

= History of supernova observation =

The known history of supernova observation goes back to 185 CE , when , supernova SN 185 appeared , the oldest appearance of a supernova recorded by humankind . Several additional supernovae within the Milky Way galaxy have been recorded since that time , with SN 1604 being the most recent supernova to be observed in this galaxy .

Since the development of the telescope , the field of supernova discovery has expanded to other galaxies . These occurrences provide important information on the distances of galaxies . Successful models of supernova behavior have also been developed , and the role of supernovae in the star formation process is now increasingly understood .

= = Early history = =

The supernova explosion that formed the Vela Supernova Remnant most likely occurred 10 @,@ 000 ? 20 @,@ 000 years ago . In 1976 , NASA astronomers suggested that inhabitants of the southern hemisphere may have witnessed this explosion and recorded it symbolically . A year later , archaeologist George Michanowsky recalled some incomprehensible ancient markings in Bolivia that were left by Native Americans . The carvings showed four small circles flanked by two larger circles . The smaller circles resemble stellar groupings in the constellations Vela and Carina . One of the larger circles may represent the star Capella . Another circle is located near the position of the supernova remnant , George Michanowsky suggested this may represent the supernova explosion as witnessed by the indigenous residents .

In 185 CE , Chinese astronomers recorded the appearance of a bright star in the sky , and observed that it took about eight months to fade from the sky . It was observed to sparkle like a star and did not move across the heavens like a comet . These observations are consistent with the appearance of a supernova , and this is believed to be the oldest confirmed record of a supernova event by humankind . SN 185 may have also possibly been recorded in Roman literature , though no records have survived . The gaseous shell RCW 86 is suspected as being the remnant of this event , and recent X @-@ ray studies show a good match for the expected age .

In 393 CE , the Chinese recorded the appearance of another " guest star " , SN 393 , in the modern constellation of Scorpius . Additional unconfirmed supernovae events may have been observed in 369 CE , 386 CE , 437 CE , 827 CE and 902 CE . However these have not yet been associated with a supernova remnant , and so they remain only candidates . Over a span of about 2 @,@ 000 years , Chinese astronomers recorded a total of twenty such candidate events , including later explosions noted by Islamic , European , and possibly Indian and other observers .

The supernova SN 1006 appeared in the southern constellation of Lupus during the year 1006 CE . This was the brightest recorded star ever to appear in the night sky , and its presence was noted in China , Egypt , Iraq , Italy , Japan and Switzerland . It may also have been noted in France , Syria , and North America . Egyptian physician , astronomer and astrologer Ali ibn Ridwan gave the brightness of this star as one @-@ quarter the brightness of the Moon . Modern astronomers have discovered the faint remnant of this explosion and determined that it was only 7 @,@ 100 light @-@ years from the Earth .

Supernova SN 1054 was another widely observed event , with Arab , Chinese , and Japanese astronomers recording the star 's appearance in 1054 CE . It may also have been recorded by the Anasazi as a petroglyph . This explosion appeared in the constellation of Taurus , where it produced the Crab Nebula remnant . At its peak , the luminosity of SN 1054 may have been four times as bright as Venus , and it remained visible in daylight for 23 days and was visible in the night sky for 653 days .

There are fewer records of supernova SN 1181 , which occurred in the constellation Cassiopeia just over a century after SN 1054 . It was noted by Chinese and Japanese astronomers , however . The pulsar 3C58 may be the stellar relic from this event .

The Danish astronomer Tycho Brahe was noted for his careful observations of the night sky from his observatory on the island of Hven . In 1572 he noted the appearance of a new star , also in the

constellation Cassiopeia . Later called SN 1572 , this supernova was associated with a remnant during the 1960s .

A common belief in Europe during this period was the Aristotelian idea that the world beyond the Moon and planets was immutable . So observers argued that the phenomenon was something in the Earth 's atmosphere . However Tycho noted that the object remained stationary from night to night ? never changing its parallax ? so it must lie far away . He published his observations in the small book *De nova et nullius aevi memoria prius visa stella* (Latin for " Concerning the new and previously unseen star ") in 1573 . It is from the title of this book that the modern word nova for cataclysmic variable stars is derived .

