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Methods and Techniques for Detecting and Calculating the Trajectory of the Potential Asteroid *SNI2307*

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Preface: ***In June 2024, Author embarked on a journey of astronomical discovery by joining the Astronomy Club iAstronomer**, run by **Space India. Through a series of lectures and workshops, author developed a strong interest in celestial observation and learned about the All-India Asteroid Search Campaign- Phase-II, organized by the International Astronomical Search Collaboration (IASC), a NASA-affiliated initiative. From 1st to 26th July 2024, author participated in this campaign, having first attended a pre-campaign workshop that introduced me to the technical processes involved in asteroid detection. Equipped with the Astrometrica software and image datasets provided by the campaign, author encountered challenges in interpreting the initial black-and-white data. However, by delving deeper into the data's nomenclature and enhancing her understanding of celestial mechanics, author successfully identified a potential asteroid, which author named SNI2307. This discovery was formally recognized by the IASC and awarded author a Certificate of Appreciation for her contribution. This research paper provides an in-depth analysis of the image datasets and the steps leading to the discovery of SNI2307, offering a detailed look into the methods and tools employed in this research.***

Abstract: ***During 1st to 26th July 2024, author participated in the All-India Asteroid Search Campaign- Phase-II[1], organized by the International Astronomical Search Collaboration (IASC)[2] and Space India[3], where author identified a potential asteroid, designated SNI2307. Using Astrometrica software[4] and data from a 1.8-meter Ritchey-Chrétien telescope[5,6], author analyzed celestial images to differentiate moving objects from background stars. The object exhibited consistent motion, with shifts of 1.6 arcseconds in Right Ascension and 16 arcseconds in Declination, suggesting continuous movement. Magnitude variations from 21.3 to 20.9, likely due to changes in rotational orientation or surface reflectivity, along with a significant Signal-to-Noise Ratio (SNR) [7], reinforced the object's classification as a potential asteroid. These results were submitted to the Minor Planet Center (MPC)[8] for verification. Author conducted further independent research to estimate its speed, momentum, size, and orbital trajectory, contributing valuable data to the study of Near-Earth Objects (NEOs)[9]. This research aims to enhance our understanding of celestial motion and improve detection methods for NEOs, ultimately supporting efforts in planetary defence. By integrating citizen science into this critical field, author hope to inspire future advancements in asteroid detection and promote wider engagement in astronomical research.***

Keywords: SNI2307, Asteroid, Astrometrica, International Astronomical Search Collaboration, IASC, NASA, Space India, IAstronomer, Trajectory, Planetary defence, Near Earth Objects, NEO, Minor Planet Center, MPC, Pace Junior Science College

1. Introduction

Driven by a passion for planetary defence, author participated in the All-India Asteroid Search Campaign, an initiative organized by the International Astronomical Search Collaboration (IASC), a NASA**[10]** partner, in association with Space India. This campaign invites citizen scientists to engage in asteroid discovery and monitoring, leveraging community involvement to enhance global efforts in identifying Near-Earth Objects (NEOs). Since 2006, IASC participants have contributed substantially to asteroid research, with over **3,800** provisional detections and **120 numbered asteroids[11]**.

Near-Earth Objects (NEOs), which include asteroids and comets, are classified based on their orbits relative to Earth's distance from the Sun. Specifically, NEOs have a perihelion distance (the closest point to the Sun) of less than 1.3 astronomical units (AU). For context, 1 AU is the average distance from the Earth to the Sun, approximately 93 million miles or 150 million kilometres.

Near-Earth Asteroids (NEAs), a subset of NEOs, are categorized further into different groups based on their orbits:

- **Atiras**: Orbits entirely within Earth's orbit.
- **Atens**: Earth-crossing asteroids but having smaller semi-major axis.
- **Apollos**: Earth-crossing asteroids with larger semi-major axis.
- **Amors**: Earth-approaching asteroids orbiting in space between orbits of Earth and Mars.

This classification is crucial for understanding their potential risk to Earth, particularly as some NEOs are considered potentially hazardous due to their orbits bringing them close to our planet

Using Astrometrica software and data from a 1.8-meter Ritchey-Chrétien telescope, author analyzed celestial images to differentiate moving objects from background stars. One object exhibited consistent movement, suggesting continuous motion. Magnitude variations, along with a significant Signal-to-Noise Ratio (SNR), reinforced the object's classification as a potential asteroid. These results were submitted to the Minor Planet Center (MPC) for verification.

This research aims to analyze the object's real image data sets to estimate its speed, momentum, size, and orbital trajectory.

By contributing valuable data to the study of NEOs, this research hopes to enhance our understanding of celestial motion and improve detection methods for NEOs, ultimately supporting efforts in planetary defence. Additionally, this research underscores the value of citizen science in astronomy.

The following sections will delve into the analysis of the real image data sets using the methods outlined in the previous sections on asteroid detection methodologies. We will focus on:

1) **Optical Detection**: Analyzing the data to confirm the object's movement and potential asteroid classification.
2) **Signal-to-Noise Ratio (SNR)**: Evaluating the data quality and determining the object's visibility.
3) **Data Cleaning and Noise Reduction**: Optimizing the data to improve the accuracy of trajectory analysis.
4) **Application of Fourier Series and Calculus in Analyzing Object Trajectories and Motion**: Utilizing mathematical tools to model the object's path.

Research study on the Discovery of a Potential Asteroid "SNI2307" using Astrometrica Software:

In July 2024, author participated in the All-India Asteroid Search Contest, organized by the International Astronomical Search Collaboration (IASC), a NASA partner, and Space India. Through her involvement with the IAstronomica Club, author developed a deep passion for astronomy, fostered by numerous workshops and hands-on experiences with celestial mechanics. The campaign gave me the unique opportunity to translate this passion into scientific action, analyzing astronomical data to identify asteroids.

Using Astrometrica software and data from a 1.8-meter Ritchey-Chretien telescope (TEL F52) equipped with a CCD[12] camera, author worked meticulously over several weeks to analyze celestial images. The software enabled me to track object movement across the sky and differentiate between asteroids and background stars using Signal-To-Noise ratio (SNR) calculations.

Author identified a potential asteroid, preliminarily designated **SNI2307**, with precise positional data captured on July 2, 2024. **SNI2307**'s Right Ascension[13] (~20h 24m 09.25s) and Declination[13] (~ -08° 18' 17.2"), alongside its magnitude of **21.3** as captured in the 1st data set, indicated it was faint but significant.

In recognition of her discovery, author was awarded a **Certificate of Appreciation** by the **International Astronomical Search Collaboration (IASC)** in **August 2024**. The discovery was a major milestone in her scientific journey, with **SNI2307** holding personal significance-its name reflects her initials **(SNI)** and birth date/year **(23/07)**. Every time author gaze at the night sky, author feel a deep connection, knowing that her name is inscribed among the stars, forever linked to this asteroid.

1) **Dataset Analysis for SNI2307:**

SNI2307 was detected using Astrometrica software using four datasets, captured on **July 2, 2024**:

```
COD F52
OBS N. Primak, A.Schultz, S.Watters, J.Thiel, T.Goggia
MEA S. Keshari
TEL 1.8 - m f / 4.4 Ritchey - Chretien + CCD
ACK MPCReport file updated 9/17/2024 3:48:40 PM
NET PPMXL

     SNI2307  C2024 07 02.52557 20 24 09.25 -08 18 17.2  21.3 G   F52
     SNI2307  C2024 07 02.53880 20 24 08.72 -08 18 22.4  21.1 G   F52
     SNI2307  C2024 07 02.55197 20 24 08.18 -08 18 27.6  20.9 G   F52
     SNI2307  C2024 07 02.56518 20 24 07.65 -08 18 33.1  21.1 G   F52


----- end -----
```

Output result of Astrometrica for the Celestial Object SNI2307

a) C2024 07 02.52557 (20h 24m 09.25s, -08° 18' 17.2") - Magnitude: 21.3 G, F52
b) C2024 07 02.53880 (20h 24m 08.72s, -08° 18' 22.4") - Magnitude: 21.1 G, F52
c) C2024 07 02.55197 (20h 24m 08.18s, -08° 18' 27.6") - Magnitude: 20.9 G, F52
d) C2024 07 02.56518 (20h 24m 07.65s, -08° 18' 33.1") - Magnitude: 21.1 G, F52

2) Inferring Data Sets:

a) COD F52

- **COD**: This refers to the Code for the observatory where the observation took place.
- **F52**: The Observatory Code assigned to this specific observation location, indicating which facility recorded the **SNI2307**'s position.

