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Mr. Brooks asked if eclipses of the same saros series would overlap. I guess this is quite easy on high (northern or southern) latitudes. Just look at the annular eclipses of saros 147 (the first is the eclipse of 31 May 2003) during this century. For total eclipses you can take saros 152 (also visible in 2003, and so on).

I've often been wondering how people in the Ancient Times could have discovered the saros period. I guess it must be interesting to look at the Thales of Milete-eclipse (see Espanak's Eclipses of historical interest) of 28 May – 584 and that of 18 May –602. Looking at the central lines (for a map of the last one, you'll have use other ways), you'll see that the areas of visibility of the total eclipse do not overlap, but it is quite possible that Thales saw the –584 eclipse as total while he saw the –602 eclipse as a very great partial solar eclipse. Thales lived from –639 to –545. Did he discover the saros period in that way (although historians say that he predicted the –584 eclipse)

From: Rybrks1@cs.com

As soon as I launched the question about overlapping eclipses while running upstairs in answer to my wife's summon to the dinner table, the polar-view image of the #120 Saros entered my mind from Fred's book or maybe from Guy Ottewell's. That is the only Saros I have seen successive eclipses so far.

I am sure it shows the last few eclipses up north overlapping quite a bit. So I should have phrased the question, "What is the lowest latitude that there can be overlapping same-saros eclipses?" Ray Brooks

From: Jean Meeus

Ray Brooks asked: "Do any adjacent two eclipses within a saros ever overlap?"

I presume he asked whether the central lines of two solar eclipses, separated by one Saros (not "within" a Saros), can cross each other. Well, the answer is yes.

I looked at the central lines of all solar eclipses during the period 2000-2040 and their successor one Saros later, and I found no less than ten cases. They are given in the following list. 'A' means that the two eclipses are annular, 'T' that they are total. The next columns give the date of the first eclipse, and that of its successor one Saros later. The next column gives the approximate geographical latitude of the crossing point.

Note that the years 2030 and 2038 both will have TWO cases.

A 2002 Jun 10 2020 Jun 21 +13° Western Pacific Ocean
T 2008 Aug 1 2026 Aug 12 +83° Northern polar regions
A 2012 May 20 2030 Jun 1 +40° NW Pacific Ocean
A 2020 Jun 21 2038 Jul 2 + 8° Sudan
A 2021 Jun 10 2039 Jun 21 +80° Northern polar regions
A 2030 Jun 1 2048 Jun 11 +48° Russia
T 2030 Nov 25 2048 Dec 5 -23° South Africa
A 2038 Jul 2 2056 Jul 12 + 2°
T 2038 Dec 26 2057 Jan 5 -15°
A 2039 Jun 21 2057 Jul 1 +69°

Jean Meeus

From: Rybrks1@cs.com

Thank you, Jean Meeus. The first and fifth overlapping eclipse pairs you listed show up nicely on Fred's World Maps of 2001-2020 and 2021-2040.

A 2002 Jun 10 2020 Jun 21 +13° Western Pacific Ocean

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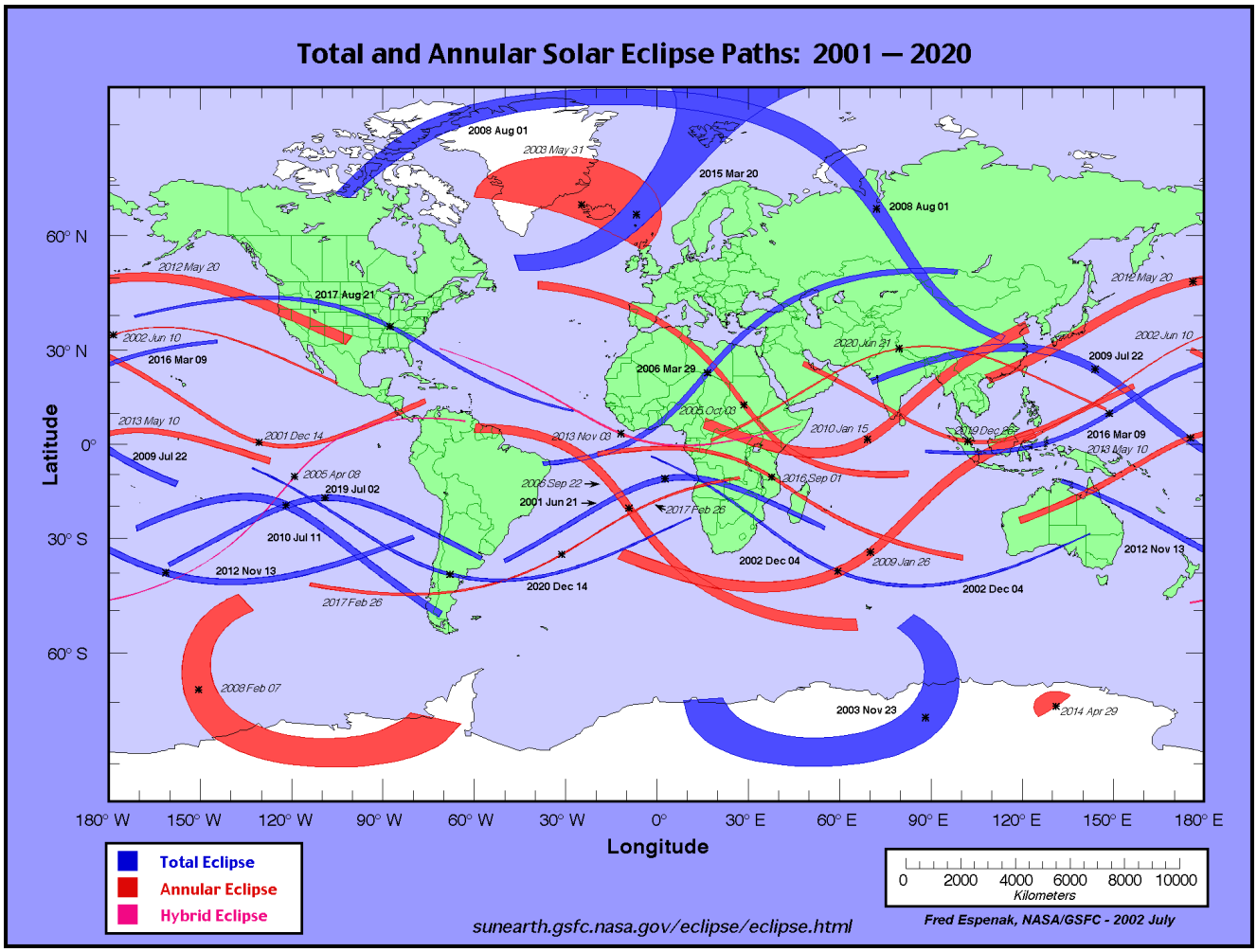
A 2021 Jun 10 2039 Jun 21 +80° Northern polar regions

Ray Brooks



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The Dukes of Grafton

"The Eclipses were Speedy and Fady, and the Herods Hard and Stout "

Four pillars of the modern thoroughbred (left to right): Matchem, Eclipse, Herod, Highflyer.

The Breeding

Historians of thoroughbred racing and breeding generally credit four eighteenth century stallions as the mainspring of the present day classic thoroughbred--Eclipse, Matchem, Herod and Herod's son, Highflyer (out of a Godolphin Arabian line sire (Blank) mare, Rachel). Late eighteenth century breeders exploited the advantages of crossing the sons of each of these stallions on the daughters of the others, to get the speed and stamina desired for the increasingly popular, and eventually principal markers of racehorse success, the one and one-half mile classics. Although these four horses ran when distance and durability were still primary factors in racing, they all, to a greater or lesser extent, passed on to their progeny an ability to run the shorter distances at speed, and at a younger age.

