12th Hel.A.S Conference
Thessaloniki, 28 June - 2 July, 2015
CONTRIBUTED POSTER

The explosions of supernova SN2014J in M82 and Nova Delphini 2013 as distance tracers

G. Lois[1] *and K. Gazeas*[1]
[1] Department of Astrophysics, Astronomy and Mechanics, University of Athens, GR 15784 Zografos, Athens, Greece

Abstract: On January 21, 2014 a supernova erupted in M82 galaxy (NGC 3034), being the closest type-Ia supernova discovered in the past 42 years. On the other hand, on August 14, 2013 a Galactic white-dwarf in the constellation Delphinus erupted, producing the brightest nova since 2007. It is classified among the 30 brightest novae ever recorded. Both events were observed from the University of Athens Observatory, in order to study their long-term light variation. Galactic and extragalactic novae and supernovae can be used as standard candles and their observed light curve can be used for estimating the distance of their explosive progenitor. It is found that while Nova Delphini follows the expected light variation for the known novae in our Galactic vicinity, supernova SN2014J gives a clear disagreement with the known bibliographic value. Apparently the peak brightness does not fit the currently existing model of type-Ia supernovae or the light coming from the supernova is strongly reddened. Alternative models are investigated, for explaining this enigmatic event.

1 Introduction

In this study we present the long-term photometric observations of two explosive events in our Universe. Both objects were observed almost after their discovery from the University of Athens Observatory in BVRI bands, in order to construct their light curves. Photometric data were then used for computing photometric parameters, as well as estimating the progenitors distances.

2 Imaging and photometry

High resolution CCD images were taken from the University of Athens Observatory (UoA) soon after the explosive events, showing the very bright new objects rapidly fading out with time. Nova Del 2013 was observed from UoA Observatory a few hours after its discovery. The photometric data shows that Nova Del 2013 was getting brighter two days after its discovery, reaching a maximum brightness on August 16.45 UT at $m_V \approx 4.39 \pm 0.05$ mag (Fig.1). The high Galactic latitude of the nova (-9.4 deg) means that the line-of-sight exits the dust layer on the Galactic equator well before reaching the nova, which is the main reason for the low observed reddening. The explosion of SN2014J in M82 belongs to a class of highly energetic extragalactic events, while it is an enigmatic explosion due to its local circumstances. SN2014J was observed from UoA Observatory just two days after its discovery and has been followed photometrically for about 3.5 months (Fig.1). Despite the small distance of $\sim$3.27 Mpc [5], it is surprisingly faint with a maximum apparent magnitude of $m_V \approx 10.53 \pm 0.05$ mag.

3 Data reduction and distance estimation

Precise times of maximum light were determined on Nova Del 2013, as well as the observed apparent magnitude on light maximum ($m_V \approx 4.39 \pm 0.05$ mag). Based on these values, we found an absolute magnitude of: $M_V \approx -8.68 \pm 0.08$ mag and therefore the distance modulus is: m-M$\approx 13.07 \pm 0.08$ mag. Taking into account all the above we estimate the distance to be: d$\approx 3.17 \pm 0.20$ kpc.

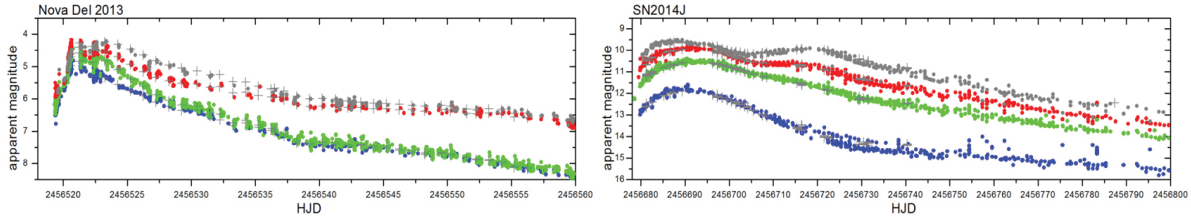

Figure 1: The photometric variability of Nova Del2013 (left) and SN2014J (right) in BVRI photometric bands, utilizing UoA and AAVSO database. Photometric observations from the UoA Observatory on both targets are superimposed on the plots by crosses.

	Our study	Literature	Reference
Nova Del 2013	3.17 ± 0.20 kpc	3.20 ± 0.40 kpc	Chochol et al. (2014)
SN2014J	3.56 ± 0.31 Mpc	3.27 ± 0.15 Mpc	Foley et al. (2014)

Figure 2: Distance of Nova Del2013 and SN2014J after this study compared with literature values.

For SN 2014J we used the absolute magnitude calibration (M_V≈-19.30±0.03 mag, according to [6]) and our apparent magnitude measurement: m_V≈10.53±0.05 mag. This value corresponds to a distance 10.99±0.32 Mpc. However, independent distance estimations of M82 using Cepheid variables (P-L relation) made for M81-M82 groups by [3] and [2] give a distance of ∼3.2 Mpc. The obvious disagreement may imply that SN2014J is not a typical SN Ia-type supernova and it belongs to a different type (or subtype) of explosive events [7]. An alternative explanation is that interstellar absorption is high, due to the dusty galaxy M82. Using the interstellar absorption values from [4] we get A_V=2.07±0.18, which confirms that absorption within M82 and along the line of sight is quite high. Using the above model we find that the distance modulus of SN2014J is m-M ≈ 27.76±0.19 mag and therefore the distance is d≈3.56±0.31 Mpc.

4 Novae and Supernovae as distance indicators

The distance of Nova Del 2013 has been calculated using our average value of absolute magnitude M_V and taking into account a negligible interstellar reddening. SN2014J occurred inside the dusty galaxy M82, resulting in major absorption and color extinction through M82 interstellar medium. We used the absolute magnitude calculation following [6] and extinction values from [4] for calculating its distance. Our results are summarized in Fig.2, in comparison to the most recent distance estimations. Considering no interstellar absorption and given the distance of M82 by independent measurement, the absolute magnitude is much fainter. This is actually what prompted towards an alternative explanation of the explosive event: SN2014J either does not follow the most common SN Ia single-degenerate scenario, where a white dwarf gains matter from its companion star in a binary system or that the explosion is caused by a double-degenerate system, where two white dwarves merge and explode [7].

References

[1] Chochol et al., 2014 Contrib. Astr. Obs. Skalnat Pleso 43, 330

[2] Gerke et al., 2011, ApJ, 743, 176

[3] Dalcanton et al., 2009, ApJS, 183, 67

[4] Foley R. J., et al., 2014, MNRAS, 443, 2887

[5] Fossey J., et al., 2014, CBET, 3792, 1

[6] Hillebrandt W., Niemeyer J. C., 2000, ARA&A, 38, 191

[7] Pérez-Torres M. A., et al., 2014, ApJ, 792, 38