

## The Mystery of the Missing Magnetosphere

Like many a *whodunit*<sup>1</sup> drama this investigation is presented in three acts, contains a *sting in the tail*<sup>2</sup> and is conducted by an eccentric amateur who leaves the audience to decide whether the story should be filed under fact or fiction.

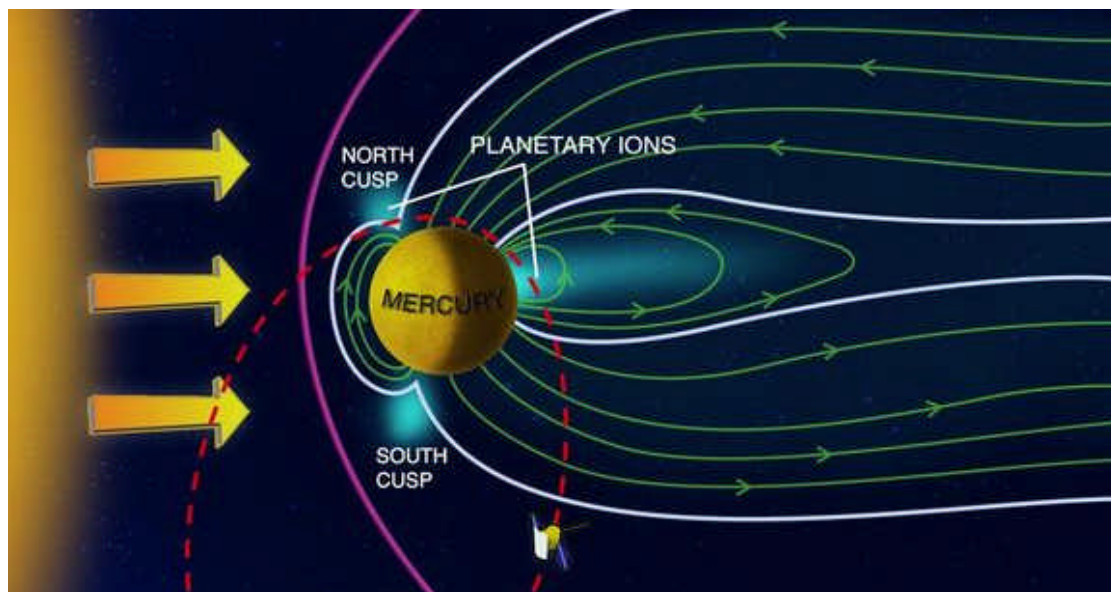
The mystery began when it was noted that *settled science*<sup>3</sup> believes that the *Moon*<sup>4</sup> only has a *mini-magnetosphere*<sup>5</sup> lurking on the far side of the Moon that is 360 kilometres across and is surrounded by a 300 kilometre thick region of enhanced *plasma flux*<sup>7</sup> caused by the *solar wind*<sup>8</sup>.

The diminutive size of the Moon's *magnetosphere*<sup>9</sup> is apparently associated with the Moon's *very weak*<sup>10</sup> external magnetic field which is described as being *less than one-hundredth*<sup>11</sup> that of the *Earth*<sup>12</sup>.

The plot thickens when comparisons are made with other terrestrial planets.

Mercury is described as having a *strong magnetosphere*<sup>13</sup> and a *significant*<sup>14</sup> magnetic field which is also [contradictorily] *weak*<sup>15</sup> because it is only *about 1.1% as strong as the Earth's*<sup>16</sup> i.e. very close to the Moon's *less than one-hundredth*<sup>17</sup> that of the Earth.

Mercury's *magnetotail*<sup>18</sup> is estimated to vary from *10s Mercury radii to 100s Mercury radii*<sup>19</sup> and even up to *1.5 million miles*<sup>20</sup>. Using values from Wikipedia the magnetosphere of Mercury may extend up to a maximum of 100 R<sub>M</sub> (Mercury radii)<sup>21</sup> i.e. 243,970 kilometres.



Mercury's magnetosphere

Image Credit: Science/AAAS<sup>22</sup>

Venus lacks an *intrinsic magnetic field* but a *weak* external magnetic field is induced by an *interaction between the ionosphere and the solar wind* that supports an *induced magnetosphere*<sup>23</sup> that stretches for *some 45,000,000 kilometres into space*<sup>24</sup>.

Therefore, the core of the mystery is:

**Why doesn't the Moon have a large magnetosphere like Mercury and Venus?**

## Act I – Lumps of Rocks in Space

Perhaps the best way to start the investigation is to remove ourselves from the whole concept of magnetospheres. Let's begin by simply focusing upon how *lumps of rock in space* interact with the *solar wind*<sup>25</sup> as they travel through the Solar System<sup>26</sup>.

Lumps of rock in space are also known as Comets<sup>27</sup> and Wikipedia informs us (without any sign of blushing and without reference to American astronomer Fred Whipple<sup>28</sup>) they are also *popularly described as "dirty snowballs"*.

Comets are irregular rocky objects varying between 100 metres and 100 kilometres in size (depending upon what reference you read) that form long *tails*<sup>29</sup> as they eccentrically orbit around the sun.



Comet Hale-Bopp

Image Credit: Wikipedia



Comet McNaught

Credit: Akira Fujii 30

The shape and size of the tail varies as the orbital motion of the comet rotates in relation to the direction and intensity of the solar wind.

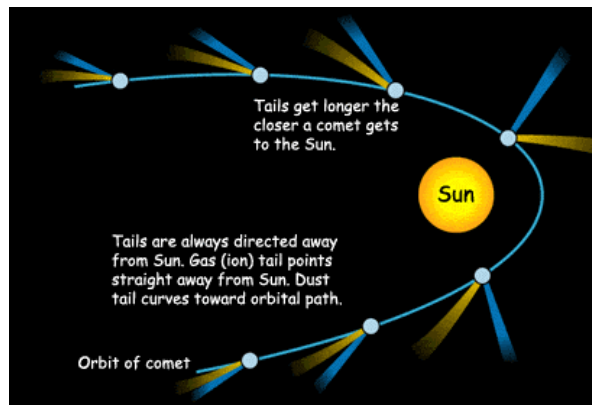


Image Credit: NASA

The comet's tail is composed of three parts:

### 1. Plasma Tail

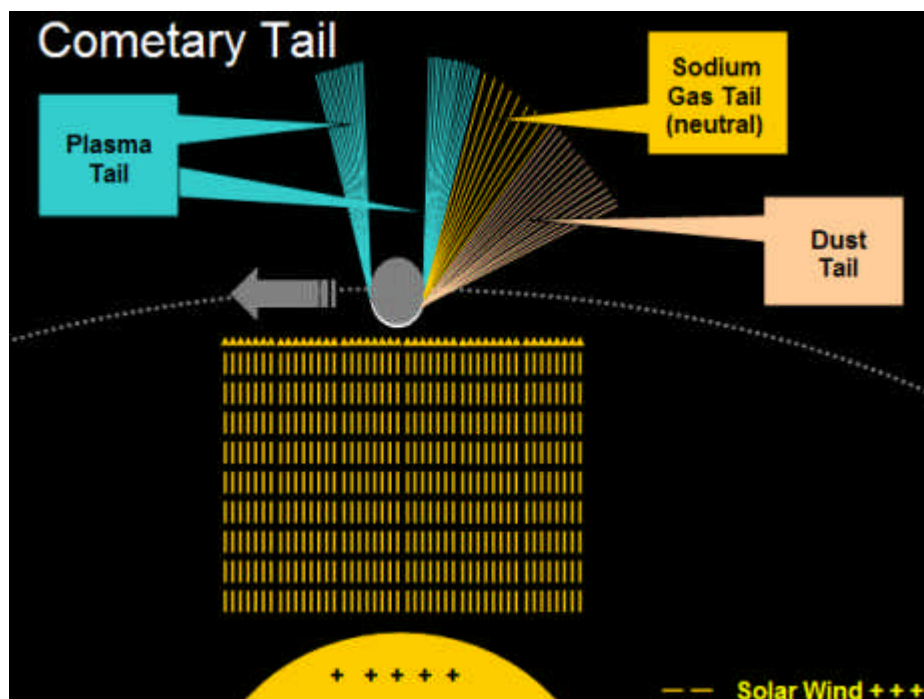
The plasma<sup>31</sup> tail contains glowing ionised gas particles and is pointed directly away from the sun and has been observed to extend up to 570,000,000 kilometres. Surprisingly, the plasma tail is called an *induced magnetosphere*<sup>32</sup>.

### 2. Dust Tail

The dust tail forms a generally curved orbital path behind the comet although it is partially deflected away from the sun by the solar wind. Dust tails reflect sunlight and have been observed to extend over several million kilometres.

### 3. Sodium Tail

Sodium Tails have recently been observed wedged between Plasma and Dust tails. The low levels of neutral sodium in these tails can only be observed using narrow band yellow filters. However, the sodium tail will be ordinarily visible if it becomes ionised whilst passing very close [less than 0.05 AU] to the sun.



However, understanding how comets interact with the solar wind is still a challenge because the cornerstones of *settled science* cometary theory have been discredited:

### **Dirty Snowball**

Fred Whipple's *dirty snowball* theory has been falsified because *recent observations have revealed dry dusty or rocky surfaces*<sup>33</sup> and the 2005 *Deep Impact* collision with comet 9P/Tempel *generated a large and bright dust cloud that contained more dust and less ice than had been expected*<sup>34</sup>.



Comet 103P/Hartley

Credit: Wikipedia <sup>35</sup>

### **Solar Heated Glow**

The assumption that a comet's star-like nucleus and glowing coma could be attributed to more intense heating by *solar radiation*<sup>36</sup> as the comet neared the sun was discredited in 1991 when Comet Halley inexplicably *displayed an outburst that lasted for several months, releasing a cloud of dust 300,000 km across*<sup>37</sup> halfway between Saturn and Uranus as it moved away from the sun. The theory was further confounded when observations of Comet Hale-Bopp in 2007 confirmed that *the comet was still active*<sup>38</sup> as it was moving towards Neptune at distance of 25.7 AU from Sun.

