ELSEVIER

CrossMark

Chinese Astronomy and Astrophysics 41 (2017) 549–557

CHINESE
ASTRONOMY
AND ASTROPHYSICS

Spectral Classification of Asteroids by Random Forest† ⋆

HUANG Chao[1,2,3] MA Yue-hua[1,2△] ZHAO Hai-bin[1,4] LU Xiao-ping[5]

[1] *Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210008*

[2] *Key Laboratory for Planetary Science, Chinese Academy of Sciences, Nanjing 210008*

[3] *University of Chinese Academy of Sciences, Beijing 100049*

[4] *Lunar and Planetary Science Laboratory, Macau University of Science and Technology–Partner Laboratory of Key Laboratory of Lunar and Deep Space Exploration, Chinese Academy of Sciences, Macau 000853*

[5] *Faculty of Information Technology, Macau University of Science and Technology, Macau 000853*

Abstract With the increasing spectral and photometric data of asteroids, a variety of classification methods for asteroids have been proposed. This paper classifies asteroids based on the observations in the Sloan Digital Sky Survey (SDSS) Moving Object Catalogue (MOC) by using the random forest algorithm. In combination with the present taxonomies of Tholen, Bus, Lazzaro, and DeMeo, and the principal component analysis, we have classified 48642 asteroids according to their SDSS magnitudes at the g, r, i, and z wavebands. In this way, these asteroids are divided into 8 (C, X, S, B, D, K, L, and V) classes.

Key words asteroids: general, line: profiles, methods: random forest

1. INTRODUCTION

Asteroids are important small objects in the solar system, the observational research on them has become an active field in the modern astronomy. To acquire the exact compositions of asteroids will help us to understand in depth the early environmental condition and the evolution of the solar system. In the Earth, Mars, and other Earth-like planets of the

† Supported by National Natural Science Foundation (11573075, 11403107, 11273067), Natural Science Foundation of Jiangsu Province (BK20141045), Macau Science and Technology Development Foundation (095/2013/A3)

Received 2016–03–28; revised version 2016–04–22

⋆ A translation of *Acta Astron. Sin.* Vol. 57, No. 5, pp. 526–533, 2016

△ yhma@pmo.ac.cn

doi:10.1016/j.chinastron.2017.11.006

solar system, because of the effects of various factors, such as the evolutionary process and atmospheric environment, etc., the evidence remained in the formation of the early solar system has been very difficult to be found, however, the asteroids as the components during the formation of these Earth-like planets, especially the main-belt and Trojan asteroids, still keep the state several thousand million years before, and remain the important evidence in the formation of the early solar system[1]. The analysis of asteroid photometric data is an important measure to study the compositions of asteroids, and it provides also an important basis for the study of asteroid classification methods.

In 1929, Bobrovnikoff[2] published a report about the spectral measurement of asteroids, limited by the technical development at that time, the spectral measurement was of low efficiency and low accuracy. In the middle of the 50s of the 20th century, along with the employment of the UBV photometric measurement, the researchers had got a large number of spectral observation data of asteroids. Using these data, Wood et al.[3], Chapman et al.[4] obtained the reflection features of asteroid spectra, and hereby classified asteroids into two major types, namely the "S" type asteroids and "C" type asteroids. Zellner[5] found that the asteroid reflectivity has a double-peaked distribution, and hereby classified the asteroids into the dark carbonaceous type and bright stony type. Later, more and more scientific projects were dedicated to the research of asteroid optical properties, this makes it possible that a more accurate and strict asteroid classification method was proposed in the middle of the 70s of the 20th century. After analyzing the albedos of some asteroid photometric measurements, Chapman et al.[6] further classified the asteroids into the "C", "S", and "U" three types: "C" represents the dark carbonaceous type, "S" represents the stony type, and "U" expresses the uncertain type. The different types of asteroids reveal their different matter compositions to a certain extent.

Combining with the existing classification results, using the random forrest algorithm, we have made a judgment of type for most of the asteroids observed by the Sloan Digital Sky Survey (SDSS) Moving Object Catalogue (MOC)[1]. The observational instrument of the SDSS is the 2.5 m telescope of the Apache Observatory, New Mexico, USA, the photometric system of the telescope has used the multi-waveband filters, respectively at the u, g, r, i, and z bands, with the central wavelengths respectively at 3551 Å, 4686 Å, 6166 Å, 7480 Å, and 8932 Å[7]. This survey project is very successful, and a large number of high-precision observational data have been obtained. Using the method of principle component analysis, Ye J. H., et al.[8,9] made the asteroid classification on the SDSS data, and effectively discriminated the reflectance features of the S and C types of asteroids, but limited by the principle component analysis method, the data resolution is not high enough, only two types of asteroids are classified. The random forrest algorithm can overcome the limitation of this method, to discriminate more accurately the different reflectance features of asteroids, and to classify multiple asteroid types.

[1] http://sbn.psi.edu/pds/resource/sdssmoc.html