THE SPECTRUM OF NOVA DQ HERCULIS (1934) IN 1950*

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Received January 24, 1952

ABSTRACT

Seven spectrograms of Nova DQ Herculis obtained in May and October, 1950, reveal that the striking changes in the spectrum of the nebulosity observed between 1942 and 1949 continue, while the mean velocity of expansion remains practically the same as in previous years.

The spectrograms of Novo DQ Herculis obtained in 1947 and 1949 revealed striking changes in the nebular spectrum of this nova since 1940.[1] The [*O* III] lines, which were of very high intensity in 1940 and 1942, had become weak; [*Ne* III], [*Ne* V], and [*Fe* VII] had almost disappeared. On the other hand, λ 4686 *He* II had increased in intensity relative to the Balmer lines. The nebular spectrum was progressing toward a stage characterized by strong [*O* II], *He* II, *N* III, and $H\alpha$, the other usual emissions, especially [*O* III] and [*Ne* III], having practically disappeared. Such an evolution is of interest in relation to the physical problems presented by the planetary nebulae as well as by the nova shells.

For this reason it appeared of interest to secure additional spectroscopic material on this nova. Seven spectrograms were obtained with the Cassegrain spectrograph of the McDonald Observatory, on May 20 (two plates), 21, 22, 23, 30, and October 17, 1950, using the quartz and glass prisms and the $f/1$ and $f/2$ cameras. Three of these spectrograms are excellent, especially that of May 22, which was measured twice. The slit passed through the nucleus in an east-west direction, hence at an angle of approximately 45° with the axis of the shell. The magnitude of the nucleus was estimated as between 14 and 15, that is, very nearly the same as before the outburst ($m_p = 14.6$).

The nucleus has a very intense continuous spectrum in the ultraviolet; actually this continuum is still intense at λ 3400. There seem to be very broad intensity fluctuations in the continuum, somewhat like the wide emission lines of a Wolf-Rayet spectrum. However, these suspected features are too faint and too wide for measurement. At any rate, the nucleus must be a very hot object.

The $H\beta$, $H\gamma$, and $H\delta$ lines still reveal the double structure which was studied in previous years. Of all the hydrogen lines, $H\gamma$ provides the most accurate value for the separation between the components. $H\alpha$ is perturbed by [*N* II]. The dispersion at $H\beta$ is lower than at $H\gamma$, and $H\delta$ is asymmetrical on account of the blending by *N* III lines. The two maxima in $H\gamma$ are measured at λ 4338.0 and λ 4346.7, giving a separation of 8.7 A or 601 km/sec. The mean velocity of expansion in 1950 is thus 300 km/sec, that is, the same as in 1949, 1947, and 1942. The resolution of our 1950 spectrograms is too low to permit us to determine accurately the range in velocities by the measurement of the outer and inner edges of the components. From a comparison with spectrograms of the same resolution obtained in 1949, 1947, and 1942, it is evident that the range in velocities has not changed much.

Table 1 describes the 1950 emission spectrum. The first column lists the wave lengths of the intensity maxima in the lines, except for $H\beta$, $H\gamma$, and $H\delta$, where the centers of the doublets are given. The approximate extensions of the lines are tabulated in the second

* *Contributions from the McDonald Observatory, University of Texas*, No. 211.

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[1] P. Swings and P. D. Jose, *Ap. J.*, **110**, 475, 1949.

column. The wave lengths have been corrected for the radial velocity of the nova, assuming $v = -33$ km/sec, as found by Humason.[2] The intensities in successive years are given in the third to seventh columns.[3]

Examination of Table 1 reveals the following variations in the spectrum: (*a*) [*Ne* v], which was fairly strong in 1940, is now absent or too weak to appear on the continuous background (which is still fairly strong at γ 3426); (*b*) [*Ne* III] is no longer observed in

