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MASTER OT J095321.02+202721.2: Luminous Type II-L Supernova

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The optical transient MASTER OT J095321.02+202721.2, discovered in 2014, was not classified or confirmed as a supernova. We present the light curve of this object which allows us to classify it as a type II-L supernova with the absolute magnitude at maximum brightness $M_R \approx -19\overset{\mathrm{m}}{.}4$.

Modern wide-field sky surveys discover many transients, and a significant part of them remain unclassified. Most of the unclassified transients are fainter than $\sim 18 - 19^{\mathrm{m}}$, but sometimes, even much brighter objects remain unexplored. One of them is MASTER OT J095321.02+202721.2 (an abbreviated designation Mast953 is used hereafter). It was discovered by the MASTER-Kislovodsk auto-detection system at $\alpha = 9^{\mathrm{h}}53^{\mathrm{m}}21\overset{\mathrm{s}}{.}02$, $\delta = +20°27'21\overset{''}{.}2$ (J2000), on 2014-10-08.05230 UT, its unfiltered magnitude was $15\overset{\mathrm{m}}{.}9$. The object was located $17''$ West and $26''$ North of the center of the galaxy 2MASX J09532220+2026551 at $z = 0.02$ (Balanutsa et al. 2014). The transient was also detected by Catalina Sky Survey (CSS) and designated CSS 141025:095321+202721[1].

Our photometric observations were performed by MASTER telescopes at Kislovodsk and Tunka sites (Lipunov et al. 2010) and at the 60-cm telescope of the Crimean Astronomical Station of Sternberg Astronomical Institute (SAI CAS), Lomonosov Moscow University. The standard image reductions and photometry were made using IRAF[2]. Photometric measurements of the SN were made relative to local standard stars using PSF fitting with the IRAF DAOPHOT package.

The image of SN Mast953 and comparison stars is shown in Fig. 1. The stars were calibrated using Gaia synthetic photometry[3]. The SN is located in an area with low surface brightness, and subtraction of galaxy background is not necessary.

The results of photometry are reported in Table 1, and the light curves are shown in Fig. 2. In the Table, the uncertainties are presented in parentheses, the telescope codes are: M40, 40-cm MASTER telescopes; C60, the 60-cm telescope of the SAI CAS. Unfiltered MASTER images were calibrated with R-band magnitudes of the comparison stars. We also plot the data retrieved from the CSS site, they agree quite well with our R-band magnitudes. There are no observations on the rising branch of the light curve, and the maximum cannot be determined reliably.

[1] http://crts.caltech.edu/

[2] IRAF is distributed by the National Optical Astronomy Observatory, which is operated by AURA under cooperative agreement with the National Science Foundation.

[3] https://gea.esac.esa.int/archive/documentation/GDR3/Gaia_archive/chap_datamodel/sec_dm_performance_verification/ ssec_dm_synthetic_photometry_gspc.html

Table 1: $BVRI$ photometry of SN Mast953

JD−2450000	B	V	R	I	Tel.
6938.55			15.41 (0.07)		M40
6938.55			15.44 (0.08)		M40
6938.60			15.41 (0.17)		M40
6938.60			15.29 (0.10)		M40
6938.60			15.39 (0.17)		M40
6966.58	17.71 (0.05)	16.75 (0.04)	16.49 (0.04)	16.46 (0.10)	C60
6969.57	17.98 (0.10)	16.84 (0.03)	16.54 (0.03)	16.22 (0.12)	C60
6975.52	18.24 (0.10)	17.21 (0.05)	16.87 (0.04)	16.48 (0.11)	C60
6994.47			17.59 (0.09)		M40
7037.33			18.76 (0.12)		M40

The brightness in the R band decreased nearly linearly during $\sim$ 85 days after discovery, with a rate $\sim$ 0.04 mag/day. The decline rate slowed down at about JD 2457025, and after this date, it was about 0.009 mag/day, which is close to the rate expected from the radioactive decay of ^{56}Co to ^{56}Fe. The photometric evolution is typical of SNe II-L.

