2MASS J06562998+3002455: Not a Cool White Dwarf Candidate, but a Population II Halo Star

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2MASS J06562998+3002455 or PSS 309-6 is a high proper-motion star that was discovered during a survey with the 2.1 m telescope at Kitt Peak National Observatory (Humphreys et al. 1991). The nature of this object was investigated by de la Fuente Marcos & de la Fuente Marcos (2005) using rather uncertain data to conclude that it could be a nearby cool helium-atmosphere white dwarf candidate; other alternatives discussed by de la Fuente Marcos & de la Fuente Marcos (2005) included the possibility of PSS 309-6 being a Population II subdwarf ejected from a globular cluster with a tangential velocity as high as $435^{+111}_{-85}$ km s$^{-1}$. Here, we reevaluate the status of this interesting star using Gaia DR2 (source 888147903365642112).

Gaia DR2 (Gaia Collaboration et al. 2016, 2018b) supplies high-quality input data —namely, equatorial coordinates, parallax, radial velocity, proper motions, and their respective standard errors— to study the kinematics of PSS 309-6, which is placed at a distance of $560^{+70}_{-56}$ pc, i.e. it is not located nearby. Gaia DR2 does not provide a value for the radial velocity of PSS 309-6 and we will assume that its radial motion is negligible in comparison with its tangential one. Following the approach outlined by Johnson & Soderblom (1987), we have used the input data to compute Galactic space velocities and their uncertainties in a right-handed coordinate system for $U$, $V$, and $W$; axes are positive in the directions of the Galactic Center, Galactic rotation, and the North Galactic Pole. The necessary values of the Solar motion were taken from Schönherr et al. (2010).

Computed as indicated above, the heliocentric Galactic velocity components are $U = 46 \pm 5$ km s$^{-1}$, $V = -348 \pm 39$ km s$^{-1}$, and $W = 33\pm30$ km s$^{-1}$ (Figure 1, left-hand side panels); the corresponding Galactocentric Galactic velocity components are $U = -35\pm5$ km s$^{-1}$, $V = -92\pm39$ km s$^{-1}$, and $W = 40 \pm 30$ km s$^{-1}$. These results strongly suggest that PSS 309-6 could be a Population II star as the value of its $V$ component is close to $V = -220$ km s$^{-1}$, which is typical for halo stars in the immediate solar neighborhood (Fuchs & Jahreiß 1998). The average $V$ velocity for the halo is still under debate, but probably lies between $-270$ and $-180$ km s$^{-1}$ (Majewski 1993). PSS 309-6 appears to be a relatively distant Population II subdwarf, not a nearby white dwarf as argued by de la Fuente Marcos & de la Fuente Marcos (2005). We have compiled Gaia DR2 data on six well-studied halo stars of diverse spectral types —Kapteyn’s star (sdM1), APMPM J0559-2903 (sdM7), HD 134439 (sdK1), HD 134440 (sdK2), 2MASS J15484023-3544254 (sdK5), and 2MASS J19294099-4310368 (sdM7)— and plotted them in Figure 1 to place PSS 309-6 in its proper context. Both the kinematic and photometric properties of PSS 309-6 and the subdwarfs are consistent: it could be a late K dwarf/early M subdwarf.
Kapteyn’s star is the nearest known halo star and PSS 309-6 exhibits similar kinematic and photometric signatures (Figure 1). Its properties also resemble those of 2MASS J15484023-3544254, which was once thought to be the nearest cool white dwarf but was later reclassified as K-type subdwarf (Scholz et al. 2004; Farihi et al. 2005). Although it is virtually certain that PSS 309-6 is not a nearby white dwarf but a more distant Population II subdwarf, further spectroscopic information, including radial velocity measurements, is necessary to fully characterize this probable member of the Galactic halo.

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