Table I: The image sets used in this research work have been captured by the following telescope

Observatory Code Map	Observatories, programs, surveys, and dedicated telescopes	Country	Region	MPC description	Latitude & Longitude
F52	Pan-STARRS 2 (PS2) at Haleakala Observatory[6]	USA	Hawaii	Pan-STARRS 2, Haleakala	19°36′N 155°30′W

b) OBS N. Primak, A. Schultz, S. Watters, J. Thiel, T. Goggia
- **OBS**: These are the Observers, the individuals who took part in collecting the data.
- **N. Primak, A. Schultz, S. Watters, J. Thiel, T. Goggia**: These are the names of the astronomers or citizen scientists involved in the observation.

c) MEA S. Keshari
- **MEA**: This refers to the Measurer—the individual responsible for processing and analyzing the data from the observation.
- **S. Keshari**: The name of the individual who measured **SNI2307**'s position. That's me.

d) TEL 1.8 - m f/4.4 Ritchey-Chretien + CCD
- **TEL**: This specifies the **Telescope** used for the observation.
- **1.8 - m f/4.4 Ritchey-Chretien + CCD**: This describes a 1.8-meter Ritchey-Chretien telescope with an f/4.4 ratio (Focal Length to Aperture Diameter) equipped with a CCD (Charge-Coupled Device) camera, which is commonly used for precise astronomical imaging.

e) ACK MPC Report file updated 9/17/2024 3:48:40 PM
- **ACK**: Acknowledgment indicating that this report was processed and acknowledged by the Minor Planet Center (MPC).
- **MPC Report**: A file containing observation reports submitted to the MPC.
- **9/17/2024 3:48:40 PM**: The time and date the report was last updated.

f) NET PPMXL
- **NET**: The reference **star catalogue** used for astrometric calculations.
- **PPMXL[14]**: PPMXL is a compilation of astrometric data for approx. 900 millions of stars used for astrometric purposes to determine the position of celestial objects.

g) Observation Data Lines:

Each of the following lines provides specific information on **SNI2307**'s position over time:
- **SNI2307:** Designation of the observed celestial object (potential asteroid) defined by the MEA (myself) being tracked.
- **C2024 07 02.52557**: The date and time of the observation. Here, it's **July 2, 2024, at 0.52557 part of the day (12:36:49.6 UTC)**.
- **20 24 09.25 -08 18 17.2**: These are the Right Ascension (RA) and Declination (De), which specify the object's location in the sky:
- **20h 24m 09.25s RA** (RA simulates the celestial equivalent of longitude).
- **(-)08° 18' 17.2" De** (De simulates the celestial equivalent of latitude).
- **21.3**: The Apparent Magnitude (**Ŕ**) [15] or brightness of the object (21.3).
- **G**: The **G** indicates the **Green photometric filter** used in the CCD observations.
- Each subsequent line records additional observations at different times to track the object's movement. For example:
- **C2024 07 02.53880** corresponds to the next observation at **12:55:51.9 UTC** with updated position coordinates.

h) Magnitude Values:

The magnitude values **(21.3, 21.1, 20.9, 21.1)** reflect how bright the object appears. A higher number indicates a fainter object. For instance, 21.3 is quite faint, suggesting the object is not easily visible without a telescope.
- **Analysis of Movement*:* SNI2307'**s position shifted approximately **1.604 arcseconds in Right Ascension (RA)** and **15.780 arcseconds in Declination (De)** across the datasets, indicating consistent motion. This change in position provides a strong signal that **SNI2307** is a potential asteroid.
- **Reflectivity Changes: SNI2307**'s reflectivity magnitude fluctuated between **21.3** and **20.9**, likely due to its rotational orientation or surface properties. These brightness changes offer clues about its composition and movement as it reflects sunlight at different angles.
- **Signal-To-Noise Ratio:** Using Fourier Transformation and considering 1st frequency**,** the average **Signal-To-Noise Noise Ratio** is calculated as **5.345**, which indicates that the data has a strong Signal as compared to its background Noise, indicating a high chance of being a potential Asteroid.
- **Trajectory, Angular Velocity, Speed, and Size of SNI2307*:*** Considering certain assumptions, the trajectory of the potential asteroid **SNI2307** is as under:

Table II: Data on the research work to ascertain SNI2307's trajectory.

Field	Unit	Calculated Data	Table No.
Average SNR Value	Ratio	5.345	Fourier Transformation
Average Angular Speed	Arcseconds per Sec	0.008348068	Table IX
Average Linear speed	Km/Sec	18.24566349	Table X
Distance from Earth	AU	1.735948	Table XII
Sun, Earth, and **SNI2307**	Angle in Degrees	152.7731942	Table XVI
Distance from Sun	AU	2.664720186	Table XVII
Specific Orbital Energy	Km^2/sec^2	-166.4326312	Calculated
Eccentricity	Ratio	0.00005853908	Calculated
Semi-Major Axis	AU	2.664876186	Calculated
Semi-Minor Axis	AU	2.664876181	Calculated
Specific Angular Momentum	AU^2/second	0.000000325	Table XVIII
Period of Revolution	Earth Years	4.353529302	Table XIX
Estimated Size	%	Varies: 70.11% to 100% of max brightness	Table XX
Avg Apparent Magnitude of **SNI2307** (**Ŕ**)	Unitless	21.1	Table XXI
Absolute Magnitude (H)	Unitless	17.77405838	Calculated
Albedo (p) (assumed)	Unitless	0.075	Calculated

Estimated size of **SNI2307**	Km	1.35264139	Calculated

i) Significance of the Data:

- **Positional Changes**: **SNI2307**'s consistent movement strongly indicates that it may be a potential asteroid, substantiated by mathematically calculated data for its orbit and trajectory.
- **Reflectivity Changes**: The fluctuations in brightness may point to rotational changes, revealing surface features that either reflect or absorb light differently.

j) Analysis:

- This analysis indicates that the detected object is faint (magnitude 21.3), with a well-fitting PSF and a moderate signal-to-noise ratio (SNR = 6.0). The astrometric data (RA and De) pinpoints the object's location in the sky, while the PSF confirms it as a point source, ruling out an extended object like a galaxy.
- The designation **"SNI2307"** implies that the identified object is designated as **SNI2307** by the MEA (myself), is under further observation by MPC.
- Using Astrometrica, a faint object has been identified, with real and measurable data. Further analysis and follow-up observations by MPC shall be required to understand the trajectory and behaviour of the discovered object.

k) Significance of the Discovery:

This discovery represents a significant contribution to the growing catalogue of known asteroids. This campaign also highlighted the impact of **citizen science** in advancing our knowledge of **Near-Earth Objects (NEOs)** and improving planetary defence strategies.

l) Further Observations and Analysis:

- **SNI2307** is currently in **Provisional Status**, and with continued tracking over **6-10 years**, it may eventually achieve **Numbered Status**. author may have the opportunity to propose a formal name for **SNI2307** - an honour for any budding astronomer.
- **Trajectory Calculation**: More precise observations and calculations by the **Minor Planet Center (MPC)** for a further period of 6-10 years will fully determine the nature of **SNI2307** and its trajectory. This research work aims to calculate the trajectory of the **SNI2307** based on the captured image data sets.

m) Surface and Rotation:

Variations in brightness suggest that **SNI2307** may have an irregular surface or rotate, presenting different reflective properties over time. The actual shape, size, and material content of the **SNI2307** shall be ascertained during further observations and analysis by MPC.

3) Challenges and Learning:

One of the key challenges author encountered during the campaign was refining techniques to clean noisy data and extract meaningful signals from interference. Author applied **Fourier Transformation** to analyze light frequencies and employed **vector algebra** and **calculus** to accurately determine asteroid trajectories. Understanding the significance of maintaining an **SNR** greater than 5 was crucial for identifying asteroids in the data sets. These challenges sharpened her data analysis skills and deepened her patience and persistence, essential traits for success in astrophysical research.

