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SN 1994W: UNPRECEDENTED BRIGHTNESS DECLINE AT LATE STAGE

Supernova (SN) 1994W in NGC 4041 was discovered by Cortini and Villi (1994) on July 29, 1994. Precise position was measured by Pollas (1994): $\alpha = 11^{\rm h}59^{\rm m}37\overset{\rm s}{.}67$, $\delta = +62°25'14\overset{''}{.}6$ (1950.0); the corresponding offset from the center of the galaxy is $7\overset{''}{.}8$ west and $17\overset{''}{.}5$ north.

The spectroscopic observations obtained in the period July 31 – August 13 were reported by Bragaglia *et al.* (1994), Filippenko and Barth (1994), Cumming *et al.* (1994). They showed that SN 1994W was a peculiar type II supernova. Relatively narrow (FWHM = 1200 km/s) hydrogen Balmer emission lines were superimposed on much broader bases (FWZI = 7500 km/s); broad (FWHM about 5000 km/s) He I 587.6-nm emission was also visible, with no narrow component. The Balmer lines did not show broad P–Cyg absorption. However, they did exhibit narrow (FWHM = 300 km/s) P–Cyg absorption components with minima displaced by 700 km/s from the emission-line cores. The broad (FWHM 2000 km/s) emission in He I at 447.1 and 706.5 nm, and narrow P–Cyg lines of Mg II, Si II, and O I were also identified. The constancy of the H I profiles and the presence of narrow P–Cyg absorption allowed to suggest that the supernova was exciting a massive, dense circumstellar shell, rather than a radiatively accelerated stellar wind. The similarity of these spectra with the spectra of SN 1984E was noted by Gaskell (1994).

CCD photometry of SN 1994W was reported by Bragaglia *et al.* (1994) and Mikuz (1994). Richmond *et al.* (1994) reported CCD observations in the R band obtained in July with respect to our comparison star 3. From our data we estimated R magnitude for this star ≈ 13.8 and calculated corresponding magnitudes for supernova. Visual brightness estimates were reported by Cortini and Villi (1994), Spratt (1994), Vanmunster (1994), Hasubick (1994) and Szentasko (1994).

We started photographic observations of SN 1994W on September 8 using 70-cm reflector in Moscow and 50-cm meniscus telescope at Crimea. The star was quite bright in September and October but quickly faded below the limit of our plates early in November. The comparison sequence used for the reduction of plates is shown in Figure 1, and the magnitudes of comparison stars are presented in Table 1. The observations of supernova are reported in Table 2, the light curve is shown in Figure 2.

The data presented in Figure 2 show that supernova was brightening until about August 2–6 (JD 2449566–570). Unfortunately, in August only visual brightness estimates were obtained, and their comparison with CCD data and the intrinsic scatter show that they have large systematic and random errors. So it is difficult to determine the date and magnitude at maximum light, but it is most probable that in August SN 1994W remained at nearly constant brightness $V \sim 13.6 - 13.8$. In September and October the brightness declined linearly at a rate 0.034 mag/day in the B band and 0.029 mag/day in the V.

The $B-V$ color was quite blue and increased very slowly from about 0.2 to 0.4. After October 29 the decline rate in B increased greatly up to about 0.3 mag/day. The decline in V also steepened in similar way some days later. The observed decline rate is about twice the fastest rate for type Ia and Ib supernovae. For type II the fastest decline in B at the rate 0.37 mag/day was observed for SN 1993J immediately after the first maximum light. No known supernovae have such high rate of decline at phase $\sim$ 80 days past maximum. Similar shape of the light curve was observed for SN 1987B (Tsvetkov, 1989), but with much slower decline after the linear part of the curve. So the light curve of SN 1994W appears to be unique.

If we assume the distance 22.7 Mpc to NGC 4041 from Tully (1988), then at maximum SN 1994W reached the absolute magnitude about -18, quite normal for type II supernovae. The fast brightness decline started at $M_B \approx -16$, and the upper limit on November 8 corresponds to $M_B = -13.3$. SN 1994W could have the exponential tail starting at about the same luminosity as for type II supernovae 1980K and 1987A. Observations of SN 1994W at very late stage are needed to reveal the nature of this unique object.

Table 1
Magnitudes of comparison stars

Star	B	V
1	14.05	13.18
2	14.58	14.01
3	14.84	14.27
4	15.42	14.67
5	15.77	15.10
6	16.60	15.50
7	17.35	16.35
8	17.64	

Table 2
Observations of SN 1994W

Date		JD 2449000+	B	V
Sep	8.83	604.33	14.21	14.00
	16.81	612.31	14.49	14.18
Oct	6.76	632.26	15.12	
	28.91	654.41	15.90	
Nov	1.95	658.45	17.28	15.53
	6.99	663.49		[16.5
	8.97	665.47	[18.5	

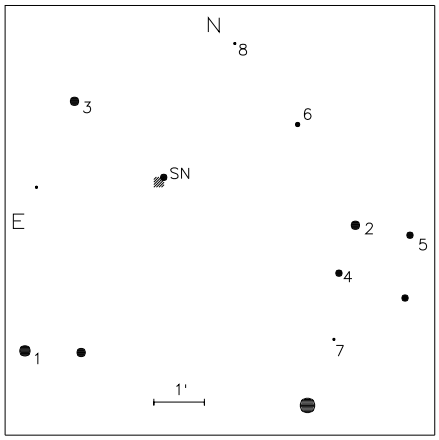

Figure 1. Comparison stars for SN 1994W

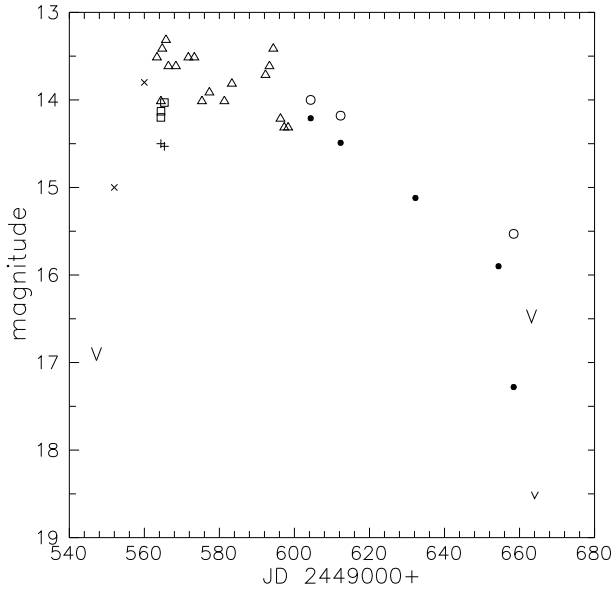

Figure 2. Light curve of SN 1994W. Dots and circles – our B and V magnitudes, pluses and squares – B and V CCD observations, triangles – visual estimates, crosses – R magnitudes based on data by Richmond *et al.* Upper limits are shown for our B and V plates and for R-band observations by Richmond *et al.*

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