TABLE 1

THE EMISSION SPECTRUM OF NOVA DQ HERCULIS

MEAN λ	APPROXIMATE EXTENSION	INTENSITIES					IDENTIFICATION
		1950	1949	1947	1942	1940	
3425.8	....	Absent	*	0?	0–1	3	[*Ne* V]
3587	....	Absent	*	0	0	1	[*Fe* VII]
3727.2	3719–3734	20	15	8	5	6	[*O* II]
3756.8	3751–3763	2	5	3	3	6	*H*12, *O* III
3774.3	....	0	2	......	......	2	*H*11
3797.9	....	0	3	2	1	2	*H*10
3839.3	....	1	5	2	1–2	3	*H*9
3869	....	Absent	0–1	1	1–2	6	[*Ne* III]
3889.3	3880–3899	4	7	3	3	6	*H*8, *He* I
3916.4	....	0	......	......	......	......	*C* II
3970.4	3962–3978	2	8	4	4	7	*H*ε
4032.6	....	0	3	1	1–0	1	(*He* I)
4069.9	4062–4080	4	8	3	2	4	[*S* II]
4100.2†	4092–4110	25	20n	10n	10	7	*H*δ, *N* III
4268.0	4260–4275	2	5	4	2–3	3	*C* II
4341.6‡	4330–4350	10	10	8	8	6	*H*λ
4363.8	....	1	6	4	4	4	[*O* III]
4381.3	4372–4388	2	7	5	4	3	*N* III
4641.6	4628–4655	8	11	10	10	6	*N* III
4686.3	4675–4697	12	12	8	7	5	*He* II
4862.3§	4847–4875	10	10	12	12	8	*H*β
4918.1	....	1	......	......	......	1	(*He* I)
4964.8	....	0	2	10	20	15	[*O* III]
5006.7	4999–5016	2	6	15	30	25	[*O* III]
5276	....	Absent	Absent	1–0	*	1	[*Fe* VII]
(5755)	....	Absent	0–1	1–2	*	6	[*N* II]
5876	....	1	2	3	*	4	*He* I
6086	....	Absent	Absent	*	*	1	[*Fe* VII]
6301.0	6286–6316	6	2	*	*	5	[*O* I]
6362.6	....	1	1	*	*	3	[*O* I]
6566.9	6533–6604	100	50	*	*	15	*H*α, [*N* II]

* Region not covered.
† Components of the doublet at 4098.0, 4106.1.
‡ Components of the doublet at 4338.0, 4346.7.
§ Components of the doublet at 4857.3, 4865.7.

1950; (*c*) [*O* II] has become very strong; (*d*) the auroral transition as well as the nebular transitions of [*O* III] has become very weak; (*e*) the nebular transitions of [*N* II] are blended in *H*α, but the auroral transition λ 5755 is not observed; (*f*) *He* I has become weaker relative to *H* and *He* II.

[2] *Pub. A.S.P.*, **55**, 74, 1943.

[3] P. Swings and O. Struve, *Ap. J.*, **92**, 295, 1940; **94**, 296, 1941; and **96**, 468, 1942; P. Swings and P. D. Jose, *op. cit.*

Our spectrograms integrate over regions of the nebulosity where different physical conditions prevail. In some cases the central part of the nova was trailed; on other spectrograms it was kept as stationary as average seeing conditions permitted on a weak and diffuse object like N Her. Our material corresponds to the central part of the nebulosity. Accurate guiding on the nucleus was never possible. On two plates the tips of the lines (outer ends of the ellipses) are fully separated from the "continuous" spectrum of the nucleus. From the Mount Wilson spectrograms[2] taken around 1942 and from direct photographs[4] it was apparent that the emitting atoms giving rise to the luminosity of the various parts of the nebulosity were not the same. Nevertheless the observed variations of the global nebular spectrum are puzzling. The disappearance of [*Ne* III], [*Ne* V], and [*Fe* VII], the fading of [*O* III], and the enhancement of [*O* II] point to a general decrease in ionization and density. However, the strengthening of *He* II relative to *H* and especially to *He* I would indicate that, at least in parts of the nebulosity, the ionization of *He* has increased. The great intensity of *N* III parallels the relative strengthening of *He* II. It appears likely that the strong variations of the integrated spectrum of the nebulosity are, at least partly, related to the inhomogeneity of the shell. Already in 1942 Baade[4] had clearly shown that [*N* II] regions were imbedded within the [*O* III] nebulosity. The evolution of regions where different physical conditions prevail must also be different. However, this does not exclude departures of the ultraviolet radiation of the nucleus from that of a black body,[1] resulting in an irregular distribution among the stages of ionization[5] or in peculiar fluorescence phenomena.

Our thanks are due Dr. J. W. Swensson for his help with the measurements and reductions.

[4] W. Baade, *Pub. A.S.P.*, **54**, 244, 1942.

[5] I. S. Bowen and P. Swings, *Ap. J.*, **92**, 105, 1947.