

= Kreutz sungrazer =

The Kreutz sungrazers ( / ˈkrɔʊts / , pronounced kroits ) are a family of sungrazing comets , characterized by orbits taking them extremely close to the Sun at perihelion . They are believed to be fragments of one large comet that broke up several centuries ago and are named for German astronomer Heinrich Kreutz , who first demonstrated that they were related . A Kreutz sungrazer's aphelion is about 170 AU from the Sun ; these sungrazers make their way from the distant outer Solar System from a patch in the sky in Canis Major , to the inner Solar System , to their perihelion point near the Sun , and then leave the inner Solar System in their return trip to their aphelion .

Several members of the Kreutz family have become great comets , occasionally visible near the Sun in the daytime sky . The most recent of these was Comet Ikeya ? Seki in 1965 , which may have been one of the brightest comets in the last millennium . It has been suggested that another cluster of bright Kreutz system comets may begin to arrive in the inner Solar System in the next few years to decades .

Many hundreds of smaller members of the family , some only a few meters across , have been discovered since the launch of the SOHO satellite in 1995 . None of these smaller comets have survived its perihelion passage . Larger sungrazers such as the Great Comet of 1843 and C / 2011 W3 ( Lovejoy ) have survived their perihelion passage . Amateur astronomers have been successful at discovering Kreutz comets in the data available in real time via the Internet .

= = Discovery and historical observations = =

The first comet whose orbit had been found to take it extremely close to the Sun was the Great Comet of 1680 . This comet was found to have passed just 200 @, @ 000 km ( 0 @. @ 0013 AU ) above the Sun 's surface , equivalent to about half the distance between the Earth and the Moon . It thus became the first known sungrazing comet . Its perihelion distance was just 1 @. @ 3 solar radii .

Astronomers at the time , including Edmond Halley , speculated that this comet was a return of a bright comet seen close to the Sun in the sky in 1106 . 163 years later , the Great Comet of 1843 appeared and also passed extremely close to the Sun . Despite orbital calculations showing that it had a period of several centuries , some astronomers wondered if it was a return of the 1680 comet . A bright comet seen in 1880 was found to be travelling on an almost identical orbit to that of 1843 , as was the subsequent Great Comet of 1882 . Some astronomers suggested that perhaps they were all one comet , whose orbital period was somehow being drastically shortened at each perihelion passage , perhaps by retardation by some dense material surrounding the Sun .

An alternative suggestion was that the comets were all fragments of an earlier Sun @-@ grazing comet . This idea was first proposed in 1880 , and its plausibility was amply demonstrated when the Great Comet of 1882 broke up into several fragments after its perihelion passage . In 1888 , Heinrich Kreutz published a paper showing that the comets of 1843 ( C / 1843 D1 , the Great March Comet ) , 1880 ( C / 1880 C1 , the Great Southern Comet ) , and 1882 ( C / 1882 R1 , Great September Comet ) were probably fragments of a giant comet that had broken up several orbits before . The comet of 1680 proved to be unrelated to this family of comets .

After another Kreutz sungrazer was seen in 1887 ( C / 1887 B1 , the Great Southern Comet of 1887 ) , the next one did not appear until 1945 . Two further sungrazers appeared in the 1960s , Comet Pereyra in 1963 and Comet Ikeya ? Seki , which became extremely bright in 1965 , and broke into three pieces after its perihelion . The appearance of two Kreutz Sungrazers in quick succession inspired further study of the dynamics of the group .

The group generally has an Inclination of roughly 140 degrees , a perihelion distance of around 0 @. @ 01 AU , and a Longitude of ascending node of 340 ? 10 ° .

= = Notable members = =

The brightest members of the Kreutz sungrazers have been spectacular , easily visible in the

daytime sky . The three most impressive have been the Great Comet of 1843 , the Great Comet of 1882 and Comet Ikeya ? Seki . Another notable Kreutz sungrazer was the Eclipse Comet of 1882 ( see further below ) .

== Great Comet of 1843 ==

The Great Comet of 1843 was first noticed in early February of that year , just over three weeks before its perihelion passage . By February 27 it was easily visible in the daytime sky , and observers described seeing a tail 2 ? 3 ° long stretching away from the Sun before being lost in the glare of the sky . After its perihelion passage , it reappeared in the morning sky , and developed an extremely long tail . It extended about 45 ° across the sky on March 11 and was more than 2 ° wide ; the tail was calculated to be more than 300 million kilometers ( 2 AU ) long . This held the record for the longest measured cometary tail until 2000 , when Comet Hyakutake 's tail was found to stretch to some 550 million kilometers in length . ( The Earth ? Sun distance ? 1 AU ? is only 150 million kilometers . )

The comet was very prominent throughout early March , before fading away to almost below naked eye visibility by the beginning of April . It was last detected on April 20 . This comet apparently made a substantial impression on the public , inspiring in some a fear that judgement day was imminent .

