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The enigmatic colors of the Centaur population

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Abstract

Centaurs are considered “transition bodies”, from the cold inactive Kuiper Belt Objects beyond Neptune to the active Jupiter Family comets. Their visual colors apparently divide the population into two distinct groups, one with grey, solar-like colors and one with redder colors. It is still unclear if this peculiar color distribution (unique in the Solar System) is due to different thermal reprocessing on their surface or to different composition and/or region of origin. The issue is further complicated by the fact that more and more Centaurs are observed with a comet-like behavior, and they all fall in the grey clump (as the few comet nuclei characterized up to now), even if very recently few active Centaurs were found with colors that classified them in between the two groups.

1. Introduction

Centaurs form a dynamical class of minor bodies in the Solar System moving on highly chaotic and unstable orbits in the region between Jupiter’s and Neptune’s orbits. With orbital lifetimes of the order of 10^6 years [1], Centaurs are brief residents in the region between the gas giant planets, and those who survive the dynamical environment in this region may become Jupiter family comets (JFCs) [2,3]. As they are considered “transition objects” from the inactive Kuiper Belt Objects to the active JFCs, 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 minor bodies in the Solar System.

Centaurs exhibit a physical property not observed among any other objects in the Solar System: their visual colors apparently divide the population into two distinct groups, the ”grey ones” (with neutral, solar-like colors) and the ”red ones” (with very red colors) [4]. The color properties of this class of targets are crucial to obtain reliable hints on the surface properties and their evolution within the Solar System: it is still unclear if the peculiar color distribution of Centaurs is due to different thermal reprocessing on their surface [4] or to a different composition and/or region of origin [5,6].

A few Centaurs (28 objects over a family of ~ 300 members, i.e., around 10% of the whole sample, as per April 2017) have been observed with a well developed dust coma in optical images. The first example was (2060) Chiron, which orbits at about 10 AU from the Sun and shows a sustained, though variable, cometary-like activity along its orbit [7,8]. Very few active Centaur has been fully characterized up to now: many of them have dust loss rate Q_d comparable or even higher than several active comets at much smaller heliocentric distances [9,10,11,12]. On the other side, there are few active Centaurs that can be considered quite weak dust emitters, despite their relatively close perihelion distance, with Q_d less than ~ 10 kg/s [9,13,14]. As a group, the main general properties of the active Centaurs was, up to very recently, that they clustered in the grey group among the whole sample, and their mean colors overlapped with those of the Jupiter Family Comets (JFC) nuclei. Only recently [15], few active Centaurs were found for the first time with colors that classified them as “intermediate” among the two groups. Actually, it is not yet possible to formally conclude at the 3σ level of confidence that the active and inactive Centaurs have different (uni-modal and bi-modal) color distributions. Figure 1 summarizes the present state-of-the-art of the color-color distribution of the Centaur population.

The question of Centaur colors and their relationship with comet-like activity is a still open issue: one hypothesis is that the “primordial” surface of bodies coming from the Kuiper Belt, consisting of irradiated organics spread on a more or less thick surface layer, is progressively blanketed with “fresh”, unirradiated material expelled from beneath after the rise of comet-like activity. Blanketing timescales are quite uncertain, since Centaur activity could be episodic and fallback will be not, in general, uniformly distributed on the nucleus surface, but some observational evidences allow to estimate that it could be very short (0.1-10 years) compared to the typical dynamical lifetime (10^6-10^7 years) of a Centaur [15]. The presence of red and ultra-red matter on the nucleus surface of active Centaurs, never observed up to now, can be considered fundamental test to constrain the “fallback blanketing hypothesis”.

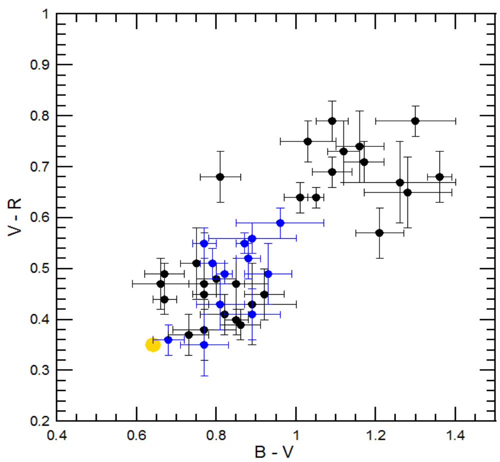

Figure 1: Color-color diagram comparing the inactive Centaurs (black dots) with the active ones (blue dots): data are taken from [9,13,15,16]. The yellow dot shows the color of the Sun.

In this talk we will present an overview of the current status and of the still open questions about the intriguing issue about the color of Centaurs, also in the more general framework of the dynamical and evolutionary link about groups of small bodies in the Solar System. We will also present the first results of an ongoing large observing program specifically tailored on the Centaurs’ colors, and discuss about the investigation of the actual comet-like activity frequency in the group, which could in some case stymie the physical studies about these objects.

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