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LETTER

Letter to the Editor

Metals in the variable DA G29-38*

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Abstract. We report the detection of the heavy elements Ca, Mg, Fe in the atmosphere of the variable DA white dwarf G29-38. The abundance of Ca can be understood only if accretion from interstellar matter is going on currently at a high rate. This lends support also to the interpretation of the observed infrared excess as due to heated circumstellar material, from which the accretion onto the star takes place.

Key words: stars: white dwarfs — stars: abundances — stars: G29-38

1. Introduction

G29-38 (WD2326+049) is one of the brighter members of the class of variable DA or ZZ Ceti stars. It has one of the largest amplitudes in its variations and shows the typical complex variable lightcurves of other large-amplitude DAVs. This star has been observed repeatedly since Zuckerman & Becklin (1987) found an infrared excess in the star's spectrum above 2 μm. These authors argued that the most likely explanation for the excess was a 1200 K brown dwarf companion in orbit around the white dwarf (see also Greenstein 1988).

The Whole Earth Telescope observed this star in 1988 and Winget et al. (1990) reported a large phase change in the largest amplitude oscillation without any change in amplitude, indicating the presence of a massive companion — either a neutron star, or a black hole. A prediction of such a model is a large radial velocity variation in the spectrum of G29-38, which was, however, not found in high-dispersion observations (Graham et al. 1990a). This result gives support for an alternative explanation of the infrared excess as due to a cloud of matter orbiting G29-38 and heated by the white dwarf (Zuckerman & Becklin 1987; Graham et al. 1990b; Tokunaga et al. 1990; Telesco et al. 1990). A small radial velocity variation still seems possible (Barnbaum & Zuckerman 1992), although recent photometric observations over a five year time span (Kleinman et al. 1994) did not show any evidence of orbital motion in the system.

2. Observations

A UV spectrum of G29-38 was obtained with the FOS on the Hubble Space Telescope, covering the range 1150 to 3000 Å with a resolution of 6 Å. To support the analysis, we have also obtained two optical spectra at the DSAZ (Calar Alto) with very high S/N at a resolution of 3.8 Å. All spectra are dominated by the hydrogen lines and the quasi-molecular satellites of Ly α in the UV. We have analyzed the observations using an extensive grid of DA model atmospheres with convection included at medium efficiency as found appropriate for the DAV by Koester et al. (1994) and Bergeron et al. (1995). Fig. 1 shows the fit to the Balmer lines at the final parameters obtained from the analysis: $T_{\rm eff}$ = 11600 K, log g = 8.05. This fit is also consistent with the overall shape of the UV spectrum, including the quasi-molecular satellites at 1400 and 1600 Å, as shown in Fig. 2.

Inspection of the blue wing of Hϵ in Fig. 1 shows an absorption feature, which is present in both optical spectra and can easily be identified as the H line of the CaII resonance doublet. The red part of the FOS spectrum also clearly shows metal lines: the MgII resonance lines and several strong features due to numerous FeII lines can be identified. The features are weaker, but generally similar to those observed e.g. in L745-46A (Koester and Allard 1996); many of the FeII lines originate from exited levels and not the ground state, we therefore assume for our analysis that these absorption features are photospheric and not caused by circumstellar material.

This identification of metal features places G29-38 in the very small DAZ spectroscopic class; to our knowledge it is the first one in the typical DA range between 10000 and 25000 K.

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* Based on observations with the NASA/ESA Hubble Space Telescope and on observations obtained at the DSAZ Calar Alto

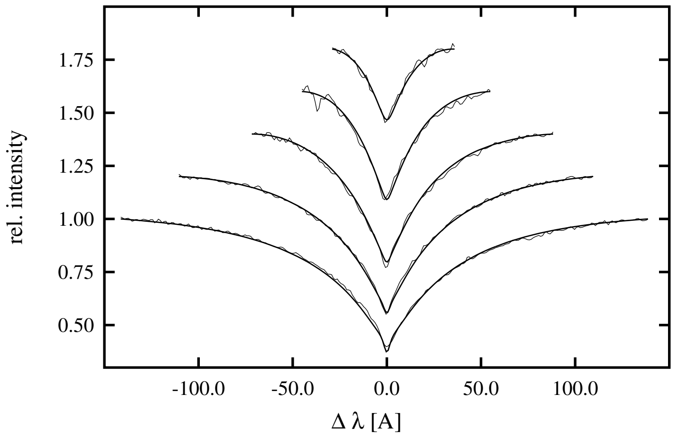

Fig. 1. Model fit to Balmer lines Hβ to H8 from bottom at $T_{\rm eff}$ = 11600 K, log g = 8.05

