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Spectroscopic Monitoring Observations of Nova V1724 Aql in 2012

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Abstract

Spectroscopic and photometric monitoring observations of nova Apl 2012 (V1724 Apl) were conducted at Koyama Astronomical Observatory, Fujii-Kurosaki Observatory and Bisei Astronomical Observatory. The nova was initially considered as an outbursting pre-main-sequence young stellar object. Our monitoring observations have revealed the nova to be a Fe II type classical nova. The temporal evolution of spectra and light curves of the nova were similar to those of a slow nova (e.g., V1280 Sco and V5558 Sgr). We observed no evidence of molecule formation in V1724 Aql in contrast with V2676 Oph in which dust formation occurred after the molecular formation in the nova outflow.

Keywords: cataclysmic variables - classical novae - optical - spectroscopy - photometry - individual: V1724 Aql.

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1 Introduction

Nova Aql 2012 (later named as V1724 Aql) was discovered on 2012 October 20.4 UT (Nishiyama & Kabashima 2012). The brightness of the nova during the discovery was reported as 12.6 mag. Just after the discovery, we conducted our spectroscopic monitoring observations at the Koyama Astronomical Observatory (KAO), Fujii-Kurosaki Observatory (FKO) and Bisei Astronomical Observatory (BAO) in Japan.

The first optical spectrum taken on October 21.4 UT was reported by Fujii (2012) at FKO. The object showed a sharp Hα emission (probably with a P Cygni profile) on a very red continuum. This object was considered a classical nova affected by a severe interstellar extinction (strong absorption of the Na D line was observed). Munari (2012) also reported that the spectrum of this object on October 21.8 UT showed a weak and sharp Hα emission on a very red continuum, with strong Na I and Ba II absorption lines. This spectrum was basically consistent with that reported by Fujii (2012). However, it was considered that the spectrum is more similar to that of an outbursting pre-main-sequence young stellar object than that of a nova before maximum brightness. On 2012 October 23.5 UT, Ayani (2012) also reported the optical spectrum of this object taken at BAO, with Fe II emission and O I emission with a P Cygni profile. This object was finally identified as a Fe II type classical nova according to the classification by Williams (1992).

Here we report the spectroscopic and photometric observations of V1724 Aql performed in a collaboration among three observatories (KAO, FKO and BAO) in Japan.

2 Spectroscopic and Photometric Observations

The observations conducted in our collaboration were follows. Spectroscopic observations were performed at three sites:

1. A 0.4-m telescope with a low-dispersion spectrograph (λ = 4500 — 9000 Å with $R \sim 500$) at Fujii-Kurosaki Observatory,
2. A 1.01-m telescope with a low- and moderate-dispersion spectrograph (λ = 3600 — 9000 Å with $R \sim 1500$ for a low-resolution mode) at Bisei Astronomical Observatory, and
3. A 1.3-m Araki telescope with a low-dispersion

spectrograph LOSA/F2 ($\lambda = 3800 — 8000$ Å with $R \sim 600$; Shinnaka et al. 2013) at Koyama Astronomical Observatory.

In addition to the spectroscopic observations, photometric observations were performed at KAO by the imaging camera ADLER (Araki DuaL-band imagER; Nakagawa et al. 2013) with intermediate and broad-band filters (y-, i'-, and z'-band filters).

Figure 1 shows the spectral evolution of V1724 Aql. Figure 2 shows the light curves (with the multi-band light curves taken from AAVSO database). We also show the close-up views for Hα and O I emission lines to make clear the evolution of their line shapes. Clearly, the line widths increased for later epochs in the case of Hα while the temporal change in the P Cygni profile of O I emission indicated faster expansion velocities at later dates.

