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Spectroscopic Observations of Eleven Cataclysmic Variable Candidates using the Liverpool Telescope

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ABSTRACT

This paper presents spectroscopic observations of eleven candidate cataclysmic variables. Observations of the candidates were performed using the Liverpool Telescope and the SPRAT spectrograph, following initial identification from the Gaia Alerts Index. Through line identification, with supporting evidence from Gaia light curves, nine out of the eleven targets show emission features consistent with that of cataclysmic variables, leading to their classifications as CVs. No obvious emission features are identified in the remaining two, meaning further observations are required for classification.

INTRODUCTION

Modern day all-sky surveys, such as the Gaia Photometric Alerts Index (Hodgkin et al. 2013), provide an effective tool for the discovery of transient events, such as dwarf nova (DN) outbursts. These characteristic outbursts are observed in the DN subclass of cataclysmic variables (CVs: Warner 1995). CVs are semi-detached binary star systems, typically consisting of a white dwarf (WD) primary, accreting mass from a main sequence (MS) companion.

Eleven candidate CVs were identified using the Gaia Photometric Alerts Index, using candidate selection criteria of a quiescent magnitude brighter than ~ 19.5 magnitudes, clear outbursts of amplitude ≥ 2 magnitudes, observable at the time of identification, and no previous classification. Spectroscopic observations were made using the Liverpool Telescope (LT: Steele et al. 2004): a 2-metre, fully robotic, optical-infrared telescope situated at the Observatorio del Roque de los Muchachos on the Canary Island of La Palma, and its spectrograph, SPRAT (Piascik et al. 2014). SPRAT employs a long-slit configuration, with a wavelength range of $4000 - 8000$Å and a resolution of $R \sim 350$. SPRAT also features a two-position adjustable grating, which can be optimised for blue and red wavelength ranges. SPRAT produces fully reduced spectra upon observation, through an automated reduction pipeline, which includes bias-subtraction, sky-subtraction, flat-field correction, wavelength calibration and flux calibration. Two blue-optimised exposures of $600 - 1000$ seconds were taken of each candidate, and merged using a median function. Cosmic rays were identified through discrepancies between the spectra and manually removed, however no correction was applied to the spectra to account for galactic extinction.

RESULTS

The fully reduced, combined spectra of all eleven candidates are shown in Figure 1.

The combined spectrum of Gaia18DHV is the result of two, ten minute exposures taken on 11th March 2025. Identified emissions lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with He I 4388, He I 4471, He I 6678 and He II 5015 emission lines. The continuum of this spectrum is relatively flat, with a slight increase at blue wavelengths.

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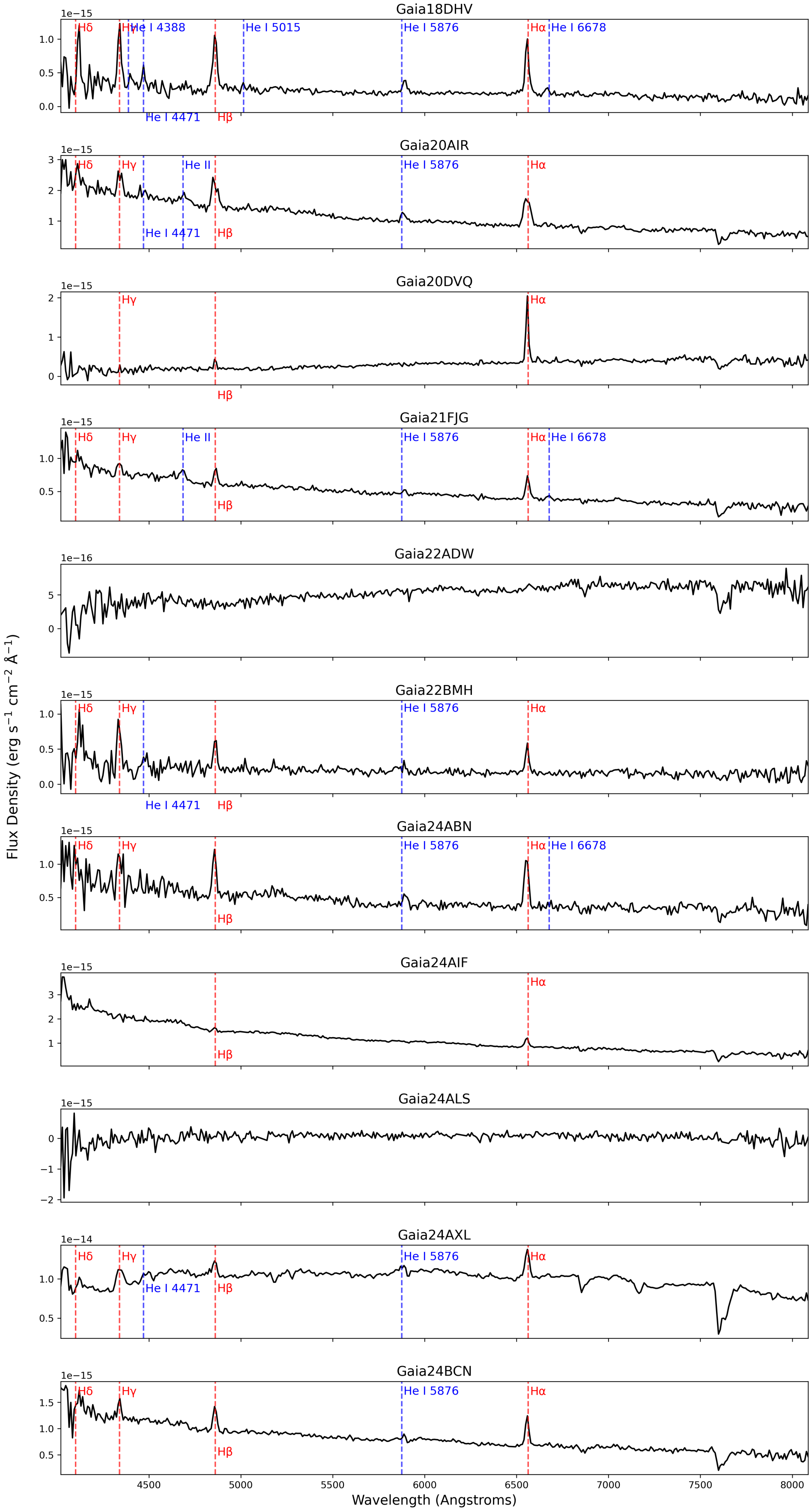

