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Publication date:
2024-01

Permanent link:
https://doi.org/10.3929/ethz-b-000649509

Originally published in:
Monthly Notices of the Royal Astronomical Society 527(3), https://doi.org/10.1093/mnras/stad3422

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

MNRAS 527, 6312–6320 (2024) https://doi.org/10.1093/mnras/stad3422
Advance Access publication 2023 December 1

A bright triple transient that vanished within 50 min

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Accepted 2023 November 2. Received 2023 November 2; in original form 2023 October 16

ABSTRACT

We report on three optically bright, ∼16th mag, point sources within 10 arcsec of each other that vanished within 1 h, based on two consecutive exposures at Palomar Observatory on 1952 July 19 (POSS I Red and Blue). The three point sources have continued to be absent in telescope exposures during 71 yr with detection thresholds of ∼21st mag. We obtained two deep exposures with the 10.4-m Gran Telescopio Canarias on 2023 April 25 and 27 in *r* and *g* band, both reaching magnitude 25.5 (3σ). The three point sources are still absent, implying they have dimmed by more than 10 mag within an hour back in 1952. When bright in 1952, the most isolated transient source has a profile nearly the same as comparison stars, implying the sources are subarcsec in angular size and they exhibit no elongation due to movement. This triple transient has observed properties similar to other cases where groups of transients (‘multiple transients’) have appeared and vanished in a small region within a plate exposure. The explanation for these three transients and the previously reported cases remains unclear. Models involving background objects that are optically luminous for less than 1 h coupled with foreground gravitational lensing seem plausible. If so, a significant population of massive objects with structure serving as the lenses, to produce three images, are required to explain the subhour transients.

Key words: gravitational lensing: micro – techniques: image processing – surveys – virtual observatory tools.

1 INTRODUCTION

Since decades, astronomers have carefully scrutinized the sky looking for sources that vary in brightness. Numerous surveys have been conducted at all wavelengths, successfully revealing many classes of objects that vary by more than 1 per cent. Low-mass flare stars, pre main-sequence objects, pulsating variables, novae, supernovae, gamma-ray bursts, fast radio bursts, tidal disruption events, and mergers of black holes and neutron stars are examples of some of these types of variable objects.

However, only a few surveys have been carried out to detect fast transients (FTs), defined as those that remain bright for less than 1 d. To name a few, Becker et al. (2004), using Deep Lens Survey data, reported three unusual optical transient events flaring on 1000 s time-scales; Rau et al. (2008) discovered five FTs (two flaring M dwarfs and three periodic variables) using the Irénée du Pont telescope at Las Campanas, while Berger et al. (2013) found 19 FTs (8 asteroids and 11 flaring M dwarfs) using repeated observations of the Pan-STARRS1 Medium-Deep Survey (PS1/MDS) fields. Optical searches for transients lasting less than a minute were carried out by Richmond et al. (2020) and Andreoni et al. (2020), but no such transients were definitively found.

Current searches for subhour transients suffer from confusion by tens of thousands of satellites and space debris in orbit around the Earth that reflect sunlight briefly and glint on time-scales of seconds or less (e.g. Corbett et al. 2020; Nir et al. 2021). One solution to this problem would be to employ all-sky imaging performed prior to the launch of Sputnik in 1957 (Villarroel et al. 2022b). The first Palomar Sky Survey (POSS I), with its images of the sky obtained in the early 1950s, provides this data base of images. The survey was conducted using the 48-inch Oschin Schmidt telescope at Mount Palomar (Minkowski & Abell 1963), covers the entire sky north of −45° declination and was carried out using photographic plates, later converted into a digital format. In order to obtain colour information, each region of the sky was photographed twice, once using a blue sensitive Kodak 103a-O plate, and once with a red sensitive Kodak 103a-E plate, peaking at ∼4100 and ∼6 400 Å, respectively. The limiting photographic magnitudes of the blue and red plates are 21.1 and 20.0 mag, respectively. Typically, two exposures, one in the red and one in the blue, were taken within 1 h of the same 6.5° × 6.5° field.

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The VASCO[1] team has identified thousands of star-like sources that appeared on one photographic plate but not on the next one taken within 1 h, constituting subhour transients.[2] The several thousand VASCO transient candidates have peak brightnesses of typically *R* magnitude 17–20, but they do not appear in later all-sky surveys with CCD detectors, indicating dimming by 2–5 mag.

Of particular interest was one field of 10 arcmin that contained nine point sources that did not appear in the image taken an hour later, nor in any images during the following 70 yr (Villarroel et al. 2021, 2022a). These 'nine simultaneous' transients remain a mystery. Subsequent work identified 83 cases of such 'multiple transients' including some that are apparently aligned as well as some double and triple transients (Villarroel et al. 2022a).

In this paper, we describe an extraordinary transient candidate composed of three ∼16th mag point-like sources, within 10 arcsec of each other, that dimmed within an hour and for which deep imaging with the 10.4-m GTC telescope reveals no counterparts at a limiting magitude of 25th mag.

2 OBSERVATION OF THE TRIPLE TRANSIENT

We used the list[3] of 5399 candidate point-source transients from Solano, Villarroel & Rodrigo (2022) that were detected in digitized photographic exposures of the first Palomar Observatory Sky Survey (POSS I), and that are absent in images from modern surveys including Pan-STARRS, ZTF, and SDSS. In brief, SEXTRACTOR was used to identify sources in POSS I Red, and counterparts were searched for within a 5 arcsec radius in Gaia EDR3 and Pan-STARRS DR2 catalogues. Sources having no counterparts were retained for further vetting in other surveys, including POSS I Blue, POSS II, and ZTF. Those with no visible counterpart were deemed candidate transient sources.

A particularly interesting case of multiple transient event was discovered in the POSS I Red image, of 50 min exposure time, taken on 1952 July 19 (Fig. 1). The centre of the image contains the three star-like sources, identified by the blue arrow, at coordinates RA = $21^{\mathrm{h}}18^{\mathrm{m}}10\overset{\mathrm{s}}{.}4$, Dec. = $+50^{\circ}22'43\overset{''}{.}4$ (J2000). Fig. 1 shows the POSS I photographic image digitized by SuperCosmos (Hambly et al. 2001) that provides high resolution and a sampling of 0.7 arcsec per pixel instead of the usual 1.7 arcsec per pixel in the STScI digitization of the POSS Digital Sky Survey. The three transients also appear clearly in the STScI digitization shown in Fig. 2 at upper left.

