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EXPANSION VELOCITY AND SPECTROSCOPIC CLASSIFICATION OF NOVA DELPHINI 2013

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ABSTRACT

Low resolution spectra of Nova Delphini 2013 (V339 Del) in the optical range have been obtained at Bosscha Observatory, Indonesia during its maximum light (V = 4.3). Spectra were observed from August 16 to 27, 2013. The GAO-ITB RTS 20.3 cm telescope, and SBIG DSS-7 spectrograph and SBIG ST-7 XE as the detector have been employed throughout the observations. The spectra show P-Cygni profiles in Balmer, NaI'D' and Fe II lines, from which we determined shell expansion velocities of 1421.66±39.18 km/s, 1227.54±21.57 km/s and 1402.86 km/s, respectively. Our spectroscopic observations followed the spectral evolution of V339 Del from the pre-maximum phase to early Orion phase. The characteristics of the nova Delphini 2013 resembles those of Fe II-type novae.

Key words: stars: double star, stars: novae, cataclysmic variables stars: white dwarfs techniques: spectroscopic stars: individual: V339 Del

1. INTRODUCTION

Nova Delphini 2013 (V339 Del) was first discovered by Koichi Itagaki (Teppo-Cho, Yamagata, Japan) and reported by S. Nakano (Sumoto, Japan) at mv = 6.8. Itagaki discovered this object in August, 14.584 UT and he measured a position of R.A.= 20h 23m 30.73s and Dec. = +20d 46m 4.1s (J2000). The nova increased in brightness to mv = 4.3 by August, 16th. The spectrum showed the P-Cygni profile in its prominent emission lines during the maximum.

2. OBSERVATIONS

Observations were carried out at Bosscha Observatory, Indonesia from August 16 to 27, 2013. Using a GAO-ITB Remote Telescope System with 8 inch aperture and focal ratio 10 as the collector, and as the spectrograph a SBIG DSS-7 and CCD SBIG ST-7 XE (765× 510 pixel, 9 pixelsize). We used an Hg lamp and HR7950 as wavelength and flux calibrators, respectively. The combination of our instruments gave a resolution of about 400 with an effective wavelength coverage of 4000 to 8000 Å. During the nearly two weeks of observations, only 8 spectra were obtained for each day, due to the weather.

3. DATA REDUCTION AND ANALYSIS

We used IRAF (Image Reduction and Analysis Facility) to do the data reduction and analysis. We dark-substracted and flat field-corrected the data to reduce the noise. Spectroscopic reduction was carried out using the twodspec and onedspec packages in IRAF. This process resulted in wavelength and flux calibrated spectra. The spectrum of V339 Del on Aug. 16, around pre-maximum brightness, showed a stellar-like spectrum with absorption lines dominating. Balmer lines in P Cygni profile were seen, but weaker than the other spectra. The Fe II emission line also showed a P Cygni Profile. On Aug. 17, the emission lines became dominant compared to the Balmer lines, and Fe II were also intense. In the spectrum of Aug. 18, the emission lines were more intense than Aug. 17 with the addition of the NaI'D' emission line showing a P Cygni Profile. The next spectrum, on Aug. 21 did not show a P Cygni Profile in the Balmer lines. The Balmer lines became strong diffuse emission lines, still dominated by the Fe II lines. The spectrum of Aug. 27 showed the OI line becoming stronger, which can be explained by Nova Delphini 2013 entering the Orion phase.

4. DISCUSSION

To derive the shell expansion velocity of the object, we carried out measurements of the wavelength of the absorption and emission components of the P Cygni profile. Before measuring the shell expansion velocity, we measure the radial velocity using the Doppler relationship:

$$V_r = \frac{\lambda_{abs} - \lambda_{emi}}{\lambda_o}. \quad (1)$$

Correction due to the velocity of the Earth revolution around the Sun is needed. The heliocentric correction equation is given by

$$V_{helio} = V_x cos\delta cos\alpha + V_y cos\delta sin\alpha + V_z sin\alpha. \quad (2)$$

The result of measuring the shell expansion velocity from 8 spectrum in 3 chemical lines is showed in Tables 2, 3, 4, and 5. We measured velocities of the Balmer line of 1421.66±39.18 km/s, in NaI'D' of 1227.54±21.57 km/s, and of Fe II of 1402.86 km/s.