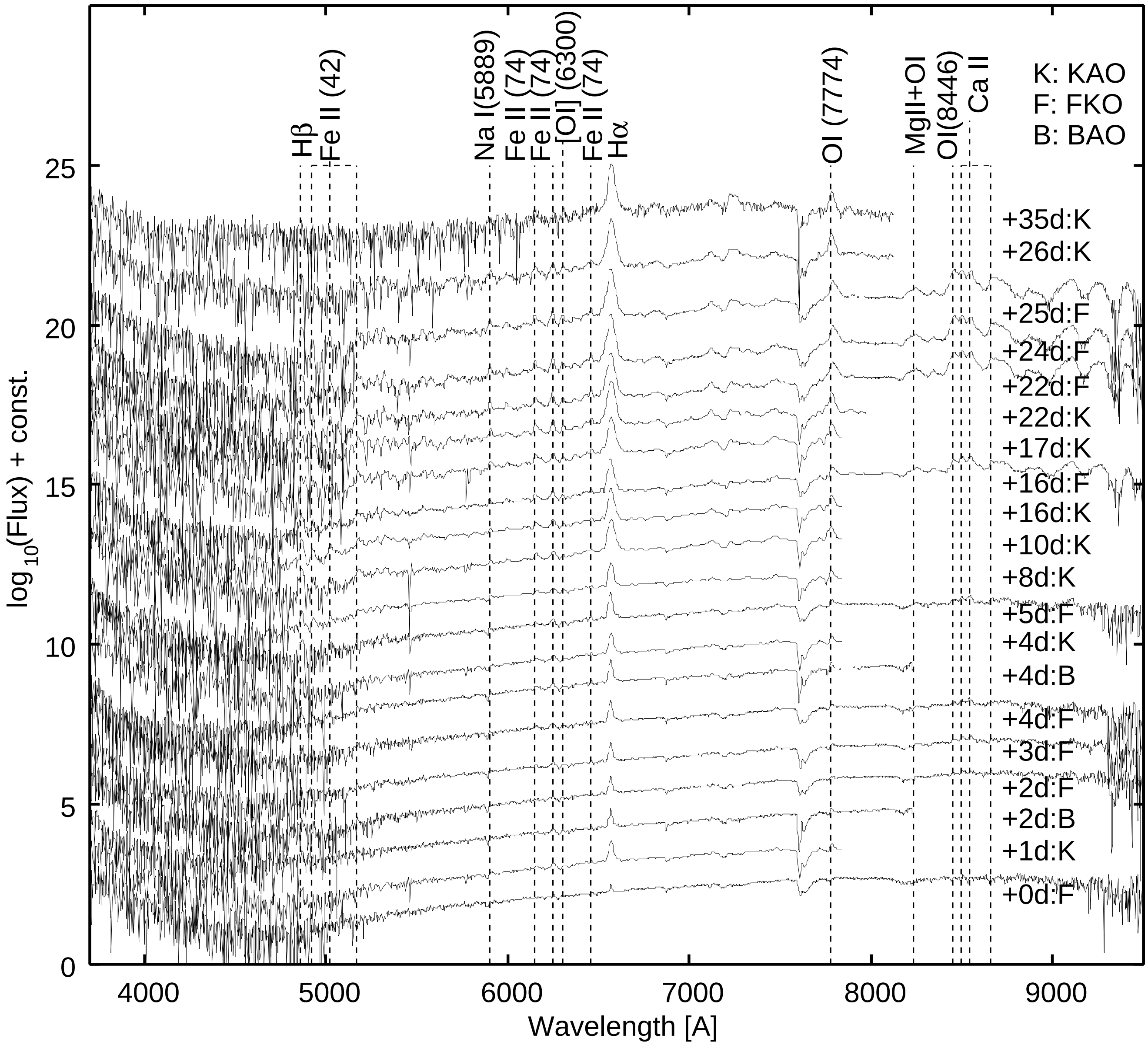

Figure 1: Low-dispersion spectra of V1724 Aql obtained at three sites from 2012 Oct 21 to Nov 25 UT. All spectra are shifted by different offsets for readability. Emission lines were on the highly red continuum. The line width of Hα emission became broader and stronger compared with the nearby continuum, and the Ca II triplet emission lines bacame stronger later. Note that the bluish continuum might overlap with the spectra of the nova in the shorter wavelength region ($\lambda < 4500$ Å), probably due to a forground (or background) star.

