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The spectroscopic properties of the Lixiaohua Family, cradle of Main-Belt comets

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Abstract

The Lixiaohua collisional family lies in the Outer Main Belt, close to the well characterized Themis (and its Beagle sub-family) primitive class family. It is one of the only three families that hosts two active asteroids: 313P/ Gibbs and 358P/PANSTARRS (P/2012 T1). We present results of a visible and infrared spectroscopic program using the 4.1m SOAR and the 3.56m Telescopio Nazionale Galileo. We observed asteroids members of the Lixiaohua family with the aim of: (1) accurately determine the spectral class and spectroscopic properties of the family; (2) measure the water content by studying the 700nm absorption band and the UV drop below 500nm due to hydrated minerals on their surfaces and derive information about the mineralogical composition and degree of heating of the family parent body, (3) analyze if active asteroids P/2012 T1 and 313P are real family members. The study of the collisional families that host the Main Belt Comets is of fundamental importance to understand their activation mechanisms and the abundance of water in the main belt.

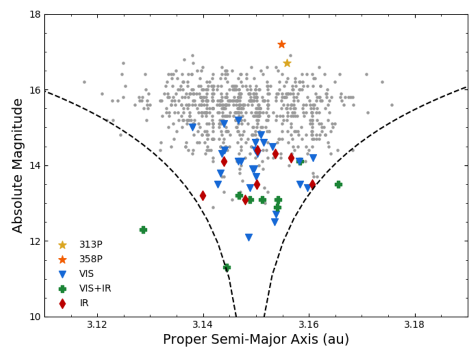

Figure 1: Absolute Magnitudes of Lixiaohua family asteroids as a function of the semi-major axis (grey circles). Blue triangles indicates members that were observed only in visible wavelengths, while red diamonds indicates the ones obtained only in the near-IR. Purple plus signs shows objects observed in both regions. The black solid line represents the Yarkovsky envelope [11]. The brown and yellow stars are MBCS 358P and 313P, respectively, with estimated absolute magnitude obtained from JPL (*https://ssd.jpl.nasa.gov/*).

1. Introduction

Active Asterods (AAs) are small bodies with orbits typical of asteroids ($T_J > 3.00$) that exhibit comet-like activity. There are several mechanisms that can trigger activity in an asteroid , such as an impact, rotational break-up, thermal fracturing or sublimation of volatiles [**?**]. Objects in which the activity is believed to be driven by sublimation of ices are also refereed to Main-Belt Comets. The relation of AAs with collisional families is not considered to be uncommon[**?**].

The object 358P/PANSTARRS (hereafter 358P) was originally discovered active in the October of 2012, while 313P/ Gibbs (hereafter 313P) was discovered in September 2014 [5, 9]. A strong indicative of a sublimation-driven coma is the recurrent activity when the objects are near to their perihelion. This behavior was detected in both MBCs. The object 313P was observed active in precovery images from 2003 of the Sloan Digital Sky Survey (SDSS)[3, 7]. [1] observed 358P on July and August 2018, months before the object reached perihelion, and found that activity was not detectable at the distance. While recently, presented new images of 358P with recurrent active on November, 2017 [4].

The discovery of water ice in the main-belt, indirectly through MBC, and directly in the surface of (24) Themis, (65) Cybele and (1) Ceres [2, 12, 10] are specially interesting for Solar System and Earth formation models. These objects can help to constrain the thermal and dynamical history of the Solar System, and where primitive asteroids were actually formed. Also, there is modern theories that proposes that Earth's volatiles were accreted from collisions with ice bodies, preferably originated from the asteroid belt.

2. Experimental Design

In this work we investigate the spectral properties of the family, using the 4.1m SOAR and the 3.56m Telescopio Nazionale Galileo, and the possible link to the main comets 311P and 358P. We present new data in the following wavelength coverage:

- 13 objects observed in the 0.5-0.9 μm range.
- 13 objects observed in the 0.4-0.9 μm range.
- 8 objects objects observed only in the near-infrared (0.9-2.4 μm).
- 3 objects observed in the 0.5-2.4 μm.
- 6 objects that were observed with a wavelength coverage of 0.4-2.4 μm.

In fig. 1 we show the Yarkorvisky cone for the Lixiaohua family, together with the information of observed targets of this work, and the Main-Belt comets members.

3. Comparison with the Main-Belt Comets

We compared the family spectroscopic properties with the data available for the AA members. Only object 358P has published spectra in a comparable region with our sample. In fig 2 we show the spectrum of 358P [5, 14] in comparison with the family mean. In the case of 313P, there were only colors available in the literature [9, 7]. Both objects have a spectral slope compatible with members observed in the family, though there is probably a *blueying* effect in these measurements produced by the presence of a faint comma [13].

4. Summary and Conclusions

With the exceptions of one object, all Lixiaohua members presented featureless spectra with a mean reddish slope both in the visible and in the near-IR wavelength regions. We found few members with a turn-off of reflectance, including the two largest family members, but no unequivocal hydration feature were found.

We found that the Lixiaohua family is the possible source of Main-Belt Comets 313P and 358P. The Lixiaohua family is one of the reddest and darkest families (mean albedo of 0.042) in the main belt. The physical properties of the family in combination to the presence of ice bearing objects and the absence of hydrated minerals suggests that the parental body has undergone nearly no heating since its formation, which indicates an origin close or beyond the snow line.

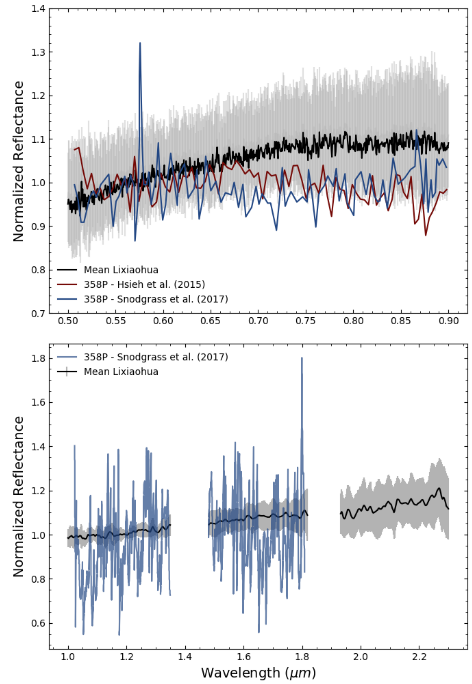

Figure 2: The mean spectrum of the Lixiaohua family members (black) in comparison with the spectra to the main belt comet 358P obtained by [5] (red) and by [14] (blue). The gray region represents the one sigma deviation from the Lixiaohua mean spectrum. We performed a rebinning of the visible spectra of 358P using boxes of 11Å, for better visualization.

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