During this period, broodmares, almost always former racing mares, were increasingly drawn from the ranks of the daughters of these sires, the Eclipse-Herod nick being the most immediately successful and frequently exploited. There were breeders who insisted that Eclipse be seen in the top line, with Herod daughters below, and there were those who insisted the reverse was more successful. Eclipse's owner, Dennis O'Kelley, persisted in bring Herod mares to his stallion and his stallion's sons, he would have "nothing else." Richard Tattersall, owner of Highflyer, sought out Marske mares (generally agreed-upon sire of Eclipse). Two eighteenth-century paddock axioms (see right) were generally adhered to during this period; Snap (Snip-Fox mare), bred by Cuthbert Ruth was a grandson of Flying Childers, who beat another speedy descendant of the Darley Arabian, Marske (sire of Eclipse) twice at Newmarket in 1756.*

Eclipse

The notion of identifying and categorizing the tail-female lines of these mares was still far in the future, although it is clear from looking at the patterns of successful late eighteenth century broodmares, that their close-in female relatives, at least, weren't completely ignored when making breeding decisions. Still, the Grafton mares were among the first to be recognized as prepotent in their own right, and a filly from the Julia line was a highly sought commodity, when available, and often not only as a probable successful race mare in her own right, but a source of future excellent racehorses.

The 4th Duke of Grafton periodically branched out to purchase horses not bred at Euston. He was often quoted as saying "Let us find the horse and then we'll talk about the jockey." Although this essay focuses on the Grafton classic winners and their progeny, many other important races were held in the south, and a number of animals bred at Euston, usually, but not always, descended from the Julia mares or their sons, were winners in such races as the Oatlands Stakes, the Garden Stakes, the Beacon Course Two Middle Miles, and others. Horses bred or descended from Prunella daughters sold to other studs were successful in the Albany Stakes (Dardanelles, Sultan-Pawn Junior); the Winchester Cup and Saltram Stakes (Omen, Orville-Whizgig), and many more.

Herod

Zaida was an 1806 filly purchased by the 4th Duke to breed back to the bloodlines established by Prunella. Zaida was a daughter of Sir Peter (1784, Highflyer-Papillon), out of the mare Alexina 1788 (King Fergus-Lardella), and thus fairly closely related to the stallions to which he bred her.

Bred to Partisan (1811, Walton-Parasol) , she produced the 1818 filly Zeal. Parasol was a Prunella daughter, and Walton a "cobby-looking" horse by Zaida's sire, Sir Peter. At age three Zeal won the 1,000 Guineas. She, in turn was bred by the Duke to Woful, another Grafton-bred stallion (1809, Waxy-Penelope), producing the in-bred filly Arab in 1824, who also won the Duke the 1,000 Guineas, this time in 1827. When bred to Saracen, Zeal produced Alumnus (1833), who won the Newmarket St Leger and the Prendergast Stakes.

Highflyer

In 1820 Zaida foaled the brown filly Zinc, by Woful, one of the 4th Duke's better racing fillies in three decades of good performers. She won the 1,000 Gs and the Oaks, and placed second

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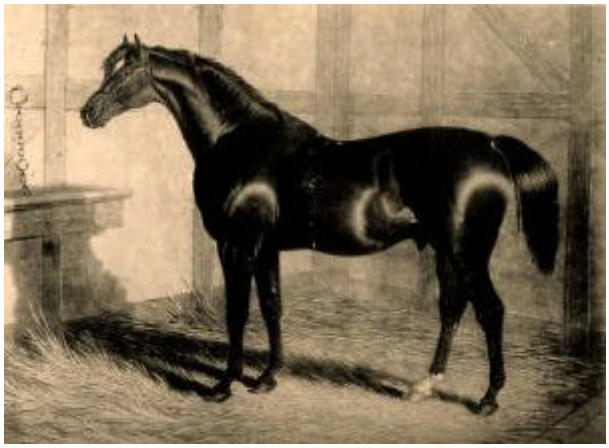
in the Newmarket Stakes and the Grand Duke Michael Stakes.

Matchem

Another mare in the 3rd Duke's broodmare band, who was not directly related to Julia, was Drab (1791) by Highflyer, out of Hebe, a grand-daughter of Blank with several strains of Darley Arabian and Godolphin Arabian and a large number of other oriental sires in her pedigree. When the 3rd Duke bred her to Pot-8-Os, she produced Dabchick in 1798, who entered the stud relatively early at the age of 5. She was bred to another of the Herod sire line so favored by the Duke, Buzzard. Buzzard, a "large, coarse horse with lop ears" owned by Lord Egremont of Petworth, was out of a Matchem sire line mare, Misfortune, and was the sire of three famous sons, Castrel (1801), Selim (1802) and Rubens (1805). The result of this breeding, the 1803 filly Vanity, won twelve races for the Dukes prior to being retired to the stud in 1810; her daughter, Catgut, by Juniper or Comus, won the Oaks for the 4th Duke in 1819. It was through Vanity's Grafton-bred daughter, the 1814 chestnut filly Coquette, that this line went forward to Lady Maura, dam of *Galore (1885), and Flocarline, dam of Master Robert by *Mazagan.

Family Tree



Partisan

The 3rd Duke of Grafton purchased Julia, a Blank-Partner mare, in 1763, from "polite Tommy Panton," son of an established horse breeding family and brother-in-law to the Duke of Ancaster. Bred to Snap by the 3rd Duke, she produced a 1768 filly, Promise, and bred to Herod the following year, she produced the 1769 filly Princess. Retained by Grafton, these two mares in turn produced daughters of great significance to the thoroughbred breed.

Promise, bred to Highflyer when she was 19, produced the filly Prunella, destined to become one of the most significant broodmares in thoroughbred history through both her daughters and her sons. Another daughter of Promise's, Peppermint (1787, by Eclipse), sent two strong mare lines forward, one of which terminated with the mid-nineteenth century brothers, Gunboat and Lifeboat (Sir Hercules), the other leading to the tiny, game and excellent racehorse of the 1880s, The Bard (1883, The Petrarch-Magdalene), and the Italian sire Massena (1903, Melanion-Maranine).

Princess was bred to Herod and had the filly Puzzle in 1778, whose daughters and grand-daughters produced classic winners for the Graftons, and whose later descendants led to important sires, Dollar, Speculum and, later down the line, Spearmint, as well as a number of significant broodmares.

Penelope 1

The 3rd Duke bred some of his mares to the most successful sire son of Eclipse, Pot-8-Os, owned by Lord Grosvenor. But it was the Grosvenor-owned son of Pot-8-Os, 1793 Derby winner Waxy, to whom Grafton repeatedly and successfully took his Julia-descended mares. The bay Waxy, whose dam was by Herod, is considered to "...have brought more 'high quality' into English bloodstock than any other single sire."* His head, with its concave profile, reflected his arab antecedents, and was something he passed on to many of his progeny. After patronizing him for years, the 3rd Duke finally purchased the aging stallion for the Grafton stud in 1808 (Waxy died in 1818 at the age of 28). When Waxy was crossed to the mares from Julia, he got classic winners and a lasting impact on the General Studbook. Both the 3rd and 4th Dukes, also took advantage of the other top stallions of the day standing at other studs, notably Trumpator, Rubens, Walton, and later Selim and Phantom, weaving back into their mares' foals the blood of Eclipse, Herod, Highflyer and Matchem.

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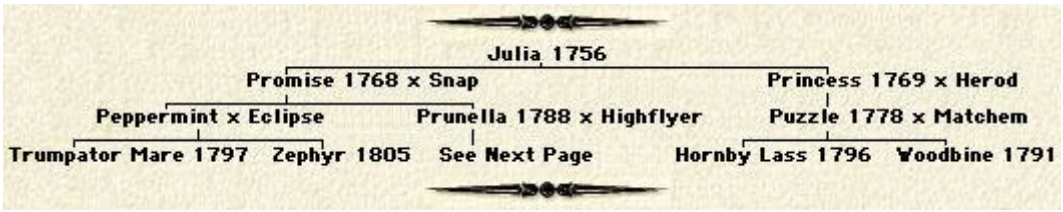
Julia's descendants were not the only ones bred at the Grafton stud; the 4th Duke, in particular had classic winners from other mares, and some of these have come forward to today as well. See below for some notes regarding these horses.