This is confirmed by comparison of the light curve of SN Mast953 in absolute R-band magnitudes to those for four type II-L SNe: 1979C, 1980K, 1998S and 2016gsd (Balinskaia et al. 1980; Buta 1982; Fassia et al. 2000; Reynolds et al. 2020), which is shown in Fig. 3. The distance to SN Mast953 was estimated from the galaxy's redshift, using $H_0 = 73$ km s^{-1} Mpc^{-1}; the distance modulus is $\mu = 34.68$. We corrected the magnitudes for small Galactic extinction $E(B-V) = 0^{\mathrm{m}}_{.}02$[4]. The location of SN Mast953 in the host galaxy allows us to assume that host extinction is negligible. The distances and extinctions for the SNe from comparison sample were taken from the papers cited above.

The absolute magnitude of SN Mast953 at discovery is about $M_R \approx -19^{\mathrm{m}}_{.}4$, and it may be even brighter because the maximum could not be determined reliably. This value is high even for type II-L SNe, for which the mean absolute magnitude was estimated by Richardson et al. (2014): $M_B = -17^{\mathrm{m}}_{.}98$. Type II SNe have quite blue colors near maximum, for example, for SN 1998S the color was $(B-R)_0 \approx 0^{\mathrm{m}}_{.}1$ (Fassia et al. 2000), so the mean M_R is close to mean M_B, and SN Mast953 is at least about $1^{\mathrm{m}}_{.}4$ brighter than an average SN II-L.

The light curves presented in Fig. 3 are similar in shape and luminosity, SN 1998S appears to be the best match for SN Mast953. We conclude that this comparison permits a definite classification of SN Mast953 as type II-L SN with a very high luminosity at maximum.

Acknowledgements

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[4]https://ned.ipac.caltech.edu/

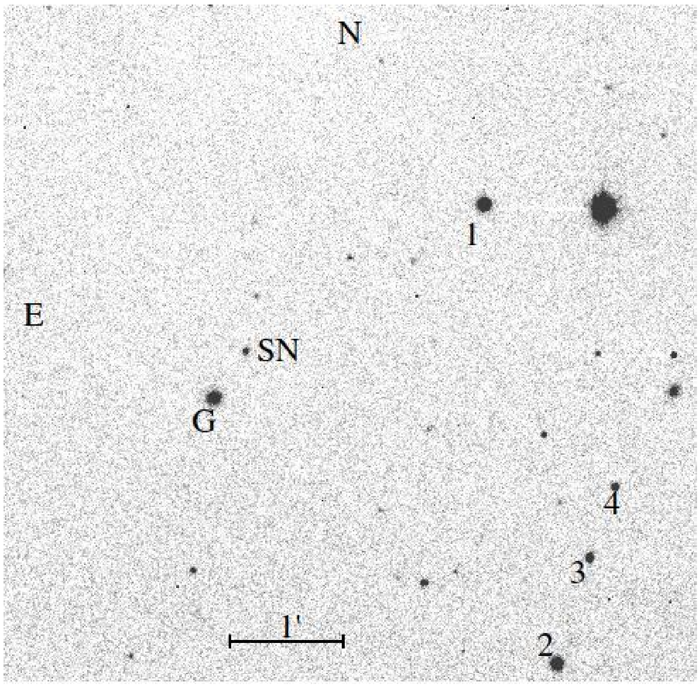

Figure 1.
SN Mast953 and comparison stars. G is the nucleus of the host galaxy. The image was obtained at the 60-cm telescope of SAI CAS with the *R* filter.

