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Space weathering and the color-color diagram of Plutinos and Jupiter Trojans

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Abstract

The Jupiter Trojans and the Plutinos are two peculiar populations. They are dynamically resonant, therefore with heliocentric distances relatively bounded for long timescales, as a fairly general rule. As a consequence, some correlation with the surface color properties of their respective members is expected. Indeed, there are apparent differences in the B-V vs. V-R color-color diagram of the two populations. Using a simple model based on the surface color due to the contribution of two components, one pristine and one altered, we find as plausible that the difference is due to the interplay of space weathering by solar wind ion bombardment and collisional effects.

1. Introduction

The study of the physical properties of small objects in the outer Solar System may give information on the processes and original composition in the early outer proto-planetary disk. The surfaces of atmosphere-less bodies are irradiated by a large variety (in terms of energy and mass) of cosmic and solar wind ions, by UV photons, and collide with interplanetary dust. Collisions of the bodies with various-sized objects, from similar size to small grains, also reset and contribute to the current state of their surface and sub-surface composition.

As the localization of the members of Plutinos and Trojans is approximately well bounded in the heliocentric distance, (the Plutinos orbit about the 3:2 mean-motion resonance with planet Neptune and the Trojans about the 1:1 mean motion resonance with planet Jupiter), it seems plausible that the surface properties of both groups will, in some way, reflect the difference in heliocentric distance at which they are located. Solar wind irradiation and collisional timescales would be scaled approximately equally for all members in each group.

When the B-V vs. V-R color-color diagram of Plutinos and Jovian Trojans populations is plotted, we notice a remarkable difference in the “slopes" of the two distributions (Fig. 1). The data plotted correspond to the MBOSS database [1], available at http://www.sc.eso.org/~ohainaut/MBOSS. Here we suggest an explanation for the noticeable difference in the “slopes” of the two distributions in the plot.

As it was recently shown by Kauňchová et al. [2], the observed surface colors of the outer Solar System bodies can be considered as the result of the interplay between the space weathering and collisional resurfacing. The objects with the different ratio of weathered and pristine surface material lie on specific lines in the color-color diagrams [2]. Here we present a model which supports this idea.

2. Model

We model the surface of Jupiter Trojans and Plutinos as composed of two components: component 1 is constituted by a material characterized by a flat spectrum - i.e. having solar colors, these can be for instance pure water ice or completely dehydrogenated carbons; component 2 is composed of materials whose colors can be affected by energetic processing (for instance silicates, complex organics, C-bearing ices, etc.).

In the case of Trojans, the component 1 is assumed to be dark, of visual albedo ~4% [3]; the component 1 of Plutinos is assumed to be of high albedo ~80-100%, representing ices (water, methane, etc). As template of component 2 material we use polystyrene irradiated with different ion fluences because it is able, upon ion irradiation, to cover a very wide range of colors and, at the highest doses it is carbonized and has a flat spectrum and a low albedo (see [2] for details on experiments and characteristics of sample).

Further, we have computed the collisional timescale for both the Jupiter Trojans τ_T and the Plutinos τ_P for several relevant values of the target body radius R and impactor size. E.g., for the targets of radii in the range 1 to 200 km the ratio between collisional timescales τ_P and τ_T is approximately 2000.

The time in which the surface of the object can be modified by the solar wind ions is counterbalanced by the collision timescale in which the surface is completely renovated (i.e. it is excavated and fresh original material is exposed). Thus, the population of objects can be characterized by a “mean level of space weathering", i.e. the mean value of dose absorbed by the surface of individual objects. Several isoquants representing a different level of weathering were calculated using the model proposed by [2]. Similarly, the fraction of the processed C-bearing material, using which, the proposed model is able to cover the whole color distribution of objects was estimated.

The colors of the Trojans can be reproduced using the combination of a dark material of visual albedo ~0.04 and < 15% of a fresher organic material that is processed “in average” for about 10^2 yrs (Fig. 2).

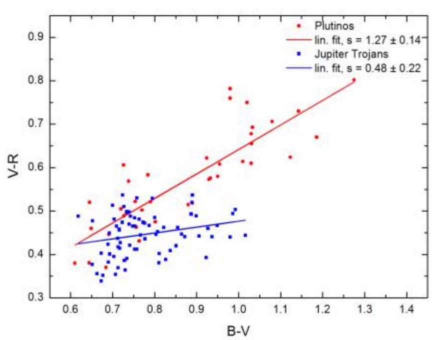

Figure 1: V -R vs. B -V plots for the Plutinos and the Jupiter-Trojans. The linear fits and the appropriate values of slopes are indicated for each population.

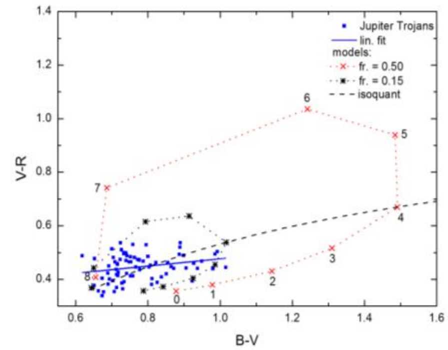

Figure 2: V-R vs. B-V color diagram of the Jupiter Trojans asteroids with visual colors contained in the MBOSS catalogue. The linear fit of the data, the values obtained by a model with albedo of the component 1 equal to 4% and fractions of organic compounds equal to 15% and 50%. Isoquant is a theoretical trend of color distribution of objects differing in the amount of surface component 2, weathered to the same level (85 yrs).

2. Summary

We have found the curves in the color-color diagram (isoquants) describing the balance between space weathering and collisional resurfacing for two populations - Plutinos and Jupiter Trojans, and compared the average time of the surface exposure of two populations with the collisional timescales.

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