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## The Northern Lights; a clue about the real cause of Global Warming?

The Northern Lights, also known as the Aurora Borealis, are a phenomenon that have fascinated people for hundreds of years. Visible from both the northern and southern hemispheres (where they are known as the Southern Lights or Aurora Australis), they are a dynamic, luminous display of colours and shapes seen in the night sky, which appear to move and flicker.



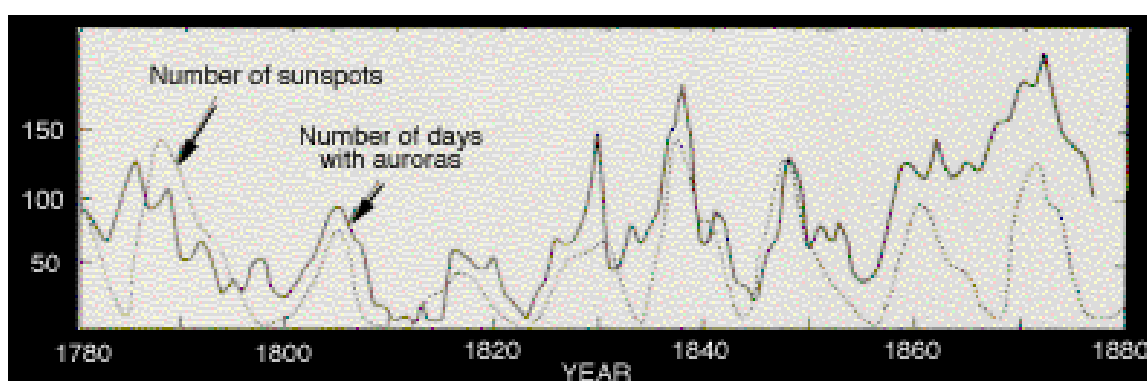
Credit:<http://www.northern-lights.no/>

The Northern Lights have had many names over the years: The Ancient Greeks referred to them as "blood rain"; the Germans called them "heaven light" and the Eskimo name was "sky dwellers". Seen most commonly in Finland, the early inhabitants used to believe that the purple, red, yellow, orange, green and blue lights that sometimes flickered in the sky were caused by a giant fox swishing its tail across the snow-clad crests of the Arctic hills. The lights were also thought to represent events happening in the world: many older people in Finland remember that the sky was blood red just before the outbreak of the Winter War in 1939. Weather forecasts were often based on the lights, and changes in climate were thought to be linked to the appearance of the lights. This idea of the climate change affecting the lights however is now known to be correct.

The mystery of these lights prompted a search for a scientific explanation. In the 19th century, they were suspected to be sunlight reflected onto the sky by ice caps and

glaciers in the Polar Regions. Other scientists speculated that they were caused by dust from meteorites burning up as they raced into the atmosphere. More exact explanations of the phenomenon could not be given until modern particle physics was developed, and satellites had measured details about the Earth's magnetosphere. We now know that the cause of these lights is actually to do with solar winds from the Sun, and their interaction with gases in the Earth's atmosphere.

The activity in the Sun fluctuates on an 11-year cycle, and is closely linked to the observations of the lights. In 1852, Edward Sabine looked at sunspot records and realized that the pattern of sunspots was the same as the pattern of Northern Lights. High sunspot activity caused a high number of sightings of lights. The graph below shows the number of sunspots compared with the number of auroras observed over a period of 100 years.



Franck Pettersen, University of Tromsø, Northern Lights Planetarium, N-9037 Tromsø, Norway

In the Sun's corona, the temperature is around several million degrees, causing collisions between gas particles to be so violent that atoms disintegrate into electrons and nuclei. Hydrogen becomes a gas of free electrons and protons called plasma. This plasma escapes from the Sun's corona through a hole in its magnetic field and is thrown out at very high speeds into space. Explosions near sunspots also cause high-energy particles to be thrown into space. These particles are called the solar wind and are the cause of the Northern Lights.