4) Analysis using Image Data Sets:

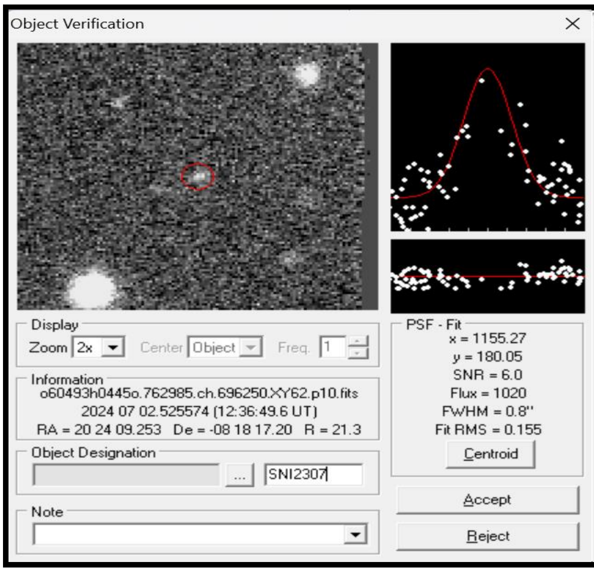

Image 1: With Data Analysis

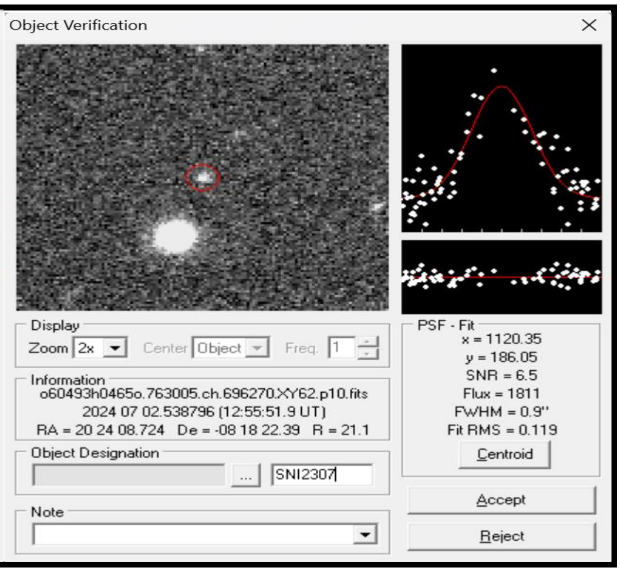

Image 2: With Data Analysis

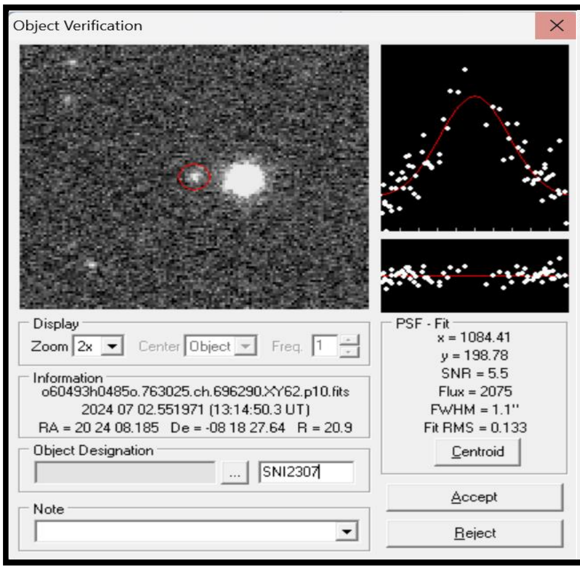

Image 3: With Data Analysis

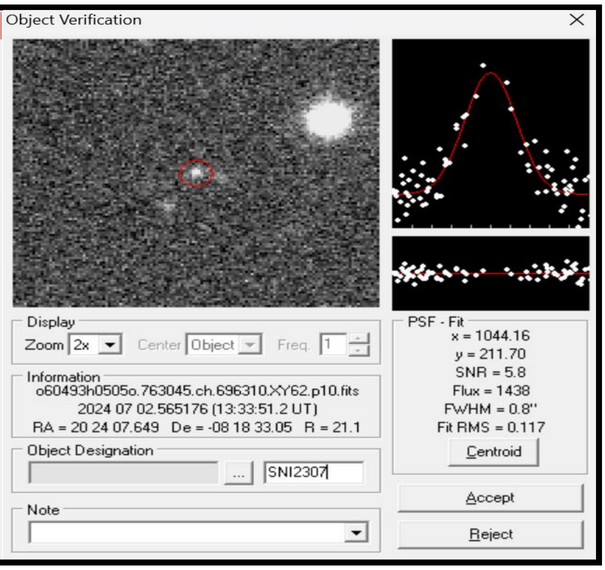

Image 4: With Data Analysis

5) **Key Data Points from Image 1:**

a) **Object Detection**:

- The red circle indicates the detected celestial object. This is the candidate discovery of a potential Asteroid named **SNI2307**, an astronomical object under further investigation by MPC.
- The image data is being analyzed, and the software marks a potential detection with a specific designation.

b) **Astronomical Datasets**:

- Image files in FITS (Flexible Image Transport System) [16] format, containing stars and asteroid observations.

c) **PSF (Point Spread Function) Fit**:

- **The PSF Fit Parameters (x = 1155.27, y = 180.05)** denote the object's location on the image's pixel grid, with **x** and **y** representing the horizontal and vertical pixel coordinates, respectively. These values are crucial for astrometric precision, as they define the exact point where the object is positioned within the image. This accuracy is essential for tracking the object's movement against reference stars. Precision is influenced by pixel resolution and telescope settings, with smaller deviations indicating greater accuracy.
- **SNR = 6.0**: The Signal-to-Noise Ratio (SNR) of 6.0 indicates that **SNI2307**'s signal is six times stronger than the background noise. In Astrometrica, this is calculated by comparing the object's brightness (signal) to the surrounding noise, with an SNR above 5 generally reliable for detection. Fourier series analysis can further refine this by separating periodic (signal) and random (noise) components. The formula for SNR is**:**

$$SNR = \frac{S_{\text{object}}}{S_{\text{background}}}$$

- An SNR of 6.0 supports a credible detection of the asteroid, enabling precise tracking and measurement.
- **Flux = 1020**: This value represents the total light received from **SNI2307**, indicating its brightness. In asteroid detection, flux helps estimate the object's apparent magnitude, with a flux of 1020 suggesting that **SNI2307** is sufficiently bright for reliable detection.
- **FWHM = 0.8"**: The Full Width at Half Maximum[17] (FWHM), expressed in arcseconds, indicates the width of an object's light profile at half its peak intensity. An FWHM of 0.8" (0.8 arcseconds) indicates minimal light spread due to atmospheric or instrumental factors, suggesting excellent resolution. This value signifies clear image quality, essential for accurate asteroid tracking, with typical values ranging from 1-2 arcseconds.
- **Fit RMS = 0.155**: The Fit RMS (Root Mean Square) of 0.155, measured in pixels, gauges the accuracy of the Point Spread Function (PSF) fit, which models how the asteroid's light is distributed in the image. The lower the RMS, the better the PSF model fit. An RMS below 0.2 is considered good, so 0.155 indicates a precise match, enhancing the accuracy of position and brightness measurements for reliable asteroid tracking.
- **Red curve overlay in scatter plot**: The red curve on the scatter plot represents the PSF (Point Spread Function) fit, which models the asteroid's light distribution. The white spots are actual observed data points, and their alignment with the red curve signals a good fit. A smooth, symmetrical bell shape of the red curve indicates a well-focused object, while deviations suggest data errors or noise. The bell curve height represents brightness, and a flatter red curve near the baseline indicates background noise.

6) **File Information:**

- **File Name**: The FITS file being analyzed is named: "e60493h0445o.762985.ch.696250.XY62.p10.fits."
- **Date and Time**: The observation was taken on July 2, 2024, at 12:36:49.6 UT.
- **RA (Right Ascension) = 20h 24m 09.253s**: This is the object's celestial longitude.
- **De (Declination) = -18° 18' 17.20":** This is the object's celestial latitude.
- **R = 21.3**: The magnitude (brightness) of the object is 21.3, which is quite faint.

7) Object Designation:

The object has been designated by MEA as **"SNI2307"**.

8) Position of SNI2307 and Sun at the time of Image capture (July 2, 2024):

Table III: Right Ascension (RA) of SNI2307

Image Set	RA	Hours	Min	Sec	Hours	Degrees	Radians
Image Set 1	20h 24m 09.253s	20	24	9.253	20.40257028	306.038554	5.341380
Image Set 2	20h 24m 08.724s	20	24	8.724	20.40242333	306.036350	5.341342
Image Set 3	20h 24m 08.185s	20	24	8.185	20.40227361	306.034104	5.341303
Image Set 4	20h 24m 07.649s	20	24	7.649	20.40212472	306.031871	5.341264
Δ RA=	0.000445556	degrees					
Δ RA=	1.60400000	arcseconds					

Table IV: Declination (De) of SNI2307

Image Set	De	Degrees	Min	Sec	Degrees	Radians
Image Set 1	-08 18' 17.27	-8	-18	-17.27	-8.304797222	-0.144946
Image Set 2	-08 18' 22.39	-8	-18	-22.39	-8.306219444	-0.144971
Image Set 3	-08 18' 27.64	-8	-18	-27.64	-8.307677778	-0.144996
Image Set 4	-08 18' 33.05	-8	-18	-33.05	-8.309180556	-0.145023
Δ De=	0.004383333	degrees				
Δ De=	15.7799988	arcseconds				

The consistent shift **Δ**RA (~1.6 arcseconds) and **Δ**De (~16 arcseconds) over the four observations confirm that this object is moving relative to the background stars constellation-**PPMXL** (a compilation of astrometric data for approximately 900 million stars), **a strong indication that it is a potential asteroid**.