Figure 1. Spectra of 11 candidate CV targets. Identified Balmer series (Red) and He (Blue) emission lines are labelled and highlighted by dotted lines at their rest wavelengths.

The combined spectrum of Gaia20AIR is the result of two, ten minute exposures taken on the 14th March 2025. Identified emission lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with He I 4471, He I 5876 and He II 4686 lines. The emission lines in this spectrum show clear double-peaks, implying a high inclination binary system. The continuum of this spectrum shows an increase in flux density at blue wavelengths, which shows a strong contribution of flux from potentially a hot, blue object, such as a WD, or from a hot spot in the accretion disc.

The combined spectrum of Gaia20DVQ is the result of two, ten minute exposures taken on 26th March 2025. Identified emission lines consist of Hα, Hβ, Hγ. The continuum of this spectrum is relatively flat.

The combined spectrum of Gaia21FJG is the result of two, ten minute exposures, taken on 4th February 2025. Identified emission lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with, He I 5876, He I 6678 and He II 4686 lines. The continuum shows an increase in flux density at blue wavelengths, suggesting a strong contribution of flux from a hot, blue object, such as a WD or potentially a hot spot in the accretion disc.

The combined spectrum of Gaia22ADW is the result of two, ten minute exposures, taken on 6th January 2025, which was the second attempt at observing this target. This spectrum shows no emission features; only telluric absorption lines centred about 7598.800Å.

The combined spectrum of Gaia22BMH is the result of two, ten minute exposures taken on 8th February 2025. Identified emission lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with He I 4471 and He I 5876 lines.

The combined spectrum of target Gaia24ABN is the result of two, ten minute exposures taken on 14th March 2025. Identified emission lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with He I 5876 and He I 6678 lines. The continuum shows an increase at blue wavelengths, along with an increase in noise, which may lead to blended emission features.

The averaged spectrum of target Gaia24AIF is the result of two, ten minute exposures taken on 4th November 2024. Identified emission lines consist of Hα and Hβ lines. The spectrum also shows a increase in flux at blue wavelengths, suggesting a significant contribution of flux from a hot object, such as a WD.

The combined spectrum of target Gaia24ALS is the product of two, twenty minute exposures taken on 8th January 2025. As this target was relatively dim compared to the other targets, longer exposures were used. However, the spectrum shows a flat continuum with no emission features.

The combined spectrum of Gaia24AXL is the result of two, ten minute exposures taken on 19th January 2025. Identified emission lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with He I 4471 and He I 5876 lines. The continuum of this spectrum is relatively flat. Additional features of this spectrum include several absorption characteristics, with the most notable being centred around 7598.80, 7517.2 and 6853.6Å. The spectrum also shows a slight increase in the 4500-4750Å range, which could be the result of blended He I emission lines.

The averaged spectrum of target Gaia24BCN is the result of two, ten mimute exposures taken on 31st October 2024. Identified emission lines consist of Hα, Hβ, Hγ and Hδ Balmer series lines, along with a He I 5876 line. The continuum shows an increase towards blue wavelengths, showing a strong contribution from a hot, blue object such as a WD. Also, there is a visible increase in noise towards the blue end of the spectrum which may result in blended He I emission lines being hidden.

CONCLUSIONS

The spectra of CVs at optical wavelengths are characterised by Balmer series and He I emission features. Through identification of such features, accompanied by evidence of outbursts in their Gaia light curves, nine out of the eleven targets can be classified as CVs. The two remaining candidates, Gaia22ADW and Gaia24ALS, show flat, featureless spectra with no identifiable emission lines. Despite increases in brightness in their Gaia light curves, that may resemble outbursts, these candidates remain unclassified, requiring further observation.

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