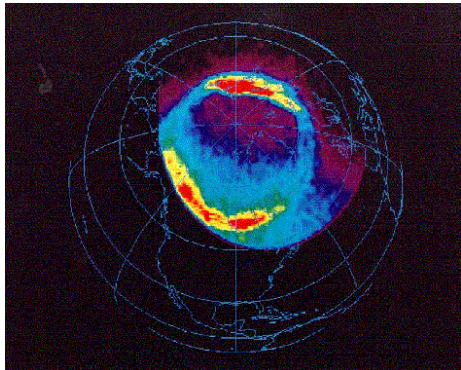
After a few days travel through space, the solar winds reach the Earth's magnetic field and are guided towards both the North and South poles. Here, they collide with oxygen and nitrogen atoms in the rarefied upper layers of the atmosphere. Most of the northern lights we see originate from the electrons accelerated into the Earth's ionosphere. Their energy is converted to visible light by a mechanism called the **quantum leap**.

This occurs when a free electron from the solar wind collides with an electron in oxygen, for example, at high speeds. Normally the electrons in oxygen would be

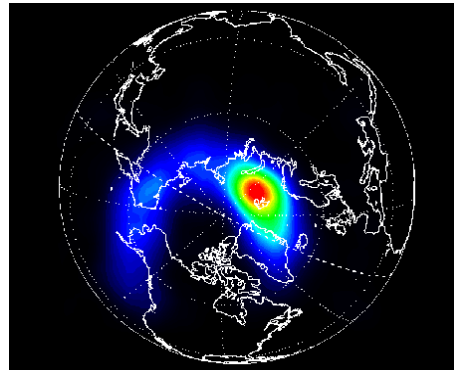
spinning in the lowest possible energy orbit. When the fast moving electron collides with an electron in oxygen, it releases energy, which results in the oxygen electron moving into a higher orbit. This orbit is further away from the nucleus, therefore has a higher amount of energy. The oxygen electron now contains a greater amount of potential energy; however it is very unstable. As the electron is unable to retain this energy, it returns to its original orbit, releasing the extra energy as a photon of light as it moves. Billions of these quantum leaps occur simultaneously, which is what is observed when watching the Northern Lights.

The different colours of the lights are produced from the high-energy particles colliding with the different gases in the atmosphere. When atomic particles hit oxygen molecules in the upper layers of the atmosphere, the moving electrons emit photons of wavelength  $\sim 700$  nm, producing red coloured lights. Collisions with oxygen at lower altitudes causes emissions of photons with a wavelength  $\sim 560$  nm (green light) and collisions with nitrogen causes emissions of photons with a wavelength  $\sim 470$  nm (blue light). The lights are most commonly of a green colour, as oxygen is the most abundant gas in the atmosphere.

Although the lights produce spectacular effects in the visible part of the spectrum, the quantum leaps also release photons of light in the non- visible part as well. Below are images showing an aurora in the UV and X-ray parts of the spectrum.



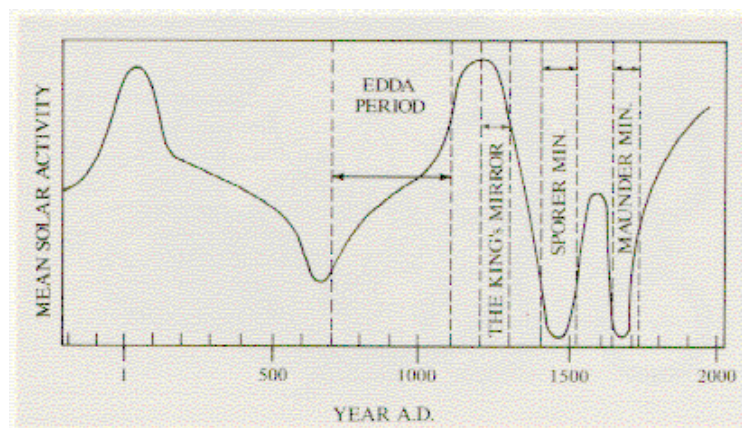
**UV**



**X-RAY**

Before the cause of the Northern Lights was properly understood, the weather forecast was often based on the appearance of the lights although, more often than not, the predictions from one area contradicted that of another. In Labrador, for example, the appearance of the lights meant fine weather was expected, whereas in Greenland, the lights were a sign of approaching winds and storms. Even in the early 1900's it was written that the Northern Lights and thunder were actually the same phenomenon with different forms of electrical discharge. It is now known that changes in weather occur in the troposphere, whereas the lights are actually in the ionosphere. This part of the atmosphere is 90km above the troposphere, therefore has no effect on the weather.

