Chinese Astronomy and Astrophysics 42 (2018) 202–212

CHINESE
ASTRONOMY
AND ASTROPHYSICS

Relation of Velocity Distribution and Mass for DA White Dwarfs† ⋆

GONG Xiao-bo[1,2,3△] LI Li-fang[1,2△△]

[1] *Yunnan Observatories, Chinese Academy of of Sciences, Kunming 650011*

[2] *Key Laboratory for the Structure and Evolution of Celestial Objects, Chinese Academy of Sciences, Kunming 650011*

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

Abstract White dwarfs are the evolutionary endpoint of the low-and-medium mass stars. In the studies of white dwarfs, the mass of white dwarf is an important physical parameter. In this paper, we give an analysis about the velocity distribution of DA white dwarfs in the Sloan Digital Sky Survey (SDSS), and hope to find the relation between mass and velocity distribution of white dwarfs. We get the radial velocity and tangential velocity of every DA white dwarf according to their proper motion and spectral shift. Through analyzing the velocity distribution of DA white dwarfs, we find that the small-mass white dwarfs, which are produced from the single-star evolution channel, have a relatively large velocity dispersion.

Key words stars: white dwarfs, stars: fundamental parameters, stars: evolution

1. INTRODUCTION

White dwarfs are the evolutionary endpoint of the low-and-medium mass (0.07-8.0 $M_\odot$ or 0.07-10.0 $M_\odot$, here $M_\odot$ is the solar mass) stars. Over 95% stars in the Galaxy will finally evolve to be white dwarfs. When a star evolves to be a white dwarf, its final degenerate core mass is less than the Chandrasekhar limit (1.44 $M_\odot$), the degenerate pressure produced by the motion of internal electron gas can resist the gravitational collapse, and make it

† Supported by National Natural Science Foundation (11373063, 11273053, 11390347, 11573062, 11573061)

Received 2016–05–11; revised version 2016–06–07

⋆ A translation of *Acta Astron. Sin.* Vol. 58, No. 1, pp. 5.1–5.9, 2017

△ gxbo@ynao.ac.cn

△△ llf@ynao.ac.cn

doi:10.1016/j.chinastron.2018.04.003

situate at a hydrostatic equilibrium state, and in its interior the nuclear reactions are almost unable to happen. The radius of a typical white dwarf is about 10000 km, the surface gravitational acceleration is about $10^8\ cm{\cdot}s^{-2}$ ($\lg g = 8$, in which g expresses the gravitational acceleration), and the averaged mass of white dwarfs is generally $0.6\,M_\odot$. Because of the difference of stellar initial mass, the degenerate core in the center of a white dwarf differs: for low-mass (0.15-0.45 $M_\odot$) white dwarfs, the degenerate core is a helium core; for large-mass white dwarfs, it is a Ne-O-Mg core; and for medium-mass white dwarfs, it is a C-O core. The cooling of white dwarf is a process of long duration, comparable with the cosmological timescale. According to the stellar evolution model, we can know the long-term cooling tracks of white dwarfs, which can provide a good observational sample for constraining the evolutionary history of the Galaxy and the evolutionary model of single stars. According to the spectral feature of absorption lines, the white dwarfs are mainly divided into two kinds: (1) the DA type characterized by the hydrogen absorption line, (2) the other type without the feature of hydrogen absorption line. About 75%-80% of white dwarfs are DA white dwarfs, and about 20%-25% white dwarfs are non-DA white dwarfs, which are generally rich of helium or other elements. The atmospheres of DA white dwarfs are generally dominated by the hydrogen element, and the effective temperature T_{eff} generally ranges between 4000 K and 8000 K.

The masses of white dwarfs have been studied by many authors, which have important relations with the evolution of their progenitor stars and the evolution of the Galaxy. And the velocity distribution of white dwarfs is correlated with the mass, which is exhibited in the following aspects: (1) The kinematic dispersion of a star may enhance with the increase of its total age, which can be attributed to the disk heating process. This process is probably caused by the local fluctuation of gravitational field on the disk[1]. Under the frame of single star evolution, the progenitor stars of white dwarfs with a rather large mass evolve rather fast, their lifetimes are relatively short, and therefore their velocity dispersion is smaller, hence the masses of white dwarfs have a certain relation with their velocity dispersion. When the binary star evolution is concerned, the situation becomes more complicated. If some large-mass white dwarfs are produced by the binary white-dwarf merging, then their evolution time will be longer than the evolution time of single stars, their velocity dispersion will become large. Thus the velocity dispersion of large-mass white dwarfs will constrain the ratio of large-mass white dwarfs produced by the binary star merging[2]. The white dwarfs with a mass less than $0.2\,M_\odot$ are produced from binary star evolution[3]. In the evolution of close binary stars, the process of mass transfer and so on will happen[3−5], the experienced evolution time will differ from that of single star evolution, and their velocity dispersion will be also different. But no matter whether the binary star evolution or the single star evolution, in the statistical meaning, we can compare the experienced evolution times of white dwarfs with different masses by through the velocity dispersion. It provides a measure for estimating the length of stellar evolution time. The evolution times of binary and