The three sources are roughly 16th mag in the *R* Supercosmos band. The northern two sources are blended. Eyeball inspection of the three transients in Fig. 1 reveals the individual sources to have profile shapes qualitatively similar to the neighboring stars. The point-like profiles are measured quantitatively in Section 4, showing they indeed exhibit no elongation or distortion compared to profiles of stars. Their star-like, circularly symmetric profile shapes distinguish them from the elongated and non-circular shapes of most asteroids, meteorites, aircraft, cosmic rays, photographic plate flaws, and any other moving objects during a 50 m exposure.

Fig. 2 shows at upper left the STScI digitization of the three transients from the same POSS I red exposure. The transients are less well sampled in this digitization, but they appear star-like, as in the SuperCosmos digitization. Immediately after the 50 m exposure, a 10 m POSS I blue exposure was taken, shown in the upper right of Fig. 2. The three transient sources are absent. Two months later, in September, another red and blue pair of Palomar photographic exposures were taken of the same field, shown in lower left and lower right of the figure. The three transient sources are also absent.

We took advantage of the Virtual Observatory[4] capabilities to look for the triple transient in more recent images and catalogues. The result of this search concluded that the transient does not appear in any later image of that region during the subsequent 69 yr. Fig. 3, upper left, shows the POSS I Red from 1952 showing the triple transient for reference. The other three panels of the figure show images of the same field from POSS II red band taken in 1991, from Pan-STARRS in 2018, and from ZTF taken in 2021, all with limiting magnitudes roughly 21.5. None of those images exhibit the triple transient. A purple cross marks the location of the southernmost transient.

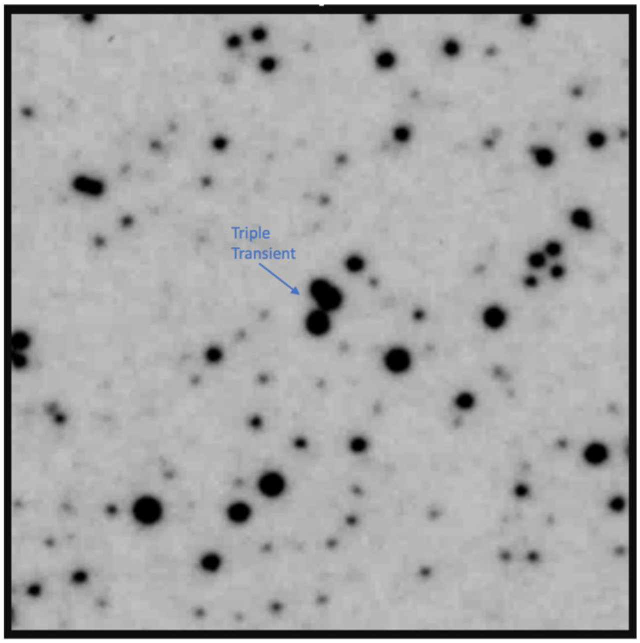

Figure 1. Supercosmos digitization (Hambly et al. 2001) of the Palomar Observatory Sky Survey (POSS) red-sensitive image, taken on 1952 July 19. This is a zoom, 3 × 3 arcmin, centred on three bright (*R* Supercosmos ∼ 16 mag) point sources, marked by the blue arrow, at coordinates RA = $21^{\mathrm{h}}18^{\mathrm{m}}10\overset{\mathrm{s}}{.}4$, Dec. = $+50^{\circ}22'43\overset{''}{.}4$ (J2000). The three sources are absent in all subsequent exposures of this region during 71 yr, including the POSS blue-sensitive image taken immediately after this exposure. The sources have profile shapes consistent with neighbouring stars of similar brightness (Section 4). They exhibit no evidence of peculiar shapes or elongation that would occur with asteroids, meteorites, cosmic rays, photographic plate defects, or aircraft.

3 OBSERVATION OF THE TRIPLE TRANSIENT WITH THE 10.4-M GTC TELESCOPE

We used the OSIRIS instrument on the 10.4-m Gran Telescopio Canarias (GTC) to image the triple transient in both the *r* and *g* band on 2023 April 25 and 27 (UT) with total integration times of 30 min (12 × 150 s) and 16.7 min (5 × 200 s), respectively. Both observations were obtained in dark time (without moon), with good seeing (<1 arcsec). The data reduction was done with self-written IDL codes. Standard bias-subtraction and flat-fielding were applied. The reduced images were aligned with integer pixel shifts

[1] https://vascoproject.org/
[2] http://svocats.cab.inta-csic.es/vanish/
[3] http://svocats.cab.inta-csic.es/vanish-possi/