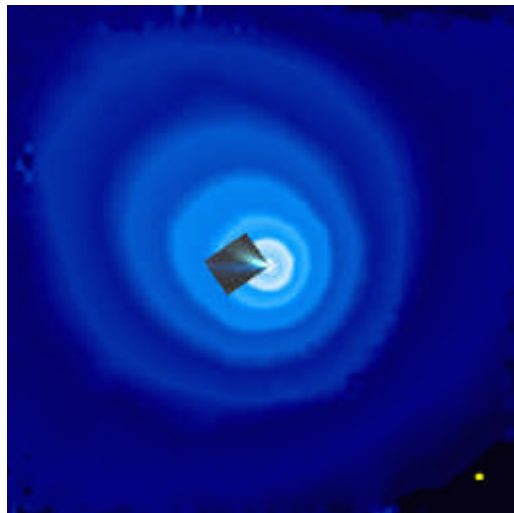


Image Credit: NASA <sup>39</sup>

Additionally, the *solar heated* theory fails to explain the coherence and banded structure of comet Hale-Bopp's 100 million kilometres wide envelope of hydrogen that was detected using the ultraviolet spectrum<sup>40</sup>.

## Plasma Discharge Model

The failures of *standard* cometary theory leaves the Plasma Discharge Model<sup>41</sup> as the only coherent contender that might help explain how *lumps of rock in space* interact with the *solar wind* in the Solar System.

This is not an endorsement of the Plasma Discharge Model but it is an acceptance that it is the only thread left to further the investigation. Therefore, the theory needs to be drafted in a generalised form that is applicable to both comets and terrestrial planets.

- 1) The Sun radiates positive electric plasma that becomes less dense with distance.
- 2) Solar system bodies are negatively charged with respect to the Sun.
- 3) Solar system bodies are surrounded by a positively charged plasma sheath<sup>42</sup>.
- 4) Plasma sheaths adjust voltage according to the local density of the solar plasma.
- 5) Plasma sheaths operate in *dark mode* at low voltages.
- 6) Plasma sheaths switch to *glow mode*<sup>43</sup> at higher voltages.
- 7) Plasma sheaths may switch from *glow mode* into *arc mode*<sup>44</sup> under stress.
- 8) Plasma arcing occurs between solar system bodies.

In specific relation to comets the model makes the following observations:

- a) A plasma *glow mode* discharge produces the visible coma around the nucleus.
- b) Electrical stress on the comet nucleus causes a sudden switch to *arc mode* where cathode arcs dance over the nucleus giving it a star-like appearance.
- c) Cathode arc discharges to the nucleus burn black scalloped craters, terraces and mesas features which are characteristic of *electric discharge machining*<sup>45</sup>. The sudden switching off and on of cometary jets is observed because cathode arcs have a tendency to jump across the cometary surface.
- d) The structure of the visible coma is maintained by electric force and the high temperature and X-ray emissions are explained by the associated plasma discharge phenomena.
- e) Comet nuclei behave like an *electret*<sup>46</sup> (similar to a capacitor, but able to store electric charge for a much longer time). As such, the nucleus may explode when the internal electrical stresses, caused by the discharge activity at the surface, results in an internal discharge.

More importantly, the Plasma Discharge Model provides a key explanation that provides a connection between the phenomena of cometary tails and magnetospheres:

- f) Rock is electrically *sputtered*<sup>47</sup> (particle by particle) from the surface and accelerated vertically into space in the form of well *collimated*<sup>48</sup> jets that follow a natural plasmoid<sup>49</sup> trajectory.
- g) The ejected ionized material thus forms a coherent tail with well-defined *Birkeland current*<sup>50</sup> filaments that may extend for tens of millions of kilometres.

### The LORIS Hypothesis

Based upon our current level of knowledge a few additions to the *plasma discharge model* are required to create a unified theory of *cometary tails* and *magnetospheres* that explains how *Lumps Of Rocks In Space* interact with the solar wind:

9) Ionised particles *sputtered* from a solar system body form *collimated jets* that follow a *plasmoid* trajectory directly away from the sun to form a coherent *plasma tail* with well-defined *Birkeland current* filaments.

10) Dust particles *sputtered* from a solar system body are not entrained in the *plasma tail* and form a curved *dust tail* along the orbital path behind the comet where the solar wind will partially deflect the *dust tail* away from the sun.

11) Electrically neutral gas particles *sputtered* from a solar system body are not entrained in the *plasma tail* and may form a *sodium tail* if they are wedged between a) two *plasma tails* or b) a *plasma tail* and a *dust tail*.

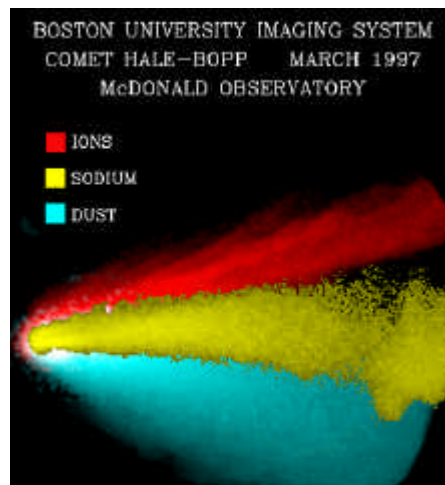
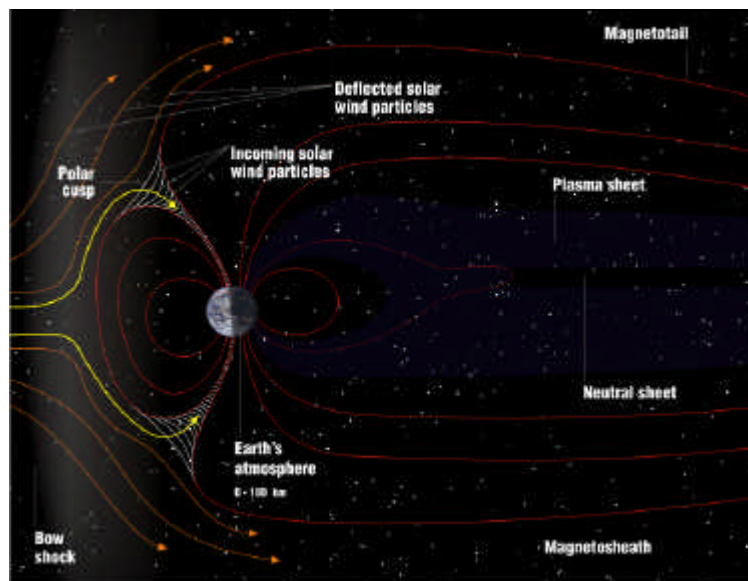


Image Credit: Boston University<sup>51</sup>

12) Solar system bodies with a sufficiently strong *intrinsic magnetic field* alter the shape and size of their plasma sheaths by magnetically forming *polar cusps*<sup>52</sup> that result in the formation of a *plasma torus*<sup>53</sup> [radiation belt] around the body.



The Earth's Magnetosphere

Image Credit: Wikipedia

13) Solar system bodies with an atmosphere form an *ionosphere*<sup>54</sup> that release ionised particles to the *plasma tail* and neutral gases to the *sodium tail*. Electrical arcing between the layers of the atmosphere connects the body to its plasma sheath.

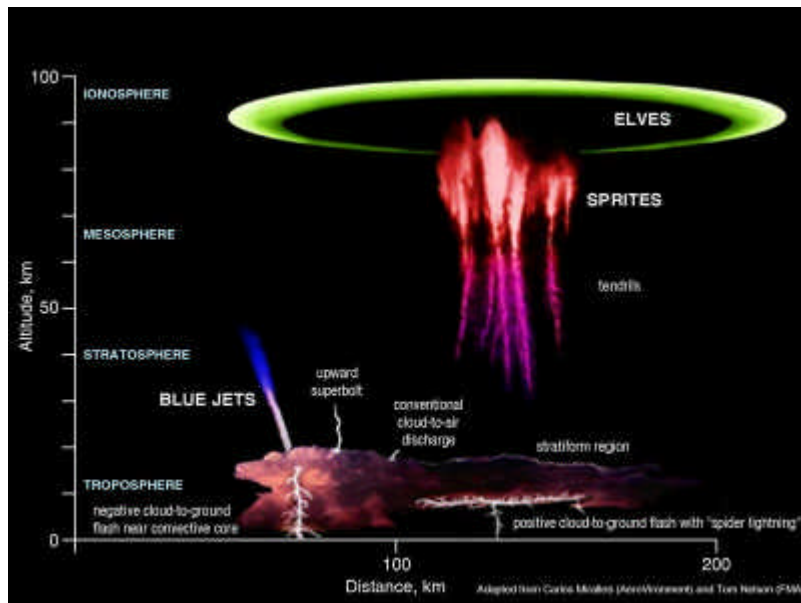


Image Credit: ElectricUniverse.inf

### Observations

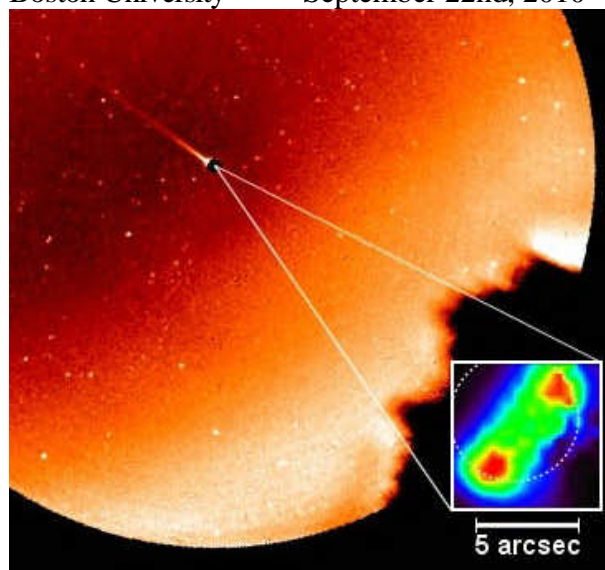
Overall, there are many similarities between *comets* and *terrestrial planets* but most importantly they are all theoretically surrounded by a *plasma sheath*.

The key differences relate to size, shape, topography, atmosphere, orbital speed and distance from the sun and it is a combination of these factors that ultimately determine whether the associated plasma sheath operates in *dark*, *glow* or *arc* mode.

