
- Information on their rotation periods, shapes, and satellite presence, derived from light curve measurements, provides insights into these groups' properties and helps elucidate the early state of the outer solar system.

Analysis Flow



Result

Preliminary Period Analysis

Provisional Designation	1999 KG15	2015 HW233	2015 NT26
Rotation Period [hour]	4.8452 ± 0.0751	3.7352 ± 0.0330	4.1975 ± 0.0292
Apparent velocity [arcsec/hr]	16.53	18.46	24.02
a/b	19.36 ± 0.20	1.660 ± 0.014	2.325 ± 0.008

Fig. 4 Lightcurve of 1999 KG15

Fig. 5 Lightcurve of 2015 HW233

Fig. 6 Lightcurve of 2015 NT26

Fig. 7 Analysis image
 Red : Target object, Green : Reference stars

Row 1: Reference-source stability

- Orange: reference-source light curves
- Blue: moving-object light curve
- More constant distribution → more stable photometric data

Row 2: Coordinate matching accuracy

- Distance between predicted and detected positions
- Matching within 5 arcsec regarded as successful identification

Row 3: All light curve

- Light curve before noise removal
- Includes all measurements

Row 4: Refined light curve

- After filtering unstable reference sources and overlapping objects
- Stable data selected for analysis

Future Work

- Analyze all 12 observation nights
- Improve period-analysis accuracy by constructing longer light curves for the same objects
- Advanced blending mitigation in crowded stellar fields
- Identify and remove background-star contamination using image comparison

References

- (1)Stern+ (2015), Science, 350, add1815, (2) Buie+ (2024), PSJ, 5, 196, (3) Yoshida+ (2024), PSJ, 724, 729, (4) Fraser+ (2024), PSJ, 5, 227, (5) Miyazaki+ (2018), PASJ, 70, S1, (6) Yanagisawa+ (2005), PASJ, 399, 408, (7) Shibukawa+ (2025), PASJ, (8) Yoshida+ (2004), PASJ