Photometry of Comet C/2013 UQ4

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***Abstract*—Comet C/2013 UQ4 (UQ4) was discovered on 23, October 2013 by the Catalina Sky Survey in Arizona. When first found the object appeared to be an asteroid with a comet-like orbit. On May 7, 2014, a coma was observed indicating that UQ4 was indeed a comet. We observed UQ4 over nine nights in June, July and August of 2014. Using time-resolved photometry we attempted to find the rotational period of the object. The apparent magnitude of UQ4 was considerably lower than previously reported.**

1. Introduction

Asteroids and comets were formed in the early stages of the solar system. The material that makes up their structure has been largely unchanged since that time. Studying asteroids and comets allows us to learn about the formational period of our solar system in a way unavailable in terrestrial studies.

Asteroids and comets can be categorized via a number of methods. One such method is Tisserand's Parameter (T_J).

$$T_J = \frac{a_J}{a} + 2\left[(1-e)\frac{a}{a_J}\right]^{\frac{1}{2}} \cos i$$

$a_J =$ Semi-major axis of Jupiter
$a =$ Semi-major axis of object
$e =$ Eccentricity of object
$i =$ Inclination of object

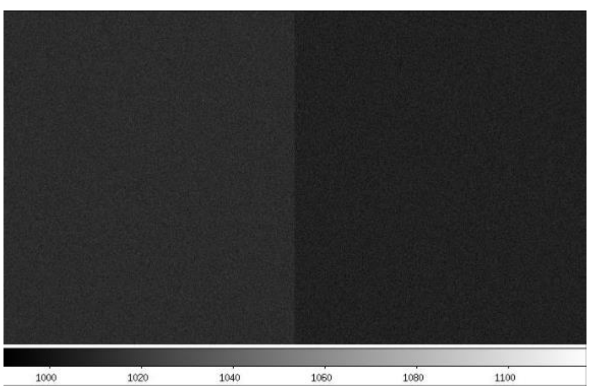
With few exceptions if $T_J > 3$ then the object is an asteroid and if $T_J < 3$ then the object is a comet. When discovered UQ4 had a $T_J < 3$ indicating that it was a comet but no coma was visible suggesting that it may be an asteroid. Interest in UQ4 was heightened due to the possibility of it being a dead or inactive comet. Accretion of matter onto the surface of a comet or simply a lack of material to eject could lead to a cometary body without a coma. These objects are particularly rare. In early 2014 UQ4 was not visible from Earth due to its conjunction with the Sun. When it reappeared a coma was visible dismissing possibilities of a dead comet. However the coma activity was noticeably lower than expected.

Another classification solar system bodies is that of Near Earth Objects (NEOs). NEOs are solar system objects that have a perihelion or closest approach to the Sun of less than 1.3 AU. On June 5, 2014 UQ4 reached perihelion at a distance of 1.08 AU classifying it as a NEO. NEOs are of particular interest for studies due to their proximity to the Earth. Smaller objects can be detected nearer the Earth because of their higher apparent magnitudes as compared to distant small objects. In the interest of accuracy of resolution we focus on NEOs for our measurements. We observed UQ4 at JPL's Table Mountain Facility (TMO) using the 0.6-meter telescope with Spectral Instruments 2K CCD camera. In order to determine the makeup of the comet, broadband photometry in the Bessel BVRI filters was used.

2. METHODS

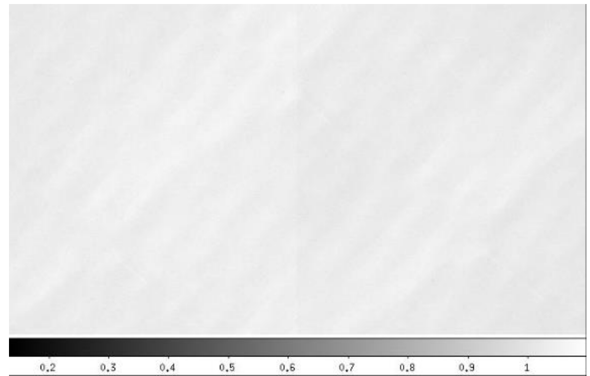
Each night of observation produces a series of images which are then analyzed to extract flux measurements of the object using a model developed by Dr. Michael Hicks. The first steps are taken to correct aberrations in the both the mirror and the CCD.

Bias frames consist of dark exposures of a closed telescope. CCDs can have individual pixels that remain charged despite lack of incoming light. The biases correct for this error by determining which pixels are charged. A series of bias images are taken and then combined to form a single bias frame in order to determine more accurately which pixels are remaining charged over time.