Additional information: The Right Ascension (RA) and Declination (De) of the Sun on July 2, 2024, can be determined using the Horizons system from NASA's Jet Propulsion Laboratory[18] (JPL), which provides precise celestial coordinates for solar system objects.

Table V: Right Ascension (RA) of the Sun at the time of Image Capture**

Synchronous to Image Set	RA	Hours	Min	Sec	Hours	Degrees	Radians
Image Set 1	06h 48m 22s	6	48	22	6.806111111	102.091667	1.781836
Image Set 2	06h 48m 26s	6	48	29	6.808055556	102.120833	1.782345
Image Set 3	06h 48m 29s	6	48	29	6.808055556	102.120833	1.782345
Image Set 4	06h 48m 32s	6	48	32	6.808888889	102.133333	1.782563

Table VI: Declination (De) of the Sun at the time of Image Capture**

Synchronous to Image Set	De	Degrees	Min	Sec	Degrees	Radians
Image Set 1	+22° 58' 09"	22	58	9	22.96916667	0.400888
Image Set 2	+22° 58' 05"	22	58	5	22.96805556	0.400868
Image Set 3	+22° 58' 01"	22	58	1	22.96694444	0.400849
Image Set 4	+22° 57' 57"	22	57	57	22.96583333	0.400829

** The position of the Sun at the time of image capture[19a]. This places the Sun in the constellation **Cancer** during that time of the year.

2. Trajectory of SNI2307 under Black and White Background Image Data Sets

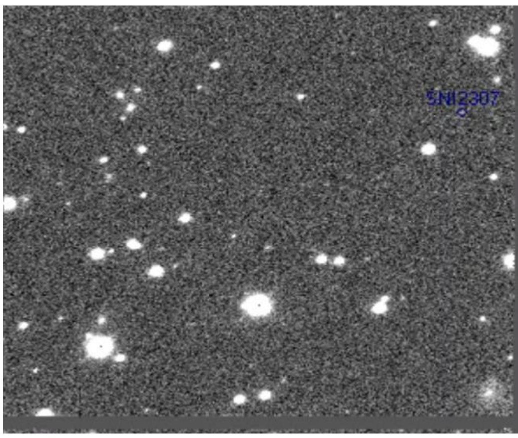

Image 1: Under Black Background

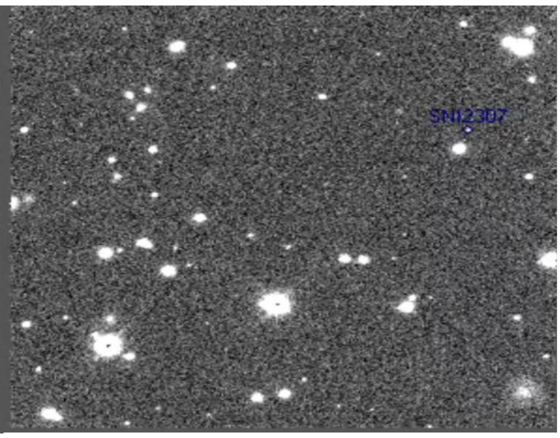

Image 2: Under Black Background

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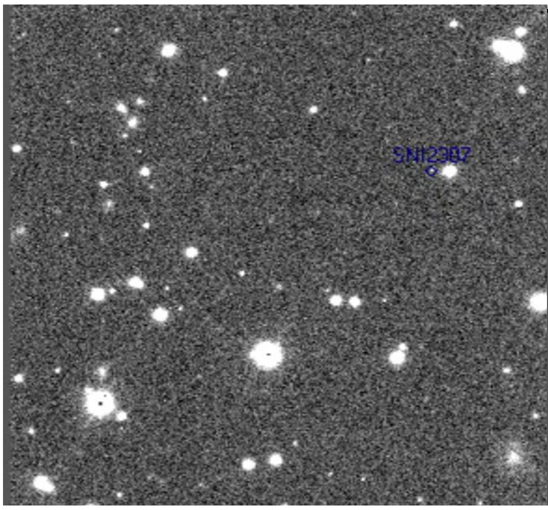


Image 3: Under Black Background

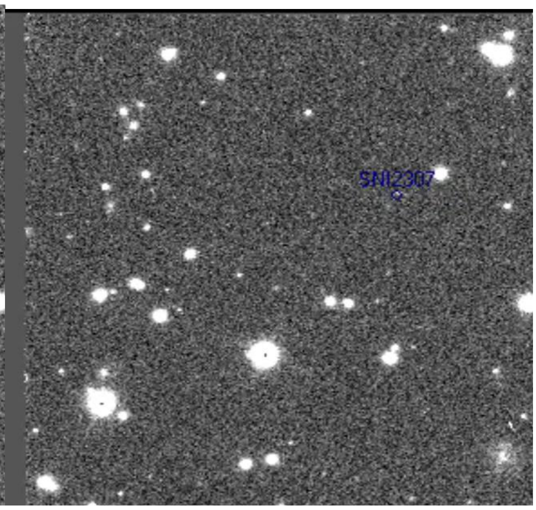


Image 4: Under Black Background

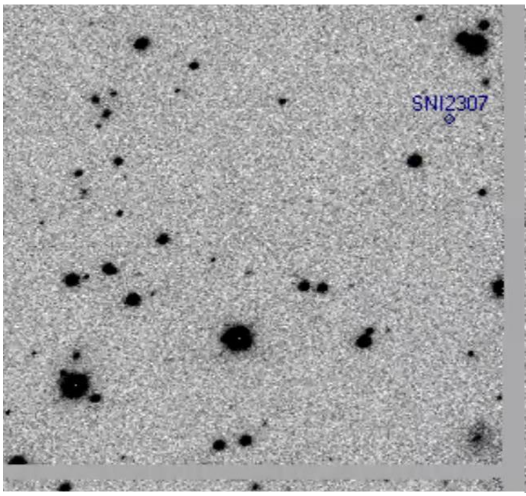


Image 1: Under White Background

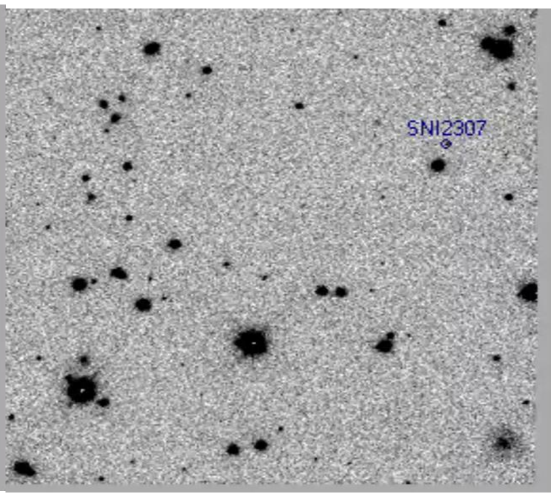


Image 2: Under White Background

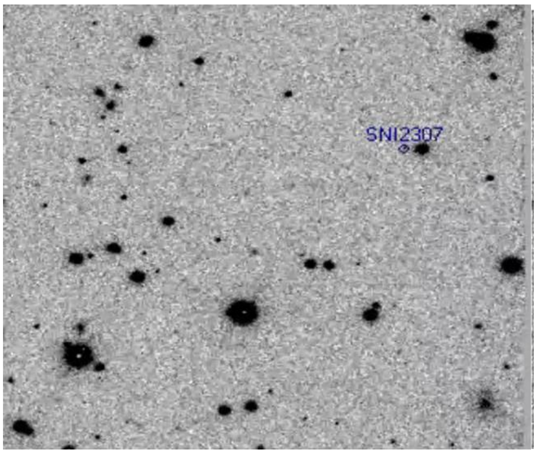


Image 3: Under White Background

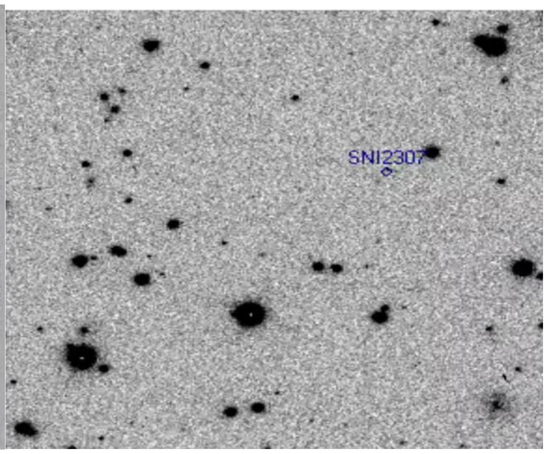


Image 4: Under White Background

3. Mathematical Calculations:

1) SNR Calculation using Fourier Transformation:

The flux data provided [1020, 1811, 2075, 1438] corresponds to signal intensities, while the SNR data ([6.0, 6.5, 5.5, 5.8]) gives a direct measure of signal-to-noise ratio for each set. To analyze the signal and background noise, the Discrete Fourier Transform (DFT) is applied to extract key frequency components.