[4] http://ivoa.net

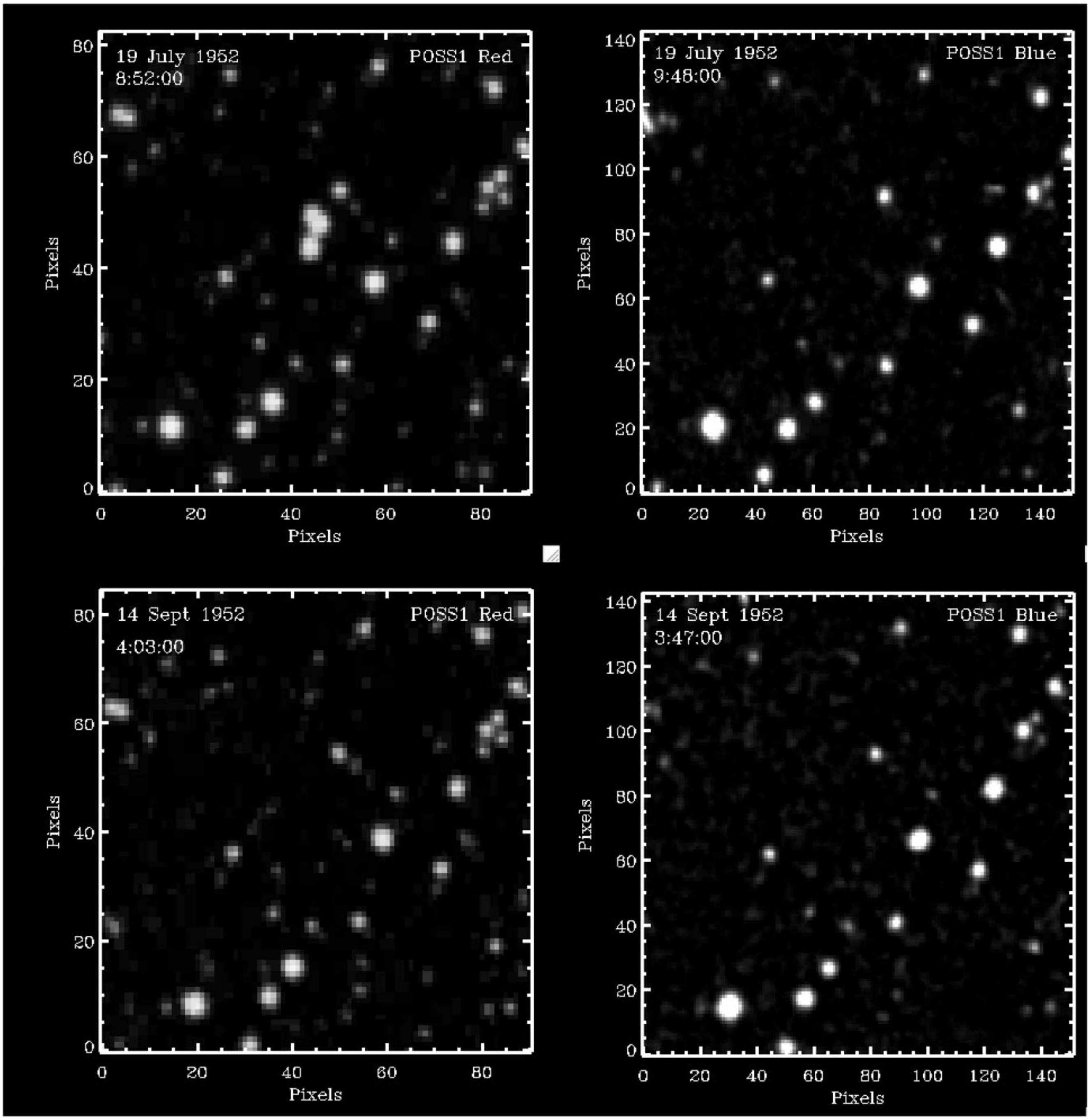

Figure 2. Four exposures taken during 1952 of the 3 × 3 arcmin region of sky centred on the triple transient seen in 1952 July. Upper left: The POSS I red image on 1952 July 19 at 8:52 (UT) containing the triple transient just above centre. Upper right: A 10 m exposure POSS I blue image taken immediately afterward, showing no evidence of the triple transient. Lower left: A POSS I red image taken two months later (September 14), showing the transient still gone. Lower right: A POSS I blue image on September 14 showing the transient gone. The triple transient dimmed by over 6 mag of its peak brightness within 50 min (or even more if the duration of the transient was shorter than the exposure time) and remained undetected for the rest of that year.

(to avoid correlated noise in the combined images) and combined with a simple mean combination. The WCS information in the FITS headers was improved with the NOVA[5] astrometry tool. We also used the Terapix swarp[6] procedure (Bertin et al. 2002) to improve the astrometry, using USNO-B1.0 astrometry as a reference field for zero-point calculations in the astrometrical solutions. We found that both methods give the same results within the expected errors. In this way, both GTC and POSS I images were calibrated in order to have the same astrometrical solution for both data sets. This approach allows us to directly compare source positions using the same reference catalogue. Despite the difference of 71 yr between GTC and POSS images, we noticed that only a few objects show

