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LUMINOUS NIGHT CLOUDS AND LOW LATITUDE AURORAS

by

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The advent of the International Geophysical Year with many observers closely watching the night sky makes it most appropriate to call attention to the luminous night clouds, the low latitude auroras, and the other sporadic night phenomena. Although many observers of these phenomena have published their data, many have done as I; that is, made and recorded the observations, but never made them available for discussion. To encourage observers to publish their data, and, especially, to encourage the observations of such sporadic phenomena during the International Geophysical Year, I am making available in this paper some hitherto unpublished accounts of seventeen instances of optical phenomena of the night sky. Most of my observations of luminous night clouds and low latitude auroras were made during the last two sunspot maxima. Inasmuch as the Geophysical Year 1957/1958 occurs as the sunspot cycle is expected to be approaching the maximum we might expect that such optical phenomena as we know takes place for low latitude auroras may again be seen frequently.

At the Pacific Regional Meeting of the American Geophysical Union held in Pasadena, California, February 8-9, 1952, Elvey, Williams, and St. Amand presented a paper discussing the luminous night clouds and specially stressing the observations of Williams and St. Amand during the period from August 31 to September 5, 1951. Their observations of luminous night clouds were made both visually and by means of a photoelectric photometer that was making routine surveys of the sky in four colors from the observing station at Cactus Peak, California (Lat. = N 36° 04' 41"; Long. = W 117° 48' 53"). The filters employed with the photometer transmitted narrow bands at the three stronger radiations of the airglow spectrum in the visual region. These are the green auroral line, 5577Å; the red auroral line, 6300Å; and the sodium lines; 5893Å; and, for comparison purposes, a region of the continuous spectrum, 5300Å. The observations during this period showed that the radiation from the luminous night cloud consisted primarily of the green auroral line. The luminous clouds were at large zenith distance both to the north and south of Cactus Peak, a fact which indicated a distribution over extended areas of Southern California. During this period, the magnetic activity for the earth as

a whole was low; the local magnetic activity as recorded by the magnetic observatory at Tucson, Arizona, was also low.

The following is a chronological record of the miscellaneous observations of optical phenomena of the night sky made by the author at the McDonald Observatory, Fort Davis, Texas (unless otherwise indicated). The quotations are from the original observing notes:

October 3, 1937. The observation of an aurora seen on this date at the McDonald Observatory, Fort Davis, Texas, has been published. (1) This aurora was observed during a magnetic disturbance in which the weighted K-index from five stations was 6.

March 19, 1938. "Shortly before moonrise the zodiacal band was visible from the position of the gegenschein to the eastward. The diffuse arc of light from the moon was visible to an altitude of about 10° and extended for a considerable distance along the horizon. The zodiacal band rose from this arc of light. Was this phenomenon the moon zodiacal light?"

At the present time there are no further comments on this phenomenon, and I have not seen any observations or discussions indicating that the moon could produce a zodiacal light.

August 21/22, 1938. "Two luminous bands, first noticed at 2:15 a.m. C. S. T., were seen in the eastern sky. Directly toward the east the bands were about 2° wide and at altitudes of 10° and 20° . They made an angle with the horizon and appear to converge on the horizon in the azimuth of the Puertacitas Mountains (southeast) or slightly to the left. The upper band could be traced to Auriga in the northeast. The intensities at the middles of the bands were about half that of the Milky Way in Auriga. At 2:55 a.m. the bands were in practically the same position but had undergone some changes in intensity. The upper band became invisible in azimuths north of east. At 3:15 a.m. the bands were very weak and hardly visible; after moonrise, 3:18 a.m., they were completely gone. The sky was quite transparent and the stars twinkled rather badly. Wind was moderate and from the south all night. The bands were quite similar in appearance to the ones called auroral streamers on October 3, 1937. There was no evidence of a polar aurora."

During the period of observation the magnetic activity was very low, K_w being slightly greater than zero. The above comment on the bands being similar to the auroral rays observed on October 3, 1937, relates to appearance and not to geometry of the rays. The observed geometry of the rays would not be expected if the rays were parts of an auroral display.

November 18/19, 1938. "Southern horizon seemed abnormally bright with suggestion of an arc at an altitude of 8° to 10° . The area is too far south to observe with the nebular spectrograph. Gegenschein was conspicuous near the Pleiades and also quite large. The zodiacal light from 5:00-6:00 a.m. was very bright."