SNR=Flux/Noise

Flux data: [1020, 1811, 2075, 1438]
SNR data: [6.0, 6.5, 5.5, 5.8]

a) Background Signal DFT

The calculated **Background Noise** for the data sets are: [170, 279, 377, 248].
The steps to calculate the DFT and extract amplitudes are as follows:

Flux Data DFT: $X[k] = \sum_{n=0}^{N-1} x[n]e^{-i2\pi kn/N}$

Where:
x[n] is the flux data for n image sets,
N=4 (number of points).

Fourier Transform (For simplicity, **k = 0** and **k = 1** are being considered as they are the dominant frequencies):
For **k = 0** (the DC component, with zero frequency):
X [0] =1020+1811+2075+1438
X [0] =6344

So, the **Amplitude A_0** of the **Signal** = 6344/4
A_0=1586.

For **k = 1** (first frequency component):
X [1] =1020+1811 x $e^{-i2\pi/4}$+2075 x $e^{-i4\pi/4}$+1438 x $e^{-i6\pi/4}$

Simplifying using the Euler formula $e^{i\theta}$= cos(θ) + author x sin(θ)
=>X [1] = (1020 + 1811 x (cos(-π/2) + author x sin(-π/2)) + 2075 x (cos(-π) +
i x sin(-π)) + 1438 x (cos(-3π/2) + author x sin(-3π/2)))
X [1] = −1055-373*i*

The signal's amplitude **A_1** at this frequency is:
A_1 = $\{(-1055)^2+(373)^2)\}^{(0.5)}$
A_1 = 1118.9

b) Background Noise DFT

We apply the DFT formula: $X[k] = \sum_{n=0}^{N-1} x[n]e^{-i2\pi kn/N}$

Where:
x[n] is the flux data point for n image sets,
N=4 (number of points).
Fourier Transform (For simplicity, **k=0** and **k=1** are being considered as they are the dominant frequencies):
For **k = 0** (the DC component, with zero frequency):
X [0] =170+279+377+248=1074

So, the **amplitude A_0** of the **Noise** =1074/4
A_0=268.5

For **k = 1** (first frequency component):
X [1] =170+279·$e^{-i2\pi/4}$+377·$e^{-i4\pi/4}$+248·$e^{-i6\pi/4}$

Simplifying using Euler's formula $e^{i\theta}$= cos(θ) + author x sin(θ):
=>X [1] = 170 + 279 x (cos(-π/2) + author x sin(-π/2)) + 377 x (cos(-π) + author x sin(-π))
+ 248 x (cos(-3π/2) + author x sin(-3π/2))
=>X [1] = −207+31*i*

The noise's amplitude **A_1** at this frequency is:
A_1 = $\{(-207)^2+(31)^2)\}^{(0.5)}$
A_1 = 209.3

c) Calculation of final SNR Ratio inclusive of all Data Points after Fourier Transformation:

Using the amplitudes from 1st frequency (fundamental frequency) of the signal and noise from the DFT calculations:

- **Signal Amplitude** **A_{signal} = 1118.9**
- **Noise Amplitude** **A_{noise} = 209.3**

The final SNR is calculated as:

- SNR= A_{signal} / A_{noise} = 1118.9/209.3 = **5.345**
- SNR value of 5.345 represents a good signal detection wrt noise, indicating that **SNI2307** may be a potential Asteroid.

d) Calculation of Trajectory, Speed, and Size of SNI2307:

Angular Distance Calculation:
Angle Between Two RA/De Points: Using the angular distance formula between successive RA and De positions, the change in angle (angular distance) between successive observations are calculated using the formula as under:

$$\mathbf{Cos\ (\Delta\theta_{12}) = Sin(\delta_1)\ x\ Sin(\delta_2) + Cos(\delta_1)\ x\ Cos(\delta_2)\ x\ Cos(\alpha_1 - \alpha_2)}$$ [19b]

Where:
δ_1, δ_2 are Declinations calculated in between two image points, expressed in radians. **α_1, α_2** are Right Ascensions calculated in between two image points, expressed in radians.

Table-VII: Calculating angular distance traversed by SNI2307:

Change in Angle	Cos(Δθ)	Δθ (Radian)	Δθ (Degree)
Between Image Set 1 & 2	0.9999999989674	0.0000454446037	0.0026037839913
Between Image Set 2 & 3	0.9999999989239	0.0000463917040	0.0026580488462
Between Image Set 3 & 4	0.9999999989122	0.0000466429887	0.0026724463949

2) Conversion of Observation Time to Seconds:

Table-VIII: Conversion of Observation Time to Seconds:

Image Time (Hr:Min:Sec)	Hours	Min	Sec	Time in Sec
Image 1: 12:36:49.6	12	36	49.6	45409.6
Image 2: 12:55:51.9	12	55	51.9	46551.9
Image 3: 13:14:50.3	13	14	50.3	47690.3
Image 4: 13:33:51.2	13	33	51.2	48831.2

$\Delta T=T_4-T_1$=48831.2 - 45409.6
ΔT= 3421.6 seconds (Observation time Between Image 1 & 4)

3) Angular Speed of SNI2307:

From calculus, the angular speed **ω** can be calculated as **Δθ/Δt** (change in angle of observations between each pair of observations and the time differences):

Table IX: Calculating Angular speed from Tables VII & VIII

Image Sets	Δθ (Radian)	Time between Images (Sec)	*ω* (Angular Speed in Rad/Sec)	*ω* (Angular Speed in Deg/Sec)	*ω* (Angular Speed in Arcseconds/ Sec)
Between Image Set 1 & 2	0.0000454446	1142.3	0.0000000398	0.0000022794	0.008205920
Between Image Set 2 & 3	0.0000463917	1138.4	0.0000000408	0.0000023349	0.008405636
Between Image Set 3 & 4	0.0000466430	1140.9	0.0000000409	0.0000023424	0.008432647

The last column of the calculation provides Angular Speed in **Arcseconds per Second**. The Average Angular Speed of **SNI2307** calculated from the four image sets is 8.348 x 10^{-3} is **Arcseconds per Second.**

4) Linear Speed of SNI2307:

Assuming that **SNI2307** is at a distance **1.735948 AU** from Earth (1 AU = 1.495978707 × 10^8 km (distance between Earth and Sun)). *This assumed distance of* ***SNI2307****is derived from iteration (to ensure that* ***SNI2307*** *distance is approximately between its semi-major and semi-minor axis of the ellipse).* Using the angular speed and distance, the expected linear speed of **SNI2307** is calculated as under:

Linear Speed of SNI2307 (*V*) = Angular Speed × Distance
(1 AU = 149597870.7 Km)

Table X: Calculating Linear Speed of SNI2307 (*V*)

Image Sets	ω (Angular Speed in Rad/Sec)	Linear Speed (*V*) in Km/Sec (Distance from point of observation = 1.735948 AU)	Avg Linear Speed (*V*) in Km/Sec
Between Image Set 1 & 2	0.000000039783	17.93498340	18.24566349
Between Image Set 2 & 3	0.000000040752	18.37148548	
Between Image Set 3 & 4	0.000000040883	18.43052158	

Therefore, assuming that **SNI2307** is at **1.735948AU** distance away from the point of observation, **SNI2307** moving at an average speed of **18.24566349 Km/Sec**.

Note: The actual distance of **SNI2307** from the point of observation is still under study by MPC.

5) Calculate the Ordinates and Abscissa of the Sun and of SNI2307 with respect to Earth.

Table XI: Formula to calculate the Ordinates and Abscissa of the celestial object with respect to the Earth

P_X co-ordinate	P*(Cos(θ_{De})*Cos(θ_{RA}))
P_Y co-ordinate	P*(Cos(θ_{De})*Sin(θ_{RA}))
P_Z co-ordinate	P*(Sin(θ_{De}))

Where **P** is the distance magnitude between the celestial object under measurement with respect to Earth.