== Eclipse Comet of 1882 ==

A party of observers gathered in Egypt to watch a solar eclipse in May 1882 were greatly surprised when they observed a bright streak near to the Sun once totality began . By a remarkable coincidence , the eclipse had coincided with the perihelion passage of a Kreutz comet . The comet would otherwise have gone unnoticed ? its sighting during the eclipse was the only observation of it . Photographs of the eclipse revealed that the comet had moved noticeably during the 1m50s eclipse , as would be expected for a comet racing past the Sun at almost 500 km / s . The comet is sometimes referred to as Tewfik , after Tewfik Pasha , the Khedive of Egypt at the time .

== Great Comet of 1882 ==

The Great Comet of 1882 was discovered independently by many observers , as it was already easily visible to the naked eye when it appeared in early September 1882 , just a few days before perihelion . It grew rapidly brighter and was eventually so bright it was visible in the daytime for two days ( 16 ? 17 September ) , even through light cloud .

After its perihelion passage , the comet remained bright for several weeks . During October , its nucleus was seen to fragment into first two and then four pieces . Some observers also reported seeing diffuse patches of light several degrees away from the nucleus . The rate of separation of the fragments of the nucleus was such that they will return about a century apart , between 670 and 960 years after the break @-@ up .

== Comet Ikeya ? Seki ==

Comet Ikeya ? Seki is the most recent very bright Kreutz sungrazer . It was discovered independently by two Japanese amateur astronomers on September 18 , 1965 , within 15 minutes of each other , and quickly recognised as a Kreutz sungrazer . It brightened rapidly over the following four weeks as it approached the Sun , and reached apparent magnitude 2 by October 15 . Its perihelion passage occurred on October 21 , and observers across the world easily saw it in the daytime sky . A few hours before perihelion passage on October 21 it had a visible magnitude from ? 10 to ? 11 , comparable to the first quarter of the Moon and brighter than any other comet seen since 1106 . A day after perihelion its magnitude decreased to just ? 4 .

Japanese astronomers using a coronagraph saw the comet break into three pieces 30 minutes before perihelion . When the comet reappeared in the morning sky in early November , two of these

nuclei were definitely detected with the third suspected . The comet developed a very prominent tail , about 25 ° in length , before fading throughout November . It was last detected in January 1966 .

= = Dynamical history and evolution = =

A study by Brian G. Marsden in 1967 was the first attempt to trace back the orbital history of the group to identify the progenitor comet . All known members of the group up until 1965 had almost identical orbital inclinations at about 144 ° , as well as very similar values for the longitude of perihelion at 280 ? 282 ° , with a couple of outlying points probably due to uncertain orbital calculations . A greater range of values existed for the argument of perihelion and longitude of the ascending node .

Marsden found that the Kreutz sungrazers could be split into two groups , with slightly different orbital elements , implying that the family resulted from fragmentations at more than one perihelion . Tracing back the orbits of Ikeya ? Seki and the Great Comet of 1882 , Marsden found that at their previous perihelion passage , the difference between their orbital elements was of the same order of magnitude as the difference between the elements of the fragments of Ikeya ? Seki after it broke up . This meant it was realistic to presume that they were two parts of the same comet which had broken up one orbit ago . By far the best candidate for the progenitor comet was that seen in 1106 ( Great Comet of 1106 ) : Ikeya ? Seki 's derived orbital period gave a previous perihelion almost exactly at the right time , and while the Great Comet of 1882 's derived orbit implied a previous perihelion a few decades later , it would only require a small error in the orbital elements to bring it into agreement .

The Sun @-@ grazing comets of 1668 , 1689 , 1702 and 1945 seem to be closely related to those of 1882 and 1965 , although their orbits are not well enough determined to establish whether they broke off from the parent comet in 1106 , or the previous perihelion passage before that , some time in the 3 ? 5th centuries AD . This subgroup of comets is known as Subgroup II . Comet White ? Ortiz ? Bolelli , which was seen in 1970 , is more closely related to this group than Subgroup I , but appears to have broken off during the previous orbit to the other fragments .

The Sun @-@ grazing comets observed in 1843 ( Great Comet of 1843 ) and 1963 ( Comet Pereyra ) seem to be closely related and belong to the subgroup I , although when their orbits are traced back to one previous perihelion , the differences between the orbital elements are still rather large , probably implying that they broke apart from each other one revolution before that . They may not be related to the comet of 1106 , but rather a comet that returned about 50 years before that . Subgroup I also includes comets seen in 1695 , 1880 ( Great Southern Comet of 1880 ) and in 1887 ( Great Southern Comet of 1887 ) , as well as the vast majority of comets detected by SOHO mission ( see below ) .