[5] https://nova.astrometry.net/
[6] https://www.astromatic.net/software/swarp/

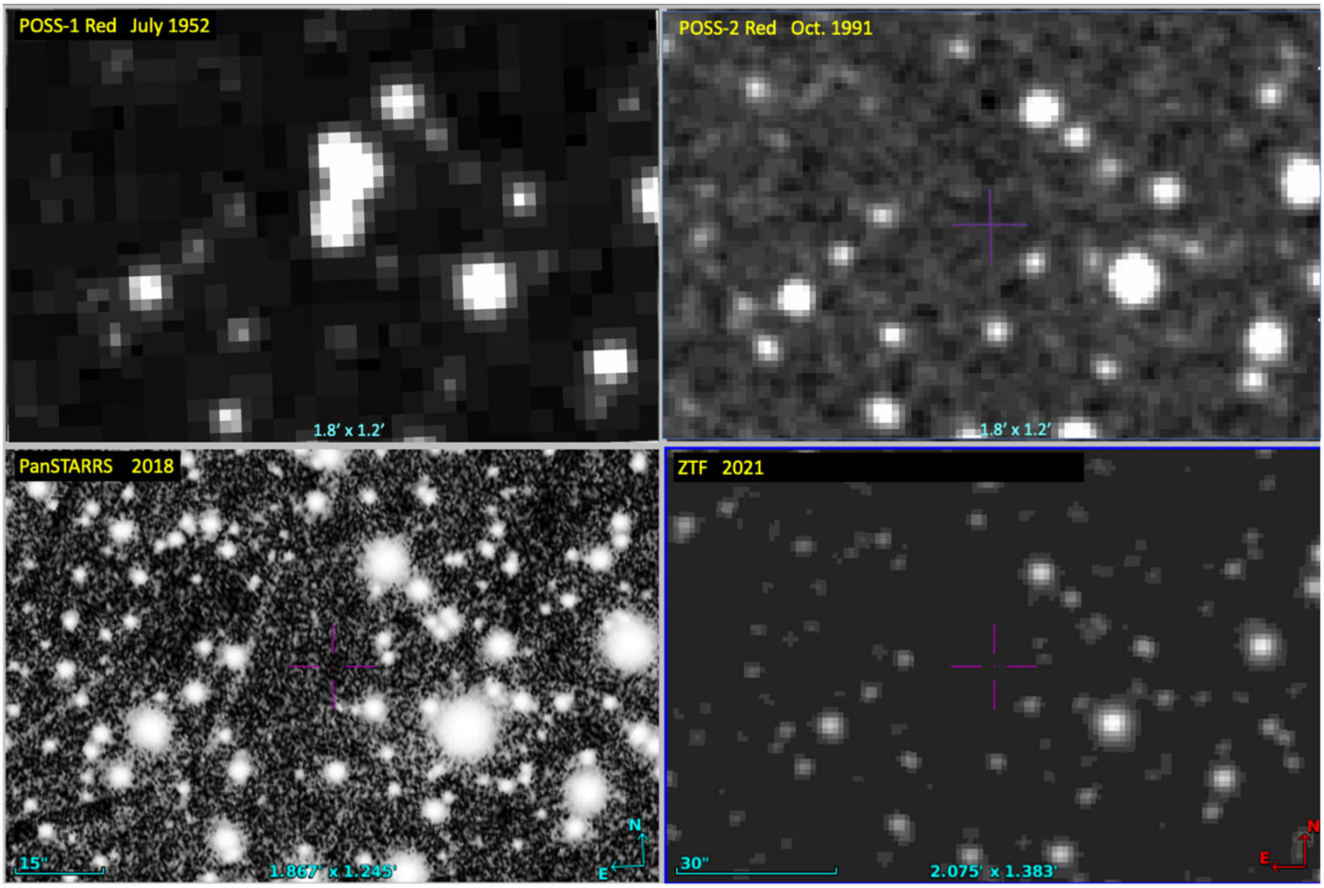

Figure 3. Four exposures of the sky centred on the triple transient, taken at four different times during 69 yr. The field dimensions are approximately 1.8 × 1.2 arcmin^2 and the position of the southernmost transient is marked by a purple cross. Upper left: The POSS I red exposure, taken in 1952 July, showing the triple transient composed of three *R* Supercomos ∼ 16th mag point-lie sources. Upper right: The POSS II red exposure, taken in 1991 October. The triple transient is absent, with a detection threshold of 21st mag. Lower left: The PanSTARRS exposure of the same field in 2018, showing no evidence of the triple transient. Lower right: The ZTF exposure of the same field in 2021, showing the triple transient still undetected. The upper two panels are STScI digitizations.

measurable proper motion while most of the stars in the field seem to have remained at the same position.

The resulting images have detection thresholds near 25.5 mag (3σ) at both *r* and *g* bands, 10 magnitudes fainter than the three transients were in the discovery image (Fig. 1).

Fig. 4 shows the *r*- and *g*-band images obtained with the GTC, displayed with the same range of RA and Dec. as the POSS I plate in Fig. 1, for direct comparison. Neither of the images obtained with the GTC show evidence of the triple transient.

Fig. 5 shows a zoom and extreme grey-scale stretch on the GTC *r*-band image (at left) that can be compared to the POSS I red image (right). We place circles around each of the transients in the POSS I image (at right), and we copy those three circles on to the GTC image. The circles are positioned based on a careful astrometric calibration performed with numerous nearby stars to set their centres in RA and Dec.

Examining Fig. 5, one sees that the three ∼16th mag transients in POSS I do not appear in the green circles in the GTC *r*-band image. However, the GTC *r*-band image shows ∼25th mag stars located roughly 3 arcsec to the south and west of the centres of the northern and southern green circles. These two 25th mag stars are not displaced by the same angular distance from the centres of their respective green circles, and there are many other point sources of 25th mag in the image. Thus, it is entirely probable that these two 25th mag stars just happen, by chance, to be located ∼3 arcsec from the previous location of the transients in the POSS-1 image. At the expected location of the middle transient (green circle), there is no star in the GTC *r*-band image at all. This casts further doubt on stars displaced by 3 arcsec in the northern and southern green circles as being relevant to the original three transients from POSS-1.

Also, we can estimate a rough probability *p* of finding a background object in the GTC images within a circle of a fix radius given the known number density of objects and the binomial distribution. We use the densities from Villarroel et al. (2021) where GTC was used to reach same depth. We place the centre of each such circle at the absolute centre of each POSS-I transient. For example, the probability of finding at least one counterpart in each of the three green ∼5 arcsec circles in Fig. 5 is roughly $p \sim 0.41$ and not particularly interesting. To obtain probabilities $p < 0.05$ and demonstrate that the counterparts inside the circles are physically connected to the transients, each POSS-I transient must have a GTC counterpart within 1.7 arcsec. However, examining the images, we can see that only one of the transients has such a close counterpart. Therefore, we conclude that the GTC counterparts are unlikely to be physically connected to the transients.