Using differential calculus, the speed of the celestial object between two image data points (a, b) can be calculated as:

- **Calculating the Sun's position vector with respect to the point of observation:**

Distance R_{Sun} of Sun from Earth = 1 AU

Table XII: Calculating the Ordinates and Abscissa of the Sun with respect to Earth

Image Set	$R_{X(Sun)}$	$R_{Y(Sun)}$	$R_{Z(Sun)}$	Magnitude R_{Sun} (AU)
Image Set 1	-0.192868013	0.900287744	0.390235709	1.0000000
Image Set 2	-0.193327873	0.900196845	0.390217853	1.0000000
Image Set 3	-0.193329462	0.900204244	0.390199998	1.0000000
Image Set 4	-0.193527442	0.900169442	0.390182143	1.0000000

- **Calculating the SNI2307's position vector with respect to the point of observation:**

Considering the Distance of **SNI2307** from Earth = 1.735948 AU **(from Table X)**

Table XIII: Calculating position vector of SNI2307 with respect to Earth:

Image Set	$R_{X(Asteroid)}$	$R_{Y(Asteroid)}$	$R_{Z(Asteroid)}$	Magnitude $R_{Asteroid}$ (AU)
Image Set 1	1.010599669	-1.389004637	-0.250738681	1.73594800
Image Set 2	1.010542571	-1.389038481	-0.250781320	1.73594800
Image Set 3	1.010484368	-1.389072928	-0.250825041	1.73594800
Image Set 4	1.010426353	-1.389106994	-0.250870094	1.73594800

1. **Calculating the Speed of Sun and SNI2307 relative to the nearby Star:**

The speed of the Celestial Object (V_{ab}) for X, Y & Z directions is calculated as:

Speed of the Celestial Object (V_{ab}) = (P_b-P_a) / (T_b-T_a)

Table XIV: Calculating Speed of the Sun relative to Alpha Centauri (nearby star)

Sun Speed Calculation (AU/sec)					Km/sec	Km/sec
Image Set	V_x Component	V_y Component	V_z Component	V_{Total}	V_{Total}	$V_{Average}$
Image Set 1 & 2	-0.0000004026	-0.0000000796	-0.0000000156	0.0000004107	61.43386218	30.14790378
Image Set 2 & 3	-0.0000000014	0.0000000065	-0.0000000157	0.0000000170	2.548387013	
Image Set 3 & 4	-0.0000001735	-0.0000000305	-0.0000000157	0.0000001769	26.46146216	

The Sun's actual speed relative to the nearby star Alpha Centauri (4.37 light-years away) is **19.4 km/s** according to NASA's NSSDC[20]. In contrast, calculations based on three data sets yield a speed of **30.15 km/s**. Increasing the number of data sets may lead to a more accurate determination of the Sun's speed.

Table XV: Speed of SNI2307 relative to PPMXL (nearby constellation):

SNI2307 Speed Calculation (AU/Sec)					Km/sec	Km/sec
Image Set	V_x Component	V_y Component	V_z Component	V_{Total}	V_{Total}	$V_{Average}$
Image Set 1 & 2	-0.0000000868	-0.0000000514	-0.0000000648	0.0000001199	17.93498395	18.24566359
Image Set 2 & 3	-0.0000000888	-0.0000000525	-0.0000000667	0.0000001228	18.37148464	
Image Set 3 & 4	-0.0000000883	-0.0000000518	-0.0000000686	0.0000001232	18.43052221	

The value corroborates with the speed of **SNI2307** calculated in **Table X** calculated from a different approach.

2. **Calculating the Angle θ between the Sun, the Earth and SNI2307**

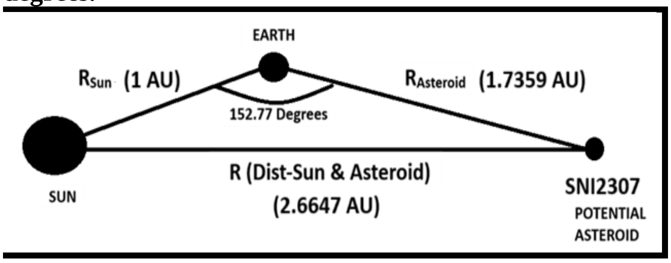
Dot Product = $X_{(Sun)}$ x $X_{(Asteroid)}$ + $Y_{(Sun)}$ x $Y_{(Asteroid)}$ + $Z_{(Sun)}$ x $Z_{(Asteroid)}$

$$Cos(\theta) = \frac{Dot\ Product}{R(Sun) X\ R(Asteroid)}$$

Table XVI: Angle Between vectors $R_{(Sun)}$ and $R_{(Asteroid)}$ using Table XII & XIII

Image Set	Dot Product	Cos(θ)	θ (Radian)	θ (Degree)	θ (Degree) (Average)
Image Set 1	-1.543263388	-0.889003235	2.665960062	152.7482599	152.7731942
Image Set 2	-1.543633452	-0.889216412	2.666425825	152.7749462	
Image Set 3	-1.543677674	-0.889241886	2.666481511	152.7781367	
Image Set 4	-1.543861926	-0.889348025	2.666713593	152.7914340	

Average Angle between Sun, Earth and SNI2307 is 152.77 degrees.



Geometric position of Sun, Earth and SNI2307 at the time of image capture.

3. **Calculating the Distance between the Sun and SNI2307, assuming SNI2307 is at a distance of 1.73594800 AU from Earth:**

Distance (Sun_Earth): R_{Sun} (1 AU)
Distance (Earth_Asteroid): $R_{Asteroid}$ (1.73594800 AU **(From Table X)**)
Distance (Sun_Asteroid): R (to be determined)
The angle between R_{Sun} & $R_{Asteroid}$ vectors: θ= 152.77 Degrees.
Using Distance formula:
$R_{(Sun\_Asteroid)} = [R_{Sun}^2 + R_{Asteroid}^2 - 2 \times R_{Sun} \times R_{Asteroid} \times Cos(\theta)]^{0.5}$

Table XVII: Calculating the Distance between the Sun and SNI2307:

Image Set	Distance R (Sun_Asteroid) in AU	Average Distance R (Sun_Asteroid) in AU	Average Distance R (Sun_Asteroid) in Km
Image Set 1	2.664590444	2.664720186	398636465.9
Image Set 2	2.664729323		
Image Set 3	2.664745918		
Image Set 4	2.664815061		

The estimated distance between the Sun and **SNI2307** was approximately **2.664720186 AU (3.986 x 10^8 Km)**, based on the assumption made in **Table X**.

4. **Calculating Specific Orbital Energy, Eccentricity, and Semi-major and Semi-minor Axis of revolution of SNI2307.**

Using the formula for the Gravitational parameter of the Sun (G x M): μ (km³/s²) = 1.327 x 10^{11} km³/s² (G is Gravitational constant (6.67 x $10^{(-11)}$) and M is the mass of the Sun (1.989 x 10^{30} Kg))**.** It is a key value used in orbital mechanics and celestial calculations.

- **Specific Orbital Energy (E):**
  Specific Orbital Energy (E) is the energy per unit mass of an object in orbit around a central body, like a planet or star. It quantifies the total energy (kinetic and potential) associated with the object's motion, aiding in determining the orbit type (circular, elliptical, parabolic, or hyperbolic). The formula for Specific Orbital Energy is:

$$E = \frac{V^2}{2} - \frac{\mu}{R}$$

E (Km²/sec²) = (-)166.4326312 (Negative indicates its orbit will form an ellipse)

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- **Calculating the Semi-major Axis of the Orbit of SNI2307:**
  Also, $E = -\frac{\mu}{2a}$ where a is the Semi-major axis of the ellipse (orbit of **SNI2307**). Therefore, Semi-major Axis $a = -\frac{\mu}{2E}$
  a = 398659803.088109 Km (2.664876186 AU)
  Calculating Eccentricity e of the Elliptical Orbit of **SNI2307**:
  $e = 1 - \frac{R}{a}$
  R is the distance between Sun and **SNI2307** and a is the Semi-major Axis.
  e = **0.00005853908** (~0, indicating that the orbit of **SNI2307** is **almost circular**).

- **Calculating the Semi-minor Axis of the Orbit of SNI2307:**
  Using the formula for the Eccentricity of an Ellipse: $e = (1 - b^2/a^2)^{0.5}$

The b (Semi-minor Axis) of the Orbit of SNI2307 = 398659802.405041 Km (2.664876181 AU).

The calculation of the assumed distance in **Table VIII** was to ensure that the calculated distance R in **Table XVII** (2.664720186 AU) is close enough to be within the limits of Semi-major and Semi-minor Axis. However, a minor variation of the distance is still possible as the object moves through various image data sets.

