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The history of KZ Hya and its unseen companions

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Abstract. KZ Hya is a short-period high amplitude metal pool population II pulsating variable. Its spectral type is B9-A7 III/IV. Its average effective temperature is 7640K. But its mass is only 0.97 solar mass. From normal stellar evolution and H-R diagram, we can not get such a solar mass star at post main sequence stage with so high effective temperature and so early type spectra. We observe this star since 1984 till now, 23years past. Finally we prove it is inside a binary with at least 2 unseen companions. The most massive companion has mass larger than 0.76 solar mass, mostly may be 0.99 to 3.99 solar mass. That means this companion must be a massive white dwarf. The distance between tow companions is about 10 AU. If the companion is white dwarf, this binary are fairly inside the nebula. This system is very old, older than 7.59 billion years. The nebula should be already diluted to very low density so that we cant see the nebula directly. As its spectra type is B9III/VI at some time of maximum light and the visual absolute magnitude is 2.78, about 2 magnitudes higher than our sun. We can image that at the end of AGB stage of the companion, the strong fast winds from hot central core push away the outer atmosphere of KZ Hya. Later KZ Hya absorbed a part of Helium rich material from the companion. This will cause hydrogen content X decrease from 0.75 to about 0.62. Then KZ Hya looks like a hot post main sequence star

Keywords. Stars: variable: other, (stars:) binaries: general, stars: white dwarfs

1. Introduction

KZ Hya = HD 94033 = SAO 179271 (V = 9.498?10.243) is one of the 13 known field SX Phe stars. Its pulsating period is 0.05951d. Due to high velocity and deficiency in metals (Fe/H = −2.40, Z = 0.0001), KZ Hya is clearly belong to Population II. Its spectral type is B9-A7 III/IV. Its average effective temperature is 7640K. But its mass is only 0.97 solar mass. ¿From normal stellar evolution and H-R diagram, we can not get such a solar mass star at post main sequence stage with so high effective temperature and so early type spectra. Yang *et al.* (1985) get a periodic variation of the O-C values of its maximum light time with period about 9 years and a binary hypothesis was proposed. Liu *et al.* (1991) confirm this hypothesis. Fu *et al.* (2008) renewed the binary solution and suggest its unseen companion is a massive white dwarf with mass larger than 0.86 solar mass. Here we try to use a binary evolution model to solve this problem.

2. The evolution of unseen companion

For single star, to get a white dwarf with mass between 1.399 to 0.999 solar mass for Z = 0.0001, its zero age main sequence mass must be between 6.0 to 3.0 solar mass. Its Hertzsprung Gap Time is 61 to 269 MY. Mass still is 6.0 to 3.0 solar mass. The core helium burning time is 62 to 271.3 MY, mass change to 5.999 to 2.999 solar mass. The first AGB time is 69 to 310.1 MY, mass change to 5.96 to 2.97 solar mass. The second AGDB time is 69.1 to 310.6 MY, with mass 5.933 to 2.94 solar mass. Then arrive to

C/O white dwarf stage, the age is 70 to 312.7 MY, with mass of 1.399 to 0.999 solar mass. Now the age is 7590 MY, the planetary nebula is already disappeared and the core white dwarf must be cooled to about 8000 K with 10 magnitude fainter than KZ Hya.in V band, so we cant see it in normal way.

3. The evolution of KZ Hya

Suppose its zero age main sequence mass is 0.80 solar mass with Z = 0.0001. When the unseen companion evolves to C/O white dwarf, large amount of Helium rich masses lost out by fast wind. Parts of them will absorbed by KZ Hya and the distance between companions enlarged to about 10 AU as today we observed. So the mass of KZ Hya become todays 0.97 solar mass. This will change the X content from 0.75 to about 0.62. As a main sequence star with X as low as 0.62, its evolution is quite special, the surface effective temperature is much higher than normal solar mass star and its radius also larger to about 1.51 solar radius. This is what we expected to explain the special observed parameters of KZ Hya.

4. The binary evolution

Really, for a binary, the evolution is much difference with single star. If we have a zero age binary with masses of 6.5 and 0.80 solar masses respectively. The semi-major axes of main component is 3.3 au 703–704 solar radii , the ellipticity e is 0.495 to 0.5. After 70.5 MY, the main component will fill in its Roche lobe, with mass about 3 solar masses. Then evolve to about 1 solar mass carbon white dwarf and 0.97 solar masses post main sequence star with period of about 10500 days or about 29 years and semi-major axis of about 5 au. The real solution is very sensitive on the input parameter of masses, ellipticity and semi-major axis. A small change can get solution with stage of fill in Roche lobe or without fill in Roche lobe stage and very different final components masses and orbital period. The calculation only can get circle orbit but our observations shown e = 0.29 should be caused by the orbital inclination angle i is not 90 degrees.

5. Conclusion

Now we get result that KZ Hya is evolved from a old binary system Its zero age mass only 0.8 solar mass. Later KZ Hya absorbed 0.17 solar mass of helium from its second time red giant companion and changed its X content from 0.75 to 0.62 and it surface temperature increase to about 7600K in average.

References

Yang, X., Jiang, S., & Guo, Z. 1985, *Chinese Astronomy and Astrophysics*, 9, 324

Liu, Y., Jiang, S., & Cao, M. 1991, *IBVS*, 3606

Fu, J. N., Khokhuntod, P., Rodriguez, E., Boonyarak, C., Marak, K., Lopez-Gonzalez, M. J., Zhu, L. Y., Qian, S. B., & Jiang, S. Y. , 2008, *Astronomical Journal* 135, 1958

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