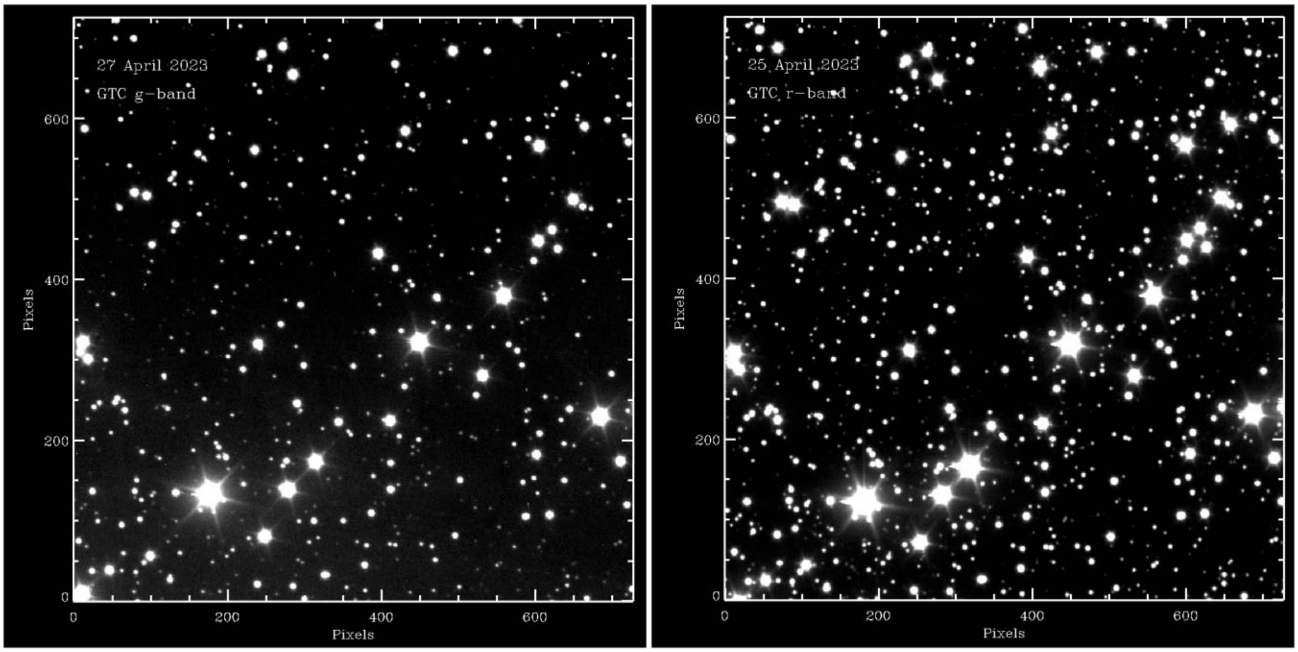

Figure 4. Left: A 17 min exposure at g band (left) and a 30 min exposure at r band (right) with the 10.4-m GTC, centred on the triple transient. The 3 × 3 arcmin^2 field is the same as the POSS I image in Fig. 1. The triple transient is completely absent. The limiting magnitude is ~25.5 (3σ).

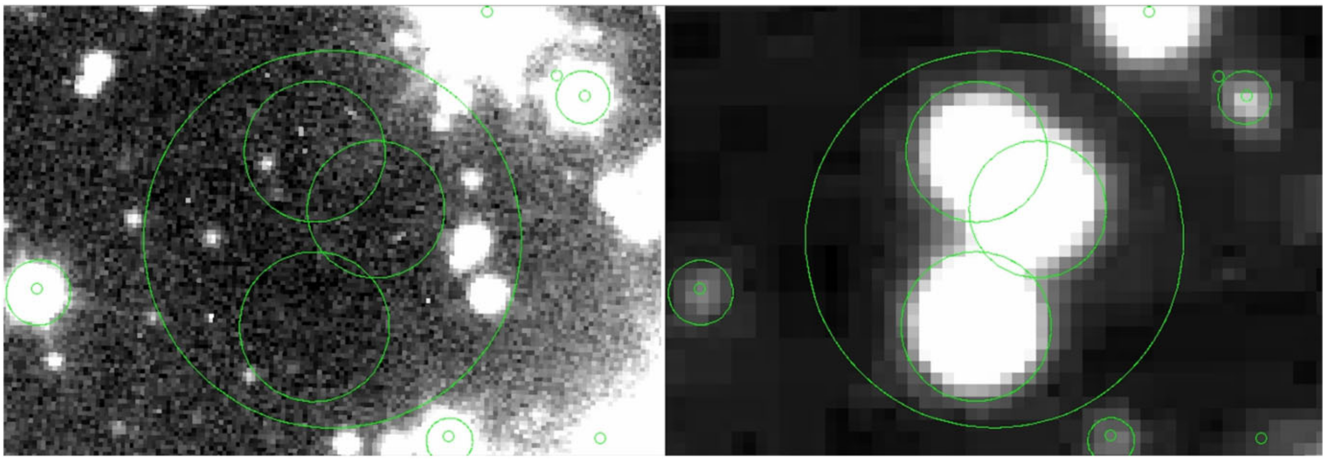

Figure 5. An extreme zoom and grey-scale stretch of the 10.4-m GTC r-band image centred at the triple transient (left). The same zoom of the POSS I red image obtained in 1952 July is shown in the right panel. The positions of the three transients are marked by three large circles, with astrometric calibration set by multiple neighbouring stars, some of which are marked by small circles. The GTC image exhibits no stars near the centre of the three circles, with a threshold of 25.5 mag. All the sources lying within the big circle are below the POSS I detection limit and, thus, are not visible on the POSS-I (right) image.

4 ANALYSIS OF THE TRIPLE TRANSIENT FROM THE PALOMAR IMAGES

We deblended and measured the brightness of the sources in the POSS I red image from 1952 July. We used SEXTRACTOR (Bertin & Arnouts 1996) and IRAF (Tody 1986), separating the three objects as well as possible. The resulting R Supercosmos magnitudes of the sources measured by both SEXTRACTOR and IRAF as well as the approximate photometric uncertainty are given in Table 1. We also estimated the R magnitudes by measuring the full width at half-maximum of the profiles of six photometric reference stars within 10 arcmin and of the profiles of the three transient sources, yielding agreement with SEXTRACTOR and IRAF within 0.4 mag, which is the value adopted as uncertainty. The uncertainty is due to the non-linear photographic response to photons and to the overlap of the star-like sources. The total angular separation of the transients, from north to south, is 9.5 arcsec.

Table 1. Position and photometry of the triple transient.

Name	RA (J2000)	Dec. (J2000)	R mag (SEX.)	R mag (IRAF)	Uncert.
Cand. 1	21:18:10.68	+ 50:22:46.85	16.0	15.7	0.4
Cand. 2	21:18:10.35	+ 50:22:43.7	16.4	16.1	0.4
Cand. 3	21:18:10.69	+ 50:22:37.45	14.9	15.1	0.4

Although a visual inspection already indicates that the transient has a clear circular shape with intensity diminishing radially outward, we

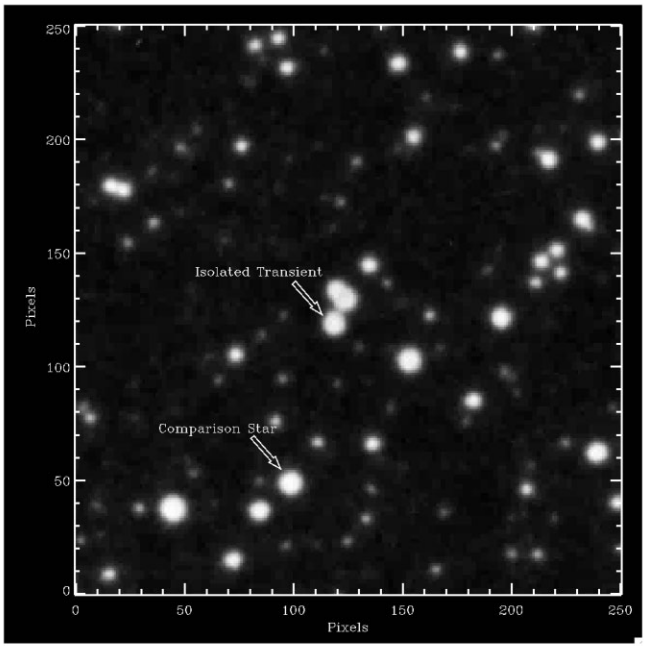

Figure 6. The POSS I red image, showing the transient that is nearly isolated from the other two. A comparison star is identified, having similar brightness to serve as a proxy for the intrinsic profile of point sources resulting from the non-linear response of the photographic plate.

