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SPECTRAL EVOLUTION OF NOVAE IN THE NEAR-INFRARED BASED ON AKARI OBSERVATIONS

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ABSTRACT

We have carried out the near-infrared spectroscopic observations of recent classical novae (e.g., V2468Cyg, V1280Sco) within a few years from the outburst with AKARI as a part of AKARI Open Time Observing Program for Phase 3-II "Spectral Evolution of Novae in the Near-Infrared based on AKARI Observations (Proposal ID: SENNA)". The homogeneous datasets of near-infrared spectra from 2.5 μm to 5 μm with AKARI/IRC collected in this program are useful to infer the physical conditions of the shell formed by the ejected materials, to examine the chemical properties of the ejecta gas, and to examine the properties of dust formed in the nova ejecta.

Key words: dust, extinction – infrared: ISM – ISM: lines and bands – novae, cataclysmic variables – stars: mass loss

1. INTRODUCTION

Classical Novae provide us with a unique opportunity to explore the dust formation and chemical enrichment processes in the circumstellar environment of evolved low- to intermediate- mass stars. Classical Novae are classified into two fundamentally different types; CO Novae and ONeMg Novae (Gehrz, 1998). ONeMg Novae result from the TNR on high-mass ONeMg White Dwarves with the mass of $M_{WD} >\sim 1.1 M_\odot$. Generally, ONeMg Novae experience the free-free emission phase followed by a coronal line emission phase, where low excitation temperature ($10^3 < T_{ex}$[K] $<10^5$) and high critical density ($10^6 < n_{cr}$[cm^{-3}] $< 10^9$) forbidden lines of heavy ions with ionization potentials of $>$ 100eV emerge (Greenhouse et al., 1993; Woodward et al., 1995). Little or no dust formation has, so far, been observationally reported for ONeMg Novae. CO Novae result from the TNR on low-mass CO White Dwarves with the mass of $M_{WD} <\sim 1.1 M_\odot$. CO Novae experience the free-free emission phase often followed by a dust formation phase. In this paper, we present the near-infrared spectra of V2468 CYGNI and V1280 SCORPII obtained with AKARI/Infrared Camera (IRC; Onaka et al., 2007).

2. V2468 CYGNI

The nova V2468 CYGNI was discovered on 2008 March 7.8UT (Nakano, 2008). The distance to V2468 CYGNI was estimated to be $d = 5.5 \pm 0.8$kpc(Iijima & Naito, 2011). Iijima & Naito (2011) reported that the nova had entered the nebular stage by the epoch of 122 days after the light maximum based on the optical spectroscopy with medium dispersion performed on 2008 July 8. Near-infrared (2.55–4.9μm) spectrum of V2468

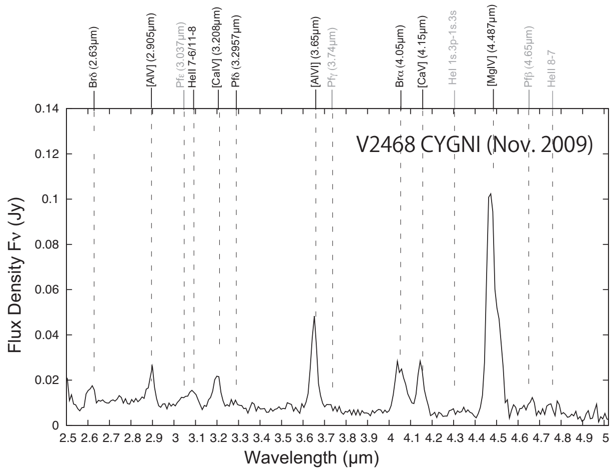

Figure 1. Near-infrared spectrum of V2468 Cyg at Day 605.

CYGNI was taken with AKARI/IRC on 2009 November 2 (605 days after the discovery). In addition to some hydrogen recombination lines, strong "coronal" lines with higher ionization potentials (e.g., [MgIV] at 4.487μm with $\epsilon_{\rm ex} = 80.1$eV, [AlV] at 2.905μm with $\epsilon_{\rm ex} = 120.0$eV, [AlVI] at 3.65$\mu$m with $\epsilon_{\rm ex} = 153.8$eV etc) are seen in the near-infrared spectrum of V2468 CYGNI at Day 605 (see Figure 1) and their strengths are summarized in Table 1. Assuming the Case B for hydrogen recombination lines (Osterbrock, 1989; Hummer & Storey, 1987; Storey& Hummer, 1995), electron density and electron temperature of V2468 CYGNI at Day 605 are estimated as $n_e \sim 10^{12}$ cm^{-3} and $T_e >$ a few thousands K, respectively. Dust formation has not been recognized for V2468 CYGNI from our dataset. Those behaviors in the infrared wavelength are consistent with a classification of V2468 CYGNI as an ONeMg Nova in a coronal emission line phase.

