Detecting Activity and Rotational Variation of Centaurs from Zwicky Transient Facility Archival Observations

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Introduction

Centaurs are small solar system bodies with orbits between Jupiter and Neptune, exhibiting both asteroid- and comet-like traits. Their orbits are unstable, lasting only a few million years due to gravitational interactions with giant planets. Close encounters with Jupiter and Saturn can shrink their semi-major axes, increasing solar heating and triggering comet-like activity. Many eventually become Jupiter Family Comets (JFCs) through these orbital shifts.

We present a photometric study of Centaurs using ZTF data from SNAPS (Trilling et al. 2023) and new observations from the SAAO 1.9m telescope and the TTT 0.8m telescope. Our analysis includes rotation period determinations, including one previously unreported.

Methodology

Data Collection

- ZTF SNAPS, SAAO 1.9m, and TTT 0.8m telescope data.
- Chiron observed for six nights to refine rotation period.
- Additional Centaurs analyzed for rotation and comet-like activity.

Rotation Periods

- Lomb-Scargle periodograms used to determine rotation.
- Lightcurve signals analyzed and compared to published values.

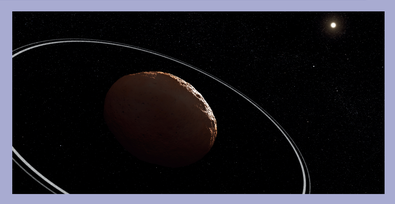


Image Analysis

- Shift-stack method used to compare PSF of Chiron and static objects and investigate activity
- Improves signal-to-noise, revealing finer details.

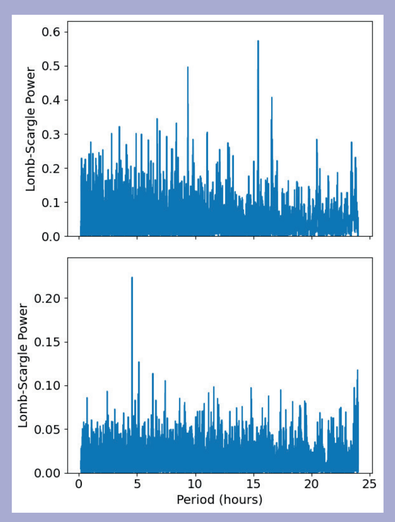


Figure 1: Lomb-Scargle periodograms for (145627) 2006 RY102 (top) and (54598) Bienor (bottom).

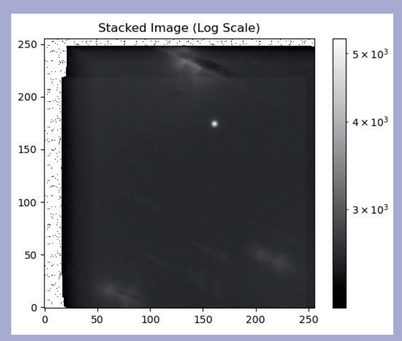


Figure 2: An image of (2060) Chiron produced by the shift-stack method.

Results

ZTF Archival Observations

ZTF observed (2060) Chiron from August 22, 2018, to January 12, 2023. Absolute magnitudes (Figure 3) show a brightness increase near aphelion, suggesting an activity pattern unrelated to solar proximity (Dobson et al. 2024).

TTT Data

Chiron was observed on two nights using the TTT telescope to assess short-term brightness variations. No significant outbursts or sudden changes were detected, indicating a stable brightness profile (Figure 3).