Bias Frame

After biases, the night sky near sunset is imaged also known as sky flats. The sky near twilight is relatively uniform in the field of view. Errors in the images will occur due to slightly differing sensitivities of the pixels in the CCD. Sky flats seek to correct those errors. Knowing that an image should be completely flat and uniform corrections can be made on the sky flat images to adjust to uniformity. Sky flats are taken in each filter to adjust for any differences between each.



B-Filter Skyflat

These corrections are applied to each image taken over the course of the night. As a result each image is free any significant aberrations due to the CCD.

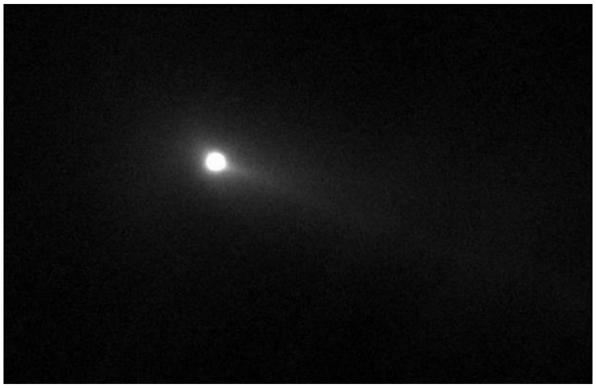
A further consideration for photometry is the effect of the atmosphere on the flux of the observed object. Atmospheric conditions change regularly and errors produced by them must be corrected. Certain stars have known magnitudes in different filters. These standard stars are imaged in each filter and then the measured flux is compared with the known flux. Standard images are taken throughout the night to account for changing atmospheric conditions.

Finally, the physical structure of the telescope can change due to its surroundings. These changes are fixed with the telescope's focus. A series of images are taken at different focuses and the best focus is chosen. Each image is then combined and the background stars average out leaving only the object and the flux from the object in the frame.

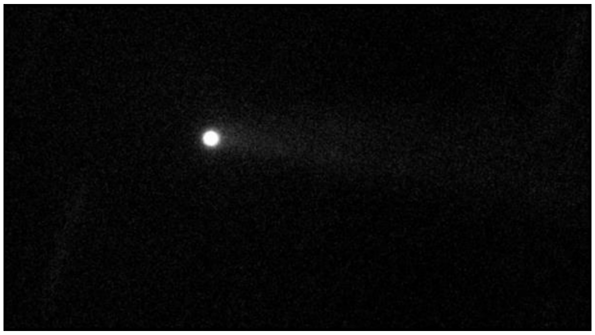
3. RESULTS

We observed UQ4 over 9 nights throughout the summer of 2014. The flux was found to be remarkably lower than expected. The coma activity was also noticeably low and dropped off much more quickly than expected. It is likely that this is due to the relatively low activity displayed by UQ4. If the comet had more active production of a coma it would have remained brighter for a longer period of time.

C/2013 UQ4 – June 29, 2014

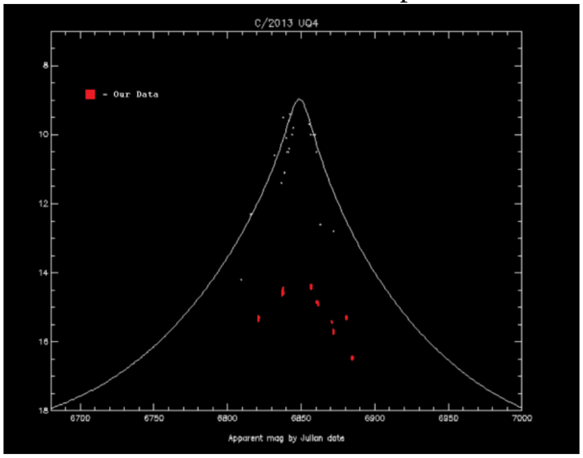


C/2013 UQ4 – July 23, 2014



C/2013 UQ4 – August 14, 2014

Also, it was found that UQ4's brightness was not only lower than expected but also lower than was being reported by other observers. The reported values were often done through less accurate means. Equipment used in these reports often is less powerful than that used at TMO and the measurement is simple visual comparisons with nearby stars. The observer gives their best approximation of the magnitude they believe the comet to be. It is possible that the expected higher magnitudes had some influence on these erroneous reported values.



C/2013 UQ4 APPARENT MAGNITUDE OVER TIME, REPORTED AND MEASURED VALUES.

Due to the low activity the cometary nebula was visible. The lack of activity corresponds to low amounts of dust. This allows determination of the composition of the cometary nebula as well as the rate of rotation of the body. Due to unforeseen technical difficulties and poor weather further observations were not possible. The rotation rate and composition was not determined at this time, however, future observations should reveal these unknowns quantities.

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