Draft version November 22, 2022
Typeset using LaTeX **RNAAS** style in AASTeX631

A Partial Disintegration of Active Centaur/Comet P/2020 MK4 ?

W. Romanishin[1, 2] and S. C. Tegler[3]

[1]*Emeritus Professor, U. of Oklahoma*
[2]*Visiting Scholar, Northern Arizona U.*
[3]*Department of Astronomy and Planetary Science, Northern Arizona U.*

ABSTRACT

Centaur P/2020 MK4 (a=6.19 AU, e=0.011) was discovered in 2020 and quickly brightened to V$\sim$ 18.5. As of early November 2022, no astrometric observations had been reported in 2021 or 2022. The object should have been easily found had it retained its 2020 absolute magnitude. We find that P/2020 MK4 now appears as an $\sim$10$''$ wide low surface brightness coma, with a faint (r $\sim$ 24.9) point-like source. The rates of brightening and fading of P/2020 MK4 are both much slower than the larger Centaur 29P/Schwassmann-Wachmann 1, which is on a similar orbit. Perhaps the image morphology and unusual brightening and fading of P/2020 MK4 were due to a partial disintegration event.

The Centaur P/2020 MK4 orbits the Sun in a nearly circular (e=0.011) orbit with a= 6.19 AU. Discovered by Pan-STARRs 1 in June 2020, at a magnitude of V $\sim$ 21.5, it soon brightened to V $\sim$ 18.5. As of early November 2022, the Minor Planet Center astrometry database [1] listed over 120 observations of P/2020 MK4 between 15 June and 13 November 2020, but none after that. It should have readily been seen, so it is logical to assume that the object had dimmed appreciably, perhaps due to change in the activity which (presumably) had caused it brighten in 2020.

On 2022 September 24 we observed the object as part of our ongoing color survey of Centaurs using the Large Monolithic Imager CCD camera on the 4.3 m Lowell Discovery Telescope (LDT) south of Flagstaff, AZ. We obtained 10 R band 180 s long exposures. We found an extended low surface brightness cloud of light moving at the rate expected for the object, with a hint of a nucleus.

On 2022 October 29, L. Wasserman obtained 20 x 180 s images of the object with the LDT using a VR (500-700 nm) filter. These images have 1$''$.3 seeing and a clear sky with no Moon. These images have a wider filter and longer total exposure time than our initial LDT observations. After aligning the images using the object ephemeris motion and adding them, we detect a faint point-like source at the edge of the cloud, moving at the cloud rate. Photometry of this source is not straightforward, due to its faintness and the inhomogeneous background. We used a manual PSF fitting photometry procedure, deriving a PSF from a nearby 18th mag star on a summed star aligned image. This was digitally smeared to match the object motion over 180 s exposures. This 18th mag star was chosen as it was isolated and its color was a little redder than solar[2] so it should give a reasonable match to the color of the object. Due to the faintness of the point-like object, and the inhomogeneous background, we cannot be sure this is a truly unresolved source.

We scaled the PSF image by various amounts and subtracted it from the summed object image to find the best looking background. We find the point-like source has r $\sim$ 24.9, with an estimated uncertainty of 0.4 mag. Using an assumed albedo of 7%, an assumed G value of 0.15, and an r band solar magnitude of -27.05 (Willmer 2018), we use the H,G formalism of Bowell et al. (1989) to derive a nuclear diameter of 2.2 km. The point-like source has $H_V = 16.7$.

The coma feature is roughly 12$''$x 7$''$ (Figure 1). The average surface brightness is less than 1% of the night sky brightness at LDT. Due to the extended nature of the coma, it has a total r magnitude (with nucleus removed) of

Corresponding author: W. Romanishin
wromanishin@ou.edu

[1] https://minorplanetcenter.net/db_search
[2] https://catalogs.mast.stsci.edu/panstarrs

about r ∼ 21.8, about 10 times as bright as the point-like source. Figure 1 shows a hint of a tail structure of even lower surface brightness.

de la Fuente Marcos et al. (2021) discuss the orbital parameters of P/2020 MK4 and note that its orbit is similar to that of 29P/Schwassmann-Wachmann 1 (SW1). SW1 is of course well known as a very active Centaur, with a history of bright outbursts. SW1 has a diameter of about 60 km (Schambeau et al. 2015).