5. CONCLUSIONS

In the above discussion we concluded that Nova Delphini 2013 was classified as an Fe II type of nova. This conclusion was derived from the shell expansion velocity and from the domination of Fe II emission lines in the spectra. The shell expansion velocity measured from different elements had different values. Consequently, we can conclude that the nova had multiple shells during its ejection (Osterbrock 1989).

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Table 1

Identification of emission features in 8 spectrum (for double wavelength insist of absorption and emission features of P Cygni profiles)

Elements	λobs (Å)							
	20130816	20130817	20130818	20130821	20130822	20130824	20130826	20130827
Hδ	4124.74	3990.91	3959.12	4002.64	3994.29	-	4117.34	4078.99
	4142.69	4007.65	3980.59					
FeII	-	-	4110.10	-	-	-	4188.77	4158.45
FeII	-	-	4186.57	4208.57	4201.75	-	4247.94	4224.46
FeII	-	-	4254.20	4265.70	4261.21	-	4311.89	4294.80
Hγ	4343.02	4356.07	4329.63	4373.93	4370.58	4264.31	4354.54	4340.85
	4362.14	4374.10	4348.76					
FeII	-	-	4420.23	4544.27	4579.69	4438.12	4528.59	4526.76
FeII	-	-	4590.45	4610.43	4607.04	4506.21	4558.89	4562.39
FeII	-	-	4630.87	4655.19	4653.60	-	-	-
NIII	-	-	-	-	-	-	4637.32	4647.22
Hβ	4829.62	4863.82	4833.22	4883.85	4882.46	4794.68	4863.60	4883.94
	4854.64	4888.41	4855.30					
FeII	-	4954.25	4927.31	4946.05	4943.99	4861.63	4925.29	4946.91
FeII	-	5024.64	5013.73	5040.96	5038.7	4960.61	5019.46	5045.20
FeII	5128.83	5214.85	5187.86	5199.28	5189.09	5119.81	5166.62	5197.06
	5153.00							
FeII	-	5254.47	5226.55	5252.90	5251.85	5183.75	5233.56	5259.72
FeII	-	5295.76	5269.11	5295.40	5293.19	5226.56	5275.41	5302.72
FeII	-	-	-	5334.80	5331.45	5268.17	5313.38	5342.27
NaI'D'	-	-	5869.77	5890.08	5885.72	5850.79	5867.98	5897.58
			5890.65	5913.25	5912.34	5873.87	5895.27	5921.86
FeII	-	6196.66	6152.96	6169.48	6164.17	6143.47	6145.61	6174.72
FeII	-	6263.25	6235.95	6255.99	6255.31	6239.01	6236.09	6266.37
FeII	-	6323.31	6293.06	6313.40	6309.32	6298.48	6291.28	6323.03
[OI]	6356.91	-	-	-	-	-	-	-
Hα	6508.68	6548.95	6523.33	6576.17	6575.27	6571.84	6557.46	6591.55
	6543.55	6583.29	6552.67					
NI	7455.40	7580.46	7527.35	7499.33	7507.10	-	-	-
OI	-	-	7789.60	7815.79	-	7858.11	7785.57	7938.36

Table 2a and 2b

Measurements on Balmer line. All wavelengths are in Å and velocities are in km/s

Spectrum	Δλ,Hα	Δλ,Hβ	Δλ,Hγ	Δλ,Hδ	Vr,Hα	Vr,Hβ	Vr,Hγ	Vr,Hδ	V,helio
20130816	-34.87	-25.02	-19.12	-17.95	-1593.98	-1544.03	-1321.51	-1312.87	-3.55
20130817	-34.34	-24.59	-18.02	-16.74	-1569.98	-1517.62	-1245.82	-1224.59	-3.99
20130818	-33.34	-22.08	-19.12	-21.47	-1524.14	-1362.78	-1321.99	-1570.18	-4.81

Spectrum	Vexp,Hα	Vexp,Hβ	Vexp,Hγ	Vexp,Hδ	Vexp, H
20130816	-1590.43	-1540.48	-1317.96	-1309.32	-1439.55
20130817	-1566.00	-1513.63	-1241.83	-1220.60	-1378.76
20130818	-1519.33	-1357.97	-1317.18	-1565.37	-1439.96

