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The Processing and Classification for the Spectra of Six Comets † ⋆

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Abstract In order to explore the relationship between comets and asteroids, the spectra of six comets, including 78P, C/2009 P1, 49P, C/2010 G2, C/2010 S1, and C/2011 F1, have been observed with the 2.16 m telescope at the Xinglong Observing Station of National Astronomical Observatories. At the same time, the spectra of some sun-like stars are also observed. The IRAF (Image Reduction and Analysis Facility) software is used to process the obtained spectra, and to obtain the relative reflectance spectra of the six comets. Then, they are compared with the 24 asteroid spectral types of the Bus-DeMeo taxonomy to derive the spectral distances of these comets. According to the order of the calculated spectral distances, the details of the reflectance spectra, as well as the results of the K-S test, the asteroid spectral types which are most close to the spectra of these comets are finally determined.

Key words: comets: individual—techniques: spectroscopic—methods: data analysis

1. INTRODUCTION

Internationally, the spectral classification of asteroids has been well developed, now the rather mature classification is the Bus-DeMeo taxonomy based on the data of SMASS II (Small Main-belt Asteroid Spectroscopic Survey II) of the Planetary Spectroscopy Group at MIT (Massachusetts Institute of Technology), which classifies the asteroids into 24 types

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according to their spectroscopic characteristics[1]. At present, the work on the spectral classification of comets is relatively rare, one of the reasons is the complexity of the comet's composition, at a short distance from the sun, there will be the structures such as the coma, comet tail, and so on. The spectroscopic characteristics may differ with different structures[2].

However, from the analysis on the cometary spectra, we can learn about the chemical properties of comets. More importantly, the relationship between comets and asteroids can be studied. At present, it is known that some asteroids are the so-called "dead comets", namely the remains of comets after their ejected matter was exhausted, for example, the parent of the Twins meteoric shower, one of three well-known big meteoric showers, is not a comet, but the No.3200 asteroid Phaethon, actually, a dead comet[3].

Recently, the hot points in the research of cometary spectra are mainly concentrated in the following aspects:

(1) Comets and Kuiper belt objects. Although it is commonly believed that the short-period comets are originated from the Kuiper belt, but the specific relationship between the comets entered into the inner solar system and the Kuiper objects far beyond the Neptune's orbit is not yet clear. The recent observations indicate that the color of comets tends to be bluer than the Kuiper belt objects, the lack of red color is a significant difference. If comets come from the Kuiper belt, then the two sorts of objects should have similar characteristics. Jewitt suggested that after a comet entered into the inner solar system, the ejection of the ancient matter covered on its surface causes the color difference between the two[4].

(2) Comets and Centauri asteroids. The Centauri asteroids belong to a sub-category of asteroids, which have no stable orbits and finally are moved away from the solar system by the giant planets. They behave as like asteroids in half, and as like comets in another half. Hence they are named after "Centaurus". The orbits of the Centauri asteroids will penetrate or have penetrated the orbit(s) of one or multiple gaseous giant planets, with a dynamical life of several million years.

Up to 2008, two Centauri asteroids (Chiron and Echeclus) have been discovered with coma activities, so they belong to not only asteroids but also comets. The orbit of the comet 166P/NEAT is very close to the type of Centauri asteroids. And some other Centauri asteroids, such as Okyrhoe, are suspected to have the activities similar with those of comets[5].

(3) Main-belt comets. Main-belt comets are the objects distributed within the main belt of the asteroid belt, but exhibit the activities and characteristics of comets as they move to some positions. Different from the orbits of most comets, which are chiefly at the distances close to Jupiter or far away from the sun, the orbits of the main-belt comets are nearly circular, and within the main belt of the asteroid belt, hence it is very difficult to discriminate them from many standard asteroids by their orbital characteristics. Although the orbital semi-major axes of some short-period comets are within the Jupiter's orbit, but they differ from the main-belt comets, because the orbital eccentricities and inclinations of the main-belt comets are similar with those of the asteroids within the main belt. The three main-belt comets known most early are all positioned in the inner side of the outer edge of the main belt.

So far, we do not know whether these comets come from the Kuiper belt, and how did they change their orbits under the relatively weak gravitational disturbances of planets to