Could P/2020 MK4 be a much smaller version of SW1? More data on the photometric behavior of the object is needed to confirm or refute this. The only readily available photometric data for the object is from the MPC astrometric database. The 123 photometric observations from 2020 in the MPC database were reported on 32 dates by 14 observatories, using 8 optical bandpasses.

We made an initial analysis of this photometry as follows. Each magnitude was converted to V band using the bandpass offsets provided by the MPC [3]. The V mags were averaged for each date. To account for varying distances and phase an H_V mag was derived from each daily averaged V mag. These H_V mags are shown in Figure 1. They show a rapid brightening (-0.18 mag d^{-1}) in June, then a roughly linear fading (0.0068 mag d^{-1}) from the beginning of July to the middle of October. At this rate, the brightness would drop 1 mag in 150 days. The rms scatter of the points around the fit to the fading is 0.26 mag, which is not too bad, given the inhomogeneous sources of the photometry.

Around day 318 (mid- November) there are a handful of puzzling photometric points. One set of points gives a very faint H_V, the other set an H_V in rough accord with the points from October. (These two sets are marked by question marks in the graph). Perhaps the faint point refers only to the nucleus, while the other refers to the coma + nucleus?

An MPEC announcing the cometary nature of this object was published 2022 November 20 [4]. This added a photometric point from 2021 September, 430 days after the peak brightness. This point gives $H_V = 13.2$. This is 0.7 mag brighter than the extrapolation of the fading slope. Our coma mag of r ∼ 21.8, 850 days after the peak, gives $H_V = 13.7$. This is 3 mag brighter than predicted from the fading slope. These two points suggest the overall brightness continues to fade, but at a slower rate than in 2020. Further searches for archival images could prove very useful.

How does this photometric behavior compare to SW1? The typical outbursts of SW1 are marked by a rapid brightening of several magnitudes in a few hours, then a fading, taking only 3 to 6 days to drop 1 magnitude (Trigo-Rodriguez et al. 2008; Miles 2016). The outburst of P/2020 MK4 thus faded roughly 30 times slower than the outbursts of SW1. The SW1 outbursts may be caused by cyrovolcanism from discrete localized sources on the SW1 nucleus (Miles 2016). We suggest that the 2020 P/2020 MK4 outburst was of a more global nature, perhaps a major partial disintegration event. The coma could be a debris cloud which is slowly fading as smaller particles are lost from the cloud.

This research has made use of data and/or services provided by the International Astronomical Union's Minor Planet Center and the Pan-STARRs photometric catalog.

Facilities: LDT,PS1

REFERENCES

Bowell, E., Hapke, B.,Domingue, D., et al. 1989, In: Asteroids II, Univ. of Arizona Press, Tucson, 524

de la Fuente Marcos, C., de la Fuente Marcos, R., Licandro, J. et al. 2021, A&A , 649, A85

Miles, R. 2016, Icarus, 272 ,387

Schambeau, C. A., Fernandez, Y. R., Lisse, C. M. et al. 2015 Icarus 260, 60

Trigo-Rodriguez, J. M., Garcia-Melendo, E., Davidsson, B. J. R. et al. 2008, A&A, 485, 599