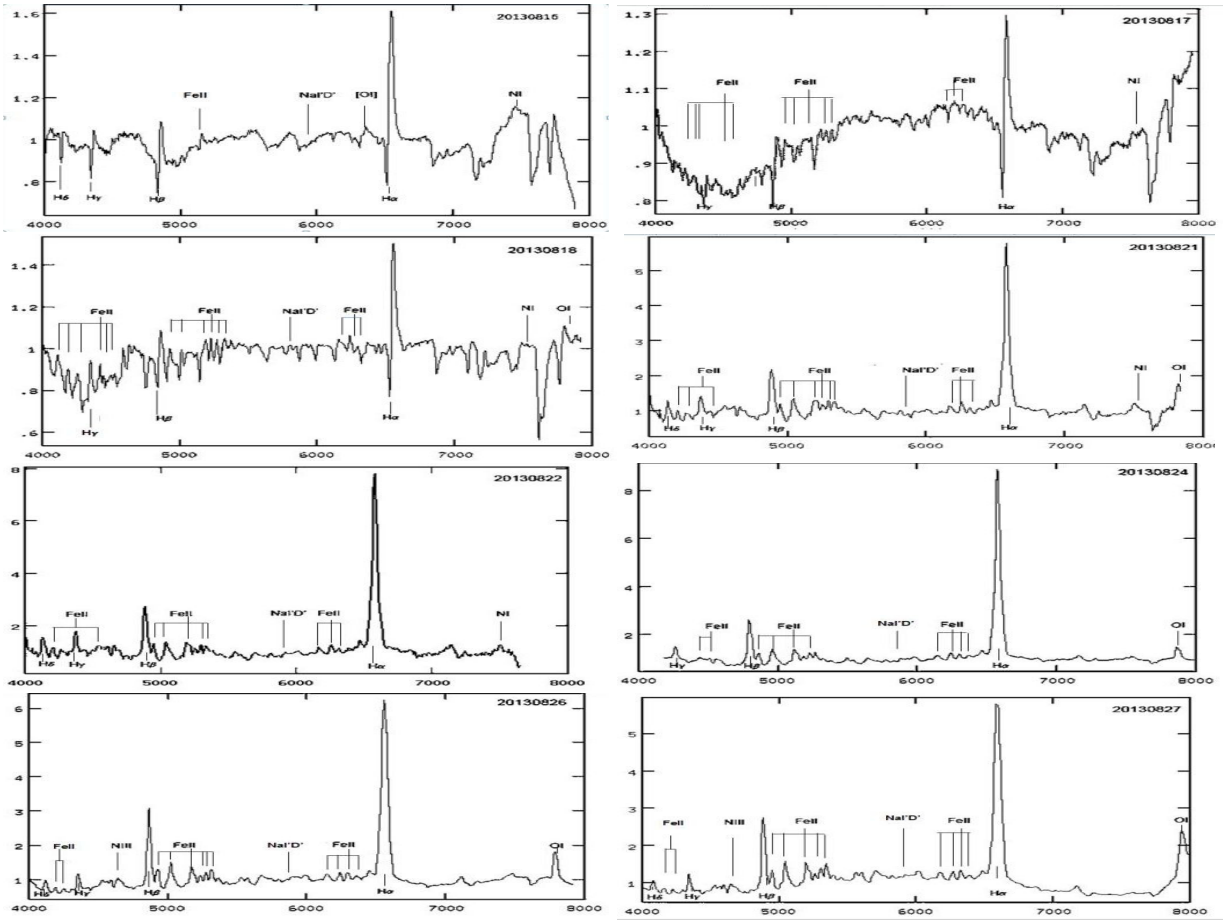

Figure 1. Spectra of 8 day of observations of Nova Delphini 2013

Table 3

Measurements on NaI'D' line. All wavelengths are in Å and velocities are in km/s

Spectrum	Δλ,NaI'D'	Vr,NaI'D'	V,helio	Vexp,NaI'D'
20130818	-20.88	-1063.68	-4.81	-1058.87
20130821	-23.17	-1180.34	-5.37	-1174.97
20130822	-26.62	-1356.09	-5.68	-1350.41
20130824	-23.08	-1175.75	-6.52	-1169.23
20130826	-27.29	-1390.22	-7.15	-1383.07
20130827	-24.28	-1236.88	-8.18	-1228.70

Table 4

Measurements on Fe II line. All wavelengths are in Å and velocities are in km/s

Spectrum	Δλ,Fe II	Vr,Fe II	V,helio	Vexp,Fe II
20130816	-24.77	-1406.413	-3.55	-1402.86