PHYSICS

Lights of the Arctic Sky

Weird Colored Flames Linked With Sunspot Maxima And Magnetic Disturbances Are Puzzle To Scientists

WEIRD green, yellow, red and purple lights flame in the northern heavens.

They are, say the Eskimo, the dancing souls of the dead.

Only within the past two generations have geophysicists provided a more logical explanation of the aurora borealis, due in part to researches of collaborators of the Carnegie Institution of Washington. Much still remains unknown. Unlike the light of sun, moon or stars, the luminescence of the top and bottom of the world seems to have no substantial source in a hot or reflecting solid body.

Streams of electrically charged particles, possibly electrons and protons, are shot from the flaming surface of the sun. Their velocity is a little less than that of light. These particles are pulled towards the north and south magnetic poles of the earth. They strike the extremely tenuous outer atmosphere extending—this is one of the findings of aurora borealis studies—as much as 800 miles from the surface of the planet.

They collide with atmospheric atoms and molecules, stripping off outer electrons and causing light-producing energy states. The elements present are chiefly nitrogen and oxygen, and the light produced is such as can be duplicated in the laboratory by putting atoms of these elements in the proper conditions of excitation.

Precise Nature Unknown

The precise nature of the particles shot from the sun—there is no other possible source — remains to be determined. Wherever they collide with atmospheric atoms they produce luminescence, but, recent investigations have shown, it is only within 50 or 80 miles of the earth that this usually becomes sufficient to produce the sublime spectacle of the aurora.

The height of the light source can be measured, just as can that of any nearby heavenly body, by photographing the phenomenon against a background of stars. This has been done by Störmer and also by the Norwegian geophysicist and Carnegie collaborator Vegard, and the distance of the aurora above the earth has been found surprisingly small.

From the first observations recorded by literate men, the sublime display of the northern lights has stirred practical observers to lyrical ecstasies, and the scientific explanation detracts little from the enthusiasm.

One of the best descriptions is quoted from a Norse manuscript of the year 1250:

Flame of Strong Fire

"It appears like a flame of strong fire seen from afar. Pointed shafts of unequal and very variable size dart upwards into the air, so that now the one and now the other is the higher, and the light is floating like a shining blaze. So long as these rays are highest and brightest, this sparkling fire gives so much light that, out of doors, one can find one's way about and even hunt. In houses with windows it is light enough for men to see each other's faces.

"But this light is so variable that it sometimes seems to grow obscure, as if a dark smoke or thick fog is breathed on it, and soon the light seems to be stifled in this smoke. As night ends and dawn approaches the light begins to pale, and disappears when day breaks. Some people maintain that this light is a reflection of the fire which surrounds the seas of the north and south. Others say it is the reflection of the sun when it is below the horizon. For my part I think it is produced by the ice which radiates at night the light which it has absorbed by day."

The aurora appears in several characteristic forms. Sometimes it is in the form of arcs or bands of vari-colored light stretching across the sky. Sometimes there is the appearance of red or violet clouds scattered over the heavens. A form often noted is a white or greenish glow near the horizon, which looks like the first glimmer of dawn. The "drapery aurora" is described by explorers. The northern sky seems to be hung with luminescent curtains. Most spectacular is the so-called "flaming aurora." Strong waves of red or purplish light move rapidly upwards, one after another, in the direction of the magnetic zenith. It looks like a rolling tide of fire.

The dominant color of the aurora most frequently is yellowish green.

This color is due to a single wavelength of light—the mysterious green line which puzzled physicists for a generation until, in 1925, Sir John McLennan of the University of Toronto was able to reproduce it in the laboratory. It is given off by atomic oxygen in a peculiar state of excitation. The green line appears only when there are mixed with the oxygen some of the other gases found normally in the atmosphere—argon, neon, helium or, most important of all, nitrogen.

The significance of this green line is due not alone to its presence in the aurora. It is also the most conspicuous light-line found in the luminescence of the night sky which is present all over the earth and is sometimes called the "non-polar aurora." On a clear night the sky light, exclusive of the moon, is approximately equivalent to that of a 25-candle-power lamp about 300 meters away. Only about a fourth of this is due to the stars. The rest comes from the high atmosphere. From six to ten per cent of the total is due to the green oxygen line alone.