3. V1280 SCORPII

The nova V1280Sco was discovered on 2007 February 4.86 (Yamaoka et al., 2007). V1280 Sco is classified as a FeII nova from its early optical spectrum (Munari et al., 2007) and, thus, is expected to be caused by an explosion on a CO white dwarf. The onset of dust formation around the V1280Sco was reported on 23 days after the discovery (Das et al., 2008; Rudy et al., 2007). These characteristics are consistent with a classification of V1280Sco as a CO nova (Das et al., 2008). Near-infrared (2.55–4.9μm) spectrum of V1280Sco was taken with AKARI/IRC on 2009 September 8 (940 days after the discovery). An unidentified infrared (UIR) band feature at 3.3μm was recognized over a strong red continuum emission (see Figure 2). This feature

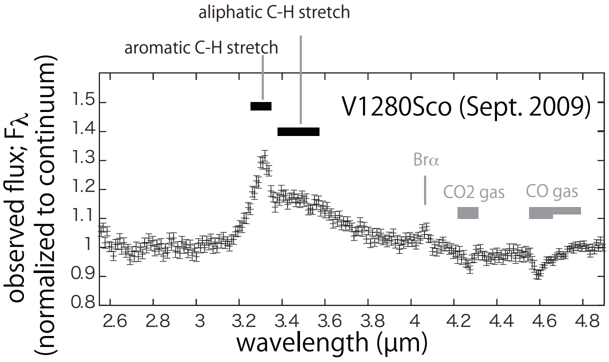

Figure 2. Near-infrared spectrum of V1280Sco at Day 940 obtained with AKARI/IRC. The spectrum is normalized to the underlying continuum emission. A small feature at 4.05μm is Brα. Absorption features at 4.25 and 4.6μm are possibly due to CO_2 gas and CO gas, respectively.

exhibits a strong red-tail in 3.4–3.6μm which is possibly contributed by aliphatic C-H streching mode. The observed high aliphatic-to-aromatic ratio of V1280Sco at Day 940 is consistent with the understanding that UIR features in novae are likely to be carried by hydrogenated amorphous carbons (HACs) rather than free-flying polycyclic aromatic hydrocarbons (PAHs) (Evans & Rawlings, 1994).

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REFERENCES

Das, R. K., et al. 2008, Near-infrared studies of V1280 Sco (Nova Scorpii 2007), MNRAS, 391,1874

Evans, A. & Rawlings, J. M. C., 1994, PAH Emission in Novae / Polycyclic Aromatic Hydrocarbons, MNRAS, 269, 427

Gehrz, R. D., 1998, IR Phenomena in Classical Novae: Quantitative Analysis of Parameters Describing the Outburst and Determination of Abundances in the Ejecta, ASPC, 137, 146

Table 1
Strengths of hydrogen recombination lines and coronal lines of V2468 CYGNI at Day 605.

Lines	Brβ	Pfγ	Brα	[CaIV]	[CaV]	[MgIV]	[AlV]	[AlVI]
Wavelength(μm)	3.74	2.63	4.05	3.207	4.150	4.487	2.905	3.650
Flux (10^{-16}Wm^{-2})	2.8±0.1	1.8±0.2	0.4±0.1	1.9±0.1	1.7±0.1	8.9±0.1	2.3±0.1	3.4±0.1

Greenhouse, M. A., et al., 1993, Infrared coronal emission lines and the possibility of their laser emission in Seyfert nuclei, ApJS, 88, 23

Hummer, D. G. & Storey, P.J., 1987, Recombination-line intensities for hydrogenic ions. I - Case B calculations for H I and He II, MNRAS, 224, 801

Hyland A. R. & McGregor, P. J., 1989, PAH emission from nova Cen 1986, Proc. of IAU Symp., 135, 101

Iijima.T. & Naito, H., 2011, Spectral evolution of the nova V2468 Cygni: asymmetric and variable profiles of its emission lines, A&A, 526, A73

Munari, S., et al., 2007, V1280 Scorpii, Central Bureau Electronic Telegrams, 1099, 1

Nakano, S., 2008, Nova Cygni 2008, IAU Circ., 8927, 2

Onaka, T., et al., 2007, The Infrared Camera (IRC) for AKARI – Design and Imaging Performance, PASJ, 59S, 401

Osterbroch, D. E., 1989, Astrophysics of gaseous nebulae and active galactic nuclei, University Science Books

Rudy, R. J., et al., 2007, Infrared and Optical Spectroscopy of the Nova V1280 Scorpii, Bulletin of the American Astronomical Society, 39, 817

Storey, P. J. & Hummer, D. G., 1995, Recombination line intensities for hydrogenic ions-IV. Total recombination coefficients and machine-readable tables for Z=1 to 8, MNRAS, 272, 41

Woodward, C. E., et al., 1995, The temporal evolution of the 1-5 micron spectrum of V1974 CYGNI (Nova Cygni 1992), ApJ, 438, 921

Yamaoka, H., et al., 2007, V1280 Scorpii = Nova Scorpii 2007, IAU Circ., 8803, 1