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LIGHT ECHOES OF SUPERNOVAE IN THE LARGE MAGELLANIC CLOUD

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RESUMEN

En años recientes fueron descubiertos ecos de luz alrededor de algunas supernovas (SNe) extragalácticas cercanas bastante tiempo después de la explosión. Sin embargo, hasta ahora no se ha descubierto ningun eco de luz de SNe históricas de origen galáctico o extragaláctico. El proyecto SuperMACHO ha descubierto ecos de tres SNe antiguas en la Gran Nube de Magallanes. Espectros de los ecos de luz tomados con GMOS en Géminis Sur indican que uno de ellos es una SN Ia superluminosa.

ABSTRACT

In recent years, light echoes have been discovered around some nearby extragalactic supernovae (SNe) well after the explosion. However, to date no light echoes of historical SNe of Galactic or extragalactic origin have been discovered. The SuperMACHO project has discovered echoes from three ancient SNe in the Large Magellaninc Cloud. Spectra of the light echoes taken with GMOS on Gemini South indicate that one of them is an overluminous SN Ia.

Key Words: **SUPERNOVAE**

In recent years, light echoes have been discovered around some nearby extragalactic supernovae well after the explosion, most notably the light echoes from SN 87A. However, to date no light echoes of historical SNe of Galactic or extragalactic origin have been discovered.

In the SuperMACHO project, we have imaged the bar of the LMC repeatedly and used an automated pipeline to subtract point-spread function matched template images from the recent epoch images. The resulting difference images are remarkably clean of the constant (in time) stellar background and are ideal for searching for variable objects. Using these difference images, we have mapped the extensive light echo complex around SN 87A further out, and deeper, than has been previously possible. Faint echo arcs can be seen as far out as 7.3 arcmin from the explosion site, or 1.1kpc in front of SN 1987A.

Besides the SN 87A light echoes, we found a number of other very faint linear structures that had high proper motions, but were spatially in a very different location than the SN 87A echoes. We suspected that these were as well light echoes from a yet unkown source. The left panel in Figure 1 shows such a light echo candidate. In order to find the source of the light echoes, we fit each light echo segment with a straight line (red). The apparent proper motion is given by the yellow vector and extrapolated backwards (blue).

The vectors extrapolated backward in time pointing to four well-defined positions as the origins of the echo complexes, one of which is SN 87A (see Figure 2). The three unidentified echo origins correspond within arcminutes to the positions of known supernova remnants (red circles, Mathewson et. al. 1985), which are also three of the six youngest SNRs in the LMC (Hughes et. al. 1995). These three SNRs are precisely the three that are classified as likely Type Ia events based on the X-ray emission spectra. Given the positional match with young SNRs and the high apparent proper motions of the variable diffuse light, we conclude that these newly detected structures are scattered light echoes from Type Ia supernovae in the LMC (Rest et. al. 2005).

We have taken a spectrum of the brightest echo from light echo group LE2 with Gemini South using GMOS with slitlets aligned along the echo segments. With careful reduction we extracted the rel-

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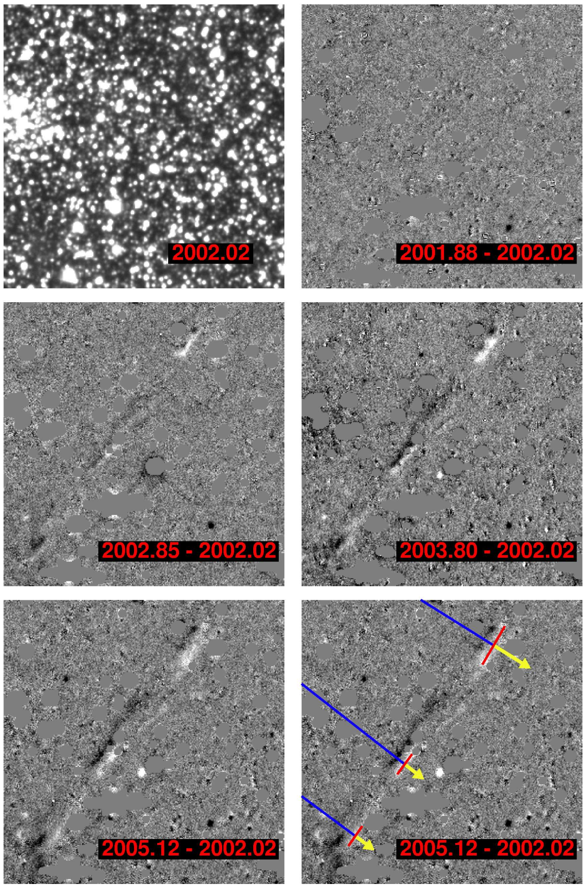

Fig. 1. Panel 1 (upper left) shows the unsubtracted (template) image which includes the cluster Hodge 243. Panel 2 (upper right) shows how cleanly the field subtracts with data taken 50d earlier. The next three panels show the echo motion 1, 2, and 3 years after the template date. White represents positive flux in the present epoch image and black in the template image. The vector motions are plotted in Panel 6 (lower right).

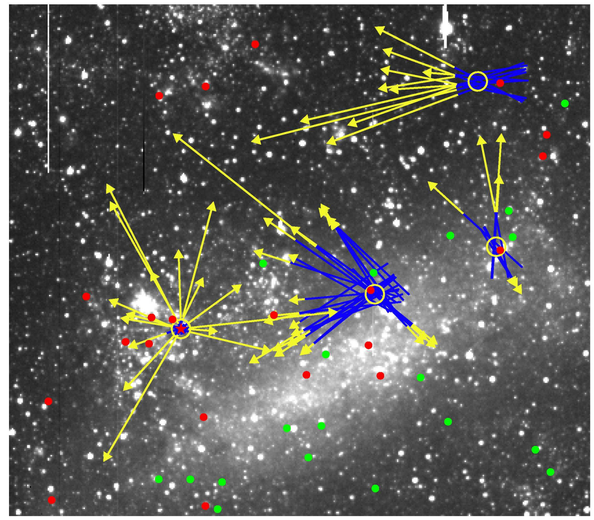

Fig. 2. A plot of the light echo vectors in the LMC. The vectors have the same meaning as in Figure 2. The centres of the echo complexes are indicated by yellow circles. The lengths of the yellow vectors are 100x the length of the echo arc. The source on the left marked with a star is SN1987A. The green circles are the location of historical novae, and the red circles are the supernova remnant locations.

atively high S/N spectrum of the echo light. We fit integrated and dust-scattered spectra of various SN types to it. We find that type II spectra do not fit the observed spectra. The best fit we obtain is for SN 1991T, an overluminous SN Ia. The spectrum of the Type Ibc produces a noticeably worse fit than the Type Ia, but cannot be completely ruled out yet.

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