= Transient lunar phenomenon =

A transient lunar phenomenon (TLP) or lunar transient phenomenon (LTP) is a short @-@ lived light , color , or change in appearance on the surface of the Moon .

Claims of short @-@ lived lunar phenomena go back at least 1 @,@ 000 years , with some having been observed independently by multiple witnesses or reputable scientists . Nevertheless , the majority of transient lunar phenomenon reports are irreproducible and do not possess adequate control experiments that could be used to distinguish among alternative hypotheses to explain their origins .

Most lunar scientists will acknowledge that transient events such as outgassing and impact cratering do occur over geologic time : the controversy lies in the frequency of such events .

The term was created by Patrick Moore in his co @-@ authorship of NASA Technical Report R @-@ 277 Chronological Catalog of Reported Lunar Events , published in 1968 .

= = Description of events = =

Reports of transient lunar phenomena range from foggy patches to permanent changes of the lunar landscape . Cameron classifies these as (1) gaseous , involving mists and other forms of obscuration , (2) reddish colorations , (3) green , blue or violet colorations , (4) brightenings , and (5) darkenings . Two extensive catalogs of transient lunar phenomena exist , with the most recent tallying 2 @,@ 254 events going back to the 6th century . Of the most reliable of these events , at least one @-@ third come from the vicinity of the Aristarchus plateau .

A few of the more famous historical accounts of transient phenomena include the following :

On June 18 , 1178 , five or more monks from Canterbury reported an upheaval on the Moon shortly after sunset . " There was a bright new moon , and as usual in that phase its horns were tilted toward the east ; and suddenly the upper horn split in two . From the midpoint of this division a flaming torch sprang up , spewing out , over a considerable distance , fire , hot coals , and sparks . Meanwhile the body of the moon which was below writhed , as it were , in anxiety , and , to put it in the words of those who reported it to me and saw it with their own eyes , the moon throbbed like a wounded snake . Afterwards it resumed its proper state . This phenomenon was repeated a dozen times or more , the flame assuming various twisting shapes at random and then returning to normal . Then after these transformations the moon from horn to horn , that is along its whole length , took on a blackish appearance . " Before you start to think these monks were crazy , you need to look at the date this happened . In 1178 , how would you describe seeing meteors crash into a new moon ? In 1976 , Jack Hartung proposed that this described the formation of the Giordano Bruno crater . However , more recent studies suggest that it appears very unlikely the 1178 event was related to the formation of Crater Giordano Bruno , or was even a true transient lunar phenomenon at all . The millions of tons of lunar debris ejected from an impact large enough to leave a 22 @-@ km @-@ wide crater would have resulted in an unprecedentedly intense , week @-@ long meteor storm on Earth . No accounts of such a memorable storm have been found in any known historical records , including several astronomical archives from around the world . In light of this , it is suspected that the group of monks (the event 's only known witnesses) saw the atmospheric explosion of a directly oncoming meteor in chance alignment , from their specific vantage point , with the far more distant moon .

During the night of April 19 , 1787 , the British astronomer Sir William Herschel noticed three red glowing spots on the dark part of the Moon . He informed King George III and other astronomers of his observations . Herschel attributed the phenomena to erupting volcanoes and perceived the luminosity of the brightest of the three as greater than the brightness of a comet that had been discovered on April 10 . His observations were made while an aurora borealis (northern lights) rippled above Padua , Italy . Aurora activity that far south from the Arctic Circle was very rare . Padua 's display and Herschel 's observations had happened a few days before the number of sunspots had peaked in May 1787 .

In 1866 , the experienced lunar observer and mapmaker J. F. Julius Schmidt claimed that the Linné

crater had changed its appearance . Based on drawings made earlier by J. H. Schröter , as well as personal observations and drawings made between 1841 and 1843 , he stated that the crater " at the time of oblique illumination cannot at all be seen " (his emphasis) , whereas at high illumination , it was visible as a bright spot . Based on repeat observations , he further stated that " Linné can never be seen under any illumination as a crater of the normal type " and that " a local change has taken place " . Today , Linné is visible as a normal young impact crater with a diameter of about 1 @.@ 5 miles (2 @.@ 4 km) .