compared the profile of the nearly isolated southern-most transient to that of a neighbouring star (Fig. 6). We were especially attentive to the wings of the profile in both the north–south and east–west directions. If the transient exhibits qualitatively different profile shape at the flanks or wings of the profile, compared to the comparison star, its stellar-like nature may be questioned and its origin attributed to plate flaws or elementary particle hits.

Fig. 7 shows the resulting profiles in the north–south and east–west directions. The profiles in both directions were produced by simply adding the digitized ADU. The two profile shapes, of the transient and the comparison star, are nearly identical. The east–west profiles of the transient and comparison star reveal no discrepancy between the two. In the north–south direction the profiles are less similar due to the contamination of the transient located northward. However, the level of agreement of the profiles in the north–nouth direction is good enough to discard a non-optical origin of the transient.

In summary, we find no evidence that the transient is anything other than a bona fide unresolved, point source of light. In particular, the profiles show no evidence of a moving source such as an aircraft, asteroid, or elementary particle nor of a defect in the photographic plate.

5 CONSTRAINTS ON THE SIZE AND DISTANCE

The triple transient has equatorial coordinates, RA = $21^{\mathrm{h}}18^{\mathrm{m}}10\overset{\mathrm{s}}{.}4$, Dec. = $+50^\circ22'43\overset{''}{.}4$ (J2000), placing it within 1° of the plane of the Milky Way, within the north-east region of Cygnus. This location raises the possibility that the triple transient is somehow physically related to the plane of the Galaxy, which has a higher density of objects, including brown dwarfs, massive stars, white dwarfs, neutron stars, and black holes. This location of the triple transient within the Galactic Plane is consistent with the notion that a gravitational lens alignment is playing a role (Section 5.2).

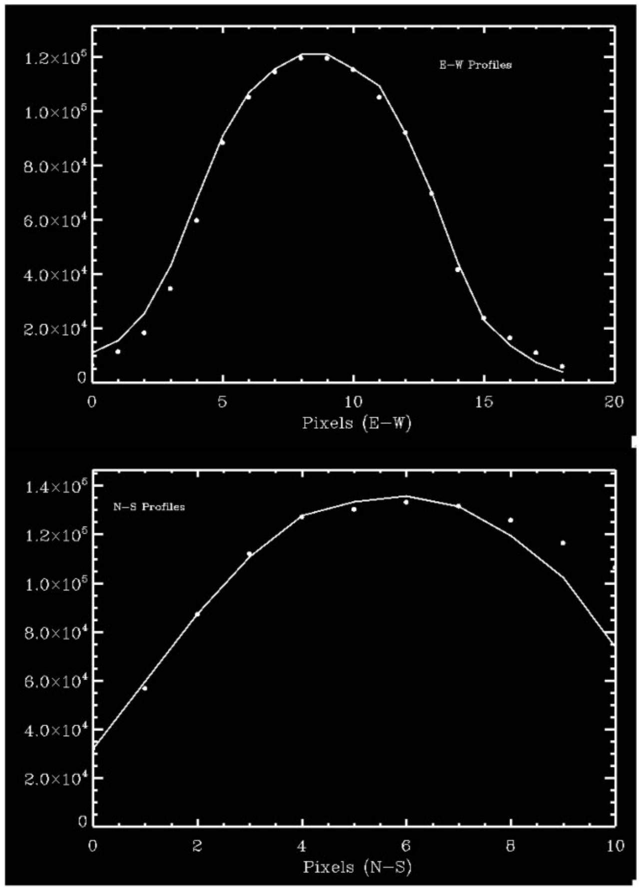

Figure 7. Comparison of the profiles of the isolated transient (dots) with a comparison star (solid line). Top: The east–west profiles (summed in N–S direction). Bottom: The north–south profiles (summed in E–W direction).

5.1 Three independent sources

We consider the possibility that the three transient sources are separate objects in space. Their physical properties are constrained by two observed properties, the dimming time within 50 min and their angular extent on the sky of 10 arcsec. Space–time causality provides constraints on their size and distance, as follows.

The dimming time-scale of 50 min is set by the two consecutive exposures in 1952 July. The three point sources delivered their photons with a fluence of ∼16th mag, each, during the 50 min exposure time. The wavelength coverage of the red plate was 600–700 nm. However, all three sources were absent in the 10 min POSS I blue exposure, between wavelengths 320 and 500 nm. This absence implies that they dimmed to roughly 1 per cent of the brightness compared to the previous POSS I red exposure within its 50 min. The absence of the three sources in the two GTC exposures that reached magnitudes 25.5 imply that the sources are now apparently <1/10 000 of peak brightness. The images from Pan-STARRS, SDSS, and ZTF confirm their absence.

The three sources could not have dimmed coincidentally and independently of each other as such dimming rarely occurs even in one source. Instead we may consider the possibility that the three sources brightened due to some common cause. If so, the fastest that all three can be caused to brighten is the speed of light. If they were separated by more than 50 min of light-travel time, all three of them could not be 'turned on' within the 50 min that they were observed to be 'on'. For the dimming of all three sources to be causally connected, the three sources must reside within a light-travel time, 50 min, of each other, corresponding to a distance less than s, given by

$$s < c \times 50\,\mathrm{min} = 6\,\mathrm{au}, \quad (1)$$

which is quite similar to the average Sun–Jupiter distance (5.2 au). Thus, this mutual causality implies that the spacing between the three objects emitting the light must not differ by more than 6 au. However, the north and south point sources are separated by an angle on the sky of only ∼10 arcsec. Assuming causal connection, the angular separation of 10 arcsec and the maximum separation of 6 au implies a maximum distance to the triple source of 2 light-years. Any greater distance, and the angular separation of 10 arcsec would imply a physical separation more than 6 au, preventing a causal connection given the speed of light.