*Theodore Cook, A History of the English Turf, V. II, p. 286. It should be noted that William, the Duke of Cumberland bred both Eclipse and Herod.
**Ibid., p. 312.



Waxy

A list of countries...?

From: Dribalz@aol.com To: SOLARECLIPSES@AULA.COM Date: Sun, 21 Jul 2002 13:48:21

Is there a list of countries that gives (let's say from this day forward) the date of the next total eclipse to touch that land?

I am trying to find the date the next total eclipse touches Puerto Rico. I use Starry night as a program to view eclipses, but is there a way to program it to search for such a specific eclipse for that island nation? Or for any country? Any ideas

From: aarnal@cantv.net

Hy there, I do not know about the existance of such a list, but the next total solar eclipse for Puerto Rico will not happen before 2017. Regards, Arnaldo Arnal Observatorio ARVAL Caracas, Venezuela Lat. 10° 30' N, Long. 66° 50' W (UT -4hrs.) http://www.oarval.org

From: Michael Gill

More Mathematical Astronomy Morsels by Jean Meeus has a chapter that contains exactly this information, not just for Puerto Rico but for 192 countries and 35 other regions...

http://www.willbell.com/math/moremorsels.htm

Puerto Rico's next TSE will be in 2153.

This book has twenty five chapters that deal specifically with eclipses and occultations as well many other essays on fascinating astronomical topics. Michael Gill

From: Fraser Farrell

Most planetarium / star atlas programs include a function to find all solar eclipses for "your location"; or only all total/ annular eclipses for "your location". This is okay for finding eclipses for a -point-; but for a country or region or large

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city it's a little more complex.

The general procedure would be:

1) Define a grid of latitude/longitudes for the region of interest. For a large city, use a "+" -shaped grid of points 10km apart, centred on the urban area. This will catch those eclipses that cover the suburbs but miss the city centre itself.

If the city is not circular then stretch the "+" as needed. When I did this exercise recently for Adelaide (Australia), I used a grid 80km long N-S but only 30km wide E-W.

For a region, define a "fence" around its boundary, of points 10km apart. On my atlas Puerto Rico looks almost rectangular, so I guess using a series of points around your coastline should work?

2) Select each of these points as "your location"; then for each location tell your program to "find the next solar eclipse" for that location. This is the slow bit; unless you have a fast computer.

3) Note down the dates & circumstances of these "next eclipses" you find.

This procedure is tedious because general planetarium / star atlas programs are not optimised for this particular question. I'm not aware of any program which has a -specific- "find the next eclipse for this region" function in it. Perhaps other readers can enlighten both of us?

A 10km spacing should catch just about any eclipse path. Well, maybe not those strange just-barely-total eclipses like the one between Iceland & Greenland in 1986... So it's likely that you would find the same eclipse being reported as "the next one" for several of your points.

Conversely you may discover that some of your points wait a very long time for their next eclipse. For exa mple there are many total/annular eclipses across Australia this century, but almost all of them miss the big cities here. cheers, Fraser Farrell

From: Wil Carton

Arnaldo Arnal, Observatorio ARVAL Caracas, Venezuela asks: Is there a list of countries that gives (let's say from this day forward) the date of the next total eclipse to touch that land? I am trying to find the date the next total eclipse touches Puerto Rico.

Yes Sir, This question is rigorously investigated by the nestor of eclipse calculations, the Belgian author Jean Meeus in his book "More mathematical astronomy morsels", published by Willmann Bell in 2002. In chapter 13 he gives a list of 5 pages, preceded by one page introductory discussion about countries, states and regions, that concluded to 192 official countries and 35 'pseudocountries'. The chapter is one of 25 chapters about interesting facts of eclipses and occultations. So write for your copy of the book to Willmann Bell, P.O. Box 35025, Richmond, Virginia 23235, United States of America. After this recommendation it seems that neither the author nor the publisher will object against the answer to your one question: Puerto Rico will see its next total solar eclipse on 2153 October 17. The previous one occurred 1405 June 26. Wil Carton, Castricum, HOLLAND

From: Dribalz@aol.com

More Mathematical Astronomy Morsels by Jean Meeus has a chapter that contains exactly this information, not just for Puerto Rico but for 192 countries and 35 other regions...

http://www.willbell.com/math/mo remorsels.htm

Puerto Rico's next TSE will be in 2153.

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This book has twenty five chapters that deal specifically with eclipses and occultations as well many other essays on fascinating astronomical topics.

I have this book on my shelf and never thought to look there. Thanks for the tip. Andrew

From: Crocker, Tony (FSA)

Emapwin has a search feature for any eclipse of magnitude >X% at a given latitude and longitude. So you can vary X depending on size of country/city. For a point you would use 100%, for many European countries 80%, for contiguous USA, India, Australia 60% is about right. This method does not work well for oddly shaped countries, Chile being the most conspicuous example.

This Emapwin search mode also has a minor bug whereby eclipses will be chosen as if the totality zone extended beyond sunrise or sunset by 10 degrees or so. You will get a few of these plus some annulars in most searches, but over a 1000 year period the complete list is usually fairly short and easy to check individually.

From: 76630,2206

I would not consider Emapwin's extension of totality paths a bug. Within ten degrees of a totality path the sun is partially eclipsed on the horizon. It's a feature. Emapwin is a very nice program for what it does. --Robert B Slobins

Special annular eclipses

From: Jean Meeus To: Solar Eclipses <solareclipses@aula.com> Date: Sat, 06 Jul 2002 08:40:31

Tony Crocker asked : So to me the next question became to find eclipses where central duration is nearly constant through the entire length.

Michael Gill replied that the next two events of Saros 121 provide good candidates (7 February 2008 and 17 February 2026). However, these will be high negative gamma events.

For instance, at the eclipse of 2008 Feb 7, central eclipse will last from 3:24 to 4:26 UT, and the length of the central line on the Earth's surface will be only 5594 kilometers. The quantity Gamma will be -0.957. I have calculated that along the central line the duration of the annular phase will be 134.1 seconds at the beginning of the path, drop to a minimum of 131.5 seconds further on, and then increase to 132.6 seconds at the end.

However, perhaps more interesting are the eclipses with a *small* value of Gamma, and hence a *long* central line. Many years ago I found that at the annular eclipse of 1951 September 1 the duration of the annular phase did not vary much along the central line. This line had a length of 14793 kilometers, with Gamma = +0.156. The duration of the annular eclipse along the central line reached the following values:

159.4 seconds at the beginning (sunrise)
163.6 seconds (maximum)
153.1 seconds (minimum)
154.3 seconds (2nd maximum!)
154.2 seconds at the end (sunset)

At annular eclipses (such as that of 2002 June 10) where the duration of the annular phase is rather short, this duration reaches a *minimum* along the central line, because there the tip of the lunar umbra closely approaches the Earth's surface. On the other hand, at long annular eclipses the duration reaches a *maximum* along the central line, because there the observer is moving (by the Earth's rotation) in approximately the same direction and the lunar shadow, and this more than compensates for the fact that the observer is closer to the tip of the shadow (which remains far from the Earth). So it is evident that somewhere between those two cases there must exist annular eclipses where the duration of the annular

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phase along the central line does not vary much. And the ASE of 1951 September 1 was such a case. Jean Meeus

From: Rybrks1@cs.com

Klipsi wrote about going to the point of Zero seconds Totality Apr 8, 2005. That has been my hope also but I wondered if there would be ship with enough people willing to do the same thing.

From: Olivier "Klipsi" Staiger

Oh yes, I'm sure we'll be able to do so. right now it is a bit early for detailed planning, but I am sure somebody will start the process, now that we discuss it ;-) Probably my friends Vic and Jen Winter of Astronomical Tours www.astronomicaltours.net will offer such a tour. I remember seeing that some cruise ships go from Miami to Los Angeles via the Panama Canal, we could try to make coincide one of those with the eclipse. But it is a long cruise. Another possibility is to get a ship to sail from Costa Rica and back. That would be probably much cheaper, and faster. Our friend Alejandra will help us there. (and hopefully this time I won't have clouds when visiting volcan Arenal ;-) hola Ale !