Willmer, C. N. A. 2018, ApJS, 236, 47

[3] https://minorplanetcenter.net/iau/info/BandConversion.txt

[4] https://minorplanetcenter.net/mpec/K22/K22W78.html

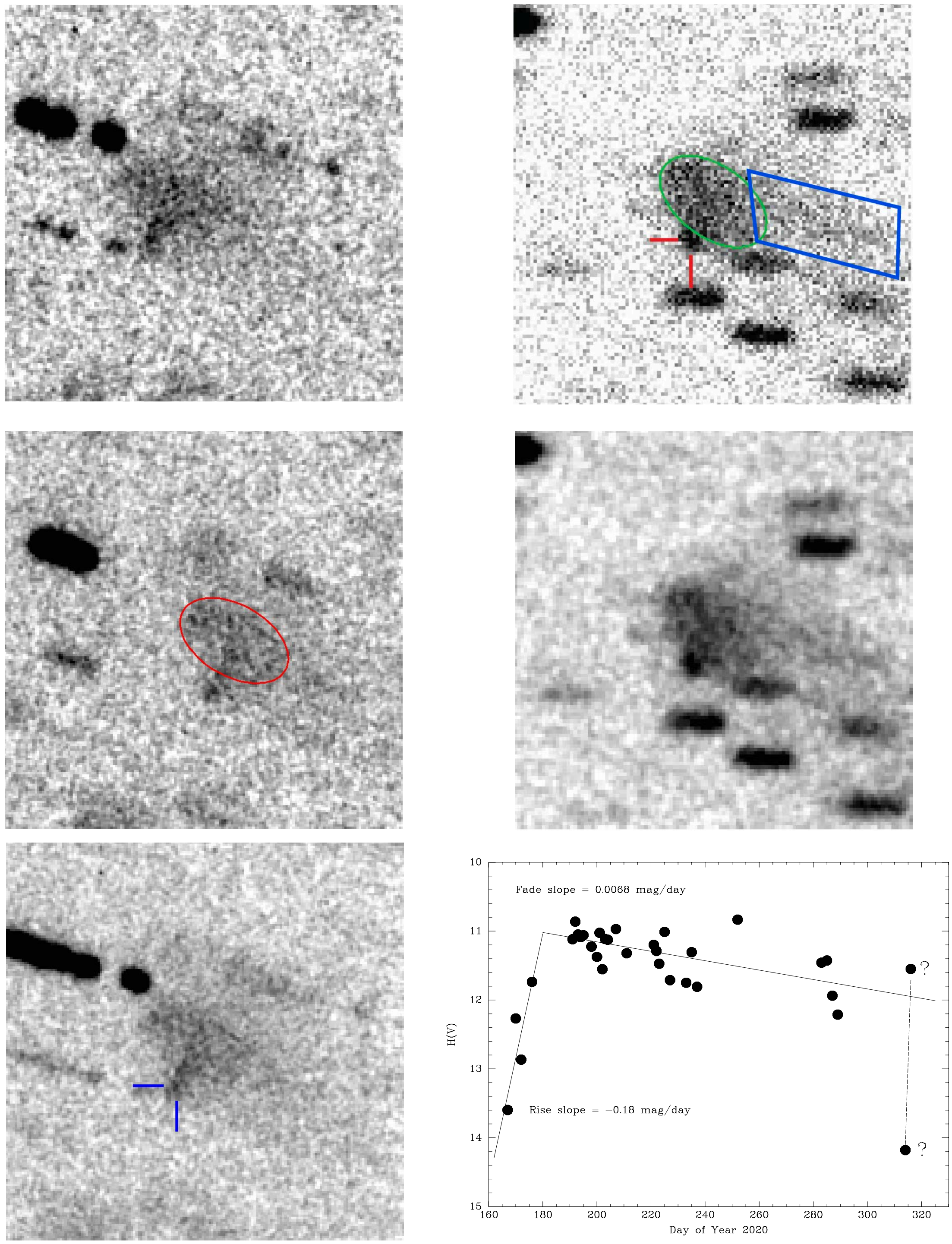

Figure 1. The gray scale images (darker equals brighter) have north at top, east at left and each covers 40″x40″ on sky. The left hand column of images show the object on 2022 Sep 24. The top image is the first half of the data, the middle image the second half, and the bottom image all the data. On the bottom image, we mark with blue line segments the point we take as the nucleus. All images show the same pointing on the sky. The middle image shows a 12″x 7″ ellipse marking the approximate limits of the cloud. The right hand column of images is from 2022 October 29. The point-like source is indicated by the red line segments, the coma by a green ellipse, and a very tentative tail structure by the blue polygon. The image at middle right is the same the image above it, smoothed to better show low surface brightness regions. The bottom right graph shows the lightcurve of P/2020 MK4 in year 2020.