Therefore, to be causally connected, the three light sources must reside physically within 6 au of each other and are no more than 2 light-year away. This distance is less than the nearest star, the alpha Cen system, bringing the venue of the three transients to a distance within our Sun's vicinity, if not the inner Solar system, or even Earth's orbit. Such a close proximity, along with typical space velocities among stars in the solar neighbourhood of ∼30 km s^{-1} (Gaia Collaboration 2018) would imply accumulated proper motion of much more than 10 arcsec during 71 yr, explaining why the three objects do not appear in the modern images. Thus, the assumption of a shared cause of the dimming implies the three sources are close to our Solar system, including arbitrarily close.

5.2 Gravitational lensing

Alternatively, the three transients may be produced by a foreground gravitational lens having sufficient mass complexity to create image multiplicity, as commonly seen in strong gravitational lensing by intervening dark matter. The rough sketch of a model consists of a single background source of optical light that is lensed by an intervening distribution of mass that produces, briefly, three nearly point-like images at Earth.

Under this hypothesis, there are two possible scenarios. In the first scenario, a single background source is moving quickly enough perpendicular to the line of sight to be lensed by a multicomponent mass distribution in the foreground, such as a planetary system around a star or a triple stellar system. In this scenario, a sequence of chance alignments of that moving background source with different foreground mass concentrations causes a sequence of magnifications to produce the apparent three point sources, one after the other, during the 50 min exposure. One prediction of this scenario is that there must be a background star fainter than 25th magnitude, and also foreground masses of planets or stars that are also fainter than 25th magnitude, as no objects (foreground or background) brighter than 25th are observed in the two GTC images at *r* and *g* bands. This scenario implies that all three gravitational lensing events in the sequence produce an optical brightening of at least 10 000×. This scenario implies an unlikely sequence of nearly perfect alignments and enormous amplification for all three sources. This seems improbable.

In the second scenario, a background source intrinsically brightens at optical wavelengths by more than 10 000×, presumably due to some explosive physical event. In the foreground there is a stationary, complex mass distribution that lenses that background explosion to produce three gravitational lens images that appear as three nearly point-like sources. In this scenario, the optical emission from the explosive event is finished by the time the 50 min exposure is over, as all three point-sources fade to be undetectable in the POSS I blue image immediately after the POSS I red exposure of 50 min. This scenario predicts that there may be a background source still there but now less than 0.01 per cent as bright as it was at peak luminosity, reached by the combination of the intrinsic luminosity of the source and the gravitational lensing magnification, and there must be a foreground mass still there, also fainter than 25th mag.

In this scenario, the three path lengths of light bent by the gravitational lens must not differ by more than ∼6 au, in order to keep all three rays of lensed light appearing within the 50 min of light-travel time. Foreground lens structures that cause path-length differences larger than ∼6 au could not cause three point sources to naturally brighten and dim together within 50 min in a causal way. This constraint rules out galactic-scale dark matter because the kiloparsec size of galaxies would yield path-length differences of many light years causing arrival-time differences of much longer than 50 min.

Novae, supernovae, and cataclysmic variables take many hours or days to brighten and dim, not within 50 min. Flare stars do not become more luminous by factors of 10 000. One may consider the second scenario to take place inside or outside the Milky Way Galaxy. If within the Galaxy, the peak luminosity would need to be comparable to the supergiant stars that are 14th mag from kiloparsecs away. For extragalactic sources, optical luminosities similar to those of supernovae, kilonovae, or gamma-ray bursts are required to explain the observed brightnesses here. To match the short time-scale of the optical brightening, of less than 50 min, afterglows from mergers of compact objects may be considered. However, the gravitational light-bending must not produce ray path differences more than 50 min in order to maintain coherent brightening within that time-scale, ruling out galactic-scale mass distributions. It is possible that the briefly luminous background source is outside the Milky Way, while the gravitational lens resides within the Milky Way. If so, this constitutes a method to detect condensed objects that are dark within the Milky Way or in its dark matter halo.

The parameter space for a transient object being lensed by some intermediate object(s), producing a set of three point-like transients, is very large. Exploring this entire parameter space is an arduous task, worthy of a separate paper. Instead, we present here a toy model to confirm that gravitational lens model can plausibly yield images separated by ∼10 arcsec. The angular separation of the images from gravitational lensing is given approximately by

$$\Theta_E \approx 0.9''\left(\frac{M_l}{10^{11}\,\mathrm{M}_\odot}\right)^{0.5}\left(\frac{D_s}{1\,\mathrm{Gpc}}\right)^{-0.5}\left(\frac{D_{ls}}{D_l}\right)^{0.5}, \quad (2)$$

where $\mathrm{M}_\odot$ is the mass of the Sun, M_l is the lensing mass, and D_l, D_s, and D_{ls} are the distances from the observer to the lens, to the source, and between the lens and the source, respectively.

As a plausibility model, we may adopt a lens that resides within the Milky Way, ($D_l = 1$ kpc), and an explosive light source located 1 Gpc away ($D_s = 1$ Gpc). We also assume a lensing mass, M_l, of 10^7 $\mathrm{M}_\odot$ to avoid observable effects to the dynamics of the Milky Way. With these parameters, equation (2) shows that a separation between lens images of 9 arcsec, similar to the triple transient, can be achieved by a gravitational lens within the Milky Way and a lens mass comparable to those of common supermassive black holes. It is also important to notice that the source is at low galactic latitude ($l = 92.17°$, $b = 0.70°$). Therefore, in the scenario described above with the source at 1 Gpc, an extinction of several magnitudes in the optical range is expected.

6 SUMMARY

Three bright (∼16th mag), optical point-like sources, appeared on the Palomar Observatory Sky Survey images taken on 1952 July 19. However, within 1 h they dimmed to a magnitude fainter than 21st magnitude at blue wavelengths, and they dimmed by more than 10 mag, a factor of over 10 000, as seen in two non-detections with the 10.4-m GTC telescope. The most isolated of the three sources permits measurement of its profile, which is indistinguishable from the profiles of stars in the same exposure.