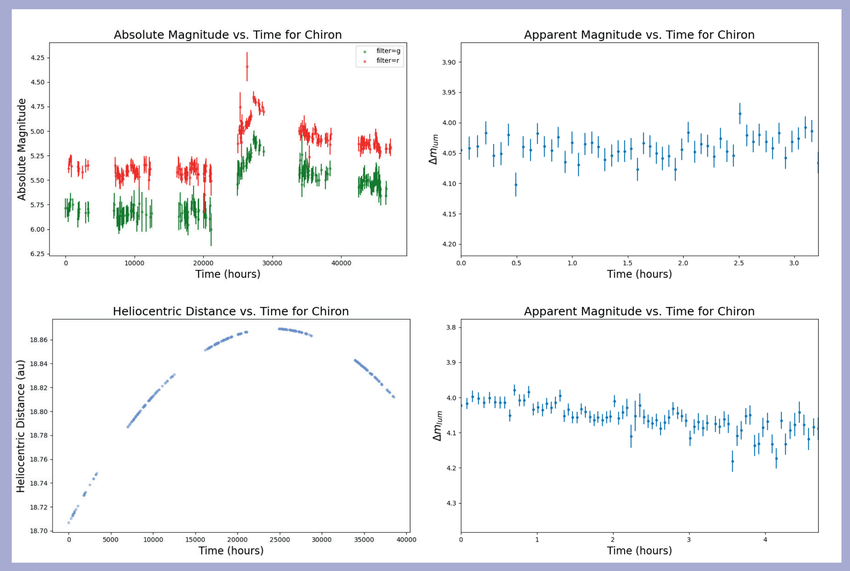


Figure 3: (**Left**) Absolute magnitude plot for Chiron showing an increase in brightness at ~25000 hours near aphelion. (**Right**) Apparent magnitude plots for Chiron from TTT data.

SAAO Observations

Chiron was observed from October 30 to November 5, 2024, to examine surface heterogeneity and rotational variability. A derived period of 6.13 hours closely matches the previously reported 5.92-hour period (Bus et al. 1989), suggesting no major rotational changes due to activity. Stacked images (Figure 2) and flux contour plots (Figure 4) show no evidence of a coma, confirming that Chiron is currently inactive.

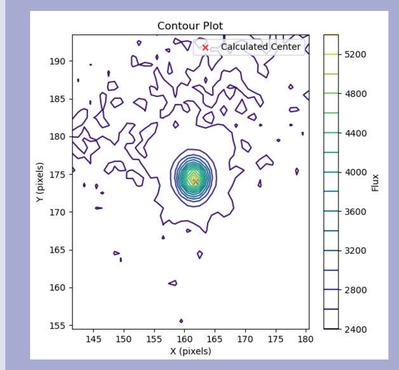
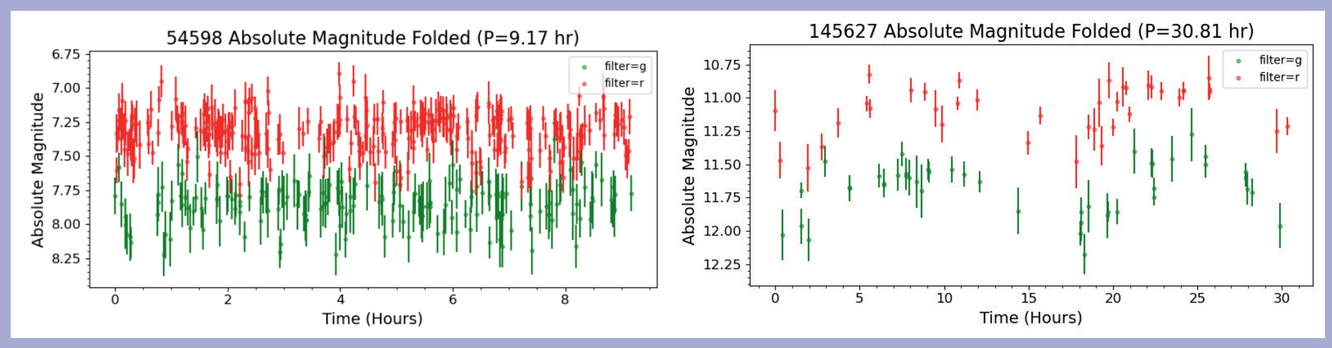


Figure 4: Contour plot of Chiron's flux on October 31, 2024.

Rotation Periods

Using ZTF data, we determined rotation periods for multiple Centaurs, including (54598) Bienor (9.17 h, consistent with Ortiz et al. 2002) and (145627) 2006 RY102 (30.81 h). Folded lightcurves are shown in Figure 5.

Figure 5: (**Left**) Absolute magnitude plot for Bienor folded over a period of 9.17 h. (**Right**) Absolute magnitude plot for 2006 RY102 folded over a period of 30.81 h.



Discussion & Future Work

Our analysis found no significant rotation period changes for (54598) Bienor (9.17 h) or (2060) Chiron (6.13 h), consistent with previous studies. Since 2006 RY102 lacks a reported period, further observations are required for confirmation. Stacked images and flux contour plots show no evidence of current activity for Chiron. These findings improve our understanding of Centaur rotation and their transition into Jupiter Family Comets.

Acknowledgments

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References

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