Before proceeding further we can take comfort from the fact that others have made observations that are supportive of the LORIS hypothesis:

### Mercury found to have comet-like appearance

Boston University September 22nd, 2010<sup>55</sup>



Mercury's Tails

Image Credit: Planetary and Space Science<sup>56</sup>

## **Act II - The LORIS Lunar Model**

Having established a working hypothesis we can now construct a specific LORIS model for the Moon so that firm predictions can either be verified or falsified.

The LORIS hypothesis states that the Moon has a plasma tail and everyday observations indicate that this plasma tail currently operates in *dark mode*.

Everyday observations indicate that the Moon does not have a dust tail.

However, because the Moon has no atmosphere the LORIS model predicts that electrically neutral gas particles will be *sputtered* from the Moon by the solar wind.

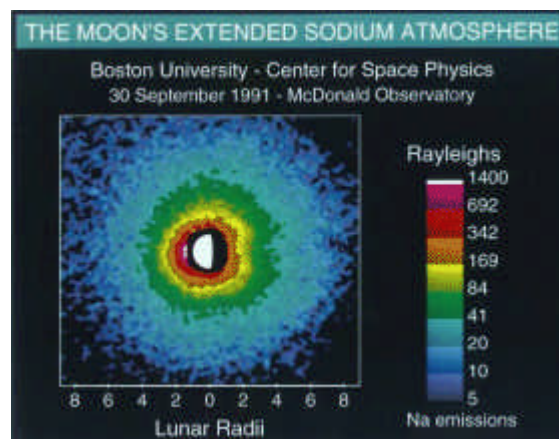
### **The Moon's Sodium Tail**

In 1998 scientists at Boston University announced their discovery of the Moon's elongated *sodium gas tail*<sup>57</sup> that extends in an *anti-sunward direction* for *hundreds of thousands of miles*<sup>58</sup>.

In 1999 the BBC reported that the *tail of sodium gas was seen to stretch for distances of at least 800,000 kilometres (500,000 miles) behind the Moon*.

This BBC report also provides support for the concept of gases being *sputtered* into a atmosphere or exosphere: "*It is one continuously being produced by evaporation of surface materials, and then continuously being lost by escape or impact back onto the surface,*" said Michael Mendillo, professor of astronomy at Boston University<sup>59</sup>.

In November 2000 NASA published a diagram from Boston University showing the extended sodium atmosphere of the Moon<sup>60</sup>.



The article also explains that meteor impacts enhance the release of sodium gas from the Moon:

*"I suspect the enhanced sodium tail in 1998 was related to the total mass of the impacting meteoroids rather than to their number," says Rob McNaught (Australian National University) who studies Leonid debris trails in collaboration with David Asher. "Of all the recent years we've studied, 1998 would probably have the greatest mass hitting the Moon and thus the greatest sodium production."*



In the same article NASA also released an animation of the 1998 observations made by Boston University.

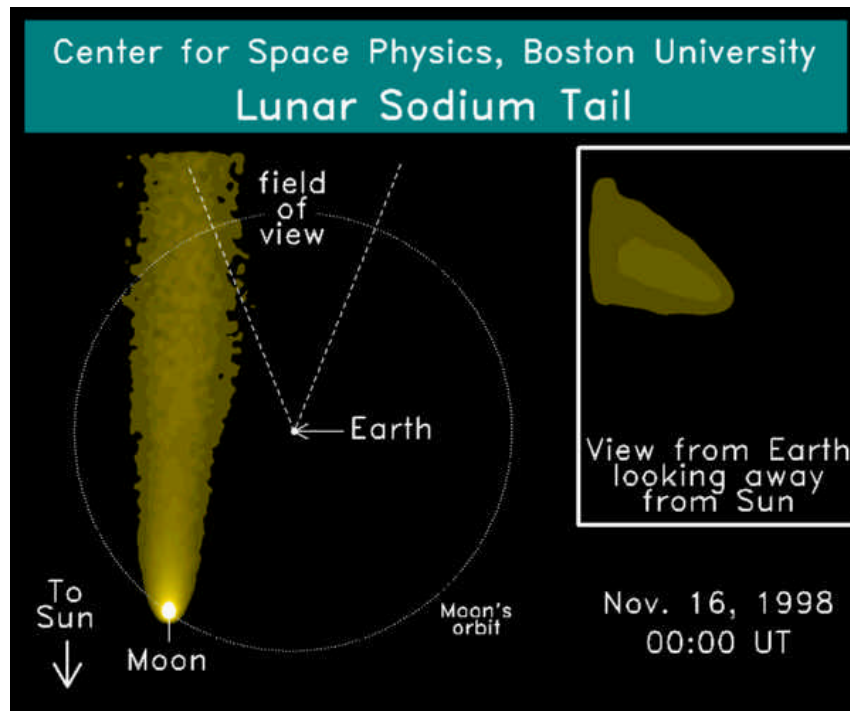


Image Credit: NASA The Moon's sodium tail sweeping past Earth  
[http://science.nasa.gov/media/medialibrary/2000/10/24/ast26oct\\_1\\_resources/tail.gif](http://science.nasa.gov/media/medialibrary/2000/10/24/ast26oct_1_resources/tail.gif)

The NASA article explains:

*The solar wind blows it into a long tail much like a comet's. It points away from the Sun and extends for hundreds of thousands of kilometers. The giant tail is so rarefied that it's completely invisible to the unaided eye even when the Earth passes through it once a month around the time of the New Moon.*

Studying the animation provides further visual support for the LORIS hypothesis:

- The *sodium tail* has retained structure integrity throughout the five day animation which is indicative of containment between the two sides of the Moon's *plasma tail*.
- The sodium gas does **not** simply dissipate into space, as one would expect, but is confined to form a tail.
- The *sodium tail* does **not** display any tangential deflection, as one would expect, as the Earth-Moon system orbits the Sun at a speed of 29.78 km/s nor does the *sodium tail* display any tangential deflection relative to the Moon *orbit* around the Earth.

### **The Moon's Surface Charge**

In April 2008 NASA published an article entitled *Earth's Magnetic Field Does Strange Things to the Moon*<sup>61</sup> that made some very interesting observations relating to the Moon's monthly traverse through the Earth's magnetotail:

*Anyone can tell when the Moon is inside the magnetotail. Just look: "If the Moon is full, it is inside the magnetotail," says Stubbs. "The Moon enters the magnetotail three days before it is full and takes about six days to cross and exit on the other side."*

Interestingly, the article continues:

*It is during those six days that strange things can happen.*

*During the crossing, the Moon comes in contact with a gigantic "plasma sheet" of hot charged particles trapped in the tail. The lightest and most mobile of these particles, electrons, pepper the Moon's surface and give the Moon a negative charge.*

The effects on the *day side* of the Moon are limited during the Moon's transit through the Earth's magnetotail by the positively charged solar wind and the effects of ultraviolet solar radiation:

*On the Moon's dayside this effect is counteracted to a degree by sunlight: UV photons knock electrons back off the surface, keeping the build-up of charge at relatively low levels.*

In comparison the *night side* effects are far more tangible:

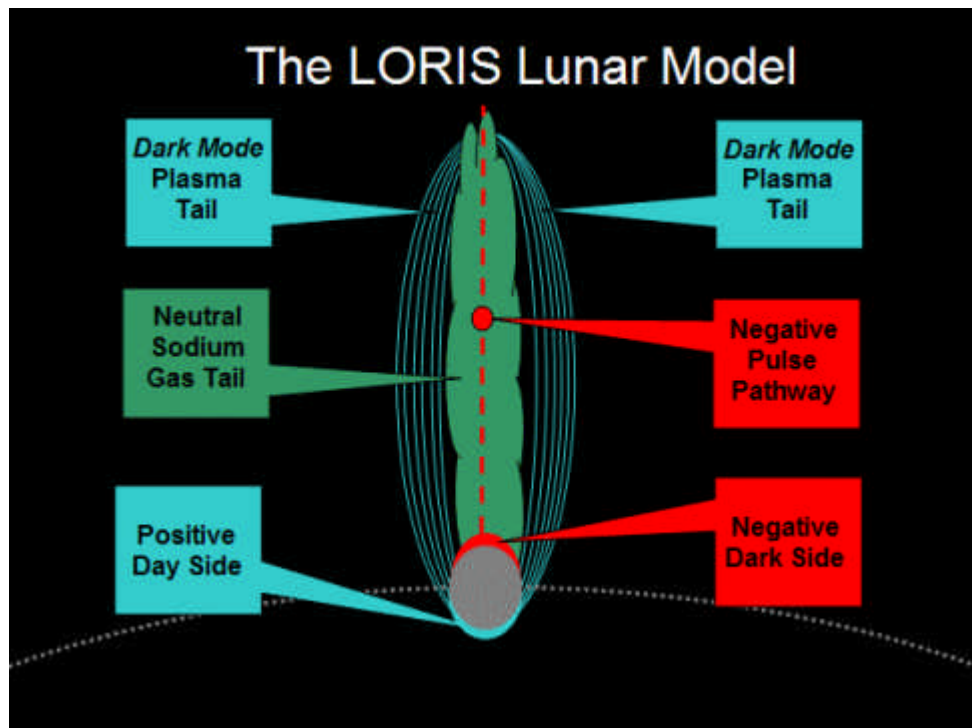
*But on the nightside, in the cold lunar dark, electrons accumulate and voltages can climb to hundreds or thousands of volts.*

.....