January 18/19, 1939. These observations cover the period from 7:30 p.m. to 9:00 p.m. C.S.T. "First noticed what seemed to be long narrow clouds in the south, but on closer examination, stars could be seen in the dark areas. These dark areas were about the same as the sky 10° higher, and were really caused by the luminous sky below and luminous bands. Luminous bands and arcs seem to vary in position and intensity. The phenomenon is very much like an auroral arc. The arc intersects the horizon near the southeast point and the other end merges with the zodiacal light. The arc prolonged would meet the horizon at the west point. The altitude of the center of the arc is about 15° . Otto Struve was observing and these notes are observations of both of us."

"At 11:00 p.m: The illumination has shown marked details, with variations in intensities and positions. Main portion of the illumination is white or slightly greenish, and the brightness is several times that of the Milky Way in Monocerotis. In general the illumination seems to be moving toward the west. About 10:30 p.m. it was composed of several bands. Best description is that it appears like an arc of polar aurora."

"Midnight: The illumination has moved westward and lower. The upper edge is quite sharp. It seems to have moved with the Milky Way, and thus, as Struve points out, indicates a cosmic origin of the exciting source."

"At 3:00 a.m: Struve reported the illumination gone."

The world-wide magnetic three-hour-range index, K_w , was 1 and $1x^{\circ}$, consequently, the phenomenon could hardly be interpreted as polar aurora. Furthermore, it was south of Fort Davis, Texas, and if we could assume that the height of the illumination is that of auroral displays, the phenomenon would have been incident over Sierra Mojada, Coahuila, Mexico.

January 21/22, 1939. "Observations by Struve and Elvey about midnight. Sky overcast but not uniform, causing streaks across the sky. Thinner portions let the brighter stars shine through. The thin clouds were distinctly luminous in contrast to the thicker ones. The thick clouds were merely opaque while the thin ones were absorbing 2 to 4 magnitudes. The luminosity of the thin

clouds is no doubt due to scattering of light from the night sky-- stars, zodiacal light, permanent aurora (now called airglow), etc."

This observation and the next one are included to point out the discrimination that an observer must exercise.

January 22/23, 1939. "Sky cleared sufficiently to begin work about 1:00 a.m. Clouds were forming and evaporating in a line from near Orion and Canis Major to the northeast. Thin portions of the clouds in the vicinity of the bright stars of Orion and Canis Major and the Milky Way were luminous compared to the clear sky while those clouds to the east and northeast, 50° to 90° from Orion, were indistinguishable from the clear sky except for the fact that they dimmed the stars. The denser clouds were dark compared to the clear sky. We are confident that which we observed on January 18/19 was not such a phenomenon." At the time these observations were made we noted that it seems probable that some of the observations of E.E. Barnard and others of "Self-luminous Night Haze" might be thin clouds which scattered the light from the bright stars, etc.

February 11/12, 1939. "About 2030 hours C. S. T. the eastern sky was noticed to be quite luminous near the horizon. The luminous area began in the southeast and extended to the northeast. The altitude directly east was 10°. Visual comparisons were made between this area and the sky to the southwest. As soon as the exposure being made with the nebular spectrograph was completed, one was started on the luminous area even though it had decreased somewhat in brightness."

A copy of the spectrogram of the luminous area noted above has been published. (2) The sodium line, 5893A, was enhanced showing that the visual portion of the lumination was due to sodium atoms radiating the D-lines. None of the other lines in the spectrum of the night sky showed any increase in intensity. The magnetic activity on this night was at a low value occurring during a 48-hour lull. The value of K_W was 0.

April 17/18, 1939. The following observation was made by Walter Linke at the McDonald Observatory. "At 4:56 a.m., six minutes before astronomical dawn, on April 18, 1939, the eastern sky seemed luminous up to an altitude of 20°; the lower edge was cut off by a low bank of thin clouds, giving the luminosity the appearance of a faint band some 15° in height, stretching from northeast, where it was brightest, across the East point and fading into darkness about 30° south of the East point. The general appearance was that

of the first traces of dawn, but its brightness did not increase during the 6 minutes before dawn; the sky also seemed luminous to the southwest and had the same appearance as the sky to the east."

The above event took place at a time when there was only moderate magnetic activity; the world-wide three-hour-range, K_W was 3^x. Approximately 24 hours previous to the observation there had been a magnetic disturbance.

October 15/16, 1939. "At 2300 hours C.S.T: bright band from the northeast to southeast horizons, reaching an altitude of 10° directly east. Width of the band was 3° to 5° and it was brightest from northeast to east. Probably auroral."

"At 0020 hours: bright band not visible but sky to north and northeast is bright near the horizon."

The value of K_W was 3 at the time of the observation.

October 16/17, 1939. "At 2200 hours C.S.T: Auroral arc slightly east of N. Altitude 15°."