Calculating the Specific Angular Momentum of SNI2307:
As **SNI2307** moves in an almost circular orbit, its velocity vector shall be tangential to its radial vector. Hence, its Specific Angular Momentum is calculated as:

Specific Angular Momentum (L): (R x *V*)

Using data from **Tables XIII and XV**, the Specific Angular Momentum for **SNI2307** is calculated as under:

Table XVIII: Specific Angular Momentum of SNI2307:

Specific Angular Momentum (L)	R x *V*
In m^2/second	7.27339×10^{15}
In Km^2/second	7273386810
In AU^2/second	3.25002×10^{-7}

- **Calculating the Time Period of Revolution of SNI2307:**
Using the formula for the orbital period from Kepler's Third Law, the Time Period (T) of the Revolution is calculated as $T^2 = (2\pi)^2 a^3/\mu$.

Table XIX: Time Period of the Revolution of SNI2307:

T (Seconds)	137292900.1
T (Earth Years)	4.353529302

Therefore, **SNI2307** is expected to revolve around the Sun in **4.3535 Earth Years.**

1. Determining Size of SNI2307:
Using the flux data, the relative size of **SNI2307** at various positions can be identified. However, the exact size cannot be calculated using Astrometrica software.

The **flux data** captured in the 4 Image Data sets are: **[1020, 1811, 2075, 1438]**.

Average Flux captured in the 4 Image data sets = (1020+1811+2075+1438)/4 **= 1586.**

Calculating the Relative Size of SNI2307 in different image data sets:
Flux ∝ Projected cross-sectional area of **SNI2307** ($\pi D^2/4$) where D is the projected diameter of **SNI2307** (considering it to be spherical in shape) facing the earth at the point of observation.
=> **Relative size:** Relative Size ∝ $(\text{Flux})^{(0.5)}$

Table XX: Relative Size of SNI2307:

Image Set	Flux	$Flux^{1/2}$	Relative Size (relative Diameter) with respect to the maximum observed size	% of the Relative Size Observed
Image Set 1	1020	31.94	70.11%	
Image Set 2	1811	42.56	93.42%	
Image Set 3	**2075**	**45.55**	**100.00%**	**Maximum Relative Size Observed**
Image Set 4	1438	37.92	83.25%	

The above data signifies that **SNI2307** was at its maximum size in the 3rd observation set among the recorded 4 observations image sets, with the relative size in the 1st image set being 70.11% of the 3rd Image Set. This signifies that **SNI2307** is in continuous rotation with respect to the Earth, resulting in different exposure surface areas at the different observation points.

- **Average Apparent Magnitude (*Ŕ*):** The Apparent magnitude of **SNI2307** can be estimated by averaging the magnitudes in the four-observation image data sets:

Table XXI: Apparent Magnitude "Ŕ" of SNI2307

Image Set	Apparent Magnitude "**Ŕ**" of **SNI2307** from the given set of Data	Average Apparent Magnitude "**Ŕ**" of **SNI2307** from the given set of Data
Image Set 1	21.3	21.1
Image Set 2	21.1	
Image Set 3	20.9	
Image Set 4	21.1	

Average Apparent Magnitude of **SNI2307** (*Ŕ*)= (21.3+21.1+20.9+21.1)/4= **21.1**

- **Limitations of Usage of Astrometrica Software**
  Astrometrica primarily provides positional and flux

(brightness) data from astrometric measurements of celestial objects like asteroids. While it tracks the position, motion, and apparent magnitude of an asteroid, it does not directly output Albedo (p) or Absolute Magnitude (H), which are essential for calculating the asteroid's absolute size. Albedo measures reflectivity, indicating how much sunlight or radiation a celestial body reflects compared to what it absorbs. These data can be sourced elsewhere, beyond this research's scope. However, **SNI2307**'s absolute size can be estimated under certain assumptions.

- **Estimating Absolute Magnitude H from Astrometrica Data**
  Calculate Absolute Magnitude H[21]: The absolute magnitude **H** is the apparent magnitude the asteroid would have if it were located 1 AU from both the Earth and the Sun. H can be calculated as per the following formula:
  $$H = \acute{R} - 5 \times \log_{10}(R_{Asteroid} \times R)$$
  where:
  $\acute{R}$ is the Apparent Magnitude from Astrometrica.
  $R_{Asteroid}$ is the distance of Asteroid from Earth in AU.
  R is the distance of Asteroid from the Sun in AU.

Based on our assumption, the value of H is calculated for **SNI2307** as:
$$H = 21.1 - 5 \times \log_{10}(1.735948 \times 2.664720)$$
H= 17.77405838.

This gives you the absolute magnitude H, which is essential for estimating the size of **SNI2307**.

Estimating Albedo (p)

a) **Albedo Data**:
- **Astrometrica does not provide albedo information**. Albedo values must be sourced from other observations, such as infrared data from space-based missions (e.g., NASA's NEOWISE[22]) or using a standard assumption based on the asteroid's taxonomic type.
- Typical albedo values range from 0.05 (dark, carbonaceous asteroids) to 0.3 (bright, rocky asteroids).

b) **Typical Albedo data**:
We can use an estimated value based on the asteroid's classification. Typical values for Albedo for different types of Asteroids[23] are as under:
- **C-type (Carbonaceous)**: Representing over 75% of known asteroids, C-types are very dark with an albedo of 0.05-0.10. Their composition is similar to the Sun but lacks hydrogen and volatiles. They mainly occupy the outer main belt.
- **S-type (Silicaceous)**: Making up about 17%, S-types are brighter (albedo 0.15-0.25) and consist of iron and magnesium silicates. They dominate the inner belt.
- **M-type (Metallic)**: Found mostly in the middle belt, M-types have an albedo of 0.10-0.30 and are rich in metallic iron.

Assuming **SNI2307** is a C-type Asteroid (which is most abundantly available) with a typical Albedo value of 0.075, the size of **SNI2307** is calculated as per the below formula:

$$D = 1329/(p)^{(0.5)} \times 10^{-0.2H}$$
$$D = 1329/(0.075)^{(0.5)} \times 10^{-0.2 \times 17.77405838}$$
D = 1.35264139 Km.

The estimated size of SNI2307 based on the above assumptions is 1.3526 Km[24].

Conclusion

In conclusion, the journey of discovering **SNI2307** has been both a personal and scientific milestone, highlighting the intersection of passion and purpose in the realm of astrophysics and planetary defence. Though **SNI2307** is currently positioned 1.73 AU from Earth, our ongoing analysis of its trajectory will be crucial in determining its future classification as a Near-Earth Object (NEO). Specifically, if its trajectory brings it closer than 0.3 AU from our planet, it could represent a potential threat that necessitates further monitoring and study.

This research not only contributes to the growing body of knowledge surrounding asteroid detection but also underscores the importance of collaborative efforts in planetary defence. By submitting our findings to the Minor Planet Centre, we have taken an essential step toward validating **SNI2307**'s status and understanding its long-term orbital behaviour. The process of confirming its orbit, which may take 6 to 10 years, is critical in assessing the asteroid's potential impact risks.

This research work on the celestial object **SNI2307** brings a key understanding on the motion of the potential asteroid, the cosmos' vast potential, and our duty as explorers. As author continue her journey in astrophysics, author remain committed to advancing our understanding of asteroids and enhancing our capabilities in safeguarding Earth from potential threats. Through research and vigilance, we can ensure our preparedness to face the challenges that may arise from these celestial bodies.

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Author Profile

Snigdha Keshari, aged 16, is currently a Class 12 Science student at Pace Junior Science College, Powai, Mumbai, India. She has a keen interest in astrophysics, with two published articles to her credit: *"Black Holes: The Key to Understanding Our Entire Universe"* and *"The Journey of Gravitational Waves: From Newton to Modern Detection."* In July 2024, during the ***All-India Asteroid Search Campaign***, organized by the ***International Astronomical Search Collaboration (IASC), a NASA partner***, Snigdha discovered a potential asteroid and designated it as ***SNI2307***. For her significant contribution, she was awarded a certificate of appreciation by IASC. This current research paper, titled ***"Methods and Techniques for Detecting and Calculating the Trajectory of the Potential Asteroid SNI2307,"*** is a continuation of her efforts to further the understanding of asteroid detection. Snigdha is passionate about pursuing a career in astrophysics and contributing to the field through scientific research and exploration.

A short poem on her Discovery of the Asteroid

"I found a planetoid of a million worth,
Miles away from the crust of Earth.
I am up in the sky with feet on ground,
In the vastness of space, her purpose is found."

Snigdha Keshari

Certificate of Appreciation from International Astronomical Search Collaboration

All India Asteroid Search Campaign: 2nd July'24-26 July'24.