On November 2 , 1958 , the Russian astronomer Nikolai A. Kozyrev observed an apparent half @-@ hour " eruption " that took place on the central peak of Alphonsus crater using a 48 @-@ inch (122 @-@ cm) reflector telescope equipped with a spectrometer . During this time , the obtained spectra showed evidence for bright gaseous emission bands due to the molecules C2 and C3 . While exposing his second spectrogram , he noticed " a marked increase in the brightness of the central region and an unusual white colour . " Then , " all of a sudden the brightness started to decrease " and the resulting spectrum was normal .

On October 29 , 1963 , two Aeronautical Chart and Information Center cartographers , James Clarke Greenacre and Edward M. Barr , at the Lowell Observatory , Flagstaff , Arizona , manually recorded very bright red , orange , and pink colour phenomena on the southwest side of Cobra Head ; a hill southeast of the lunar valley Vallis Schröteri ; and the southwest interior rim of the Aristarchus crater . This event sparked a major change in attitude towards TLP reports . According to Willy Ley : " The first reaction in professional circles was , naturally , surprise , and hard on the heels of the surprise there followed an apologetic attitude , the apologies being directed at a long @-@ dead great astronomer , Sir William Herschel . " A notation by Winifred Sawtell Cameron states (1978 , Event Serial No. 778) : " This and their November observations started the modern interest and observing the Moon . " The credibility of their findings stemmed from Greenacre 's exemplary reputation as an impeccable cartographer , rather than from any photographic evidence .

On the night of November 1 ? 2 , 1963 , a few days after Greenacre 's event , at the Observatoire du Pic @-@ du @-@ Midi in the French Pyrenees , Zden?k Kopal and Thomas Rackham made the first photographs of a " wide area lunar luminescence " . His article in Scientific American transformed it into one of the most widely publicized TLP events . Kopal , like others , had argued that Solar Energetic Particles could be the cause of such a phenomenon .

During the Apollo 11 mission in 1969 , Houston radioed to Apollo 11 : " We 've got an observation you can make if you have some time up there . There 's been some lunar transient events reported in the vicinity of Aristarchus . " Astronomers in Bochum , West Germany , had observed a bright glow on the lunar surface ? the same sort of eerie luminescence that has intrigued Moon watchers for centuries . The report was passed on to Houston and thence to the astronauts . Almost immediately , Michael Collins reported back : " Hey , Houston , I 'm looking north up toward Aristarchus now , and there 's an area that is considerably more illuminated than the surrounding area . It seems to have a slight amount of fluorescence . "

In 1992 , Audouin Dollfus of the Observatoire de Paris reported anomalous features on the floor of Langrenus crater using a one @-@ meter (3 @.@ 2 @-@ foot) telescope . While observations on the night of December 29 , 1992 , were normal , unusually high albedo and polarization features were recorded the following night that did not change in appearance over the six minutes of data collection . Observations three days later showed a similar , but smaller , anomaly in the same vicinity . While the viewing conditions for this region were close to specular , it was argued that the amplitude of the observations were not consistent with a specular reflection of sunlight . The favored hypothesis was that this was the consequence of light scattering from clouds of airborne particles resulting from a release of gas . The fractured floor of this crater was cited as a possible source of the gas .

= = Explanations = =

Explanations for the transient lunar phenomena fall in four classes : outgassing , impact events , electrostatic phenomena , and unfavorable observation conditions .

= = = Outgassing = = =

Some TLPs may be caused by gas escaping from underground cavities . These gaseous events are purported to display a distinctive reddish hue , while others have appeared as white clouds or an indistinct haze . The majority of TLPs appear to be associated with floor @-@ fractured craters , the edges of lunar maria , or in other locations linked by geologists with volcanic activity . However , these are some of the most common targets when viewing the Moon , and this correlation could be an observational bias .