The most recent supernova to be seen in the Milky Way galaxy was SN 1604 , which was observed October 9 , 1604 . Several people noted the sudden appearance of this star , but it was Johannes Kepler who became noted for his systematic study of the object . He published his observations in the work *De Stella nova in pede Serpentarii* .

Galileo , like Tycho before him , tried in vain to measure the parallax of this new star , and then argued against the Aristotelian view of an immutable heavens . The remnant of this supernova was identified in 1941 at the Mount Wilson Observatory .

= = Telescope observation = =

The true nature of the supernova remained obscure for some time . Observers slowly came to recognize a class of stars that undergo long @-@ term periodic fluctuations in luminosity . Both John Russell Hind in 1848 and Norman Pogson in 1863 had charted stars that underwent sudden changes in brightness . However these received little attention from the astronomical community . Finally , in 1866 , English astronomer William Huggins made the first spectroscopic observations of a nova , discovering lines of hydrogen in the unusual spectrum of the recurrent nova T Coronae Borealis . Huggins proposed a cataclysmic explosion as the underlying mechanism , and his efforts drew interest from other astronomers .

In 1885 , a nova @-@ like outburst was observed in the direction of the Andromeda galaxy by Ernst Hartwig in Estonia . S Andromedae increased to 6th magnitude , outshining the entire nucleus of the galaxy , then faded in a manner much like a nova . In 1917 , George W. Ritchey measured the distance to the Andromeda Galaxy and discovered it lay much farther than had previously been thought . This meant that S Andromedae , which did not just lie along the line of sight to the galaxy but had actually resided in the nucleus , released a much greater amount of energy than was typical for a nova .

Early work on this new category of nova was performed during the 1930s by Walter Baade and Fritz Zwicky at Mount Wilson Observatory . They identified S Andromedae , what they considered a typical supernova , as an explosive event that released radiation approximately equal to the Sun 's total energy output for 107 years . They decided to call this new class of cataclysmic variables super @-@ novae , and postulated that the energy was generated by the gravitational collapse of ordinary stars into neutron stars . The name super @-@ novae was first used in a 1931 lecture at Caltech by Zwicky , then used publicly in 1933 at a meeting of the American Physical Society . By 1938 , the hyphen had been lost and the modern name was in use .

Although supernovae are relatively rare events , occurring on average about once every 50 years in the Milky Way , observations of distant galaxies allowed supernovae to be discovered and examined more frequently . The first supernova detection patrol was begun by Zwicky in 1933 . He was joined by Josef J. Johnson from Caltech in 1936 . Using a 45 @-@ cm Schmidt telescope at Palomar observatory , they discovered twelve new supernovae within three years by comparing new photographic plates to reference images of extragalactic regions .

In 1938 , Walter Baade became the first astronomer to identify a nebula as a supernova remnant when he suggested that the Crab Nebula was the remains of SN 1054 . He noted that , while it had the appearance of a planetary nebula , the measured velocity of expansion was much too large to belong to that classification . During the same year , Baade first proposed the use of the Type Ia supernova as a secondary distance indicator . Later , the work of Allan Sandage and Gustav

Tammann helped refine the process so that Type Ia supernovae became a type of standard candle for measuring large distances across the cosmos .

The first spectral classification of these distant supernovae was performed by Rudolph Minkowski in 1941 . He categorized them into two types , based on whether or not lines of the element hydrogen appeared in the supernova spectrum . Zwicky later proposed additional types III , IV , and V , although these are no longer used and now appear to be associated with single peculiar supernova types . Further sub @-@ division of the spectra categories resulted in the modern supernova classification scheme .

In the aftermath of the Second World War , Fred Hoyle worked on the problem of how the various observed elements in the universe were produced . In 1946 he proposed that a massive star could generate the necessary thermonuclear reactions , and the nuclear reactions of heavy elements were responsible for the removal of energy necessary for a gravitational collapse to occur . The collapsing star became rotationally unstable , and produced an explosive expulsion of elements that were distributed into interstellar space . The concept that rapid nuclear fusion was the source of energy for a supernova explosion was developed by Hoyle and William Fowler during the 1960s .