From: **AIASC Space** <aiasc@space-india.com>
Date: Sat, 22 Jun 2024 at 22:19
Subject: AIASC 2024 Phase 2 Training workshop details
To: AIASC Space <aiasc@space-india.com>

Dear Participant,

Congratulations! We are happy to share that you have been selected for the prestigious *All India Asteroid Search Campaign 2024, Phase 2.*

SPACE India is the coordinator for the All India Asteroid Search Campaign in India. Under this highly recognized campaign, participants get exclusive access to images of the sky taken at observatories and analyze the data with specialized software provided during training to look for Asteroids. Objects reported by students could be potential discoveries. **All observations contribute to the Near-Earth Object (NEO) data compiled by NASA and Jet Propulsion Lab (JPL).**

AIASC Phase II will run from **July 1st - 26th july 2024.**

Email communication from Space India on selection for the Campaign

International Journal of Science and Research (IJSR)
ISSN: 2319-7064
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SPACE

AIASC 2024 Phase 2 list
All the communication with the participants will be done on the following mentioned email IDs.

S. no	Team name	Participant 1	Email of 1st participant	Participant 2	Email Id of 2nd participant
1	SPACE Titan	Yaser Soleimani	yaser.soleimani@gmail.com	Zahra Atri	rana.atri90@gmail.com
2	SPACE Gemini Brothers	Farid Mehrabadi	magentaflamelake@gmail.com	Matin Bayati	bayatimatin4@gmail.com
3	SPACE Andromeda	Sarina Mohammadi	sarinamohammadi971@gmail.com	Tannaz Mohajeri Parizi	Lajibolala172737@gmail.com
4	SPACE Amazing Follower	Narges Payami	zhra83859@gmail.com	Zahra Darrudi	darrudizahra5@gmail.com
5	SPACE Myrtilus	Melika Masihabadi	masihmelika86@gmail.com	Hadis Zargerani	Hadiszargerani1385@gmail.com
6	SPACE Scorpius	Ayda Rashidabadi	aydarashidi1999@gmail.com	Amir Hosein Asaadi	asaadi.amir@gmail.com
7	SPACE team 95	Swetha M	shwetham662@gmail.com	Kundan Raju Varhade	kundanvarhade2008@gmail.com
8	SPACE team 96	S. Satya Bala Anusha	anushasatyavolu98@gmail.com	Sourabh Chandrakar	sourabhchandrakar88@gmail.com
9	SPACE team 97	Lakshmi H R	lakshmihr2007@gmail.com	Avinnessh Srikanes	asrikanes26@gmail.com
10	SPACE team 98	Akshita Gotmare	akshitagotmare@gmail.com	Humayu Rasheed	rasheedhumayu202@gmail.com
11	SPACE team 99	Srilakshmi N	shrilak@gmail.com	Naman Jain	naman03jain@gmail.com
12	SPACE team 100	Bhavya Jain	bjain1349@gmail.com	Naveen Negi	nnegi3939@gmail.com
13	SPACE team 101	Devyani	choudharydevyani5@gmail.com	P Tanishka	neetu.1007@gmail.com
14	SPACE team 102	Danny Damiaio Mantero	dannydmantero@gmail.com	Sharshti Mittal	shrashtimittal323@gmail.com
15	SPACE team 103	Harishankar Nath Tiwari	harishankarnath1@gmail.com	Arnav Gupta	arnavgupta2606@gmail.com
16	SPACE team 104	Abdul Rehman	khanchetayyaba2009@gmail.com	-	-
1	Space iAstronomer 15	Ashwary Pathak	space.ash21@gmail.com	Thanmay	Priyankagattigorla92@gmail.com
2	Space iAstronomer 16	Advaith R	vet04rahul@gmail.com	Vanya Agrawal	agrawalva@uws.edu.in
3	Space iAstronomer 17	P Tanishka	neetu.1007@gmail.com	Yasaswi VSNS	callraj2002@hotmail.com
4	Space iAstronomer 18	Shivam Dan	shivamdan24052003@gmail.com	Aarush Chinchole	chincholeaarush@gmail.com
5	Space iAstronomer 19	Paridhi Ashish Shirke	smshirke01@gmail.com	Akshaj Mohit Vyas	mohitvyas2006@gmail.com
6	Space iAstronomer 20	Myraa Khattar	Bhawnamyraa@gmail.com		
7	Space iAstronomer 21	Snigdha Keshari	snigdhakeshari123@gmail.com	Yadnya Sagar	mohitcbic@gmail.com
8	Space iAstronomer 22	Pulkit Mahajan	ekta16mahajan@gmail.com	Sukhman Singh	Sukhman.live@gmail.com

A portion of the List of selected participants for the Campaign:

From: **AIASC Space** <aiasc@space-india.com>
Date: Tue, 13 Aug, 2024, 11:54 am
Subject: AIASC 2024 PHASE 2 - CERTIFICATES
To: <snigdhakeshari123@gmail.com>, <mohitcbic@gmail.com>

Dear Participants,

Greetings from the AIASC Team,

Congratulations on your participation in the All India Asteroid Search Campaign (AIASC) 2024, Phase 2.

Your participation certificate is attached to this mail.

Feel free to revert back over the same mail, in case of any query or change in the certificates.

Looking forward to your active participation in future events.

Happy Clear Skies!

Thanking You,
Team AIASC 2024
SPACE India
E: aiasc@space-india.com W: www.space-india.com

Email communication on successful identification of potential Asteroids

All India Asteroid Search Campaign

July 1 - 26, 2024

	Provisional # Object	Students	School	Location	Status	DateOfImage	Linked
Total: 14							
	P21VUZY	Y. Soleimani	SPACE Titan	India	Preliminary	06/29/24	YSO2402
	P21W6ui	N. Chauhan	Jeevanbharti Atal Lab Team 1	India	Preliminary	07/02/24	JBA0003
	P21W4JX	Z. Darrudi, N. Payami	SPACE Amazing Follower	India	Preliminary	07/02/24	NPO2414
	P21W3Sa	M. Mahapatra, D. Rajguru	SPACE Antarix	India	Preliminary	07/02/24	MAN0017
	P21W6r9	A. Pant, A. Sharda	SPACE GEU 1	India	Preliminary	07/02/24	AAS0101
	P21W6rH	S. Keshari	SPACE iAstronomer 21	India	Preliminary	07/02/24	SNI2307
	P21W6vg	S. Mittal, D. Mantero	SPACE Team 102	India	Preliminary	07/02/24	SHR1234
	P21Whct	R.Adhikari, M.Solanki	Euro School	India	Preliminary	07/06/24	EUR0010
	P21Whbn	P. Kumar, A. Tripathi	SPACE Champions	India	Preliminary	07/06/24	KDJ0003
	P21Whbq	P. Kumar, A. Tripathi	SPACE Champions	India	Preliminary	07/06/24	KDJ0002
	P21Whbr	P. Kumar, A. Tripathi	SPACE Champions	India	Preliminary	07/06/24	KDJ5149
	P21Whbi	S. Memon, S. Tripathi	SPACE Surat Team 1	India	Preliminary	07/06/24	SVT0010
	P21WhUa	A.Srikanes, L. Ram	SPACE Team 97	India	Preliminary	07/06/24	SDMN013
	P21WhUE	A.Srikanes, L. Ram	SPACE Team 97	India	Preliminary	07/06/24	VIK123

Citizen Scientists who identified potential Asteroids during the Campaign

From: **iascsearch** <iascsearch@hsutx.edu>
Date: Thu, 19 Sept, 2024, 3:09 am
Subject: RE: AIASC 2024 PHASE 2 - CERTIFICATES
To: Snigdha Keshari <snigdhakeshari123@gmail.com>
Cc: dkeshari@indianoil.in <dkeshari@indianoil.in>

Hi Snigdha,

I have attached your report and the image set.

The main steps for an asteroid are: 1) preliminary detection, 2) provisional, 3) numbered asteroid, 4) named asteroid.

A **preliminary** detection is an original observation of an object. Not every preliminary detection reaches provisional status. The object must be observed a second time within the next 7-10 days by a sky survey. If it is, then the detection is changed to provisional status by the Minor Planet Center (MPC).

Asteroid discoveries with **provisional** status are maintained in the MPC database for many years, until there have been a sufficient number of observations to fully determine the orbit. This process can take 6-10 years.

When an asteroid has a fully determined orbit, it becomes **numbered.** At this point, the MPC assigns an observatory with discovery credit. If the observatory credited is Pan-STARRS, and the object is one that was found in an IASC campaign, IASC lets the team know that object has become numbered. Objects that fit this criteria can then have a name suggested by the original team.

You can find out more about the PS2 telescope here: https://about.ifa.hawaii.edu/facility/haleakala-observatories/#panstarrs

Thank you, and happy hunting!

Cassidy Davis
IASC Coordinator

Email communication with IASC on the current status of the discovered potential Asteroid.