The good news also is that it happens in April, which is out of the Hurricane season. Klipsi

From: Crocker, Tony (FSA)

The Panama Canal is a popular and competitive cruise route. Though most trips are 2 weeks, cruise411.com shows several for next April at <$2,000 per person. April is also the month that many cruise ships are repositioned from the Caribbean in preparation for the Alaska cruise season. Unfortunately the 10-day cruises just sail into and then out of the canal fromthe Caribbean side.

From: FRED ESPENAK

Jean has pointed out yet another remarkable event! The solar eclipse of -979 August 13 (or -0979 Aug 12, Universal Time) is truly a test case on the border between a hybrid and a true total eclipse. In fact, my own eclipse cataloging software identifies this event as total (see:
http://sunearth.gsfc.nasa.gov/eclipse/SEcat/SE-0999--0900.html).

However, upon closer inspection of the path it actually begins as an annular eclipse, but by the very smallest of margins. Below is an abbreviated table of the first 8 seconds of the path of this fascinating eclipse:

Physical Ephemeris of the Umbral Shadow - Total Solar Eclipse: -0979 Aug 13

Delta T = 24256.0 s

Central Line Moon/Sun
Universal ---------- Diameter Eclipse Sun Central
Time Latitude Longitude Ratio Obscur. Alt Duration
°
18:18:12.2 03°51.1'S 177°26.2'E 0.9995 0.9990 0.0 00m01.9s

18:18:13 03°34.6'S 178°16.3'E 0.9997 0.9995 0.9 00m00.9s
18:18:14 03°26.3'S 178°41.5'E 0.9999 0.9998 1.3 00m00.5s
18:18:15 03°20.2'S 179°00.0'E 1.0000 0.9999 1.7 00m00.1s
---------- Eclipse changes from Annular to Total -----
18:18:16 03°15.2'S 179°15.4'E 1.0001 1.0001 1.9 00m00.2s
18:18:17 03°10.8'S 179°28.9'E 1.0001 1.0003 2.2 00m00.5s
18:18:18 03°06.8'S 179°41.0'E 1.0002 1.0004 2.4 00m00.7s
18:18:19 03°03.2'S 179°52.0'E 1.0002 1.0005 2.6 00m00.9s

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18:18:20 02°59.8'S 179°57.7'W 1.0003 1.0006 2.8 00m01.1s

Notice that the path begins as a 1.9 second annular eclipse at 18:18:12.2 UT. The Moon/Sun ratio of diameters is 0.9995! Between 3 and 4 seconds later, the path becomes total and remains so for the rest of the track. My own calculations give a maximum duration of totality of 01m48.5s which is in agreement with Jean. This mu st be very nearly the absolute limit for the duration of a hybrid eclipse, at least during this epoch. By the way, the duration drops to a mere 3.4s at the end of the path.

Of course, to determine the actual nature of such an eclipse, one needs to actually perform a detailed limb profile calculation instead of using just a mean limb. Nevertheless, it is instructive and fascinating to delve into these limiting cases even if using the simplification of a mean limb.

How many other instances are there of hybrid eclipse which either begin or end as total eclipses during the 500 year period -1999 to 3000? Fred Espenak

From: FRED ESPENAK

The solar eclipse of 1564 Jun 08 is an even closer test between hybrid and total than the eclipse of -0979 Aug 13 (see my last email)!

It is total for its entire path save for the last fraction of a second when it changes to annular (as revealed in the "Moon/Sun Diameter Ratio" column). My abbreviated table below shows details of the last 5 seconds of the path of this unusual eclipse. Fred Espenak

---
Physical Ephemeris of the Umbral Shadow - Total Solar Eclipse - 1564 Jun 08

Delta T = 131.3 s

Central Line Moon/Sun
Universal ---------- Diameter Eclipse Sun Central
Time Latitude Longitude Ratio Obscur. Alt Duration
°
00:13:10 03°20.6'N 094°11.5'W 1.0005 1.0010 2.2 00m01.7s
00:13:11 03°14.8'N 093°58.6'W 1.0004 1.0008 2.0 00m01.4s
00:13:12 03°08.2'N 093°43.8'W 1.0003 1.0007 1.7 00m01.2s
00:13:13 03°00.3'N 093°26.1'W 1.0002 1.0005 1.4 00m00.8s
00:13:14 02°49.8'N 093°02.4'W 1.0001 1.0002 0.9 00m00.4s
----------switch from total to annular ----------
00:13:14.8 02°27.6'N 092°12.0'W 0.9998 0.9997 0.0 00m00.5s

From: KCStarguy@aol.com

Harrington's book sends The sun and moon during this eclipse will appear almost exactly the same size. Annular eclipse will occur at the very ends of the path while the totat eclipse will occur around the center of the track path.

It is said there might be hints of the inner corona, chromosphere and prominences peak through the lunar valleys and peaks. The precise location for observing is really important.

The eclipse starts in the Pacific near New Zealand and then there is totality (16 sec) starting at long -140 and lat -31d 46.4 . Totality is 42 seconds near longitude -118 57.7 and latitude -10 and 34.6.

I can't tell where there is but probably in Pacific but chances a ship can go there.

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Then it changes back to annular and strikes a the border of Costa Rica and Panama. Annularity passes over the town of Pedregal and over or near Las Lajas , Penohome, Anton and San Carlos. Then from Panama into Columbia and Venezuela.

Makes me wish I tried to get to Atlanta to see the 1984 eclipse but this mi ght be a very interesting eclipse so bide the time between Dec 2002 (which I probably won't be able to make) and 2005. ;(

Speaking of annulars. I've been searching for my negatives of the 1994. I took pictures but remember the processor did not make a picture of them as they thought nothing was on the negative. I forgot to go back and try to have them made into prints. But I was thinking about them for the last few weeks.

Finally found the negatives. I put into my "new" slide Nikon 1000 coolscan scanner (actually a used one but new to me) with this great scanner software called Silverfast. (When I have written review of software I will post).

I got nice little pics of the annularity finally after 8 years!!! I will forward url and the account and also the landscape darkening when the site is up.

From: FRED ESPENAK

Since the long duration hybrid eclipses of -0979 Aug 13 and 1564 Jun 08 both start out annular but change to total in the first several seconds of their paths, I thought it would be interesting to compare them to the upcoming hybrid eclipse of 2013 Nov 03.

Here again, the path quickly changes from annular to total, though not as rapidly as the -0979 and 1564 hybrids. The path of the 2013 eclipse begins as a 4 second annular with a magnitude of 0.9989. Approximately 14 seconds into its path, the eclipse converts to total and remains so with a maximum duration of 01m40s and magnitude of 1.016. At the extreme endpoint of the path, the eclipse is barely total with a magnitude of 1.0002 and a central duration of 0.7 seconds!