The distinction between the two sub @-@ groups is thought to imply that they result from two separate parent comets , which themselves were once part of a ' grandparent ' comet which fragmented several orbits previously . One possible candidate for the grandparent is a comet observed by Aristotle and Ephorus in 371 BC . Ephorus claimed to have seen this comet break into two . However modern astronomers are skeptical of the claims of Ephorus , because they were not confirmed by other sources . Instead comets that arrived between 3rd and 5th centuries AD ( comets of 214 , 426 and 467 ) are considered as possible progenitors of the Kreutz family . The original comet must certainly have been very large indeed , perhaps as large as 100 km across ( for comparison , the nucleus of Comet Hale ? Bopp was about 40 km across ) .

Although its orbit is rather different from those of the main two groups , it is possible that the comet of 1680 is also related to the Kreutz sungrazers via a fragmentation many orbits ago .

The Kreutz sungrazers are probably not a unique phenomenon . Studies have shown that for comets with high orbital inclinations and perihelion distances of less than about 2 AU , the cumulative effect of gravitational perturbations tends to result in sungrazing orbits . One study has estimated that Comet Hale ? Bopp has about a 15 % chance of eventually becoming a Sun @-@ grazing comet .

= = Recent observations = =

Until recently , it would have been possible for even a very bright member of the Kreutz sungrazers to pass through the inner Solar System unnoticed , if its perihelion had occurred between about May and August . At this time of year , as seen from Earth , the comet would approach and recede almost directly behind the Sun , and could only become visible extremely close to the Sun if it became very bright . Only a remarkable coincidence between the perihelion passage of the Eclipse Comet of 1882 and a total solar eclipse allowed its discovery .

However , during the 1980s , two Sun @-@ observing satellites serendipitously discovered several new members of the Kreutz family , and since the launch of the SOHO Sun @-@ observing satellite in 1995 , it has been possible to observe comets very close to the Sun at any time of year . The satellite provides a constant view of the immediate solar vicinity , and SOHO has now discovered hundreds of new Sun @-@ grazing comets , some just a few metres across . About 83 % of the sungrazers found by SOHO are members of the Kreutz group , with the other being referred to as ' non @-@ Kreutz ' or ' sporadic ' sungrazers ( Meyer , Marsden , and Kracht1 & 2 families ) . On average , a new member of the Kreutz family is discovered every three days . Apart from Comet Lovejoy , none of the sungrazers seen by SOHO has survived its perihelion passage ; some may have plunged into the Sun itself , but most are likely to have simply evaporated away completely .

More than 75 % of the SOHO sungrazers have been discovered by amateur astronomers analysing SOHO 's observations via the Internet . Some amateurs have managed remarkable numbers of discoveries , with Rainer Kracht of Germany having chalked up 211 , Michael Oates of the United Kingdom making 144 , and Zhou Bo of China spotting 97 . As of December 2011 , over 2 @, @ 000 Kreutz sungrazers have been identified using SOHO data .

SOHO observations have shown that Sungrazers frequently arrive in pairs separated by a few hours . These pairs are too frequent to occur by chance , and cannot be due to break @-@ ups on the previous orbit , because the fragments would have separated by a much greater distance . Instead , it is thought that the pairs result from fragmentations far away from the perihelion . Many comets have been observed to fragment far from perihelion , and it seems that in the case of the Kreutz sungrazers , an initial fragmentation near perihelion can be followed by an ongoing ' cascade ' of break @-@ ups throughout the rest of the orbit .

The number of Subgroup I Kreutz comets discovered is about four times the number of Subgroup II members . This suggests that the ' grandparent ' comet split into parent comets of unequal size .

= = Future = =

Dynamically , the Kreutz sungrazers might continue to be recognised as a distinct family for many thousands of years yet . Eventually their orbits will be dispersed by gravitational perturbations , although depending on the rate of fragmentation of the constituent parts , the group might be completely destroyed before it is gravitationally dispersed . The continuing discovery of large numbers of the smaller members of the family by SOHO will undoubtedly lead to a greater understanding of how comets break up to form families .

It is not possible to estimate the chances of another very bright Kreutz comet arriving in the near future , but given that at least 10 have reached naked eye visibility over the last 200 years , another great comet from the Kreutz family seems almost certain to arrive at some point . Comet White ? Ortiz ? Bolelli in 1970 reached an apparent magnitude of 1 . In December 2011 , Kreutz sungrazer C / 2011 W3 ( Lovejoy ) survived its perihelion passage and had an apparent magnitude of ? 3 .