

**LIGHTCURVE ANALYSIS OF FIVE MAIN-BELT
ASTEROIDS: 3446 COMBES, (9410) 1995 BJ1, (17780)
1998 FY13, (24491) 2000 YT 123, AND 28341 BINGAMAN**

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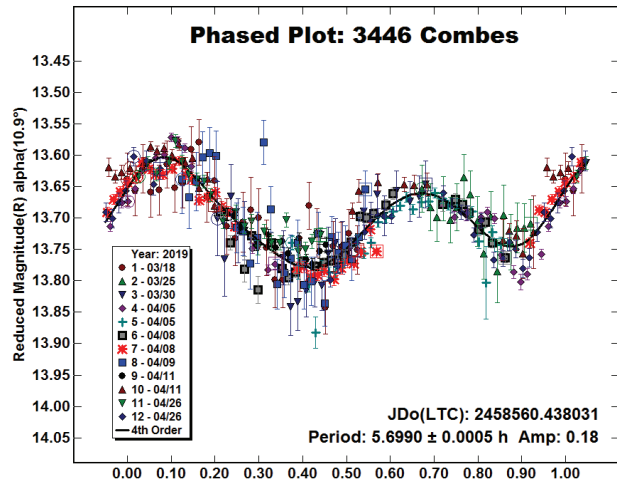
An observing campaign was conducted among teams at the University of Maryland, College Park, and in Malta to determine the rotation period of 3446 Combes during 2019 March and April. Lightcurve analysis using *MPO Canopus* of the asteroid was conducted in order to determine its rotation period. Using the eight nights of data, 3446 Combes was found to have a rotation period of 5.6990 ± 0.0005 h and an amplitude of 0.18 mag. The University of Maryland team also observed four additional asteroids that serendipitously appeared in the images: (9410) 1995 BJ, (17780) 1998 FY13, (24491) 2000 YT123, and 28341 Bingaman. These were observed only one night each and only the raw data for them are presented.

One site of observations was in the United States, by the University of Maryland team. Five asteroids were observed using an online telescope-sharing website called *telescope.net*. The telescope (T-21) is located in Mayhill, New Mexico at the New Mexico Skies Observatory (*iTelescope.net*). It was used on 2019 April 4, 7, 10, and 25. The primary diameter of the telescope is 0.43 m, with a focal length of 1.94 m. The CCD camera had a $3072 \times 2048 \times 9 \mu\text{m}$ pixel array and a full well of $100,000 e^-$. Each image had an exposure of 300 seconds, used clear filter, and 1×1 binning. All images were processed with standard bias, dark, and flat calibrations.

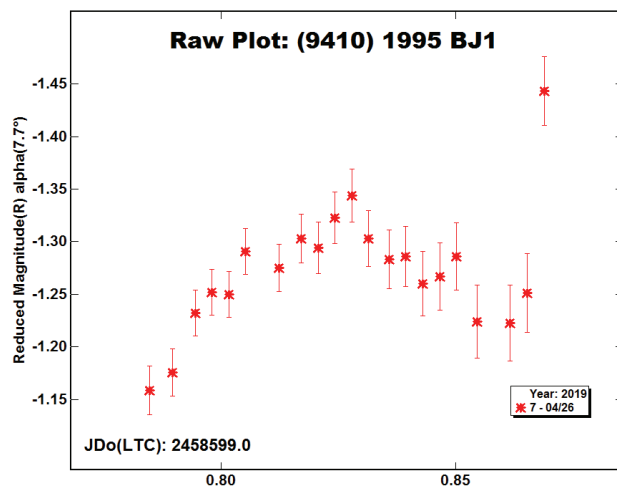
Other sites used to observe 3446 Combes were at the Flarestar Observatory, Antares Observatory, and the Znith Observatory by collaborators located in Malta. Images at the Flarestar Observatory in Malta were taken using a 0.25-m SCT telescope with a Moravian G2-1600/ KAF 1603ME CCD, and FOV of 25.5×17.0 arcmin. The pixel scale was 0.99 arcsec/pixel. Images taken at Antares Observatory in Fgura Malta, used a 0.28-m SCT telescope with a SBIG STL-11000/KAI-11000M CCD, and FOV of 45.9×30.6 arcmin. The scale was 1.37 arcsec/pixel. Images were taken from the Znith Observatory in Naxxar, Malta, using a 0.20-m SCT telescope with a Moravian G2-1600/ KAF 1603ME CCD, FOV of 30.0×20.0 arcmin and scale of 1.17 arcsec/pixel.

There were no previous rotation periods reported for any of the five asteroids based on a search through the lightcurve database (Warner et al., 2009).

3446 Combes was first discovered on 1942 March 12 by K. Reinmuth at the National Observatory for Homewaters - Königstuhl. Reinmuth named the asteroid after a French amateur astronomer Michel-Alain Combes (Schmadel, 2006). The asteroid has an orbital period of 3.66 yr, absolute magnitude $H = 13.3$, an albedo of 0.144, and a diameter of 8.411 km (NASA, 2007). Combes was observed across four days in New Mexico along with four days from international collaborators in Malta, collecting a total of 301 data points. The period was determined to be 5.6990 ± 0.0005 h and an amplitude of 0.18 mag.