*The best direct evidence comes from NASA's Lunar Prospector spacecraft, which orbited the Moon in 1998-99 and monitored many magnetotail crossings. During some crossings, the spacecraft sensed big changes in the lunar nightside voltage, jumping "typically from -200 V to -1000 V," says Jasper Halekas of UC Berkeley who has been studying the decade-old data.*

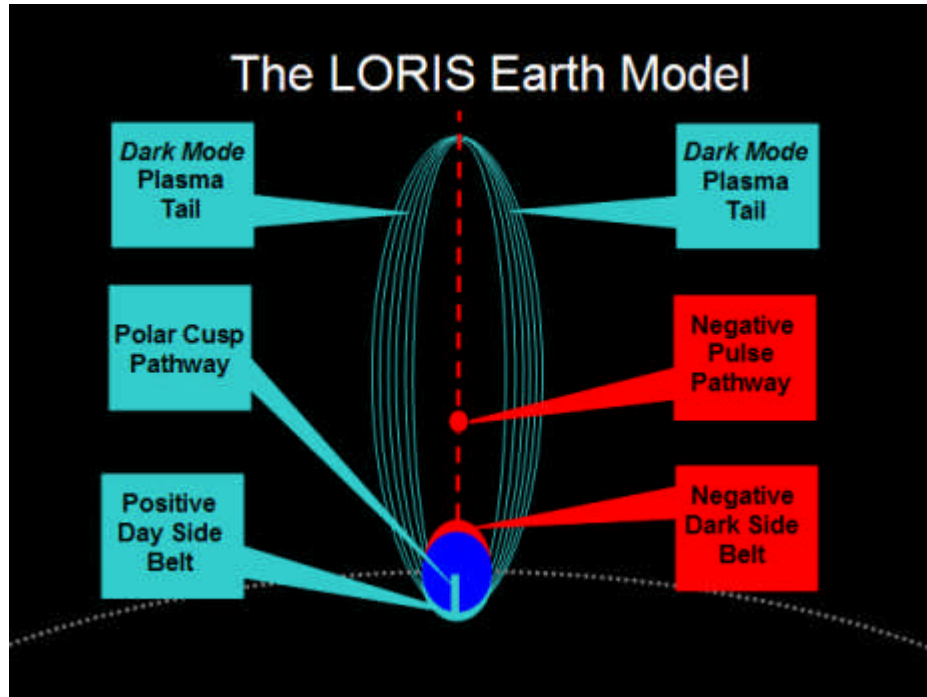
Therefore, the LORIS hypothesis is extended to incorporate:

- 14) Positive charge flowing from the day side into the plasma tail.
- 15) Negative charge accumulating on the dark side.
- 16) A pathway for the expulsion of excess negative charge accumulations.



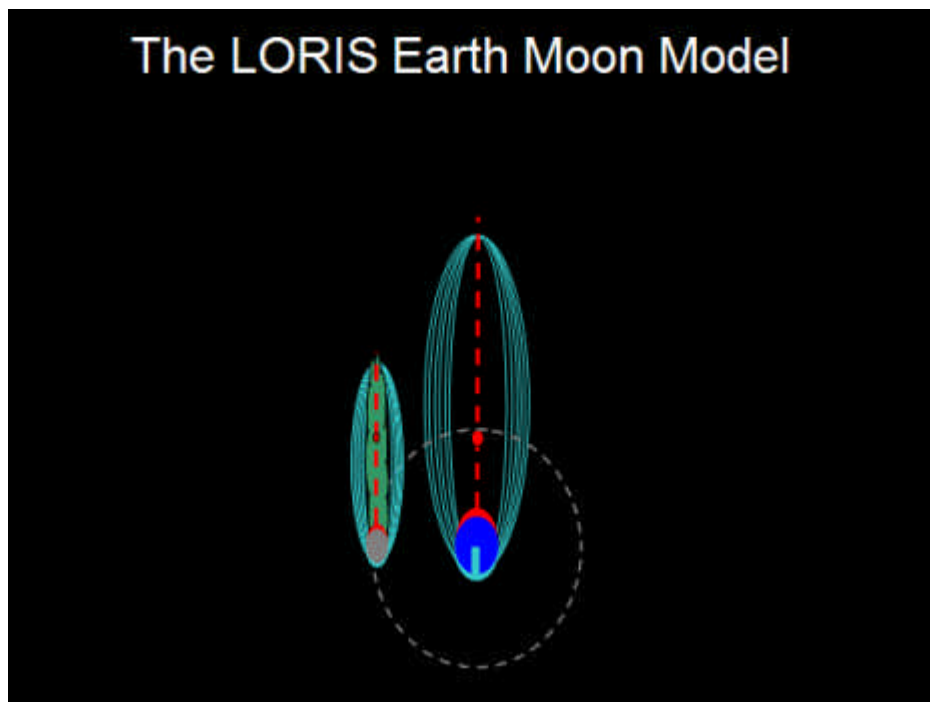
### The LORIS Earth Model

The LORIS Earth Model uses the LORIS Lunar Model as an initial template. This basic model is then enhanced to incorporate the features appropriate for a body with an atmosphere and an intrinsic magnetic field. Therefore, the *Sodium Tail* is removed; Polar Cusps are introduced as a solar wind pathway to the ionosphere and a Radiation Belt is thus established to accumulate charge far removed from the terrestrial surface.



### The LORIS Earth-Moon Model

The two individual models are then combined to form a Loris Earth-Moon model. Interesting, the Moon will generally have a more intense plasma tail because it is derived via surface *sputtering* whilst the Earth's is derived from a diffuse ionosphere.



## Lunar Erosion

The electrical erosion of the Moon's rocky surface by *sputtering*<sup>62</sup> releases ionized particles [which form the plasma sheath] and neutral gas particles which contribute to the Moon's sodium tail.

However, based upon a chemical analysis of the lunar surface regolith it is very reasonable to assume [given the low level of sodium] that several other compounds are also sputtered away from the Moon<sup>63</sup>:

Silica_____	SiO2__	45.40 %
Alumina_____	Al2O3__	14.90 %
Lime_____	CaO__	11.80 %
Iron(II) Oxide__	FeO__	14.10 %
Magnesia_____	MgO__	9.20 %
Titanium Dioxide_	TiO2__	3.90 %
Sodium Oxide_____	Na2O__	0.60 %

The level of lunar erosion has been estimated<sup>64</sup> to be in the region of 343,100 tonnes per year [equivalent to 940 tonnes per day or 47 micrograms/m<sup>2</sup>/day from the day side of the moon] based upon the Moon's observed orbital recession of 3.8 cm per year<sup>65</sup>.

## Deposition of Lunar Particles

The Earth passes through the Moon's sodium tail during the *New Moon* period and *non-ionized sodium* is deposited into the Earth's upper atmosphere where it forms a *sodium layer*<sup>66</sup> about 5 kilometres thick at an altitude of between 80 and 105 kilometres.

The Earth also passes through the Moon's plasma tail during the New Moon period. Metallic ions of Iron [Fe] and Magnesium [Mg] are known to be deposited into the Earth's upper atmosphere<sup>67</sup> where they form layers which are collectively called *Sporadic E*.

Unsurprisingly, *settled science* is puzzled by the observed correlation between *sporadic layers of sodium* and *Sporadic E*<sup>68</sup>. Settled science attributes both of these phenomena to the *ablation of meteors* and is happy to accept a mysterious *time-lag of one or two weeks*<sup>69</sup> between *meteor bursts* and the appearance of *Sporadic E*.

Unsurprisingly, as well, the appearance of *Sporadic E* is associated with electrical phenomena:

*At polar latitudes, Sporadic E can accompany auroras and associated disturbed magnetic conditions and is called Auroral-E.*

...

*One has to look for Sporadic-E (Es) clouds on either side of a severe thunderstorm cell complex.*

...

*Some of the key elements in identifying which severe thunderstorm cell complexes have the potential to produce Sporadic-E [include:] 500 mb (50 kPa) temperatures of - 20 °C or colder, which produce numerous positive and negative lightning bolts and inter-related Sprites and Elves<sup>70</sup>.*

However, this is one very beautiful surprise: Noctilucent clouds which are *the highest clouds in the Earth's atmosphere, located in the mesosphere at altitudes of around 76 to 85 kilometres* [and] *are composed of tiny crystals of water ice up to 100 nm in diameter.*

The mysterious *noctilucent clouds* or *night clouds* are tenuous cloud-like phenomena that are the "ragged-edge" of a much brighter and pervasive polar cloud layer called *polar mesospheric clouds*<sup>71</sup> in the upper atmosphere.



Image Credit: Wikipedia

But the mystery soon fades away:

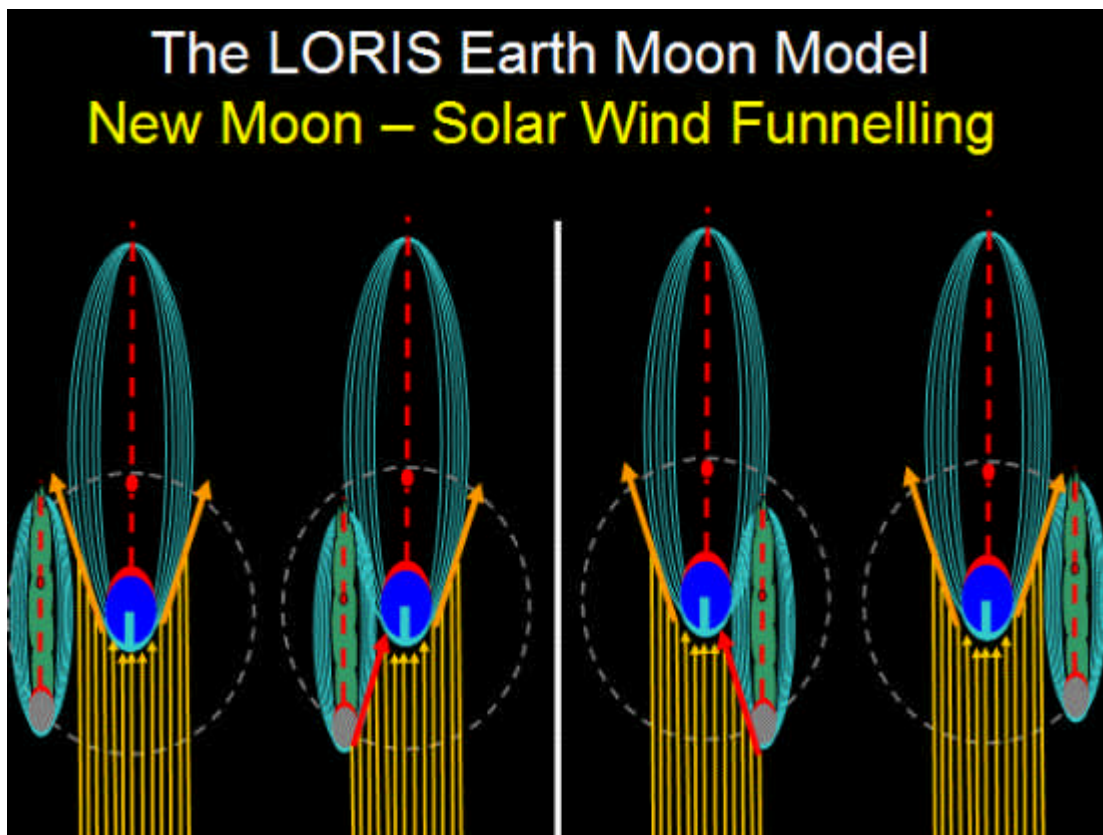
*Noctilucent clouds are known to exhibit high radar reflectivity [and] Caltech professor, Paul Bellan, has proposed a possible explanation: that the ice grains become coated with a **thin metal film** composed of **sodium and iron**, which makes the cloud far more reflective to radar*<sup>72</sup>

It is estimated that 40,000 tonnes of *debris* falls to Earth each year<sup>73</sup> and that most of this debris is *tiny particles* less than 200 microns across. Unfortunately, we have no way of knowing how many of these *tiny particles* were deposited on us by the Moon.

