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A nearby cool white dwarf candidate in Gemini

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Abstract

We report the identification of one nearby cool white dwarf candidate in Gemini. The object is called PSS 309-6 or 2MASS 06562998+3002455 and its identification came as a result of a search in SIMBAD at CDS. With uncorrected colors $B - V = 1.52 \pm 0.23$, $V - J = 2.61 \pm 0.12$, $V - H = 2.82 \pm 0.15$, $V - K_S = 3.37 \pm 0.15$, $J - H = 0.21 \pm 0.15$, $H - K_S = 0.55 \pm 0.17$, $J - K_S = 0.76 \pm 0.13$, it exhibits a proper motion of 131^{+3}_{-2} mas/yr. The photometric properties of this object appear to be consistent with those obtained in cool, helium-rich atmosphere white dwarf numerical models. If our interpretation is correct, the object may be a cool white dwarf of the Galactic old thin disk population with a temperature of about 4000 K, mass likely below $0.6M_{\odot}$ and a rough distance estimate of 17–43 pc with a heliocentric space velocity of $(U, V, W) = (2.3, -27.7, -2.9) \pm (1.0, 12.0, 1.3)$ km/s.

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1. Introduction

White dwarfs are the remnants of low mass stars that have exhausted their nuclear fuel and are gradually cooling to invisibility. They are so dense that gravitational contraction is resisted, not by thermal pressure as in main sequence stars, but rather by the Fermi energy of the object's cold degenerate electron gas. White dwarfs represent the most common outcome of stellar evolution with over 97% of the stars formed in the Milky Way eventually ending up as this type of collapsed object. Old, cool white dwarfs carry very important information on the early stages of the evolution of the Milky Way. The study of their space and luminosity distribution can help to reconstruct the history of star formation in the Milky Way disk (Noh and Scalo, 1990; Tamanaha et al., 1990; Díaz-Pinto et al., 1994; Isern et al., 1999)

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and also to determine the age of the disk (Leggett et al., 1998; Knox et al., 1999). Bergeron et al. (1997, 2001) have shown that the coolest white dwarfs observed in the local Milky Way disk have effective temperatures of about 4000 K. These are the remnants of the oldest stars that were born during the formation of the Galactic disk and the absence of cooler white dwarfs has been interpreted as the result of the finite age of the Galactic disk. These old, cool objects have been used to calculate the age of the Milky Way disk but also of some open and globular clusters. On the other hand, the new discoveries of very cool white dwarfs (see the recent reviews by Fontaine et al., 2001; Koester, 2002; Hansen and Liebert, 2003; Hansen, 2004) suggest that white dwarfs may supply all the dark mass in the Milky Way galaxy.

Stellar evolution theory predicts that the structure of an average white dwarf exhibits a stratified composition with a total mass of about $0.6M_{\odot}$. Their carbon–oxygen(–neon) cores are surrounded by a thin, helium-rich envelope itself surrounded by a hydrogen-rich shell. On the other hand, observations indicate that there are two groups of white dwarfs, whose atmospheric compositions are dominated by hydrogen or helium, respectively. This observational fact is consistent with theoretical expectations if we assume that helium-rich white dwarfs have stripped off their hydrogen-rich outer envelope. In both cases, the mass of the stellar remnant is concentrated in their carbon–oxygen(–neon) cores. The observed mass distribution of isolated white dwarfs exhibits a very sharp peak at $0.59M_{\odot}$ with a dispersion of only $0.13M_{\odot}$ (Fontaine et al., 2001). There are, however, low-amplitude tails that extend at both ends of the mass spectrum, from ~0.3 to the Chandrasekhar limit, $\sim1.2M_{\odot}$. Both the low-mass and the high-mass ends are suspected to be the result of binary evolution. Helium-rich white dwarfs account for about half of the coolest known white dwarfs (Bergeron et al., 2001). As they are intrinsically faint, they have to be close in order to be observed. Being closer than most other stars of similar apparent magnitude also implies that they show relatively high proper motions. During the last few years, high proper motion surveys have been adding new members to the known local white dwarf population on a regular basis (Kawka et al., 2004).

This paper presents findings of an object, PSS 309-6, which if identified as to be a cool, helium-rich atmosphere white dwarf is one of the closest old, disk white dwarfs found. This paper is organized as follows. In Section 2, we briefly present the data analysed. In Section 3, we calculate data corrections for extinction in order to provide a consistent identification for the object. In Section 4, we discuss our results. In Section 5, we show that the available photometry is compatible with a cool, helium-rich atmosphere white dwarf. Detailed kinematics is analysed in Section 6. Finally, in Section 7 we draw some conclusions and suggest further lines of research.

2. Data

PSS 309-6 is a faint point source located in Gemini, Fig. 1 (α(ICRS) = 06 56 30.0, δ(ICRS) = +30 02 46, l = 186.15, b = +14.20). The object was first identified by Humphreys et al. (1991) during a survey with the 2.1 m telescope at Kitt Peak National Observatory. The photoelectric observations were

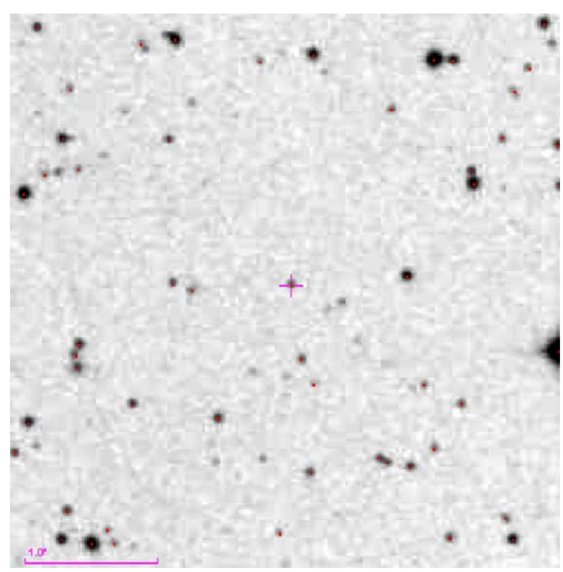

Fig. 1. POSII DSS2/STScI N/Red(IR) image of the area around PSS 309-6. The epoch of the image is 1999.844. PSS 309-6 is marked by a cross. North is up, East on the left.