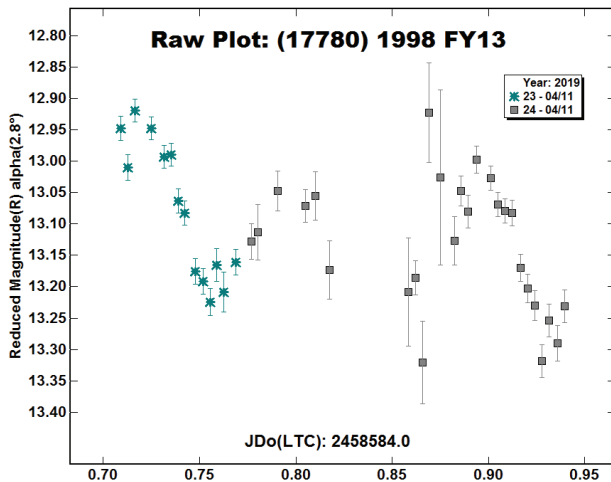


(9410) 1995 BJ1 was discovered on 1995 January 26 by astronomer Takeshi Urata at the Ohira station of the Nihondaira Observatory in Shimizu. The asteroid has an orbital period of 5.81 yr, absolute magnitude $H = 12.6$, and an albedo of 0.067 (NASA, 2007). 1995 BJ1 was observed on 2019 April 26 for a total of 21 images using the T-21 telescope. This is insufficient data to conclusively yield a rotation period, thus the raw data are provided for future analysis.

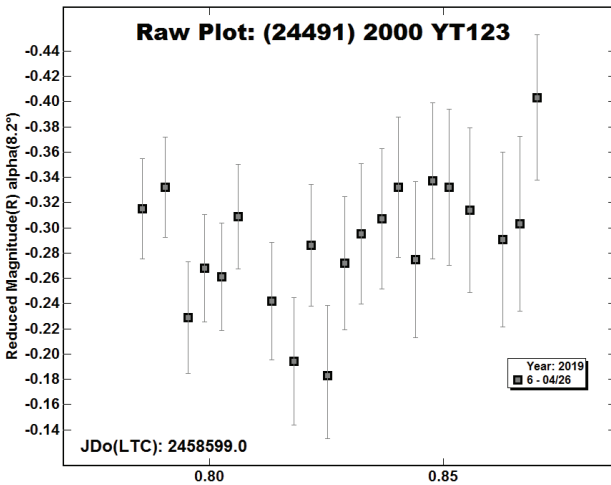


(17780) 1998 FY13 was first discovered on 1998 March 24 by Near Earth Asteroid Tracking (NEAT) from the station of Maui. It has an orbital period of 5.195 yr and absolute magnitude $H = 12.9$ (NASA, 2007). The asteroid was observed on 2019 April 10 for a total of 40 images using the T-21 telescope. This is insufficient

data to conclusively yield a rotation period, thus the raw data are provided for future analysis.

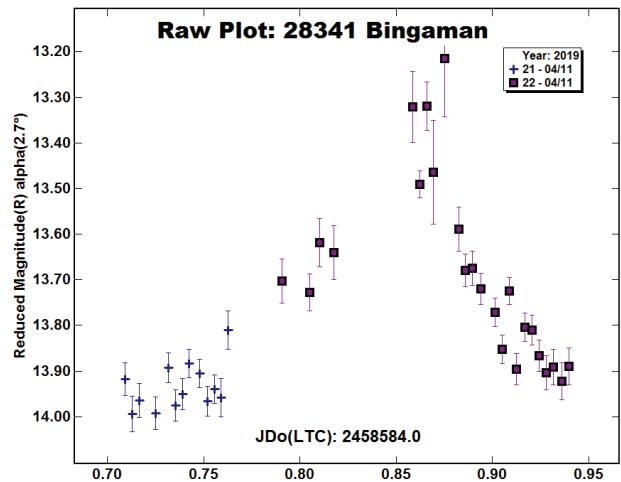


(24491) 2000 YT 123 was discovered on 2000 December 28 at the Magdalena Ridge Observatory in New Mexico through the Lincoln Near-Earth Asteroid Research Project (LINEAR). The asteroid has an orbital period of 5.91 yr and absolute magnitude $H = 13.8$ with an unknown albedo (NASA). The asteroid was observed on 2019 April 26 for a total of 21 images using the T-21 telescope. This is insufficient data to conclusively yield a rotation period, thus the raw data are provided for future analysis.



28341 Bingaman was first discovered on 1999 March 13 American astronomer Roy A. Tucker from Goodricke-Pigott Observatory in Tucson. It is named after a graphic artist Kory Bingaman. It has an orbital period of 4.94 yr and absolute magnitude of $H = 13.6$ (NASA, 2007). We observed it on 2019 April 10 for a total of 40 images using the T-21 telescope. This is

insufficient data to conclusively yield a rotation period, thus the raw data are provided for future analysis.



Acknowledgements

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Number	Name	2019 mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
3446	Combes	04/04-04/26	2.4, 10.7	196	3	5.6990	0.0005	0.18	0.02	V
9410	1995 BJ1	04/26	7.6	195	3	-	-	-	-	THM
17780	1998 FY13	04/10	2.2	196	3	-	-	-	-	EOS
24491	2000 YT123	04/26	8.0	195	3	-	-	-	-	MB-O
28341	Bingaman	04/10	2.2	196	3	-	-	-	-	KOR

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner *et al.*, 2009). KOR: Koronis; MB-O: Main-belt – outer; THM: Themis; V: Vestoid.