The observed time-scale for the dimming of the triple transient of less than the exposure time of 50 min distinguishes these sources from common transients, notably supernovae and optical afterglow of gamma-ray bursts, that last for days and weeks (e.g. Abdalla et al. 2019; MAGIC Collaboration 2019). Also, SNe and GRBs are unresolved, single sources at extragalactic distances. Here, we clearly have three sources, not one.

We considered various scenarios to explain the factor of 10 000 optical dimming of three point-sources with an angular separation on the sky of 10 arcsec. If they are separate objects, their dimming within 50 min constrains their physical separation in space to be less than 6 au for a causal connection. Their angular separation on the sky of only 10 arcsec, along with that 6 au maximum size, constrains the distance to the three objects to be less than 2 light-year, and plausibly inside the Solar system. Thus, one class of explanations involves three objects smaller than the Solar system and closer than the nearest star that brighten and dim within an hour.

Alternatively, the three sources are not separate physical objects but, instead, are images produced by a gravitational lens. One may consider scenarios involving the gravitational lensing of a background explosive event that brightens and dims at optical wavelengths by 10 000× within 50 min. The foreground gravitational lens must have enough structure to produce three point-like images. We do not know what explosive events can provide the decrease in luminosity of 10 000× with a time-scale of ∼1 h, as required by the observations. Nor do we know what possible foreground mass distributions can produce three images. The very simplest type of lens – a point mass – will create a ring if perfectly centred, or, if the lens is off-centre, a pair of approximately equally bright images, plus one very faint image. On the contrary, the creation of three images of nearly equal brightness is not expected for any simple type of lens. Alternatively, the lens might be of a more complex type, formed by multiple black holes or an inhomogeneous clump of dark matter.

The subhour time-scale of the triple transient raises the question of a possible association with fast radio bursts (FRBs), events that can be associated with magnetars originated after the merger of two neutron stars (Bochenek et al. 2020; Moroianu et al. 2023). In this scenario, the FRB is in the background. It is likely that its optical luminosity increases by a process physically related to the process that causes the increase in luminosity in the radio regime. Finally, this triple transient may have a technological origin. Given typical aircraft speeds and distances, any flash with a duration longer than >0.1 ms would be smeared or elongated by more than 1 arcsec, which was not seen. Flashes shorter than 0.1 ms were not technically possible with the incandescent light bulbs used in human aircraft in 1952. Moreover, flashing strobes on typical human aircraft are accompanied by continuous lights, while in the case of the triple transient no such continuous light is seen. Further, strobing lights on airplanes are designed to flash repeatedly to increase flight safety, while the triple transients appear to have flashed only once during the 50 min exposure.

Similar dimming of multiple transient sources within a few arcmin, were reported by Villarroel et al. (2021, 2022a), along with similar dimming of thousands of transients by a factor of 10 000 (Villarroel et al. 2020; Solano, Villarroel & Rodrigo 2022). The nine transients in Villarroel et al. (2021) within 10 × 10 arcmin raise the question of whether the same mechanism can explain the triple transient here, separated by only 10 arcsec. However, it is difficult to imagine a model that involves gravitational lensing that produces lensing images separated by 10 arcmin. The observation of the triple transient, as well as other similar events, calls for careful follow-up searches.

ACKNOWLEDGEMENTS

We thank the referee for his constructive feedback. His comments and suggestions have greatly improved the paper. This research has made use of the Spanish Virtual Observatory (https://svo.cab.inta-csic.es) project funded by the Spanish Ministry of Science and Innovation/State Agency of Research MCIN/AEI/10.13039/501100011033 through grant PID2020-112949GB-I00 and MDM-2017-0737 at Centro de Astrobiología (CSIC-INTA). We also thank the teams and staff at the Gran Telescopio Canarias and at Space Laser Awareness for valuable technical and infrastructural help. We thank the staff and technical teams at the Gran Telescopio Canarias for the excellent performance of the OSIRIS camera and 10.4-m GTC telescope facility. BV acknowledges Francisco Ricardo, Jacques Vallée, Eugene Jhong, and Christopher Mellon for helpful discussions and support for VASCO research work by Swiss Philantropy Foundation and L'Oreal-UNESCO. She thanks Heterodox Academy for support via the Open Inquiry Courage Award. The Pan-STARRS1 Surveys (PS1) and the PS1 public science archive have been made possible through contributions by the Institute for Astronomy, the University of Hawaii, the Pan-STARRS Project Office, the Max-Planck Society and its participating institutes, the Max Planck Institute for Astronomy, Heidelberg and the Max Planck Institute for Extraterrestrial Physics, Garching, The Johns Hopkins University, Durham University, the University of Edinburgh, the Queen's University Belfast, the Harvard-Smithsonian Center for Astrophysics, the Las Cumbres Observatory Global Telescope Network Incorporated, the National Central University of Taiwan, the Space Telescope Science Institute, the National Aeronautics and Space Administration under Grant No. NNX08AR22G issued through the Planetary Science Division of the NASA Science Mission Directorate, the National Science Foundation grant no. AST-1238877, the University of Maryland, Eotvos Lorand University (ELTE), the Los Alamos National Laboratory, and the Gordon and Betty Moore Foundation. This research has made use of data obtained from the SuperCOSMOS Science Archive, prepared and hosted by the Wide Field Astronomy Unit, Institute for Astronomy, University of Edinburgh, which is funded by the UK Science and Technology Facilities Council. This research has made use of the NASA/IPAC Infrared Science Archive, which is funded by the National Aeronautics and Space Administration and operated by the California Institute of Technology. This research has made use of IRAF. IRAF was distributed by the National Optical Astronomy Observatory, which was managed by the Association of Universities for Research in Astronomy (AURA) under a cooperative agreement with the National Science Foundation.This research has made use of ALADIN (Bonnarel et al. 2000) developed at CDS, Strasbourg Observatory, France. TOPCAT (Taylor 2005) and STILTS (Taylor 2006) have also been widely used in this paper.

DATA AVAILABILITY

This paper is based mostly on publicly available data, including the Palomar Sky Survey from STScI and SuperCosmos, and publicly available data from Pan-STARRS, SDSS, ZTF, *Gaia*, and USNO-B1. In addition, we obtained two images with the 10.4-m GTC, *r* and *g* band, which are available from the first author upon request.

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