Below is a truncated table showing the beginning of the path as it changes from annular to total, as well as the final point in the path. Fred Espenak

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Physical Ephemeris of Umbral Shadow - Hybrid Solar Eclipse: 2013 Nov 03
Delta T = 73.7 s

Central Line Moon/Sun Universal Time	Latitude	Longitude	Diameter Ratio	Eclipse Obscur.	Sun Central Alt °	Duration
11:05:12.8	30°26.8'N	071°13.7'W	0.9989	0.9978	0.0	00m04.1s
11:05:14	30°06.9'N	070°02.5'W	0.9992	0.9984	1.1	00m02.9s
11:05:15	29°59.8'N	069°37.7'W	0.9993	0.9986	1.5	00m02.5s
11:05:16	29°54.2'N	069°18.3'W	0.9994	0.9988	1.8	00m02.2s
11:05:17	29°49.5'N	069°01.8'W	0.9995	0.9990	2.0	00m01.9s
11:05:18	29°45.2'N	068°47.1'W	0.9995	0.9991	2.2	00m01.7s
11:05:19	29°41.4'N	068°33.9'W	0.9996	0.9992	2.4	00m01.5s
11:05:20	29°37.8'N	068°21.7'W	0.9997	0.9993	2.6	00m01.3s
11:05:21	29°34.5'N	068°10.4'W	0.9997	0.9994	2.8	00m01.1s
11:05:22	29°31.3'N	067°59.7'W	0.9998	0.9995	3.0	00m00.9s
11:05:23	29°28.3'N	067°49.7'W	0.9998	0.9996	3.1	00m00.7s
11:05:24	29°25.5'N	067°40.1'W	0.9999	0.9997	3.3	00m00.5s
11:05:25	29°22.8'N	067°31.0'W	0.9999	0.9998	3.4	00m00.4s
11:05:26	29°20.1'N	067°22.2'W	0.9999	0.9999	3.6	00m00.2s

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---------- change from annular to total ----------
11:05:27 29°17.6'N 067°13.8'W 1.0000 1.0000 3.7 00m00.1s
11:05:29 29°12.8'N 066°57.9'W 1.0001 1.0001 4.0 00m00.2s
11:05:30 29°10.5'N 066°50.3'W 1.0001 1.0002 4.1 00m00.3s
.
. (last point on central line follows)
.
14:27:36.4 06°31.7'N 047°12.2'E 1.0002 1.0004 0.0 00m00.7s

Corona

From: Rybrks1@cs.com

A few months prior to the June 21 2001 TSE in Africa I raised a question about whether I unwittingly recalled any motion or shimmering in the corona in any previous TSE's.

During the 2001 eclipse there were about a dozen people with me and we all consciously looked for some evidence of motion but saw none. Ray Brooks

From: Egan Mark

This also raises lots of other questions from my very curious mind:

Has anyone ever seen real- time motion in a prominence?

What is the smallest time scale that motion can be seen?

I'm wondering that, if real- time motion can be seen, how fast would that motion be?

On a slightly longer time scale, can features in the corona and/ or prominences change along the length of the eclipse?

I think I remember reading about a feature in the corona at the 1980 eclipse that appeared slightly different for observers in Kenya than it did for observers in India. Is this true?

(We could split this last question into "magnified" and "naked eye" categories)

Tangent here: Did the astronomers on Mauna Kea in 1991, using their telescopes, notice real-time motion in the corona or prominences during the 4+ minutes of totality there?

Wish I could provide more answers than questions! C-ya....

Mark Egan astrophoto@yahoo.com

"Give the heavens above more than just a passing glance..." (From the song "I Hope You Dance", by Lee Ann Womack)

From: KCStarguy@aol.com

The motion effect was raised previously when a person asked, after I had shown my video of the eclipse during a multi-media presentation to my computer group, whether that movement of the corona, that seems to take place on the video, actually is real.

In Hungary 1999, some of us thought we saw "spirarling" like motions. One of the people on the video I took clearly says "Looks it's spiraling."

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Maybe it is optical illusion, lighting, our eyes trying to focus on the corona and the black disc but I always thought the corona seemed to "pulse" during totality giving me the image of slight motion.

From: Evan Zucker

I raised this issue several years ago in a private e-mail exchange with Jay Pasachoff -- one of the world's leading corona experts. Here's what he told me on April 28, 1998:

"No motion is seen in the corona in the period of an eclipse. . . . Any pulsation [in viewing a film or video of totality] would just be from uneven shutter speed on a movie camera." -- EVAN

From: KCStarguy@aol.com

Yes i remember that possible explanation now. Thanks.

Well NJay is the expert. But I still think the effect movement is cool on video but what about the human eye? Why does the corona appear to us to be spiraling by looking at it with our eyes? I still get a big kick out of my pal Jordan saying "look at it- it's spiraling."

Perhaps an eclipse illusion?

I think maybe it is because when we move our eyes back and forth the adjustment with the pupil to the scene makes it appear as movement. Or could be an effect due to the rod and cones on our retina? Comments? Dr. Eric Flescher (kcstarguy@aol.com)

From: Mike Simmons

Go to http://sohowww.nascom.nasa.gov/, click on THE SUN NOW and pick an image. You can then watch the Sun in real time and see how much the features change. Choose LASCO2 for the closest to what you'll see at an eclipse, although the inner corona is blocked by the occulting disk. You can also download the free screen saver and have real-time images displayed all day. It goes to the site and gets the latest images when the screen saver is activated. It's great! Mike Simmons

From: 76630,2206

Evan: I think we need Dr Pasachoff's input here. It is true that we do not see motion in the corona during the total solar eclipse. However, if you go to the movies from SOHO or Mauna Loa Solar Observatory, we do see motion. I also recall that he has observed transient short-term changes in the corona, but I have to leave myself open to correction when making this statement.

Of course, his observing equipment far exceeds ours in capability and power. -Robert B Slobins

From: Joseph Cali

I've never seen anything I could describe as motion during a naked eye observation.

In Zambia observing through an 80mm refractor at 25x I noticed the appearance of motion of corona and prominences. The big suspended prominence appeared to be falling. I realised this was due to the motion of the lunar disc but it's nice getting lost in the illusion.

The radial rays may appear to move due to a moire type effect on te after image on your retina. Can't say I've noticed spiralling. Joe Cali

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From: Mick Wolf

I would like to describe my experiences of viewing of coronas and their movements.So far I have observed 13 solar eclipses,in the past with 800mm,F11 refractors for B@W and colour photography,at present I use a F5.6,500mm catadioptric system with a 2x tele-extender.Most of the observing was done through SLR cameras,giving 16 and 20x magnification. With unaided eye only changes of brightness can be observed and this can give an impression of radial movement. Through the lens (800-1000mm),coronal streamers can be seen to move radially away from the solar disc and also very small changes in colour can be perceived. On a few occasions large flares were observed which changed in shape and moved during the interval between the exposures.The question is - is it real or caused by the atmospheric conditions ? but it is visible. As regards to the rotation, as mentioned by others,it is only seen during annular eclipses and is more pronounced when off centerline. This impression is due to the variation in the width of the annulus and thus its brightness as the Moon moves between the 2nd and 3rd contact Mick Wolf.

From: Jay.M.Pasachoff@williams.edu

Hi. I am sorry I have taken so long to comment on the discussion of two weeks ago about the reports of apparent fine-scale motion seen in the corona during an eclipse. I know that Evan quoted some old comment of mine.

I have never seen any motion during an eclipse, and stick by the statement that Evan quoted. I just checked the highest resolution images ever taken at an eclipse--the images with the Canada-France-Hawaii Telescope from the 1991 eclipse reported by Koutchmy and November in 1996 in the Astrophysical Journal. They found detail down to 100 km, and reported that they find no sign of any oscillatory or other change over the 3 minutes.

So I think any apparent motion seen is either an optical illusion or is caused by an uneven shutter or some similar effect.

The only real motion of which I am aware is the tennis-racquet-shaped coronal mass ejection that changed between Africa and India in 1973.

I'm just back from Chile, where one of our team (Mark Buie from Lowell) succeeded in recording an occultation of a star by Pluto from a site near Iquique, Chile. We tried to have sites both at Putre, Chile, from which I observed the 1994 eclipse, and from Aruba, from which I observed the 1998 eclipse, but those sites didn't work out. Still, the logistical contacts I had in both places from the eclipse work were useful. Jay Pasachoff

From: 76630,2206

Yes, one can see real-time motion in a prominence. I have had a Coronado H-alpha filter for over two years and have seen motion within prominences that is perceptible on the order of one minute, certainly within the time interval of most totalities. An eruptive prominence is moving fast enough to be perceptible to the naked eye over the span of a long eclipse.

Through a telescope or telephoto lens, that motion can be seen in a matter of seconds. I use an 2000/10 SCT, which is frequently used on eclipse expeditions, and have photographs of eruptive prominences that move quite a lot in 15 minutes. (Next time I have a chance at one, I would need to shoot them at much shorter intervals.) I have to say that one can see this type of motion with much shorter focal lengths, say, 500 mm, over the span of three or four minutes.