In support of the outgassing hypothesis , data from the Lunar Prospector alpha particle spectrometer indicate the recent outgassing of radon to the surface . In particular , results show that radon gas was emanating from the vicinity of the craters Aristarchus and Kepler during the time of this two @-@ year mission . These observations could be explained by the slow and visually imperceptible diffusion of gas to the surface , or by discrete explosive events . In support of explosive outgassing , it has been suggested that a roughly 3 km- (1 @.@ 9 mi-) diameter region of the lunar surface was " recently " modified by a gas release event . The age of this feature is believed to be about 1 million years old , suggesting that such large phenomena occur only infrequently .

= = = Impact events = = =

Impact events are continually occurring on the lunar surface . The most common events are those associated with micrometeorites , as might be encountered during meteor showers . Impact flashes from such events have been detected from multiple and simultaneous Earth @-@ based observations . Tables of impacts recorded by video cameras exist for years since 2005 many of which are associated with meteor showers . Furthermore , impact clouds were detected following the crash of ESA 's SMART @-@ 1 spacecraft , India 's Moon Impact Probe and NASA 's LCROSS . Impact events leave a visible scar on the surface , and these could be detected by analyzing before and after photos of sufficiently high resolution . No impact craters formed between the Clementine (global resolution 100 metre , selected areas 7 @-@ 20 metre) and SMART @-@ 1 (resolution 50 metre) missions have been identified .

= = = Electrostatic phenomena = = =

It has been suggested that effects related to either electrostatic charging or discharging might be able to account for some of the transient lunar phenomena . One possibility is that electrodynamic effects related to the fracturing of near @-@ surface materials could charge any gases that might be present , such as implanted solar wind or radiogenic daughter products . If this were to occur at the surface , the subsequent discharge from this gas might be able to give rise to phenomena visible from Earth . Alternatively , it has been proposed that the triboelectric charging of particles within a gas @-@ borne dust cloud could give rise to electrostatic discharges visible from Earth . Finally , electrostatic levitation of dust near the terminator could potentially give rise to some form of phenomenon visible from Earth .

= = = Unfavourable observation conditions = = =

It is possible that many transient phenomena might not be associated with the Moon itself but could be a result of unfavourable observing conditions or phenomena associated with the Earth . For instance , some reported transient phenomena are for objects near the resolution of the employed telescopes . The Earth 's atmosphere can give rise to significant temporal distortions that could be confused with actual lunar phenomena (an effect known as astronomical seeing) . Other non @-@ lunar explanations include the viewing of Earth @-@ orbiting satellites and meteors or observational error .

= = Debated status of TLPs = =

The most significant problem that faces reports of transient lunar phenomena is that the vast majority of these were made either by a single observer or at a single location on Earth (or both) . The multitude of reports for transient phenomena occurring at the same place on the Moon could be used as evidence supporting their existence . However , in the absence of eyewitness reports from multiple observers at multiple locations on Earth for the same event , these must be regarded with caution . As discussed above , an equally plausible hypothesis for some of these events is that they are caused by the terrestrial atmosphere . If an event were to be observed at two different places on Earth at the same time , this could be used as evidence against an atmospheric origin .

One attempt to overcome the above problems with transient phenomena reports was made during the Clementine mission by a network of amateur astronomers . Several events were reported , of which four of these were photographed both beforehand and afterward by the spacecraft . However , careful analysis of these images shows no discernible differences at these sites . This does not necessarily imply that these reports were a result of observational error , as it is possible that outgassing events on the lunar surface might not leave a visible marker , but neither is it encouraging for the hypothesis that these were authentic lunar phenomena .

Observations are currently being coordinated by the Association of Lunar and Planetary Observers and the British Astronomical Association to re @-@ observe sites where transient lunar phenomena were reported in the past . By documenting the appearance of these features under the same illumination and libration conditions , it is possible to judge whether some reports were simply due to a misinterpretation of what the observer regarded as an abnormality . Furthermore , with digital images , it is possible to simulate atmospheric spectral dispersion , astronomical seeing blur and light scattering by our atmosphere to determine if these phenomena could explain some of the original TLP reports .