The first computer @-@ controlled search for supernovae was begun in the 1960s at Northwestern University . They built a 24 @-@ inch telescope at Corralitos Observatory in New Mexico that could be repositioned under computer control . The telescope displayed a new galaxy each minute , with observers checking the view on a television screen . By this means , they discovered 14 supernovae over a period of two years .

= = 1970 ? 1999 = =

The modern standard model for Type Ia supernovae explosions is founded on a proposal by Whelan and Iben in 1973 , and is based upon a mass @-@ transfer scenario to a degenerate companion star . In particular , the light curve of SN1972e in NGC 5253 , which was observed for more than a year , was followed long enough to discover that after its broad " hump " in brightness , the supernova faded at a nearly constant rate of about 0 @.@ 01 magnitudes per day . Translated to another system of units , this is nearly the same as the decay rate of cobalt @-@ 56 (^{56}Co) , whose half @-@ life is 77 days . The degenerate explosion model predicts the production of about a solar mass of nickel @-@ 56 (^{56}Ni) by the exploding star . The ^{56}Ni decays with a half @-@ life of 6 @.@ 8 days to ^{56}Co , and the decay of the nickel and cobalt provides the energy radiated away by the supernova late in its history . The agreement in both total energy production and the fade rate between the theoretical models and the observations of 1972e led to rapid acceptance of the degenerate @-@ explosion model .

Through observation of the light curves of many Type Ia supernovae , it was discovered that they appear to have a common peak luminosity . By measuring the luminosity of these events , the distance to their host galaxy can be estimated with good accuracy . Thus this category of supernovae has become highly useful as a standard candle for measuring cosmic distances . In 1998 , the High @-@ Z Supernova Search and the Supernova Cosmology Project discovered that the most distant Type Ia supernovae appeared dimmer than expected . This has provided evidence that the expansion of the universe may be accelerating .

Although no supernova has been observed in the Milky Way since 1604 , it appears that a supernova exploded in the constellation Cassiopeia about 300 years ago , around the year 1667 or 1680 . The remnant of this explosion , Cassiopeia A ? is heavily obscured by interstellar dust , which is possibly why it did not make a notable appearance . However it can be observed in other parts of the spectrum , and it is currently the brightest radio source beyond our solar system .

In 1987 , Supernova 1987A in the Large Magellanic Cloud was observed within hours of its start . It was the first supernova to be detected through its neutrino emission and the first to be observed across every band of the electromagnetic spectrum . The relative proximity of this supernova has allowed detailed observation , and it provided the first opportunity for modern theories of supernova formation to be tested against observations .

The rate of supernova discovery steadily increased throughout the twentieth century . In the 1990s ,

several automated supernova search programs were initiated . The Leuschner Observatory Supernova Search program was begun in 1992 at Leuschner Observatory . It was joined the same year by the Berkeley Automated Imaging Telescope program . These were succeeded in 1996 by the Katzman Automatic Imaging Telescope at Lick Observatory , which was primarily used for the Lick Observatory Supernova Search (LOSS) . By 2000 , the Lick program resulted in the discovery of 96 supernovae , making it the world 's most successful Supernova search program .

In the late 1990s it was proposed that recent supernova remnants could be found by looking for gamma rays from the decay of titanium ^{44}Ti . This has a half ^{44}Ti life of 90 years and the gamma rays can traverse the galaxy easily , so it permits us to see any remnants from the last millennium or so . Two sources were found , the previously discovered Cassiopeia A remnant , and the RX J0852.0 ^{44}Ti 4622 remnant , which had just been discovered overlapping the Vela Supernova Remnant

This remnant (RX J0852.0 ^{44}Ti 4622) had been found in front (apparently) of the larger Vela Supernova Remnant . The gamma rays from the decay of titanium ^{44}Ti showed that it must have exploded fairly recently (perhaps around 1200 AD) , but there is no historical record of it . The flux of gamma rays and x ^{44}Ti rays indicates that the supernova was relatively close to us (perhaps 200 parsecs or 600 ly) . If so , this is a surprising event because supernovae less than 200 parsecs away are estimated to occur less than once per 100 ^{44}Ti 000 years .

