The Slowly Fading Light Echo Around Type Ia Supernova 2009ig

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Introduction

Supernova 2009ig (SN2009ig) is classified as a normal type Ia event. The light echo around SN2009ig, discovered in 2013, is only the sixth known and is the most luminous around a type Ia supernova.

The presence of local gas and dust around type Ia supernovae is not expected as it is around type II supernovae due to the difference in explosion mechanisms. While type II supernovae come from dying massive stars, type Ia supernovae occur when a white dwarf crosses over the Chandrasekhar mass limit, either by accreting gas from a main sequence companion (single degenerate) or by merging with another white dwarf (double degenerate). The occurrence of light echoes around type Ia supernovae supports the single degenerate method.

Light echoes can provide information on the local environment of supernovae, which is particularly important for type Ias since they are used as standard candles. The presence of gas and dust in the local environment of a type Ia can affect the observed luminosity and could impact measurements of the Hubble constant.

In September 2018, we obtained new photometry data for SN2009ig from the Large Binocular Telescope (LBT) using the Large Binocular Cameras. Here we present an updated light curve of SN2009ig that confirms the slow fading of its light echo, which is similar to that of SN1991T.

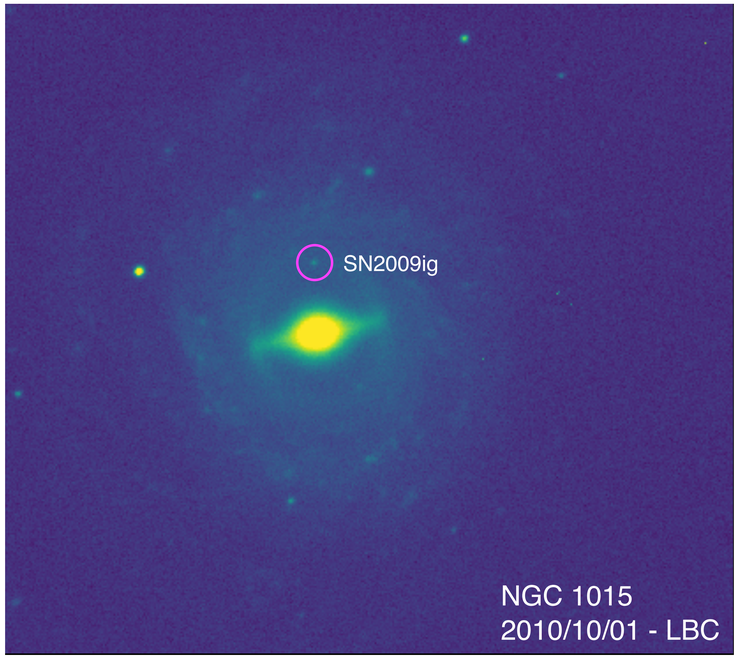

Figure 1: B-band image of SN2009ig using the LBC at the Large Binocular Telescope. Taken on October 1, 2010, the supernova was still bright enough to be easily identifiable.