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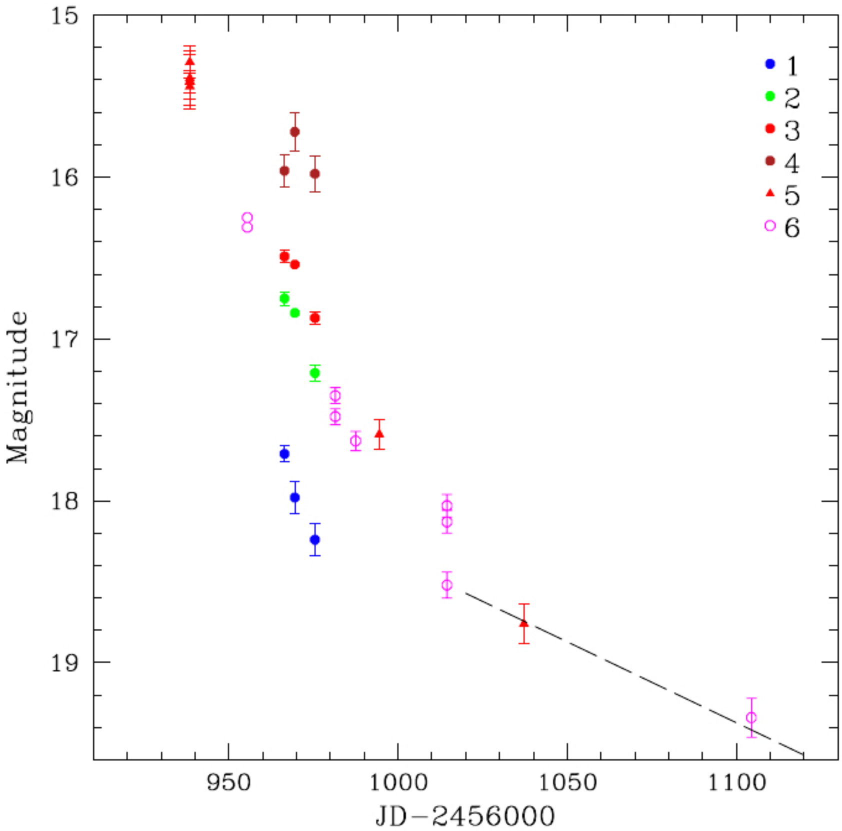

Figure 2.
The light curve of SN Mast953. 1, 2, 3, 4: *B*, *V*, *R*, *I* magnitudes from the 60-cm telescope of SAI CAS (*I* magnitudes were shifted by $-0^{m}.5$); 5: MASTER observations; 6: data from CSS. The dashed black line shows the brightness decline rate expected from radioactive decay of ^{56}Co.

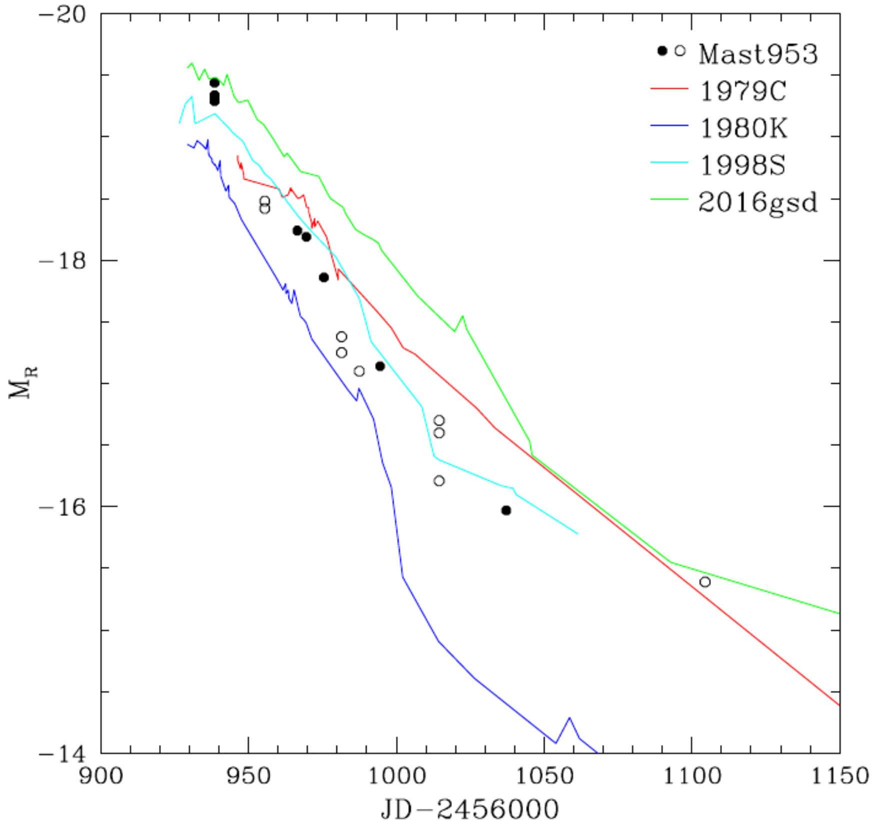

Figure 3.
The light curve of SN Mast953 in absolute *R*-band magnitudes and comparison with the light curves of four type II-L SNe (for SN 1980K, the *V*-band light curve is shown). Dots are our magnitudes, circles are the data from CSS.