It was noticed, however, that fluctuations in the climate were closely related to the appearance of the lights. This has been proven to be true. Between 1645 and 1715, there was a significant absence of aurora, which coincided with a minimum in solar activity. This period is known as the **Maunder minimum**. Since aurora are produced as a result of plasma escaping the Sun through sunspots in the corona, the lack of solar activity meant there were very few sunspots, which in turn meant there were very few sightings of aurora for 70 years.



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According to predictions about the Northern Oval, which is the region in which the lights were most likely to appear, the lights should have been visible. However, this period of low solar activity meant that very little solar winds were produced, preventing the lights from appearing. This theory was also used to explain another minimum, the **Spörer minimum**, which had occurred in the early 16<sup>th</sup> century.

There was a lot of scepticism about the reliability of the prolonged sunspot activity, and two scientists in particular, Herschel and Luby both claimed that the main reason for a low number of sunspots was that people were not actually observing the Sun systematically; therefore it was likely the lack of sunspots was caused by lack of observations. However, in 1976 in an article called *Science*, a scientist named J. A. Eddy managed to convince many researchers that there was actual evidence for the lack of sunspot activity in the Maunder Minimum. By linking the minimum to the tree-ring <sup>14</sup>C record, he used the hypothesis that during a period of low solar activity, the high-energy cosmic rays, which produce <sup>14</sup>C in the atmosphere, are repelled less than normal by the solar wind. This would mean that high levels of <sup>14</sup>C would be present in tree-rings. It was then shown that during the Maunder Minimum, a higher number of rings than expected were formed containing <sup>14</sup>C, confirming that the Maunder Minimum, as well as the Spörer minimum in the early 16th century, had were periods of low solar activity. Eddy also managed to use this evidence to identify a maximum of sunspot activity spanning the 12th and 13th centuries (**Edda Period**), in which references about a high number of appearances of the lights can also be found.



Eddy also claimed that the Maunder minimum coincided with a period of very cold weather. At this time, there was an absence of magnetic activity as well as solar activity, which was accompanied by an overall decrease in the total radioactive output of the Sun, causing the climate to become cooler than usual. Since the Maunder minimum, there has been a general increase in solar activity, and also radioactive output, which, it is speculated, has caused the subsequent warming of the Earth. This evidence has been used by solar physicists, and has been associated with the recent climate change as the primary agent of global warming.

The main cause of global warming is usually considered to be the increase of greenhouse gases in the atmosphere. It is thought that the gases cause a general warming of the Earth due to the complex nature of the physical processes which accompany the reactions with other gases in the atmosphere. The big increase of gas emissions in industry and transport is believed to be causing global warming to happen faster than expected. Although there is no definite evidence that rules out this theory, there are other ideas about the cause of the increase of temperatures on the Earth's surface. Since the Maunder minimum, there has been a steady increase in solar activity, and many people believe that we are simply experiencing a higher than expected maxima, similar to those experienced in the 12<sup>th</sup> and 13<sup>th</sup> centuries. If this were the case, it is possible that the greenhouse effect is not the main cause of global warming, or even a cause at all.

Although a lot is now known about the Northern Lights, like anything to do with the science, there is still on-going research into what affects them. The link with changing climates is still under investigation, as the recent increase in the Earth's surface temperature is causing the lights to be seen far more frequently, and much further south than ever before. Although it is thought by many people that the fluctuations in solar activity is one of the main causes of global warming, the fact that the levels of greenhouse gases in the atmosphere are increasing cannot be ruled out as a possibility. Whatever the science behind them is, they are still one of the most amazing displays to be seen on Earth, could this beautiful phenomenon really be a clue to understanding the increasingly irregular and extreme weather the planet has been experiencing?



Credit: <http://www.northern-lights.no/>