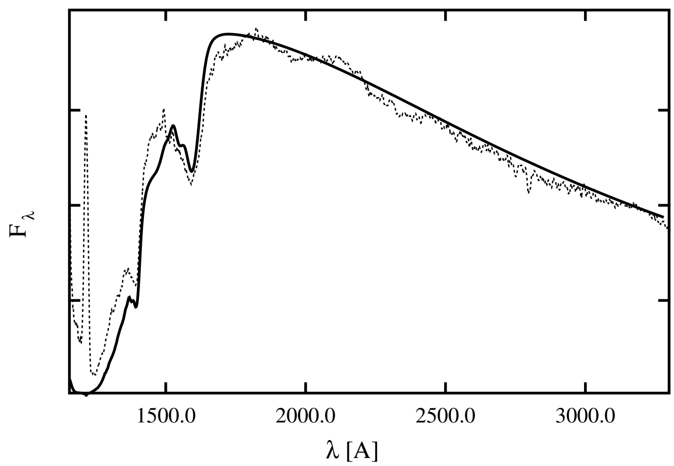

Fig. 2. Model fit to the FOS spectrum with Lyman alpha satellites for the same model as in Fig. 1. (Dotted: observation; thick continuous line: model.

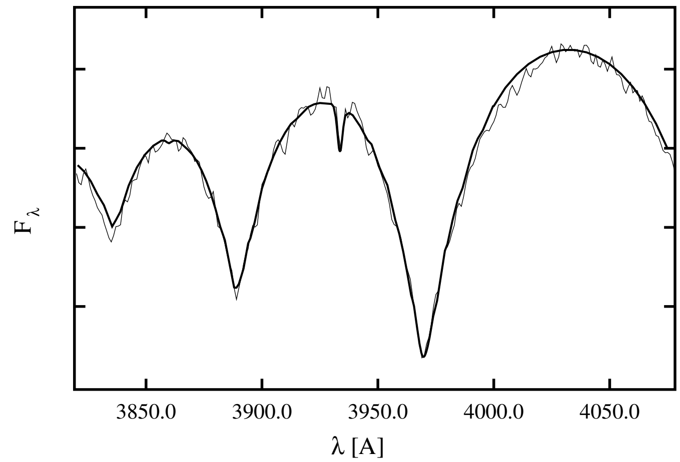

Fig. 3. CaII H resonance line in G29-38

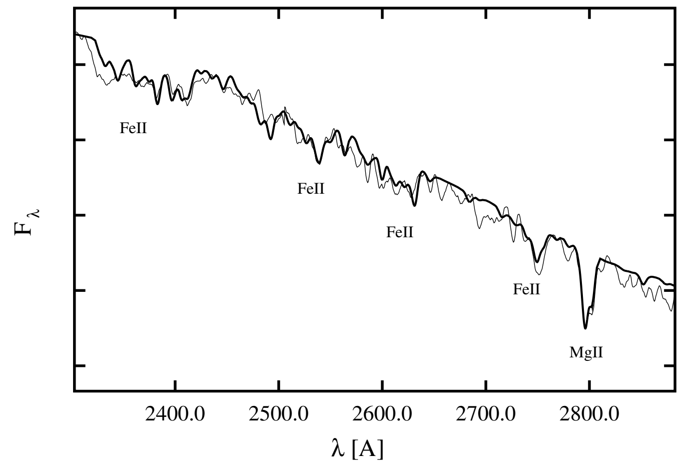

Fig. 4. MgII resonance lines and FeII lines in G29-38

3. Element abundances and discussion

Under the photospheric assumption we have determined the abundances of Ca, Mg, and Fe from detailed comparisons with synthetic spectra. Fig. 3 shows the fit to the CaII line and the higher Balmer lines. Our fit to the region of the MgII resonance lines and the region toward shorter wavelengths, where numerous FeII lines are visible, is displayed in Fig. 4.

