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2013 UL10: the first very red active Centaur

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Abstract

We present observations of 2013 UL10, a Centaur orbiting between Jupiter and Uranus and dynamically similar to the few tens of active Centaurs so far known. We analyzed BVR images of the Centaur obtained at the TNG (La Palma, Canary Islands, Spain). We observed that Centaur 2013 UL10 is the unique Centaur so far known that has both very "red" surface colors and revealed an episode of comet-like activity. Its nucleus has a color index [B-R] = 1.88 ± 0.11, and we derived an upper limit for its size of $D \leq$ 10 km. We estimated a rather low dust production rate of Q_d ~ 10 kg/s at 6.2 au, just after its perihelion passage.

1. Introduction

Centaurs form a dynamical class of small bodies in the Solar System (SS) moving on highly chaotic and unstable orbits in the region between Jupiter's and Neptune's orbits. They are considered "transition objects" from the inactive Kuiper Belt Objects to the active Jupiter Family Comets, therefore the study of their physical properties is a main topic to assess the relationship and establish reliable patterns between the object classes, and to constrain the evolution of small bodies in the SS. Around 10% of the whole sample of Centaurs have been observed with a comet-like coma in optical images: the activity among Centaurs is part of a wider debate on the activity of small bodies at great distances from the Sun, outside the so-called "water zone", where it cannot be explained with classical water ice sublimation, and other mechanisms (i.e., release of trapped gas upon ice crystallization) should be invoked to explain the phenomenon.

It is still unclear which is the real fraction of active Centaurs, why more than half of the Centaurs that could potentially be "comets" are inactive instead, which is the real fraction of sustained activity cases with respect to episodic ones, if there is any intrinsic difference among active Centaurs, and, most of all, how and to which extent the physical studies of Centaurs are stymied by a possible underestimated coma contribution.

2. Results and discussion

During our observations in December 2015, Centaur 2013 UL10 showed clear hints of comet-like activity (Figure 1), previously unreported. Assuming that its nucleus is a point-like source embedded in a surrounding coma, we sample the nucleus contribution (plus an unknown, but presumably small, contribution from the near-nucleus coma) using all the flux inside the photometric aperture corresponding to the stellar PSF. We derived the following preliminary nucleus colors: [B-V] = 1.13 ± 0.10, [V-R] = 0.75 ± 0.12, [B-R] = 1.88 ± 0.11.

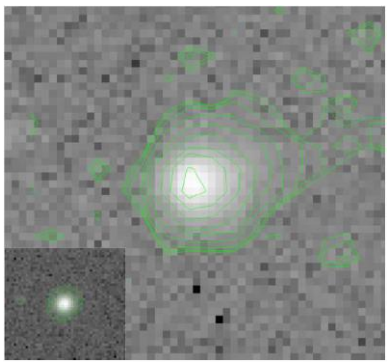

Figure 1: R image of Centaur 2013 UL10, taken at TNG on 11 December 2015 (linear scale 5.3 × 10^4km). The inset in the low-left corner is the image of the inactive Centaur 2008 FC76, obtained in the same observing night (reported for comparison)

These colors would pose 2013 UL10 among the traditional "red group" of Centaurs, significantly distant from the active Centaurs hitherto known (Figure 2).

We estimated a preliminary upper limit for the nucleus of 2013 UL10, adopting a value for the albedo A = 0.12, following the recent studies on the dependence of albedo on objects' color (1,2): we obtained $D \leq 10$ km, quite a small size when compared to average size of inactive Centaurs, more than one order of magnitude larger (3,4). This is consistent with the fact that, in general, active Centaurs are found to be smaller than inactive ones (5).

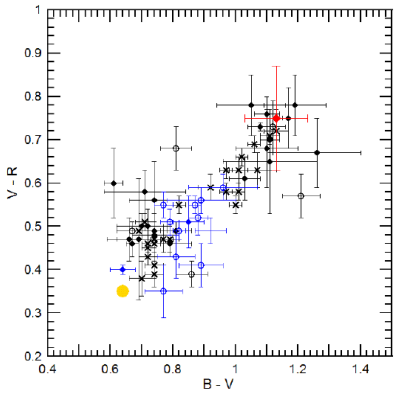

Figure 2: Color-color diagram comparing the inactive Centaurs (black symbols) with the active one (blue symbols): black and blue diamonds (6); black asterisks (7); blue open circles (3); black and blue open diamonds (8); blue cross (9). The yellow dot is the Sun. The red diamond is 2013 UL10 (this work).

In order to obtain a first-order estimate of the dust production rate, we applied the "photometric method" (3). Results should be regarded as a crude order of magnitude, since they are strongly model-dependent: making the assumption of average grain size $a \sim 30$ μm and velocity $v = 20$ m/s, we obtained an estimate of $Q_d \sim 10$ kg/s at 6.2 au (just after the perihelion passage).

The color diversity among Centaurs is a still unexplained feature of the class: they could reflect their different formation location (a primordial, temperature-induced, composition gradients), or could be due to the combined effect of quite recent evolutionary processes. An effect of the "fall back blanketing" (8) could be the "destruction" of the red matter eventually present on the surface by fallback debris composed by "fresh", un-irradiated material expelled during comet-like activity. Timescales for the blanketing process are very uncertain, but are estimated to be quite short (≤ 100 years) with respect the average lifetime of Centaurs on their unstable orbits (10^7 years): therefore, the probability to observe outgassing activity on red surface among the Centaurs, as we actually observed for 2013 UL10, is very low.

This fact, combined with the observation that 2013 UL10 showed significant difference in the colors of nucleus and surrounding dust, with the latter being more neutral than the underlying nucleus, points to the conclusion that: 1) either the blanketing physics should be further constrained, as its timescale can be rather larger than expected (as it is strictly dependent on the dynamical and physical properties of the Centaur and on the level of persistency of its comet-like activity); 2) or we have been extremely lucky to actually observe in December 2015 the comet-like activity of 2013 UL10 just after its onset; 3) or in the specific case of 2013 UL10 the comet-like activity observed in December 2015 has been only episodic and is due to an isolated event (e.g., collisional), and should not be considered the starting point of a sustained comet-like activity able to (rapidly) bluish the Centaur.

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