### Solar Wind Funnelling

As the Moon approaches *New Moon* additional solar wind is *funnelled* towards Earth. This *funnelling* process peaks at about 72 hours before New Moon. The strength of this process depends upon the intensity of the solar wind and the vertical alignment of the Moon and the Earth. Whenever the Earth and Moon are closely aligned vertically the Earth will experience a geomagnetic jolt as the *funnel* suddenly *snaps* shut.

A similar process occurs as the Moon moves away from its New Moon station. Additional solar wind is *funnelled* towards Earth and this process peaks at about 72 hours after New Moon. The strength of this process depends upon the intensity of the solar wind and the vertical alignment of the Moon and the Earth. Whenever the Earth and Moon are closely aligned vertically the Earth will experience a geomagnetic jolt as the *funnel* suddenly *pops* open.



## Full Moon

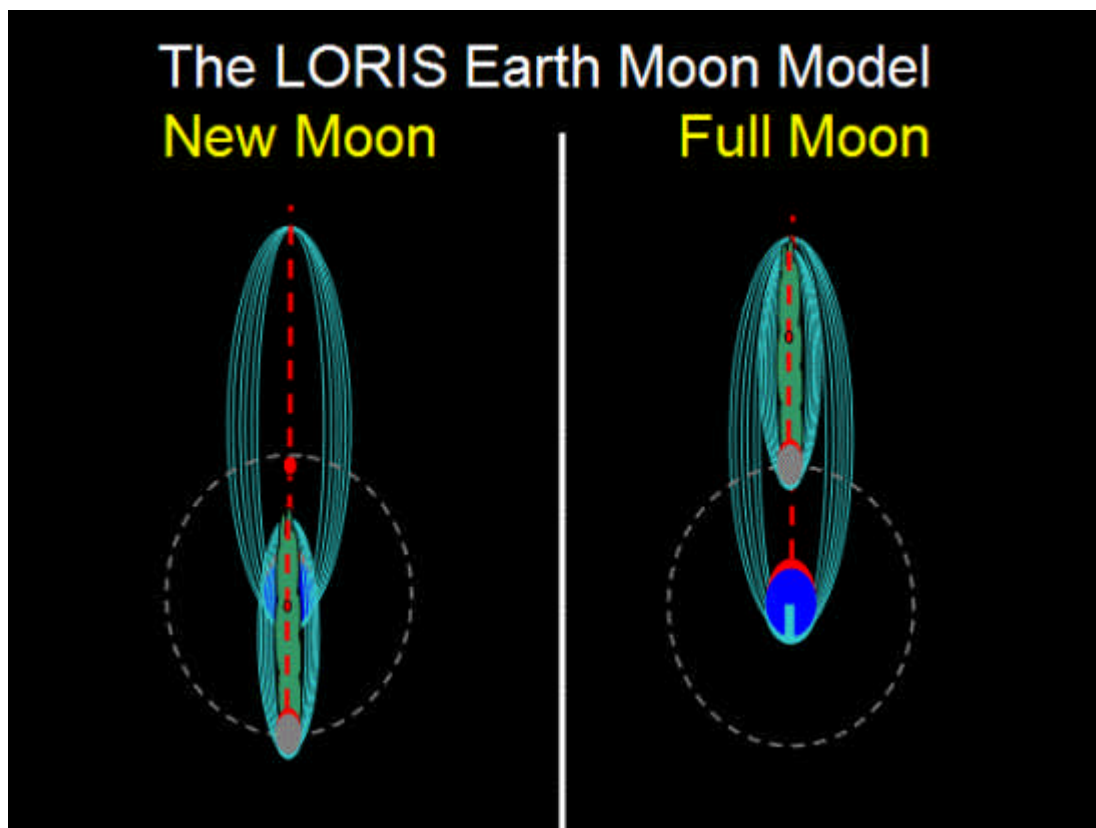
The *Full Moon* configuration presents some very interesting possibilities depending upon horizontal separation, vertical separation and levels of accumulated charge.

When there is no vertical separation [Lunar Eclipse] the Moon passes into a *solar wind shadow* during its six day transit through the Earth's plasma sheath. The driving force [solar wind] for the Moon's plasma sheath is thus removed and the Moon's plasma sheath starts to weaken. When the Moon reaches its *Full Moon* station [in the neutral core of the Earth plasma sheath] it is directly aligned with the accumulated negative charge on Earth's *dark side* which [in its turn] is attracted to the Moon's positively charged surface. The Earth will then experience geomagnetic shocks at the accumulated negative charge pulses down the neutral core towards the Moon. The Moon then starts to move away from its *Full Moon* station and emerges back into the solar wind three days later and its plasma sheath starts to strengthen once again.

Usually the degree of vertical separation makes this six day *Full Moon* transit far less traumatic, even quiet, but further observations are required, especially of the Moon's sodium tail, to provide addition details and insights into this transit process.

## New Moon

In the *New Moon* configuration the roles are reversed and the Earth faces the negative charge accumulated on the Moon's *dark side*. This is potentially the most *shocking* configuration for the Earth because the Moon has the potential to accumulate a more intense negative charge than the Earth.



### **ACT III – The Sting In The Tail**

The debate over the lunar effects upon the Earth, especially with regard to earthquakes, has a very long track record.

The *settled science* approach constrains lunar influence to the realm of tidal effects. From their perspective there is no other mechanism because [in their view] the Moon has no intrinsic magnetic field, the Moon has no magnetosphere [they choose to ignore electrical forces] plus there is no valid data to support any other conclusion. Thus, *settled science* labels other perspectives as purely anecdotal.

On the other side of the debate there are many advocates.

Ken Ring<sup>74</sup>, for example, writes:

*We can check each quake against Moon phases.  
96% of those quakes recorded which were above 6 on the Richter Scale,  
occurred exactly on or within a day of one extreme feature of Moon cycle, that  
is, New Moon, Full Moon, Apogee or Perigee. 75% involved two factors;  
when the say, the Perigee plus Full or New moon were on the same day.*

Proponents of lunar influences face three major problems when arguing their case:

- 1) Correctly identifying the influential factors.
- 2) Correctly quantifying these influential factors.
- 3) Correctly formulating these factors so they can make predictions.
- 4) Correctly separating observational results from background noise.

Validation of the LORIS Earth Moon Model confronts exactly the same issues.

Therefore, it is more practical, as this stage, to look for a ***Proof of Concept***.

The complexities of the first three issues are minimised if a very simple forecast is made for a theoretical extreme situation.

During a solar eclipse the Sun-Moon-Earth are horizontally and vertically aligned. But even then the selection of a solar eclipse does not address the issue of proximity [perigee] or the level of accumulated charge [which is a complete unknown].

The problem of background noise in our electrical and geomagnetic observation can be minimised if we select a solar eclipse in a period of low solar activity from the historical record.

Therefore, the specific *Proof of Concept* hindcast is:

**There was a sudden, unexpected surge in electrical and geomagnetic activity during the solar eclipse of 22<sup>nd</sup> July 2009.**

The final pages of this paper present evidence from the historical record so that the reader can decide:

Was the hindcast successful?

Does the Moon have a plasma sheath?

**Tim Cullen – Malaga – April 2012**



## 22<sup>nd</sup> July 2009 Solar Activity Forecast

24-hours forecast of magnetic storms: **No magnetic storm is expected**

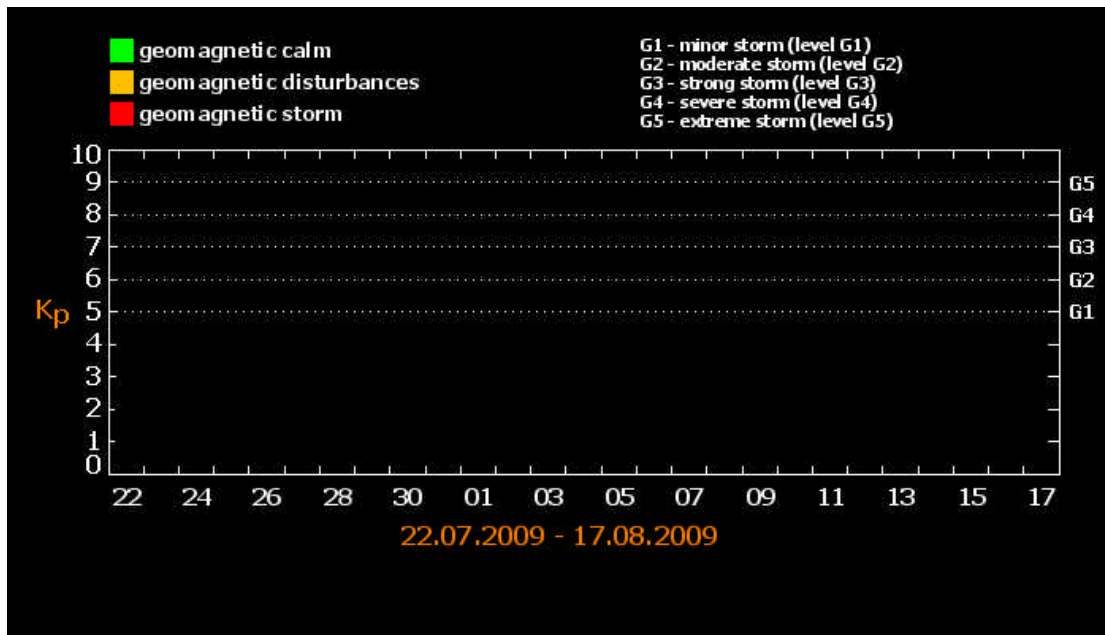


Image Credit: TESIS<sup>75</sup>

[http://www.tesis.lebedev.ru/en/forecast\\_activity.html?m=7&d=22&y=2009](http://www.tesis.lebedev.ru/en/forecast_activity.html?m=7&d=22&y=2009)