The line list used in our calculation is obviously incomplete and the fit to the observations is far from perfect. However, using only stronger features, we believe that the abundances of the 3 elements are fairly well determined. The resulting number abundances (relative to H) are:

$$\mathrm{Mg/H} = (5.5 \pm 1.5)\ 10^{-7},$$
$$\mathrm{Ca/H} = (7.0 \pm 3.0)\ 10^{-8},$$
$$\mathrm{Fe/H} = (6.0 \pm 3.0)\ 10^{-7}.$$

The error estimates are rough estimates derived from comparing the observations with theoretical spectra of different abundances. They do not include contributions from systematic errors of the atmospheric parameters $T_{\rm eff}$ and log g, and of atomic data (e.g. damping constants). More realistic assumptions of the real errors would probably be a factor of 3 in both directions.

The most likely scenario for the interpretation of metal traces in cool white dwarfs (DZ) is accretion from interstellar matter with subsequent diffusion out of the atmosphere and convection zone into deeper layers. This scenario has been studied in a series of 3 fundamental papers by Dupuis et al. (1992, 1993 a,b). Most of the metal traces are found in helium-rich atmospheres, and therefore most of the accretion/diffusion calculations are done for metals in helium. The authors give only one result for Ca in DA atmospheres, with upper temperature limits at 10000 K, because no hotter DA with metals was known at that time. If we, however, extrapolate the curves in their Fig. 5 (Dupuis et al. 1993b) slightly to our higher temperature, our measured Ca abundances agrees exactly with their prediction of the equilibrium abundance for a *high* accretion rate of 5 10^{-15} $M_\odot$ per year. The conclusion we draw is that we are probably observing this object currently in the process of accreting material from its surroundings, lending further support to the interpretation of the infrared excess as due to heated circumstellar material. Even with accretion at a high rate ongoing, the CaII resonance line is weak and has escaped detection in spite of intensive study of this star. Once accretion stops the abundance will decrease rapidly and the metals will become unobservable. This is in sharp contrast with the majority of the DZ class with helium atmospheres. Due to the much smaller opacity of helium metal traces remain visible at much lower abundances and for several million years even after the end of accretion episodes. The fact that almost no DA are known with metal traces is an observational selection effect.

A second DA (WD 1337+705) in the typical temperature range with metal traces (MgII in the optical spectrum) has been found very recently by Holberg et al. (1997). At the higher temperature (20000 K) of this object there is no convection zone serving as reservoir of accreted heavy elements and the time scale for disappearance of Mg out of the atmosphere by diffusion is estimated at a few days only. The authors therefore conclude that accretion must still be going on in this object, similar to our conclusion for G29-38.

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References

Barnbaum C., Zuckerman B. 1992, ApJ 396, L31
Bergeron P. et al. 1995, ApJ 449, 258
Dupuis J., Fontaine G., Pelletier C., Wesemael F. 1992, ApJS 82, 505
Dupuis J., Fontaine G., Pelletier C., Wesemael F. 1993a, ApJS 84, 73
Dupuis J., Fontaine G., Wesemael F. 1993b, ApJS 87, 345
Holberg J.B., Barstow M.A., Green E.M., 1997, ApJ, 474, L127
Graham J.R., McCarthy J.K., Reid I.N., Rich R.M. 1990a, ApJ, 357, L21
Graham J.R., Mathews K., Neugebauer G., Soifer B.T. 1990b, ApJ, 357, 216
Greenstein J.L. 1988, AJ, 95, 1494
Kleinman S.J. et al. 1994, ApJ 436,875
Koester D., Allard N.F., Vauclair G. 1994, A&A 291, L9
Koester D., Allard N.F. 1996, ASP Conf.Ser. 96, 324
Telesco C.M., Joy M., Sisk C. 1990, ApJ, 358, L17
Tokunaga A.T., Becklin E., Zuckerman B. 1990, ApJ, 358, L21
Winget D.E. et al. 1990, ApJ 357, 630
Zuckerman B., Becklin E. 1987, Nature, 330, 138

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