3 Discussion and Conclusion

From the viewpoint of the spectral evolution, the spectra of V1724 Aql slowly changed during the period of our observations. Emission lines (Hα, Hβ, Fe II, Na I, O I and Ca II) were on the reddened continuum. We estimated E($B-V$) based on the measurements of Balmer decrement by the method described in Helton et al. (2010), E($B-V$)$\sim$3.1, which indicated severe interstellar extinction for the nova. This value is slightly higher than that reported by Rudy et al. (2012) but both values indicate severe interstellar reddening. Note that the spectra of the nova showed enhancement in a shorter wavelength region ($\lambda < 4500$Å) that appeared similar to a bluish continuum component but was noisier. The nova may be overlapped with another foreground (or background) stellar object that had a high temperature. Although one may consider that we should estimate E($B-V$) based on the ($B-V$) of the nova around the optical brightness maximum, we had to be careful of the contamination with the B-band brightness of the nova.

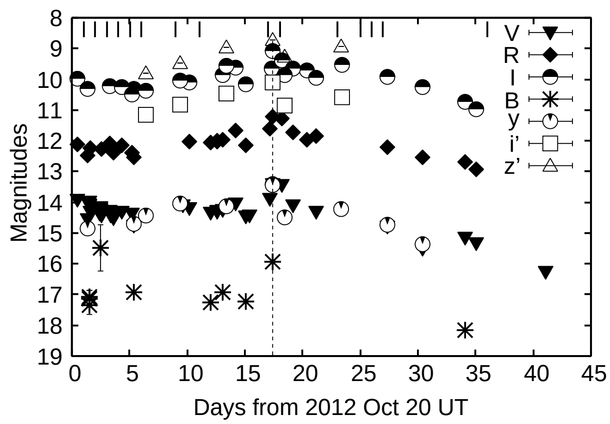

Figure 2: Optical light curves of V1724 Aql obtained at KAO with the multi-band light curves of the nova taken from AAVSO database. The vertical tick-marks at the top of panel indicate the dates of our spectroscopic observations.

The line width of Hα emission had clearly increased and became stronger compared with the nearby continuum, and O I and Ca II triplet emission lines grew at later dates. The ejection velocity was $\sim$400 km/s based on the P Cygni profile of Hα at t=1d after the outburst (Figure 3). It then increased; 630 km/s (t=2d), 640 and 750 km/s (t=5d), and 1150 km/s (t=9d) based on the P Cygni profiles of O I as shown in Figure 4. Finally, the ejection velocity reached $\sim$2000 km/s based on the FWZI of Hα (Figure 3) after the brightness maximum at t=17d. The ejection velocities were slower during the earlier phase, and faster during later phase. Such temporal changes in ejection velocity in V1724 Aql was similar to those of slow novae, e.g., V1280 Sco (Naito et al. 2012) and V5558 Sgr (Tanaka et al. 2011). V1724 Aql was similar to a slow nova from the viewpoint of spectral evolution.