## 22<sup>nd</sup> July 2009 Solar Activity Report

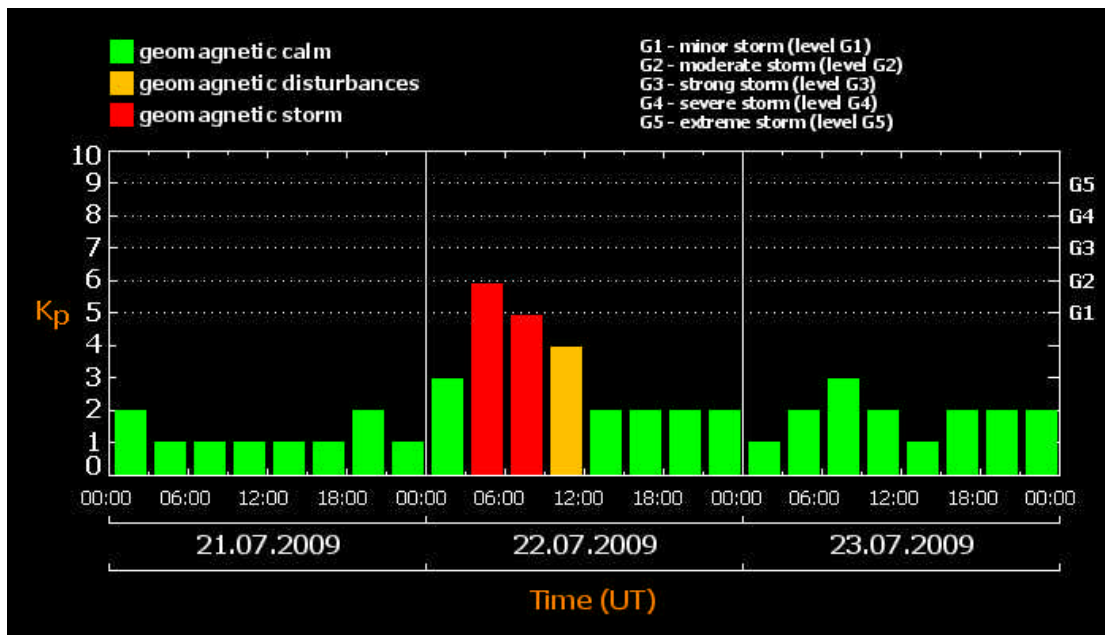


Image Credit: TESIS<sup>76</sup>

[http://www.thesis.lebedev.ru/en/magnetic\\_storms.html?m=7&d=23&y=2009](http://www.thesis.lebedev.ru/en/magnetic_storms.html?m=7&d=23&y=2009)

# 22<sup>nd</sup> July 2009 Anomalous Magnetic Field

## Kangerlussuaq (Søndre Strømfjord) – Greenland

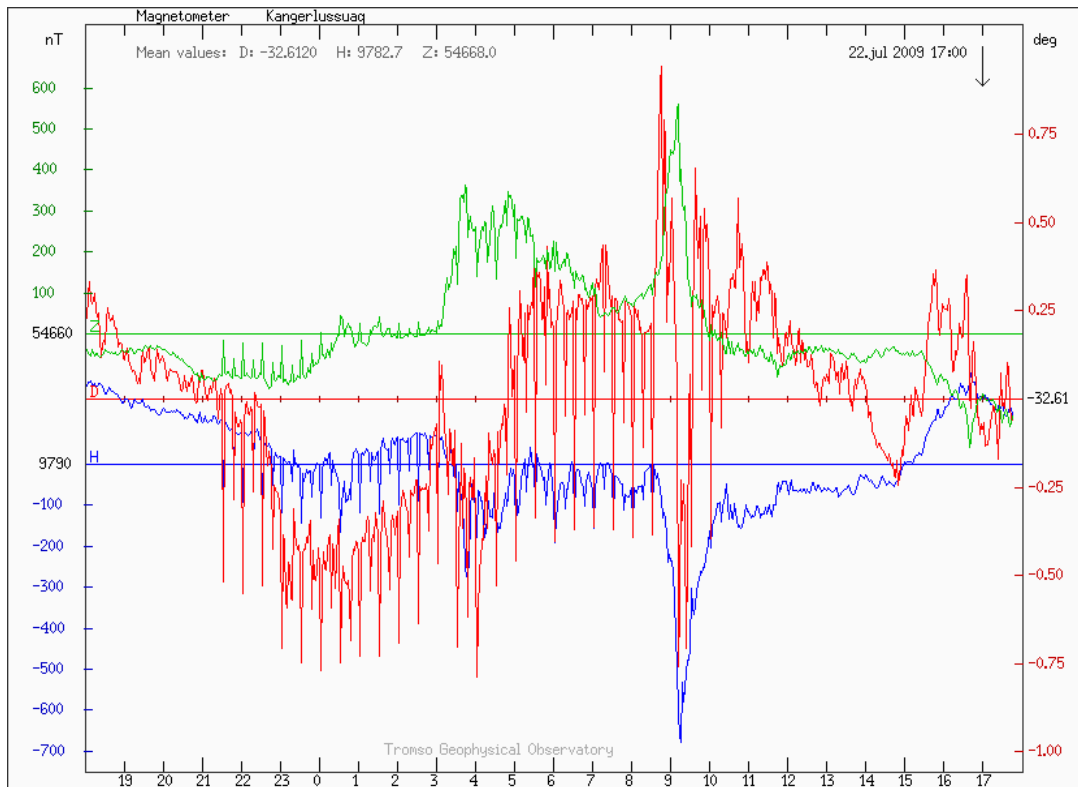


Image Credit: Tromsø Geophysical Observatory

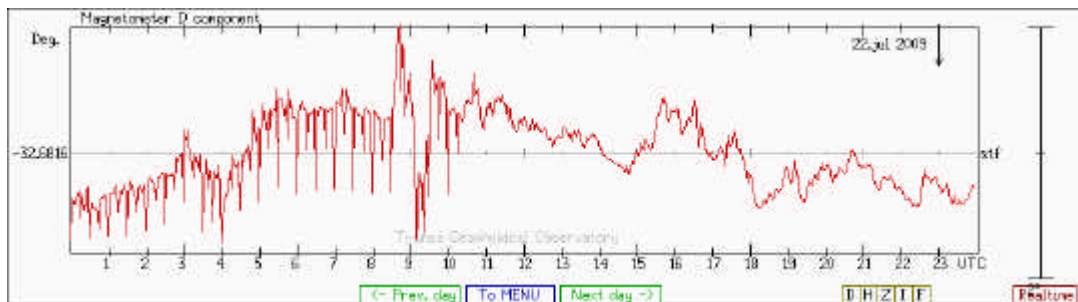
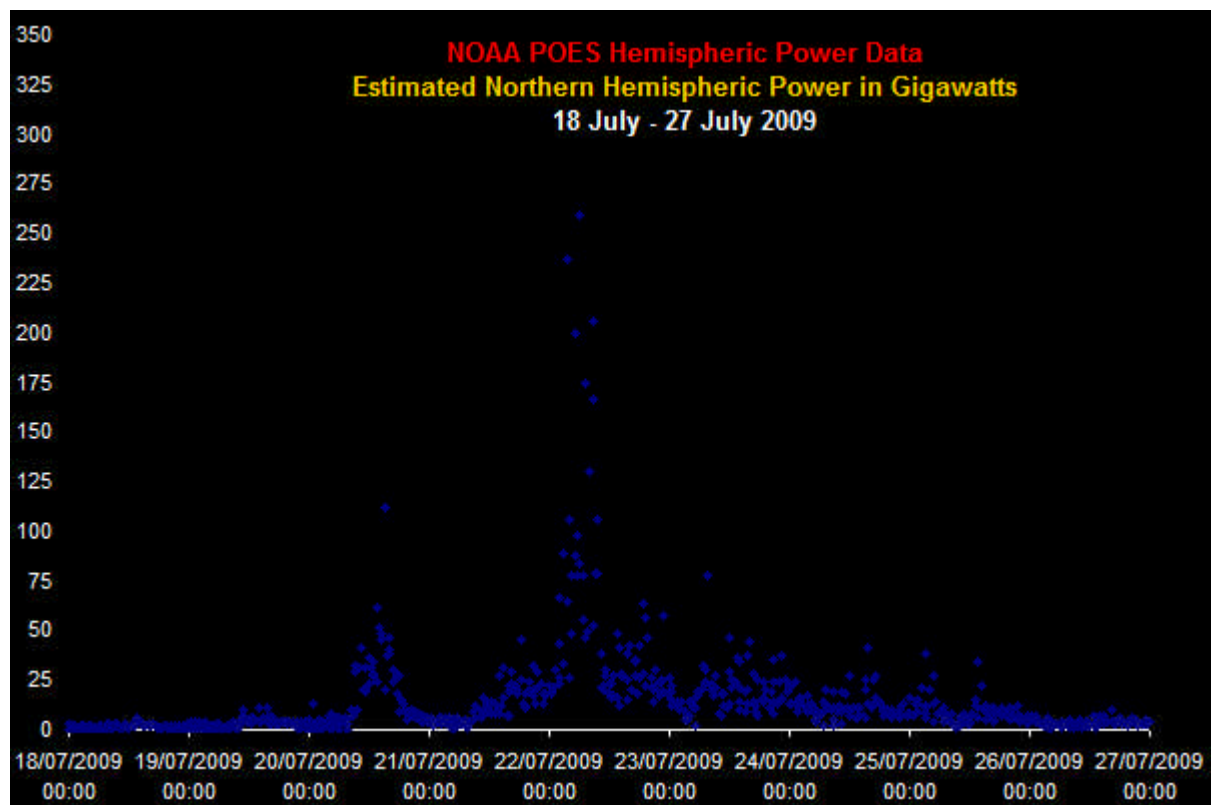
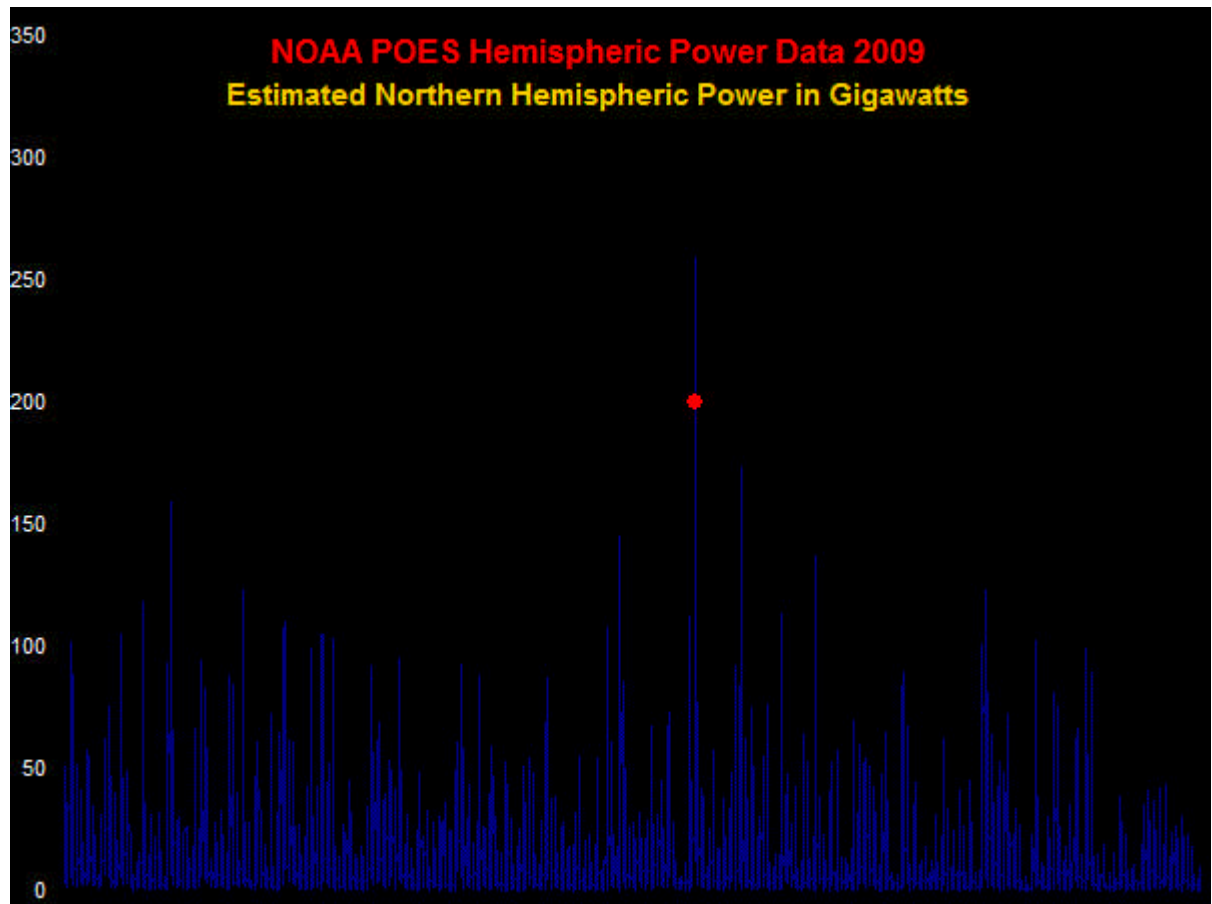


