MULTI-BAND PHOTOMETRY TO TRACE OUTBURSTS EXPERIENCED BY HYPERBOLIC COMET C/2013 X1 PANSTARRS.
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Introduction: New comets coming from the Oort cloud are interesting objects to study during their approaches to the inner solar system. Inside OAdM the comets C/2013 X1 (PanSTARRS) is a hyperbolic comet discovered on 4 December 2013 by the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) 1 telescope on Mount Haleakala. Parabolic and hyperbolic comets may come from the Oort cloud, or perhaps even have interstellar origin [1]. They are though to be fragments of primitive ice-rich bodies that were gravitationally scattered during the early stages of solar system evolution [2]. Consequently, these objects could have escaped significant thermal and collisional processing and being pristine enough to preserve bulk physical properties and chemistry of relevance to better understand their formation conditions. For the reasons mentioned above, and the good observational conditions of this comet during 2015-2016 we have selected it to be studied inside the CSIC-IEEC multiband photometric program on comets. We focus here in the first 3-months follow-up made by our team from Nov. 2015 until early Jan. 2016. We think that observations of the apparent comma diameter and multi-aperture photometry can be relevant to compute several physical parameters associated with the activity of this comet, particularly once the size of the comet will be better established from future studies with larger instruments. Another key reason to keep our telescopes following this object is its possible primeval chemical nature that could produce episodes of unexpected outbursts in its luminosity during its approach to perihelion. Such events are extremely interesting and are sometimes associated with cometary disruptions that need to be studied carefully to infer information on the internal structure of these objects [4]. Our team has demonstrated the importance to keep a continuous follow up of pristine comets like e.g. the Centaur 29P/Schwassmann-Wachmann 1 [5-6]. A monitoring of pristine comets can give clues on their nature, inner structure, and the physico-chemical processes playing a role in driving their cometary activity [7]. The degree of primitivity of comets has been suggested to be associated with their bulk physico-chemical properties [8].

Methods: Our monitoring program of ground-based photometry of C/2013 X1 was performed using standard Johnson-Cousin filters following the same methodology explained in [5]. Due to our interest in learning about the development of the comma we have stacked guided exposures to achieve good signal/noise ratios to determine the presence or absence of cometary activity. By building the respective photometric growth curves we are in conditions of detecting outbursts [5].

Figure 1. C/2013 X1 PanSTARRS imaged on Dec. 13.785 from OAdM when the comet was in +13.1 R.

We have been monitoring this object on different nights from three observatories (see Table 1). All astrometric and photometric observations were reported to the Minor Planet Center (MPC). In here we will discuss our photometric coverage focusing in the measurements in the R band, but also providing color indices to get clues on its pristinity. Photometry is standardized to an aperture of 10 arcsec, and the photometric growth curves are studied using increasing photometric apertures to infer clues on the nuclear cometary activity. It is well known that the growth curve of an extended object soon departs from that of a point like source. Using that simple approach we plan to cover the cometary evolution during its perihelion approach, and study its behavior.

Observatory (MPC code)	Instrument
Gualba, Barcelona (442)	SC 36.0 f/7
Guadarrama, Madrid (458)	SC 25 f/10
Obs. Ast. Del Montsec (C65)	RCT 80.0 f/9.6

Table 1. Observatories involved in this follow-up.

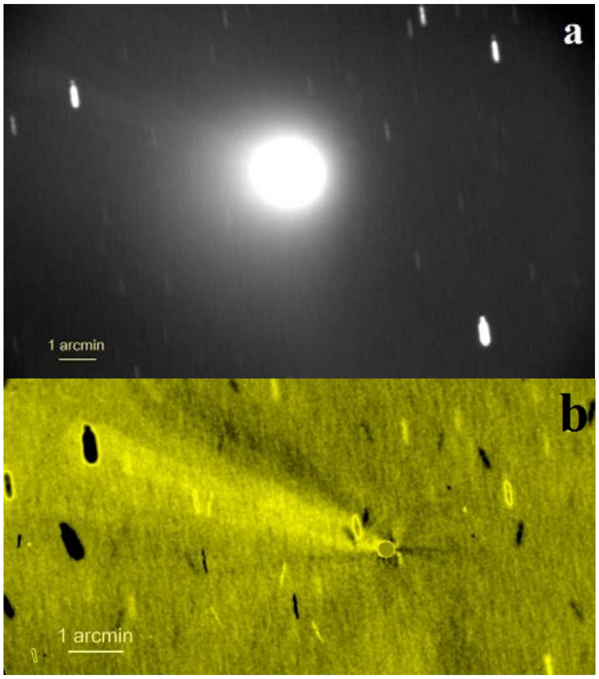

Figure 2. a) C/2013 X1 image obtained on Nov. 19.81, 2015 from MPC 442. b) Nucleus inset image processed using a Larson-Sekanina filter reveals significant jet activity, and the intrincate tail structure.

Results and discussion: So far we have monitored the comet from mid-November 2015 when it was at a heliocentric distance of 2.52 AU until its approach to the Sun at ~2 AU. Relevant cometary activity was found in the inner comma from the study of the images (Fig. 3). From the multiband photometry were obtained the following color indices: (V-R)=0.44±0.05, (B-V)=0.63±0.07 and (R-I)=0.15±0.05. These indices are consistent with other cometary nucleus that are statistically redder than the Sun [9]. The color distribution of cometary surfaces compared to other solar system objects may provide information on their interrelationships [10]. Fig. 3 compiles our photometric observations in the R band that can be used to trace outbursts [5]. A 10 arcsec standard aperture was used in all cases. On Jan. 2.79, 2016 we detected a concentrated comma profile probably produced by fresh micron-sized dust released from the nucleus and producing about one magnitude increase characteristic of an outburst (Fig. 4) [4-5]. It was not surprising because our late Nov. 2015 photometric data suggested us that the comet also experienced another outburst, but our data sampling was poor to be conclusive there.

Conclusions: Our follow-up of comet C/2013 X1 with medium-sized telescopes reveals that it is a quite pristine comet. It exhibits significant cometary activity, and experienced an outburst on Jan. 2.8, 2016. This is a promising outcome for a comet that follows the magnitude forecast. Consequently, we predict that this comet will become a naked-eye object during its post-perihelion approach to Earth on June 22nd, 2016.

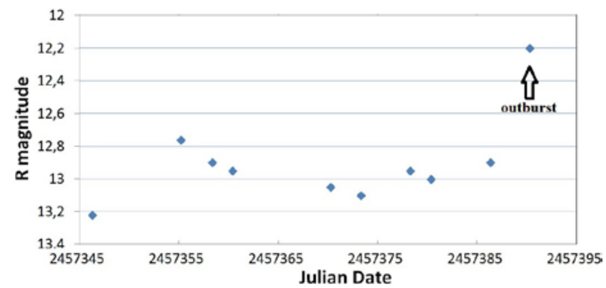

Figure 3. C/2013 X1 PanSTARRS photometry in the R band obtained for a 10 arcsec standardized aperture. Uncertainty is about 0.05 magnitudes.

Figure 4. C/2013 X1 PanSTARRS imaged on Jan. 2.79 from OAdM when the comet was in +12.2 R magn.

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