I can cite the 1919 total eclipse (THAT one) whose results confirmed Einstein's work. There was a huge eruptive prominence. If one could get a hold of the plates from Brasil and Africa, scan them on a PROFESSIONAL flatbed scanner, that prominence could be seen to change appearance. Other observatories recorded it also, and it was, I believe, the biggest eruptive prominence until 1946.

The 1980 eclipse featured a coronal mass ejection, or CME. These CME's move very fast. Those that trigger major aurora displays can make it here within one to two days, as what happened on 4-5 November 2001. Certainly, a CME can change the naked-eye appearance of the corona during the course of an eclipse.

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For more information, please start with www.spaceweather.com and www.spacew.com. These are great sites to start your solar physics education. There are also yahoo groups and the Coronado filters web site www.coronadofilters.com. Have fun.

As far as coronal motions are concerned, I believe that one of this list's contributors, Dr Jay Pasachoff, is very much involved in studying them. (Dr Pasachoff, please let us know if I am correct.) He goes to eclipses to gather information on motions in the innermost corona, that part that is 4 million degrees K.

However, unless the seeing is positively atrocious, the corona does not show large-scale motion to the naked eye.

This raises an issue: How does one use Photoshop or other manipulation software to obtain the enhanced detailed images of total eclipses? At a sufficiently large scale, one of the subjects, the moon, is moving. I am not even considering the possibility of a 1919-style prominence which would be so bright as to cause bleeding into the corona for long exposures and motion over the course of a six-minute totality. How does one keep the numerous images registered? --Robert B Slobins moving.

From: Evan Zucker

At 07:55 PM 7/22/02, Robert wrote: As far as coronal motions are concerned, I believe that one of this list's contributors, Dr Jay Pasachoff, is very much involved in studying them. (Dr Pasachoff, please let us know if I am correct.)

I can confirm that you are quite correct. One of his special areas of study is determining the cause for the high temperature of the corona. See, for example:

http://sunearth.gsfc.nasa.gov/eclipse/TSE98reports/TSE98Pasachoff.html

http://solar-center.stanford.edu/eclipse/news4.html

http://www.firstscience.com/site/articles/corona.asp -- EVAN

From: 76630,2206

Last night, Region 10039 put out an X4.8 flare with a Moreton wave. It did an X 3 two days before. These flares happen very, very fast and are very, very bright.

It is possible that a flare of sufficient intensity can be visible during the course of totality, provided that the moon does not cover it. One could discern motion with magnification. Whether or not the associated CME would show during totality, I do not know; however, 2000 km/second is quite an impressive speed.

We would have to be very lucky to see this during totality. --Robert B Slobins

From: Wil Carton

Prof. Jay Pasachoff wrote: "The only real motion of which I am aware is the tennis-racquet-shaped coronal mass ejection that changed between Africa and India in 1973."

The year 1973 is not correct. This eclipse was the African-Indian total solar eclipse of 1980 February 16, that passed through equatorial Africa and bent then in northeastern direction to India. I saw this eclipse from Malindi, Kenia. On my movie film I see motions in the corona, but I am absolutely sure that this is a sham affect, caused by cumuli cirri (small "sheep clouds" separated by small clear spots between them) that moved along the sky and across the eclipsed solar disc and corona. All "motions" there in the same direction (to the same azimuth). Before and after totality these small clouds are well visible and recorded as white clouds in our terrestrial atmosphere. The rotal solar eclipse of 1973 June 30 began in Suriname (s-America northern coast), traversed the Atlantic Ocean, the Sahara desert of Mauritania etcetera. bent southeastward and passed through Kenya in the afternoon and the path went in southeaster diercton to the Indian Ocean,

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not to a landfall in India nor elsewhere. There is a sad tale about it. The Dutch amateur astronomers society organized a touristic expedition, that was planned to reside in a hotel on the Canary Island (outside the path), and would make an airplane trip to the airport of Atar in the Mauratinia desert. But there were many professional expeditions of the International Astronomical Union (IAU). The IAU in those years warned governments of countries in the totality-path some years in advance and requested in this "standard procedure" to minimize airtraffic on eclipse day on airports in the path, aimed to get undisturbed observation conditions for the ground based astronomical expeditions. "Never before a government reacted to this desire of the IAU", told dr. Jaap Houtgast of the Dutch professional expedition, but in the last months before the 1973 eclipse the government of the shortly independant Mauretanian state reacted and promissed to cut off all air traffic around Atar and Akjoujt. This message blew up the planned Dutch amateur expedition of Arie Mak with which I and my wife would travel to the 1973 eclipse. I calculated in a hurry that we could choose an alternative site on the Cape Verde Islands Santo Antao or Sao Vicente (4 minutes totality), but those islands had no airstrip large enough for our planned passenger airplane. So fifty Dutch amateur astronomers got a few weeks before the voyage would begin, the tremendous deception that the entire trip had to be cancelled. So I was at home that day, in Castricum (Holland), where the entire lunar disc just missed the entire solar disc (the penumbral limit passed through Belgium). Wil Carton.

From: Wil Carton

Addition to my previous message: During the TSE of 1980 Febr 16, the lunar umbra traversed among others the African countries Tanzania and Kenya from 8.00 o'clock U.T. to 8.30 U.T., when the umbra leaved the African coast. In these two countries were many expeditions. Next landfall of the umbra occurred in India at 10.10 o'clock U.T. and the totality traversed this country in 15 minutes. There were many expeditions too. For groundbased observers the maximum duration of totality was about 4 minutes. In Africa professional expeditions recorded the tennisracket shaped Coronal Mass Ejection (CME). But in India, 1 hour and at least 40 minutes later, the racket-top was blown up and was gone. Only the "spanning spikes" of the CME remained on the in India recorded images. These interesting details complete my previous message. I remember that 'Sky and Telescope' has brought these information. Too, Prof. Serge Koutchmy mentioned these details during the Antwerp eclipse conference in October 2000. Wil Carton

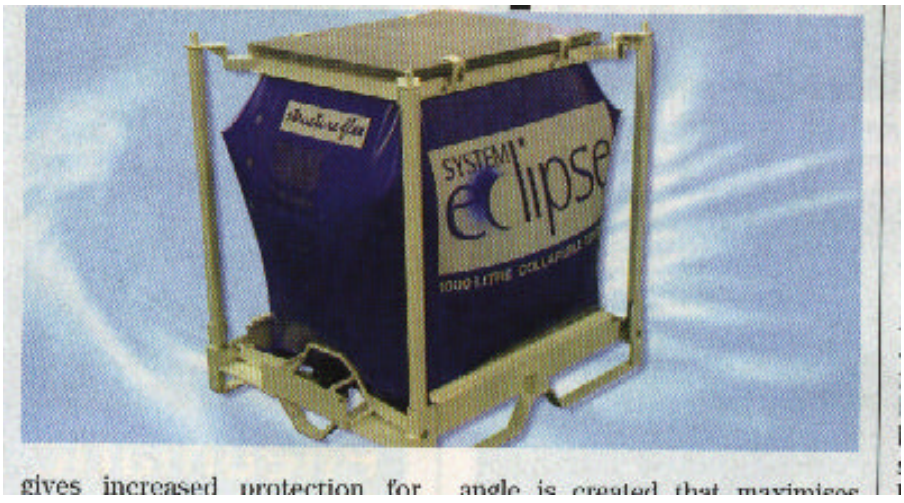
From: Jay.M.Pasachoff@williams.edu

Of course, the correctors of my date is correct: the eclipse with the tennis-racket shape coronal mass ejection was 1980, which I observed from India. In 1973, I observed from Africa (Kenya), and mentioning Africa just made the wrong date pop into my mind.