Image Credit: Tromsø Geophysical Observatory

<http://flux.phys.uit.no/cgi-bin/mkstackplot.cgi?&comp=D&cust=&site=stf1d&Sync=1248303600&>

## NOAA POES Hemispheric Power Data 2009



Source: NOAA/ National Weather Service - Space Weather Prediction Center  
Data: <http://www.swpc.noaa.gov/ftpdir/lists/hpi/>

## 22<sup>nd</sup> July 2009 Magnetosphere - Simulation

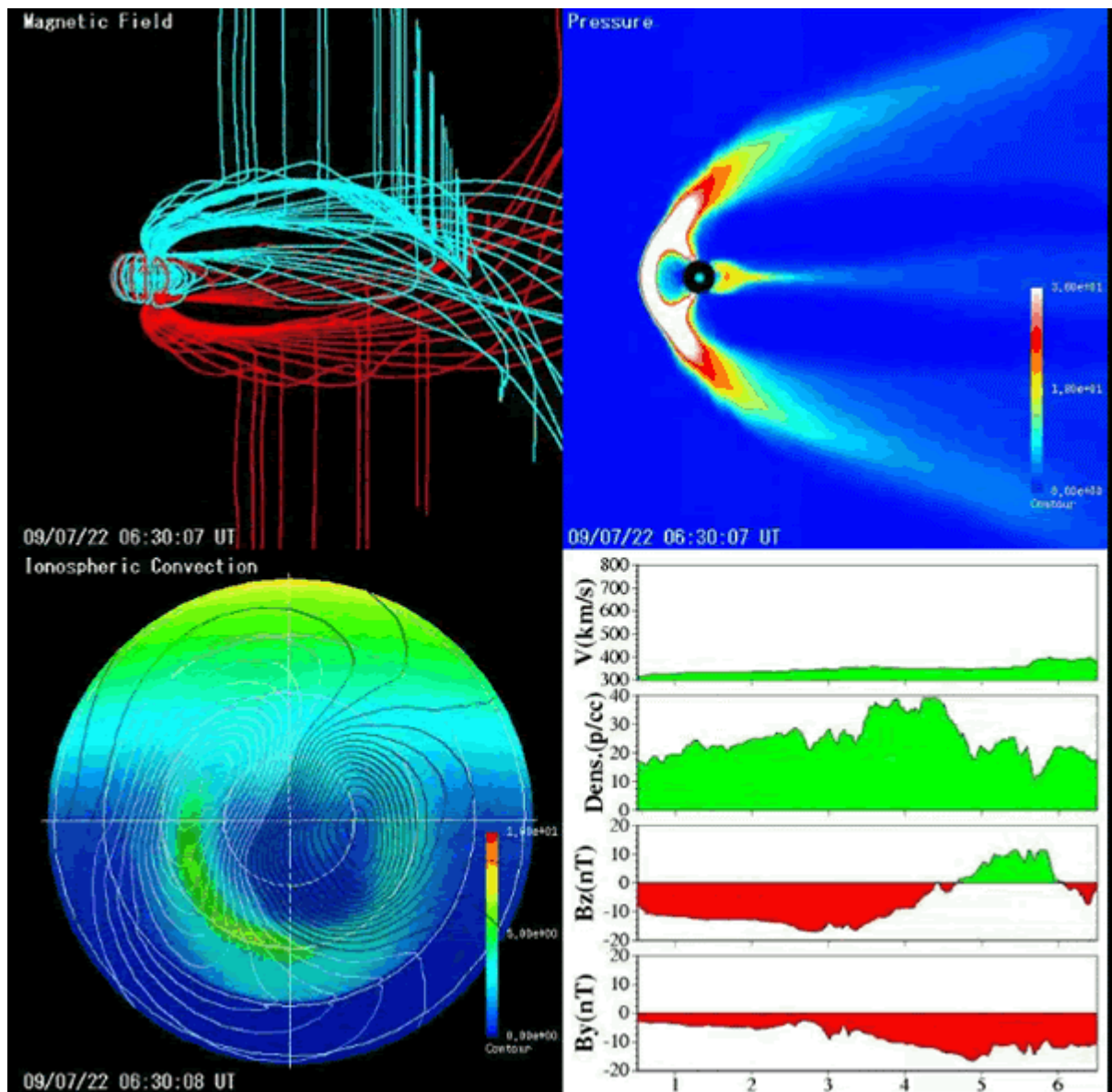


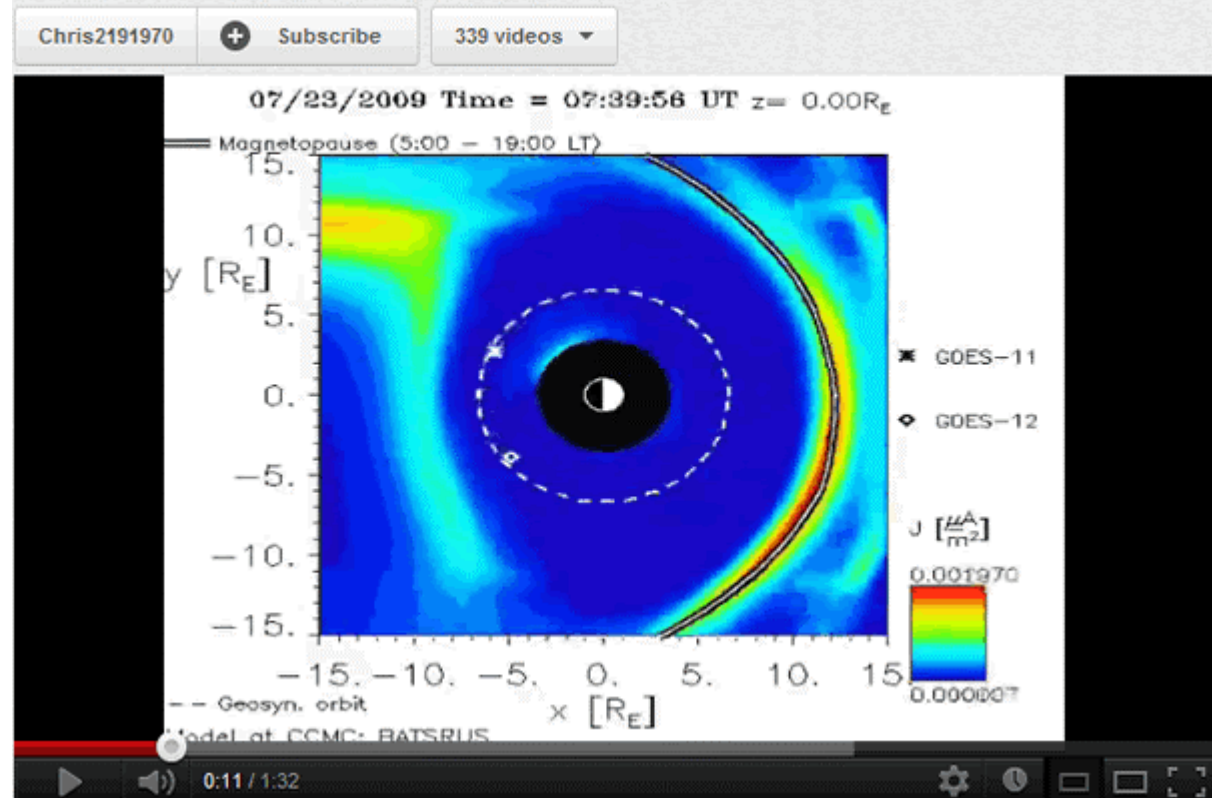
Image Credit: National Institute of Information and Communications Technology – Japan  
<http://www2.nict.go.jp/y/y223/simulation/realtime/home.html>