= = 2000 to present = =

The " SN 2003fg " was discovered in a forming galaxy in 2003 . The appearance of this supernova was studied in " real ^{44}Ti time " , and it has posed several major physical questions as it seems more massive than the Chandrasekhar limit would allow .

First observed in September 2006 , the supernova SN 2006gy , which occurred in a galaxy called NGC 1260 (240 million light ^{44}Ti years away) , is the largest and , until confirmation of luminosity of SN 2005ap in October 2007 , the most luminous supernova ever observed . The explosion was at least 100 times more luminous than any previously observed supernova , with the progenitor star being estimated 150 times more massive than the Sun . Although this had some characteristics of a Type Ia supernova , Hydrogen was found in the spectrum . It is thought that SN 2006gy is a likely candidate for a pair ^{44}Ti instability supernova . SN 2005ap , which was discovered by Robert Quimby who also discovered SN 2006gy , was about twice as bright as SN 2006gy and about 300 times as bright as a normal type II supernova .

On May 21 , 2008 , astronomers announced that they had for the first time caught a supernova on camera just as it was exploding . By chance , a burst of X ^{44}Ti rays was noticed while looking at galaxy NGC 2770 , 88 million light ^{44}Ti years from Earth , and a variety of telescopes were aimed in that direction just in time to capture what has been named SN 2008D . " This eventually confirmed that the big X ^{44}Ti ray blast marked the birth of a supernova , " said Alicia Soderberg of Princeton University .

One of the many amateur astronomers looking for supernovae , Caroline Moore , a member of the Puckett Observatory Supernova Search Team , found supernova SN 2008ha late November 2008 . At the age of 14 she has now been declared the youngest person ever to find a supernova . However , in January 2011 , 10 ^{44}Ti year ^{44}Ti old Kathryn Aurora Gray from Canada was reported to have discovered a supernova , making her the youngest ever to find a supernova . Ms. Gray , her father , and a friend spotted SN 2010lt , a magnitude 17 supernova in galaxy UGC 3378 in the constellation Camelopardalis , about 240 million light years away .

In 2009 , researchers have found nitrates in ice cores from Antarctica at depths corresponding to the known supernovae of 1006 and 1054 AD , as well as from around 1060 AD . The nitrates were apparently formed from nitrogen oxides created by gamma rays from the supernovae . This technique should be able to detect supernovae going back several thousand years .

On November 15 , 2010 , astronomers using NASA 's Chandra X ^{44}Ti ray Observatory announced that , while viewing the remnant of SN 1979C in the galaxy Messier 100 , they have discovered an object which could be a young , 30 ^{44}Ti year ^{44}Ti old black hole . NASA also noted the possibility

this object could be a spinning neutron star producing a wind of high energy particles .

On August 24 , 2011 , the Palomar Transient Factory automated survey discovered a new Type Ia supernova (SN 2011fe) in the Pinwheel Galaxy (M101) shortly after it burst into existence . Being only 21 million lightyears away and detected so early after the event started , it will allow scientists to learn more about the early developments of these types of supernovae .

On 16 March 2012 , a Type II supernova , designated as SN 2012aw , was discovered in M95 .

On January 22 , 2014 , students at the University of London Observatory spotted an exploding star SN 2014J in the nearby galaxy M82 (the Cigar Galaxy) . At a distance of around 12 million light years , the supernova is one of the nearest to be observed in recent decades .

= = Future = =

The estimated rate of supernova production in a galaxy the size of the Milky Way is about one every 50 years . This is much higher than the actual observed rate , implying that a portion of these events have been obscured from the Earth by interstellar dust . The deployment of new instruments that can observe across a wide range of the electromagnetic spectrum , along with neutrino detectors , means that the next such event will almost certainly be detected .