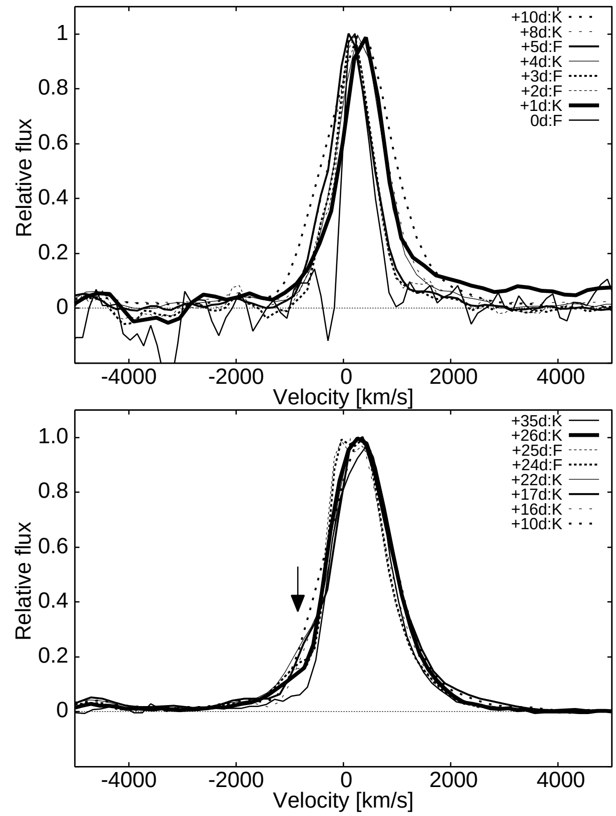

Figure 3: Temporal change of Hα emission line before and after the brightness maximum at t=17d after the outburst (upper and lower panels, respectively). The line widths became broader at later dates. The black arrow in the lower panel shows the change in blue-shift component that could have been caused by the change in the velocity structure of the ejected materials.

Based on the light curves shown in Figure 2, nova V1724 Aql showed very slow evolution in brightness after the outburst until its brightness maximum in the V-band (t=17d, V=13.6$\pm$0.2 mag). The visual brightness was almost unchanged (but oscillating with small amplitude) until the brightness maximum since the outburst (14.4$\pm$0.4 mag in V-band). The evolution in brightness was slow for V1724 Aql in earlier phase. However, after the brightness maximum (t=17d), its brightness in V-band become fainter with a decline rate of +0.14 mag/day (t_2 was 14.3 days). Although this decline rate was indicative of a fast nova rather than a slow nova (Payne-Gaposchkin 1957), the light curves after the brightness maximum might be affected by dust formation as suggested by the molecular formation observed by Rudy et al. (2012).

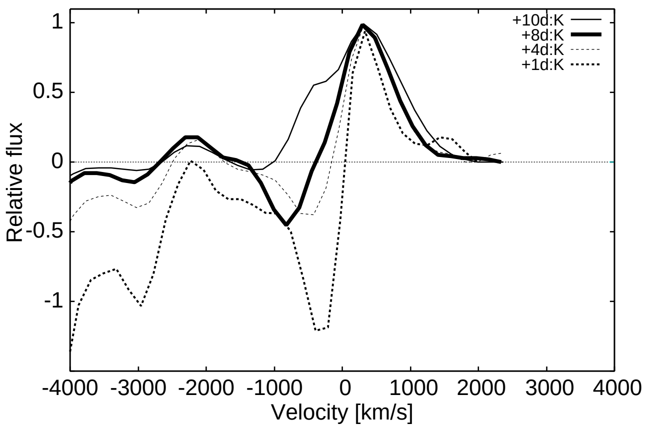

Figure 4: Temporal change of the P Cygni profile for O I (7774 Å at rest) emission line before the brightness maximum. The measured ejection velocites based on the P Cygni profiles were 630 km/s (at t=2d), 640 and 750 km/s (at t=5d), and 1150 km/s (at t=9d).

Rudy et al. (2012) reported the detection of CO molecular emission in the near-infrared spectra taken on 2012 Oct 27 and 28 UT (before the brightness maximum), indicating that molecule formation was ongoing, with dust formation likely to follow. Nova V1724 Aql was probably a slow nova that showed CO emission during the pre-maximum halt (at least, before the maximum). However, there were no hints for C_2 and CN absorption bands in optical spectra of the nova (c.f. V2676 Oph, Nagashima et al. 2014). Those molecular absorption bands were expected to appear during several days (as in the cases of V2676 Oph and DQ Her). Our spectroscopic observations were performed frequently enough to detect them if a considerable amount of molecules formed in the outflow of the nova. We propose the hypothesis that the ejecta of V1724 Aql was oxygen-rich and the atomic carbon might not be over-abundant with respect to the atomic oxygen ($C < O$) in the ejecta. As demonstrated by the model calculations (Pontefract & Rawlings 2004), formation of C_2 (and also CN) is more difficult than CO in an oxygen-rich atmosphere. V1724 Aql might have oxygen-rich ejecta. The spectroscopic observations of V1724 Aql in the nebular phase (if reported in the future) will be helpful to test this hypothesis.

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