Watch the animation at:

[http://www3.nict.go.jp/y/y223/simulation/realtime/movie/2009/test\\_6.20090722.avi](http://www3.nict.go.jp/y/y223/simulation/realtime/movie/2009/test_6.20090722.avi)

## 22<sup>nd</sup> July 2009 Magnetosphere Breach

### 7-22-2009 Magnetosphere Breach |



<http://www.youtube.com/watch?v=FgN3MwaZx8I>

*It would appear that this breach in the magnetic shield happened because the solar wind contained a magnetic field that was oriented in the opposite direction to a portion of the Earth's field.*

Uploaded by Chris2191970 on Jul 23, 2009

## 22<sup>nd</sup> July 2009 Aurora Borealis



Image Credit: Zoltan Kenwell / Examiner.com

**Examiner.com**

**NEWS July 23, 2009**

### **Fantastic Northern Lights Over North America!**

*Another free light show greeted residents from Iowa into Canada the on the morning of July 22nd as a stream of solar particles interacted with the upper reaches of the Earth's atmosphere, making for a brilliant Aurora Borealis, more commonly known as the Northern Lights.*

<http://www.examiner.com/article/fantastic-northern-lights-over-north-america>

## 22<sup>nd</sup> July 2009 Noctilucent Clouds



**SpaceWeather.com**

### ***NLC ALERT:***

*"While India and China were enjoying a total solar eclipse, here in Europe we were treated to a sky show of our own," says Tomasz Adam of Staszów, Poland, where the night sky lit up with **intense noctilucent clouds** (NLCs) on July 21st and 22nd. "It was easily the best display I've ever seen."*

<http://www.spaceweather.com/archive.php?view=1&day=22&month=07&year=2009>



# 22<sup>nd</sup> July 2009 Total Solar Eclipse

## Total Solar Eclipse of 2009 Jul 22

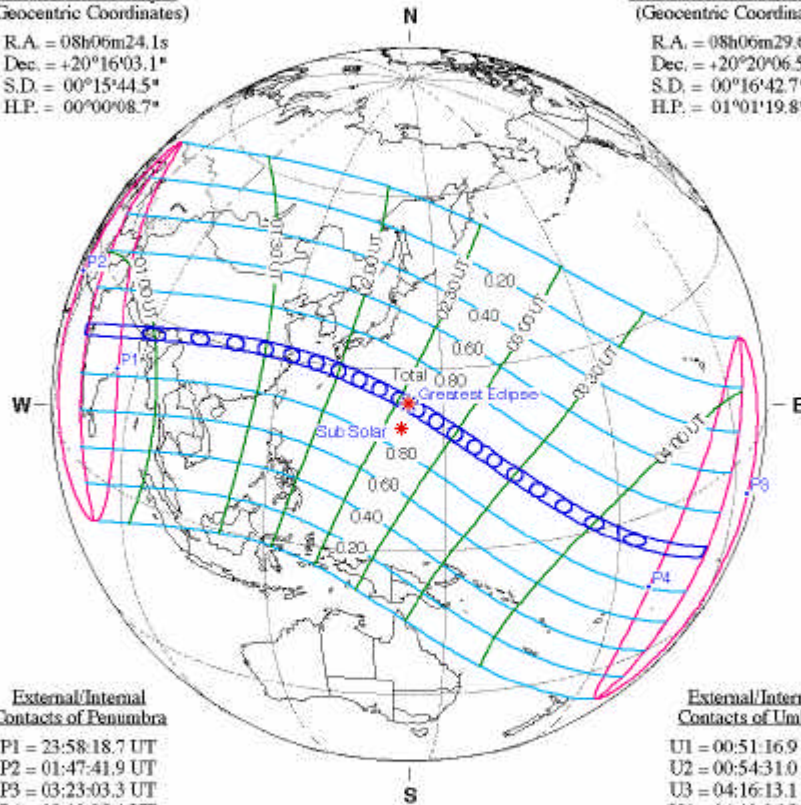
Geocentric Conjunction = 02:33:04.4 UT    J.D. = 2455034.606301  
 Greatest Eclipse = 02:35:21.1 UT    J.D. = 2455034.607884  
 Eclipse Magnitude = 1.0799    Gamma = 0.0696  
 Saros Series = 136    Member = 37 of 71

### Sun at Greatest Eclipse (Geocentric Coordinates)

R.A. = 08h06m24.1s  
 Dec. = +20°16'03.1"  
 S.D. = 00°15'44.5"  
 H.P. = 00°00'08.7"

### Moon at Greatest Eclipse (Geocentric Coordinates)

R.A. = 08h06m29.6s  
 Dec. = +20°20'06.5"  
 S.D. = 00°16'42.7"  
 H.P. = 01°01'19.8"



### External/Internal Contacts of Penumbra

P1 = 23:58:18.7 UT  
 P2 = 01:47:41.9 UT  
 P3 = 03:23:03.3 UT  
 P4 = 05:12:25.1 UT

### External/Internal Contacts of Umbra

U1 = 00:51:16.9 UT  
 U2 = 00:54:31.0 UT  
 U3 = 04:16:13.1 UT  
 U4 = 04:19:26.5 UT

### Ephemeris & Constants

Eph. = Newcomb/ILE  
 $\Delta T = 66.2$  s  
 $k1 = 0.2724880$   
 $k2 = 0.2722810$   
 $\Delta b = 0.0''$      $\Delta l = 0.0''$

### Local Circumstances at Greatest Eclipse

Lat. = 24°12.6'N    Sun Alt. = 85.9°  
 Long. = 144°06.4'E    Sun Azm. = 197.6°  
 Path Width = 258.4 km    Duration = 06m38.8s

### Geocentric Libration (Optical + Physical)

$l = 0.66''$   
 $b = -0.09''$   
 $c = 10.53''$

Brown Lun. No. = 1071



F. Espenak, NASA's GSFC - Fri, Jul 2,  
[sunearth.gsfc.nasa.gov/eclipse/eclipse.html](http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html)

Image Credit: NASA <sup>77</sup>

## 22<sup>nd</sup> July 2009 Solar Activity



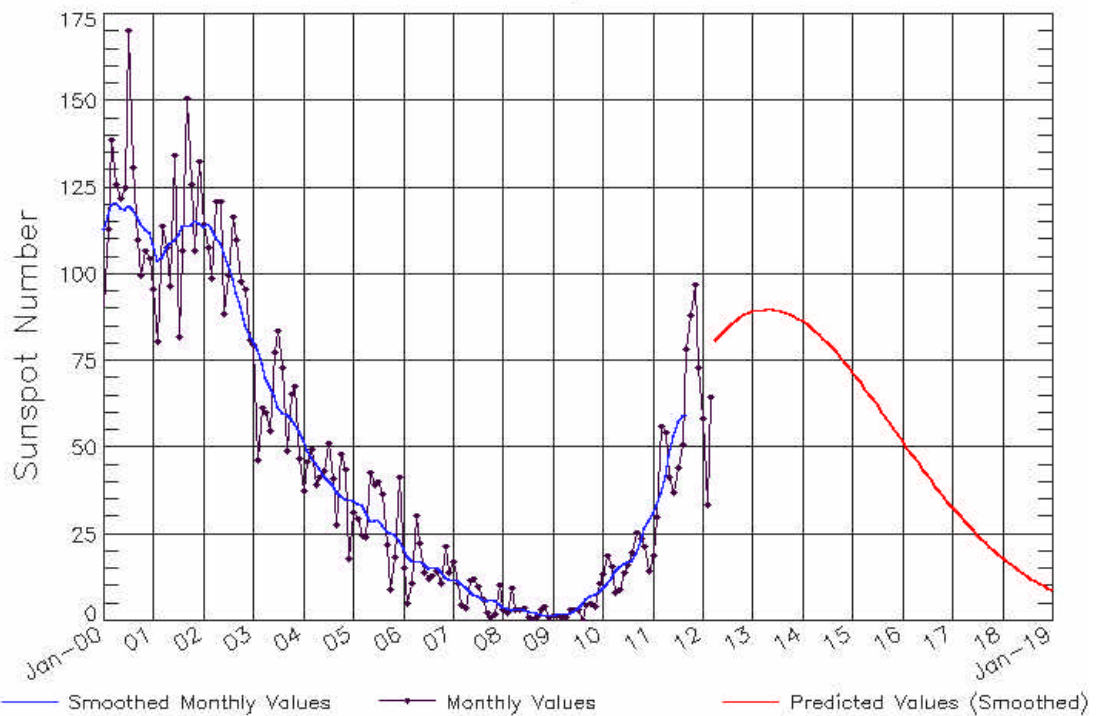
Image Credit: SpaceWeather.com

Daily Sun: 22 July 09

The sun is blank--no sunspots.

<http://www.spaceweather.com/archive.php?view=1&day=22&month=07&year=2009>

ISES Solar Cycle Sunspot Number Progression  
Observed data through Mar 2012



Updated 2012 Apr 9

NOAA/SWPC Boulder, CO USA

Image Credit: NOAA/Space Weather Prediction Center

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