The value of K_W was 4^x at the time of this observation, and thus, indicated only moderate magnetic activity.

March 16/17, 1940. "At 5:15 a.m: Luminous area in the eastern sky centered 10° south of east, - about 45° long. The top edge is quite sharp and the altitude 10°. Color is white. Intensity greater than the Cygnus Cloud but fainter than the Sagittarius Cloud. This illumination is not zodiacal light - furthermore, the area is parallel with the horizon. Not sufficient time to prepare sky spectrograph to get spectrum."

The magnetic activity at this time was very quiet, K_W being 0. The K-indices at Sitka and Tucson for the period of observation was 1.

May 7/8, 1940. "A luminous area was visible to the north about 11:45 p.m. W. Linke was asked to obtain a spectrogram and to describe the luminous area, which is as follows:

"At 00:00 to 3:00 a.m: sky to north was bright down to horizon from an altitude of approximately 12°; and above at altitude of 15° was a bright streak. The luminosity was lost in the Milky Way to the east and became more diffused towards the west, fading out at about azimuth 100°."

The magnetic activity during the observation was low, the K index being 0 and 1, respectively at Sitka and Tucson.

July 3/4, 1940. "At 11:30 p.m: Auroral arc extended from west point to the east point. The maximum altitude from north horizon was 20°."

At this time the magnetic activity was moderately active with K-index being 3 and 2 respectively at Sitka and Tucson. If this were a normal auroral arc with height 100 km the arc would have been incident over Roswell, New Mexico.

May 7/8, 1941. "Just after the moon set, about 4:20 a.m. C.S.T., the earth's shadow (from the moon) was distinctly visible in the east. It disappeared as the sky darkened. Some 25 minutes later the dawn appeared. The sky was quite transparent."

From the McDonald Observatory, near Fort Davis, Texas, the earth's shadow at sunset was frequently observed and it was very vivid; but this is the only time I have observed the earth's shadow at moonset.

May 12/13, 1948, near Cactus Peak, Calif. "At 2:30 a.m. a luminous area near the horizon in the northeast was seen and measured with a visual reading photoelectric photometer using a Cs0 photocell. Measurements were made at zenith distance 80° from azimuth 315° through the peak intensity at azimuth 30° to 90° . The peak intensity was 35 (arbitrary units) as compared to 30 for the background sky at the same zenith distance but other azimuths."

During the above interval there was only moderate magnetic activity, K_p being 3, and the K-index being 4 each at Sitka and Tucson.

June 8/9, 1948 near Cactus Peak, Calif. "At 2220 hours PDT. Luminous clouds, one about the size of the bowl of the large dipper (UMa) and two smaller ones were observed between Ursa Major and Polaris. Brightness was about that of the Milky Way. The luminous areas had disappeared by 2230 hours. The horizon to the north and northwest was bright."

The magnetic activity was small at the time, K_p during that three-hour period was 2 plus. The K-indices at Sitka and Tucson were 3 and 4 respectively.

October 31/November 1, 1951, Cactus Peak, Calif. An all night exposure with the C-1 Huet spectrograph revealed that the sodium line, 5893A, was much stronger than normal. An estimate of the intensity as seen on the spectrogram showed the sodium line to be equal to that of the green auroral line. When the relative sensitivity of the photographic emulsion, Eastman spectroscopic 103a-F, is taken into account, the sodium line is actually more intense than the green auroral line. At the request of the author, Dorothy D. Locanthi determined the average intensities at the zenith for the two radiations from the records of the photoelectric photometer operating at the same location. The intensities in units of 10th magnitude type G_0 stars are 878 and 470, for the sodium line and

the green auroral line respectively. An examination of the photometric records showed that the maximum intensity of the sodium line was attained in the north at 3:30 a. m.

No attempt will be made either to review observations made by others or to discuss generally the several optical phenomena which are observed in the night sky. As mentioned in the first paragraph, my primary concern is to interest others in reporting their past observations and to encourage as many as possible in the latitudes away from the auroral zone to take note of the sky and to report the sporadic optical phenomena. If the observations are to be valuable, they must be made in areas free from city and other terrestrial lights. Also, the observers eyes must be dark-adapted. A good test is whether one can see the Milky Way and faint stars with ease.

The primary center for collecting aurora observations within the continental United States will be at Cornell University, address: c/o Dr. C. W. Gartlein, Cornell University, Ithaca, N. Y. The center for the Alaskan area will be: Geophysical Institute, P. O. Box 938, College, Alaska. Those who do not wish to publish their observations are urged to send them to either of the two centers.

REFERENCES

1. Pop. Astr.; 45, 517, 1937.
2. Ap. J.; 93, 347, 1941.