Nitrogen Chief Contributor

Oxygen bombarded by the corpuscles from the sun also contributes a little of the red light found in auroras. Most of the luminescence, however, comes from ionized nitrogen atoms, especially the blue and purplish shades often reported by observers. Nitrogen remains the chief constituent of the earth's atmosphere, at great heights as well as near the surface.

Actually the northern lights seldom are seen south of the southern boundary of Canada. They can be observed on every clear night within an irregular ellipse around the north magnetic pole, and usually a few hundred miles to the southward. Occasionally they are reported as far south as the latitude of Washington and even—the observations are somewhat questionable — at the equator.

Their southward extension comes at the time of great magnetic storms. The relation between the two phenomena is of exceptional interest to students of terrestrial magnetism and constitutes a tool by which magnetic storms can be studied. Such storms, it now is recognized, come with the maximum number of spots—supposedly titanic whirlwinds—in the fiery atmosphere of the sun. The number of sunspots increases and decreases in approximately an eleven-year cycle. One maximum has just passed and it is probable that another decade will pass before the aurora borealis is seen far to the southward of its normal limits.

Nature Not Clear

The exact nature of the relationship is still unknown. Presumably during a sunspot maximum the surface of the solar body is in an unusually excited state. Larger and more frequent streams of corpuscles than ordinary are shot out into space and hence a greater effect is produced on the outer atmosphere of the earth. The electrical state of the air is altered and there are produced both the luminescence and the magnetic phenomena.

All sorts of weird cycles have been linked up with the progress of sunspots from minima to maxima and back again—from the recurrence of wars to the state of the stock markets. Few of these can be definitely proved, or disproved. The northern lights and the magnetic storm cycles are exceptions of which there can be no question.

At least 50 miles away and usually diffuse and variable, the northern lights are difficult to study. At first sight they may seem extremely bright, but the absolute intensity of the light never is great. Strong aurora may on very rare occasions give enough light to read by, but the total illumination seldom is as great as that of the full moon. Usually on a clear night bright stars can be seen through the curtain of luminescence. There have been reports of auroras in full sunshine. These cannot be verified and seem quite improbable. The color effects of sunlight falling on cirrus clouds might easily be mistaken for the northern lights.

May Last All Night

The duration of the aurora differs from night to night. Sometimes it lasts only a few minutes. It may continue all night and the light appear strongest just before dawn. The phenomenon always has been difficult to photograph because of the absolute dimness of the light. The first successful pictures were taken in Lapland in 1892 with exposures of seven or more seconds. Recently natural color photographs have been obtained.

The spectrum of the northern lights, reproduced and studied under laboratory conditions, sheds some light on the temperature of the earth's atmosphere at great heights. If the air were as dense as at sea level, of course, it would be very hot, but actually it is somewhere between —30° and —40° centigrade.

Hardly a fair start has been made on the scientific study of the northern lights. They are of absorbing interest in at least three fields.

The high atmosphere of the earth, far above the stratosphere which is the limit of airplane exploration, remains a region of mystery. The aurora is one of the few observable phenomena—and by far the most striking—which take place there. If the aurora were thoroughly understood, much light would be thrown on its physical surroundings.

The relation between the strength of the luminescence and the magnetic field of the earth already has been mentioned. Is this a coincidence? It is generally agreed that there is a physical association. When the nature of this is cleared up there will be a better understanding of magnetic phenomena in general.

Studies of the aurora already have given a better understanding of the physical composition of the high atmosphere. They may be expected in the future to prove even more revealing.

The sun is approximately 90,000,000 miles away from the earth. Upon its light and heat all life on this planet depends. But between events on the sun and on the earth there is little observable relation. The northern lights, however, respond specifically to specific changes on the sun's surface and may prove of inestimable value in interpreting these changes.

Does Aurora Sing?

A common belief regarding the aurora is that it "sings." Many observers, including some scientists, claim to have heard strange, semi-musical sounds which increase and diminish in intensity with the northern lights themselves.

The nature of these sounds, if they actually can be demonstrated as real, remains an unsolved mystery of the Far North. That they are due to the aurora, per se, seems impossible.

Occasionally odors—probably the pungent smell of ozone from an electrical discharge—also have been reported as accompanying auroral displays.

AURORA

This photograph taken in Norway shows how spectacular the Northern Lights are at that latitude.