In any case, I am unaware of other successes in seeing motion in the white-light corona, even over the several hours that it takes from one end of the path to the other. Koutchmy organized several identical telescopes along the path of the 1991 eclipse from Hawaii to Mexico and beyond, but I think that only one functioned fully. Jay Pasachoff

From: dietmar.staps@wiesbaden.netsurf.de

los alamos eclipse flight (indian ocean near kenyan coast) imaged the racket rusin and rybansky report about coronal observations at the 80 eclipse in india. the racket was recorded at 7,2-9,4 solar radii. greetings dietmar staps



Eclipse in Packaging

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Eclipsechat

From: Olivier "Klipsi" Staiger To: SOLARECLIPSES@AULA.COM Date: Thu, 25 Jul 2002 21:59:00

yo, for those of you who want to chat about eclipses, I have now put up a chatroom at http://eclipse.span.ch/klipsichat.htm welcome ! Klipsi

Eclipses of the mid 2200's

From: Dribalz@aol.com

Fred: Are there any plans to cover the 23rd century eclipses on your World Atlas Page? I am curious as to the eclipses due in this time frame. Andrew Hans

From: Mike Simmons

Wow, what an optimist! :-) Mike Simmons

From: Bob Morris

According to EMapwin, there are five central eclipses (May 26, 2245T; Sept 29, 2247A; July 19, 2251A; Dec 31, 2252T; and May 17, 2254T) in 9 years, touching North America. Far enough away that the cryogenic thing just might work. In my will I'm specifying "Do not defrost before 2244." LRM

From: FRED ESPENAK

Yes, I will be posting more maps in the "World Atlas of Eclipse Paths" web page later this week or early next week. - Fred Espenak

Highway coordinates

From: Dave Schmahl To: SOLARECLIPSES@AULA.COM Date: Fri, 26 Jul 2002 19:37:06

Hello the List, I am making plans to see the Dec 4th TSE from South Australia. With limited finances, I won't be joining any of the many tours available, I'll be going it alone. Since the eclipse path will conveniently cross major highways near Ceduna and Woomera, having Lat and Long coordinates of those highways crossings would be a big help. They would be good waypoints to set in my GPS unit. Has anyone on the list calc'd coordinates for those highway crossings? Best wishes to all, Dave Schmahl

From: Jean-Paul GODARD

Hi Dave.... Just let me explain the right way to use a gps in your case.... You surely have a "navigation mode" to go from one point to an other point... and when you "navigate", the Gps can tell you the distance from your actual location to the direct route.....by example "ten miles left" or "300 meters right" (this mode is used by sailors on boat or (private) pilots in the air...) Just enter 3 or more points from the center line in memory... Define a virtual route with these points.....and start the "navigate mode".... On your "highway", the GPS gives you the distance to the straight line joining points of the center line... To get this you just need the approximate UT time of totality and after that to look at the tables given by Fred ESPENAK....

From: Dave Schmahl

That is a tremendous help! Thanks so much. It's about time I learned how to use the "navigation mode".

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How is this for bad advice?

From: Jay.M.Pasachoff@williams.edu To: solareclipses@aula.com Cc: dpasachoff@yahoo.com Date: Tue, 23 Jul 2002

To the mailing list: My daughter Deborah, who reads Parenting Magazine because she has an on-line business selling toys and gift baskets for newborns and other children, sent me the following Jay Pasachoff

Forwarded Message From: Deborah Pasachoff <dpasachoff@yahoo.com>

It's a little late, but still worth writing.....I'm reading "Parenting" magazine from June/July. On page 151, there is a brief section of "Most Entertaining Sky Shows"

For June 10: Check out the annular (ring-like) eclipse of the sun....Remember the old advice about not looking directly at the sun--UV rays can damage eyes. Instead, stand with your back to the sun and watch the eclipse in a mirror. (A MIR-ROR!)

Address mail to Letters, Parenting, 530 Fifth Ave, New York, NY 10036, fax 212-522-8699, or e-mail letters@parenting.com. Thanks, D

Oppolzer

From: Jean Meeus To: Solar Eclipses <solareclipses@aula.com> Date: Sun, 28 Jul 2002 06:55:20

< I don't know who Oppolzer was.-

The Austrian astronomer Theodor von Oppolzer (1841-1886) was the author of the monumental "Canon der Finsternisse" (Canon of Eclipses), containing the elements of all 8000 solar eclipses from -1207 (1208 B.C.) to A.D. 2161, a classical work in the astronomical literature. Jean Meeus

From: Jay.M.Pasachoff@williams.edu

Leon Golub and I wrote: "For decades, the most widely used eclipse calculations were those of Oppolzer (1887, reprinted 1962), published in 1997." The 1962 book was a Dover Books reprint and might even still be available.

Jean Meeus is modest, of course. Here is the updated/corrected comment on his work vs. Oppolzer's taken from the errata/updates site for my book L. Golub and J. M. Pasachoff: The Solar Corona (www.williams.edu/astronomy/corona)--

"Oppolzer's work has been superseded by calculations by Meeus, Grosjean, and Vanderleen (1966) for 1898-2510 and by Mucke and Meeus (1983, 1992) for 2003 BC to AD 2526"

Mucke, H., and Meeus, J., (1983, 1992), Canon of Solar Eclipses, -2003 to +2526, Astronomisches Buro, Wien, Austria.

and the book goes on to say: "and, for the period 1986-2035, by Espenak (1987), who provides charts and detailed tables for those years in addition to a tabulation of eclipses and some peak values for 1901-2100."

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Prominence Occultations

From: Rybrks1@cs.com To: SOLARECLIPSES@AULA.COM Date: Tue, 23 Jul 2002 18:11:14

The note from Robert Slobins about seeing prominences with his Coronado filter opens another eclipse hobby....viewing occultations of prominences by the new moon that are close passes to the sun but not quite partial eclipses, like May 19 2004 when the moon comes within less than a solar diameter of the sun's limb seen from northern latitudes.

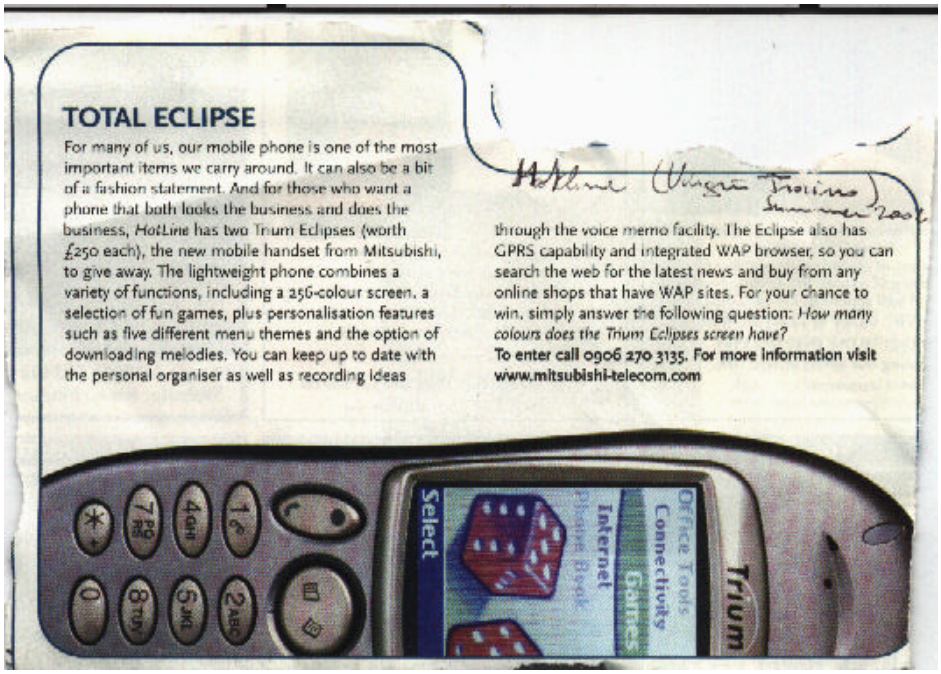
That would be pretty cool to see, though clearly less spectacular than a TSE. And one would need a fortuitously placed prominence. Ray Brooks

From: Mike Simmons

Mercury can be seen blocking the light of the chromosphere and some small prominences in a series of H-alpha images taken during the November 15, 1999 transit and made into a movie on the Big Bear Solar Observatory site at http://www.bbso.njit.edu/. There is also a movie of the June 10, 2002 solar eclipse, a deep partial from Big Bear, in what appears to me to be H-alpha (presented as monochromatic rather than "Living Color"). And lots of other great images and movies of the Sun without an interceding planet. Mike Simmons

