Draft version June 21, 2018
Typeset using LaTeX **RNAAS** style in AASTeX62

The first polluted white dwarf from *Gaia* DR2: the cool DAZ GaiaJ1738−0826

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Keywords: planet-stars interactions — stars:abundances — stars: individual (GaiaJ1738−0826) — white dwarfs

We present the first metal-polluted single white dwarf (WD) star identified through *Gaia* DR2 (Brown *et al.* 2018). GaiaJ1738−0826 was discovered to have strong Ca II absorption in initial spectroscopic characterization at Lick Observatory. Notably, GaiaJ1738−0826 resembles in many ways the first confirmed metal-polluted hydrogen atmosphere WD, the DAZ G 74−7 (Lacombe *et al.* 1983).

GaiaJ1738−0826 (*Gaia* DR2 source 4168312459956062208, J2000 RA and DEC 17 38 34.3924 −08 26 14.017) was culled from a set of color and absolute magnitude cuts applied to *Gaia* DR2 parallax, G-magnitude, and BP−RP colors. Specifically, in a *Gaia* color-absolute G-magnitude diagram, WDs were selected to have $G_{abs} \geq (12.5 \times (BP_{mag} - RP_{mag}) + 40) / 4.5$.

Characterization spectroscopy was conducted at Lick Observatory with the 3 m Shane telescope on UT 22 May 2018. The KAST spectrograph (Lick Observatory Technical Reports No. 66) was used with light illuminating a 1″ slit and then passed onto the d57 dichroic which splits light around 5700 Å. From there, light is fed into the blue arm of the spectrograph where it was dispersed with the 600/4310 grism resulting in 1.02 Å pix^{-1} on the detector. Light fed into the red arm is dispersed with the 830/8460 grating resulting in 0.94 Å pix^{-1} on the detector. Spectral coverage is 3450-7800 Å. 3000 seconds total integration time were obtained in the blue and red with final signal-to-noise ratios of ≈35 near 3950 Å and ≈65 near 6500 Å. Final spectral resolution is ≈3 Å in the red and blue. Data reduction is done with standard IRAF tasks with Feige 34 serving as the standard.

Spectral modeling is conducted similar to that described in Melis *et al.* (2011). We began with an initial solution for GaiaJ1738−0826 based on fits to Pan-STARRS PS1 photometry (Chambers *et al.* 2016) and the *Gaia* DR2 parallax assuming pure H (DA) or pure He (DB) atmospheric compositions; the spectra show this WD is H-dominated. Thus, the H solution was selected yielding an effective temperature of 7,050 K and gravity log$g$ of 8.04 (cgs units). GaiaJ1738−0826 has mass 0.6 $M_\odot$, radius 0.012 $R_\odot$, luminosity 3.3×10^{-4} $L_\odot$, cooling time of 1.7 Gyr, and photospheric layer mass ratio log$q$ of −8.3 (e.g., Dufour *et al.* 2017). A grid of spectra having a range of Ca abundances is then fit to the Ca II H+K lines (see description in Melis *et al.* 2011). Figure 1 shows a good fit to the Ca and H lines. Based on the measured Ca abundance of $\log_{10}$[Ca/H]=-8.7 ± 0.2, measured stellar parameters above, and inferred atmospheric diffusion timescale for Ca of $10^{3.74}$ years we estimate a Ca mass accretion rate in steady-state of $\approx 2.6\times10^{6}$ g s^{-1}. We do not consider thermohaline mixing or changes to convective overshooting which, in DA WDs, might dramatically increase derived accretion rates (e.g., Bauer & Bildsten 2018 and references therein). Assuming Ca makes up 1.6% of the total heavy element accretion rate (see Farihi 2016), GaiaJ1738−0826 could be accreting $1.6\times10^{8}\,\mathrm{g\,s^{-1}}$. This value lies below $3\times10^{8}\,\mathrm{g\,s^{-1}}$ where WDs frequently have detectable infrared excess emission from a circumstellar accretion disk (Jura *et al.* 2007). Archival infrared data from the VISTA Hemisphere Survey and warm *Spitzer* do not reveal the presence of a disk.