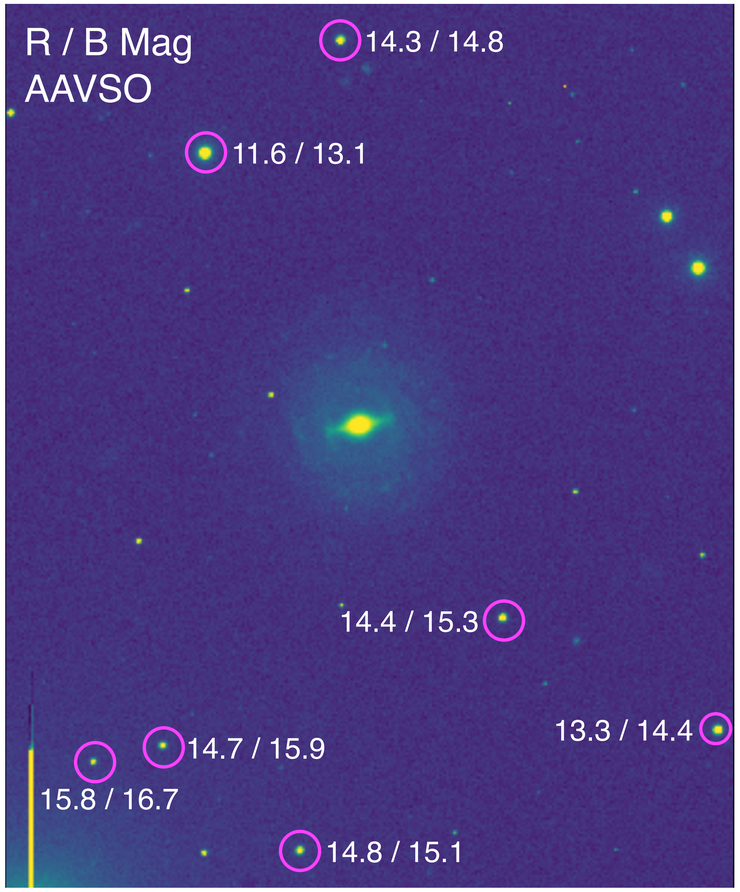

Figure 2: B-band image of SN2009ig, zoomed out to see nearby stars. Stars circled in pink are used as reference stars for photometry, with their R/B magnitudes listed beside them. Reference star data from AAVSO.

Creating the Light Curve

To create the light curve, we use photometry data from the LBT spanning from October 2010 to September 2018. While older LBT data sets (2010 - 2012) include U-, V-, and I-band photometry data on SN2009ig, we only include the B- and R-band data as it is available in every data set considered.

After reducing the data using *astropy.ccdproc*, we aligned and stacked the images to increase our signal-to-noise. Although SN2009ig was still fairly bright in 2010, it is not obviously visible in the latest images individually. We then performed aperture photometry on the supernova and seven reference stars (see Figure 2) using *photutils.aperture_photometry*.

We then plotted our photometry results as a function of time to create the updated light curve (see Figure 3).

Results and Conclusions

After including the new data, we find that the light echo is fading very slowly. This fading is similar to that of SN1991T and suggests that there is gas and dust local to the event. Since SN2009ig has nearly no extinction ($A_V = 0.01 \pm 0.01$; Foley et al. 2012), this suggests that there is a hole in the gas distribution in front of the supernova.

We note that nearly every star is saturated in our R-band images after 2011, making the photometry on our reference stars unreliable and therefore do not currently include the R-band photometry light curve.

Future Work

While aperture photometry is a great start, it introduces error by including some of the background flux. This is most important for SN2009ig itself, which is fairly small compared to the reference stars and has a higher background contribution from NGC 1015. Performing PSF photometry on SN2009ig will reduce this error and is a work in progress.

If the light echo around SN2009ig is resolved in high-resolution data, we can determine the 3-D distribution of the gas and dust. Like the Milky Way dust distribution, this can then be corrected for when using SN2009ig as a standard candle for measurements of H_0.

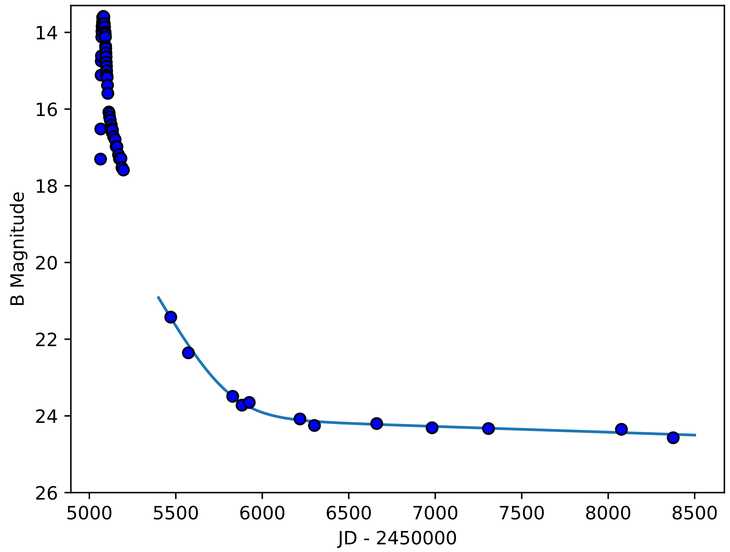

Figure 3: Light curve of SN2009ig. The supernova stops fading as expected at about JD - 2450000 = 5900, which is indicative of a light echo.

References

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