From: Olivier "Klipsi" Staiger

That reminds me of another rare event on the list of "eclipse-specials": while most of us eclipse chasers (me included) in August 1998 went to Malaysia to see the annular eclipse, German veteran eclipse chaser Freddy Dorst went to northern Australia to see the occultation of Regulus by the New Moon while the Sun was in partial eclipse !!! Because each year, Regulus is in solar conjunction around August 22nd. And it was such a wonderful coincidence to have a solar eclipse on that same date ! There it is : after seeing so many "normal " solar eclipses, you start going for really special events. Like. e.g. , going to the southern limit of a total eclipse, to trade 3 minutes of totality for 30 seconds of spectacular corona-backlit Baily's beads. ;-) Or just like the plan I have for the hybrid eclipse in April 2005 : I want to sail to the "Willcox Point", the point where totality turns to annularity, where the total eclipse lasts zero seconds... Note: this very special point in a hybrid eclipse where annularity turns into totality , and later where totality turns into annularity, has no official name. So I propose to officially name these two points "the first Willcox point" and "the second Willcox point", in honour of Ken Willcox. Look at this map by Fred Espenak: http://sunearth.gsfc.nasa.gov/eclipse/TSE2001/TSE2001fig/TSE2001fig16.GIF The arrow pointing at 22:00 U.T. on the track of the April 8 2005 , is pointing at the second Willcox Point, where totality lasts zero minutes and zero seconds. THIS is where I want to be on April 8, 2005, and have a toast on Ken . Klipsi



TOTAL ECLIPSE

For many of us, our mobile phone is one of the most important items we carry around. It can also be a bit of a fashion statement. And for those who want a phone that both looks the business and does the business, *HotLine* has two Trium Eclipses (worth £250 each), the new mobile handset from Mitsubishi, to give away. The lightweight phone combines a variety of functions, including a 256-colour screen, a selection of fun games, plus personalisation features such as five different menu themes and the option of downloading melodies. You can keep up to date with the personal organiser as well as recording ideas through the voice memo facility. The Eclipse also has GPRS capability and integrated WAP browser, so you can search the web for the latest news and buy from any online shops that have WAP sites. For your chance to win, simply answer the following question: *How many colours does the Trium Eclipses screen have?*

To enter call 0906 270 3135. For more information visit www.mitsubishi-telecom.com

From: Patrick Poitevin

I have a small account on our SEWP webpages (see below) "Practical excercises during solar eclipses", where you can measure the size of sunspots, granulae or prominences at partial solar eclipses. Please have a look. Best regards, Patrick

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Smoke in the skies

From : Richard H Sanderson <rsanderson@JUNO.COM> To : HASTRO-L@LISTSERV.WVU.EDU Date : Thu, 25 Jul 2002 18:40:04 -0400

The smoke from forest fires in Canada appeared as a solid grey cloud cover over Western Massachusetts on July 7 and was thick enough to make observing the sun's disc quite easy. At about 2 PM, deep orange sunlight cast through windows into my home appeared similar to that from a setting sun and about an hour later, the sun's disc gradually faded from view. As the sun dimmed, it remained razor-sharp. The cause of this odd phenomenon apparently was similar to that which produced the famous Dark Day of 1780, when forest fire smoke concentrated over New England resulted in a terrifying day of total darkness. Anyone interested in the 1780 event may wish to read an article I wrote a couple years ago for my column in the "Springfield (Mass.) Journal" titled "A Day Without Daylight in 1780." Here's the link: http://www.springfieldjournal.com/archives/11-2-2000/celestialwanderings. html Rich Sanderson Curator of Physical Science Springfield Science Museum Springfield, MA

Totality decrease away from centerline?

From: Geoff To: SOLARECLIPSES@AULA.COM Date: Wed, 24 Jul 2002 06:39:49

Hey there, Please excuse this question if it is rather obvious, but is there a way to determine just how much the decrease in totality time is depending on how far away from the centerline you are? For example later this year if the centerline has 33 seconds of Totality, how much does the Northern/Southern limit have? Or how much does it have half way inbetween the Centerline and the limits?

Also a question for Klipsi (or anyone else) - what exactly would the eclipse look like at the Willcox point? I guess the Moon would be exactly the same angular diamater as the Sun... but what would it look like? Baileys Beads.. ? Thanks for any help, Geoff Sims.

From: Andy Paik

The shadow is a circle. If you think of the time of totality as distance across the circle, you can figure the equation using right triangles. The radius of the circle, which is 1/2 the centerline totality time, is the hypotenuse. One leg is how close you are, which is the radius again times (1 - your ratio) as 100% would be in the center. The other leg is 1/2 of the time you are looking for.

For a given ratio to the center, say P, the right triangle equation is:

(1/2 * T * (1 - P))^2 + (1/2 * L)^2 = (1/2 * T)^2

Where T is time of totality on the center line, L is the time you are trying to figure out and P is the ratio of how close you are to the center.

Solving gives: L = T * Sqrt(2 * P - P^2)

So at totality's edge, P = 0, so your time is 0. If you are 1/2 way in, P = 1/2 so you get L = T * .866 or 28.58 seconds for a 33 second centerline. If you are 3/4 of the way to the center, P = 3/4 and L = T * .938 or 30.94 seconds or 33 seconds. Happy Hunting, Andy

From: Jean Meeus

Geoff Sims asked how much the duration of totality (or annularity) decreases depending on how far away we are from the central line.

(Note that I prefer the expression 'central line' instead of 'centerline'. Central line is the classical expression used since

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many years by the great astronomical almanacs.)

Of course, at the northern and southern limits of the path, the duration is exactly zero. For any point inside of the path, the duration can be calculated as follows.

Let D be the distance from the given point to the nearest point of the central line, taking as unit HALF the width of the path. Calculate R = square root of 1 - D*D (that is, the square root of 1 minus the square of D). Then the duration at the given point is equal to the duration on the central line multiplied by R.

In fact, the problem is similar to the following: what is the length of a chord in a circle that is situated at a given distance from the center?

Example. -- Suppose we are 33 kilometers from the central line, that the width of the path there is 82 kilometers, and that the duration of totality on the central line is 108 seconds.

Then we find :
half-width of the path = 82/2 = 41 kilometers.
D = 33/41 = 0.80488
R = square root of (1 - 0.80488*0.80488) = 0.59344.
duration = 108 * 0.59344 = 64 seconds.

This method works well in most cases, but gives inaccurate results in extreme cases such as for the exceptional annular eclipse of 2003 May 31, at which the northern limit of the path does not exist. Jean Meeus

From: Fraser Farrell

Geoff, There is a simple geometric method which gives you close to the truth, with corrections I will mention later.

Consider the Moon's shadow as a perfect circle of radius 1 (arbitrary unit), through which an eclipse observer can be moved on various chords parallel to centreline. That's chords as in geometry. What you want to know is the relationship between the Length Of Chord (LoC) which is equivalent to your eclipse time, and its separation (X, along a perpendicular) from the centreline.

The relationship between X and LoC is given by :

LoC = 2 * sin(arccos(X))
X = cos(arcsin(0.5 * LoC))

At centreline itself, X=0 and LoC=2 by this definition. At the path limits, X=1 and LoC=0.

On most calculators, the arcsin and arccos functions are marked "sin-1" and "cos-1" respectively.

A worked example: you're exactly halfway (X=0.5) between centreline and the limit. The numbers are:

arccos(X) = 60 (or if you prefer radians to degrees, 1.047198) sin(60) = 0.866 (approximate)
LoC = 1.732

Therefore your eclipse duration is 1.732 / 2 of centreline's, or 0.866. So if centreline was getting exactly 30 seconds, you would get just under 26 seconds.

Alternative example: you want to see exactly 3/4 of centreline duration for reasons known only to you and your fellow Cult members... ;-)