In many ways GaiaJ1738−0826 resembles the first confirmed DAZ WD, G 74−7. G 74−7 was identified from a list of candidate DA,F stars that showed possible evidence for Ca II H+K absorption in early spectroscopic surveys (Lacombe *et al.* 1983). Deeper observations of G 74−7 have detected also Mg, Fe, and Al (Zuckerman *et al.* 2003). Taking the most up-to-date stellar parameters (7,201 K effective temperature, gravity log$g$ 7.93, mass $0.53\,\mathrm{M_\odot}$, radius $0.013\,\mathrm{R_\odot}$, luminosity $4.1\times10^{-4}\,\mathrm{L_\odot}$, cooling time of 1.4 Gyr, and photospheric layer mass ratio log$q$ of −8.2), abundances ($\log_{10}$[Ca/H]=−8.83±0.2, $\log_{10}$[Mg/H]=−7.90±0.2, $\log_{10}$[Fe/H]=−7.89±0.2, $\log_{10}$[Al/H]=−9.00±0.2), and diffusion timescales ($10^{3.89}$, $10^{3.88}$, $10^{3.88}$, $10^{3.72}$ years for Mg, Al, Ca, and Fe respectively), we estimate accretion rates of 7.9×10^{6}, 7.3×10^{5}, 1.5×10^{6}, and $2.7\times10^{7}\,\mathrm{g\,s^{-1}}$ for Mg, Al, Ca, and Fe respectively. Calculating the total heavy element accretion rate as was done for GaiaJ1738−0826 above, we obtain $\approx10^{8}\,\mathrm{g\,s^{-1}}$.

The first polluted WD, the DZ (helium-dominated atmosphere) van Maanen's Star, was identified in 1917 (van Maanen 1917), although it was many years before the significance of this discovery was recognized (Zuckerman 2015). Polluted white dwarf stars provide a glimpse into the fate of planetary systems and an unparalleled method of determining the composition of solid material in planetary systems (Zuckerman *et al.* 2007); more recently they have been found to be capable of providing structural information for massive, differentiated rocky bodies (Melis & Dufour 2017). Much in the way the discovery and confirmation of G 74−7 advanced the study of metal-line WDs by inclusion of hydrogen-dominated atmosphere objects − a remarkably delayed 66 years after van Maanen's discovery − the identification of GaiaJ1738−0826 heralds the waiting discovery space amongst the many thousands of new WDs that *Gaia* has made available.

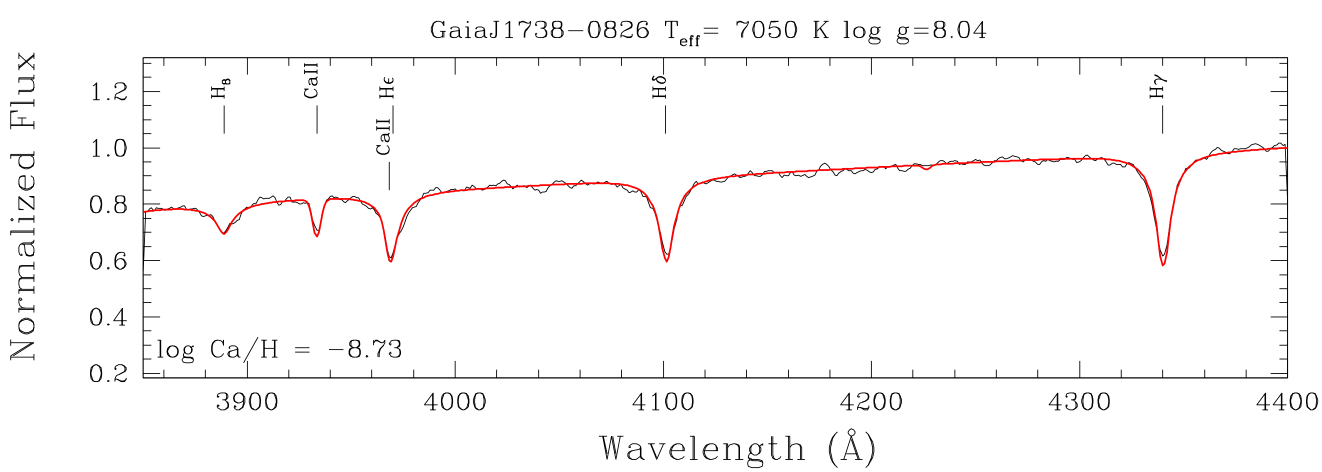

Figure 1. KAST spectra of GaiaJ1738−0826 (black curve) with model having the specified parameters overlaid (red line).

Research at Lick Observatory is partially supported by a generous gift from Google.

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