

ZODIACAL LIGHT AND COUNTER-
GLOW AND THE PHOTOGRAPHY
OF LARGE AREAS AND FAINT
CONTRASTS.

BY

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ZODIACAL LIGHT AND COUNTERGLOW AND THE PHOTOGRAPHY OF LARGE AREAS AND FAINT CONTRASTS.

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Description of Objects.—The zodiacal light is a large, faint light of conical form, seen extending upward from the western horizon in February, March and April, after night has become entirely dark. The wide base of the cone rests upon the horizon. The axis of the cone slants to the left, following the line of the ecliptic as we see it in the northern hemisphere. The maximum illumination in this light is of the order of one-ten millionth candle power per square degree as measured on the photographs here exhibited. The light cannot be seen if its slant is too close to the horizon, nor is it visible if the air illumination is too bright. Absence of city lights is the first requisite. It shows better in tropical climates, and may there be noticed even when the moon has nearly reached the first quarter. Ordinarily one looks for it on the darkest and clearest of nights.

In arid climates it is very favourably seen together with a faint continuation of it passing completely around the sky along the zodiac. The latter is called the zodiacal band. At the point exactly opposite the sun, this band shows a slightly illuminated area called the counter glow. This is from five to twenty degrees in diameter, and may be easily seen when it is far from the Milky Way and high up in the sky. The illumination of the counter glow is far less than that of the Milky Way, at least as little as one-tenth.

First Problem: How to get a Photographic Impression of Large, Faint Areas with very Slight Contrasts.—The first results were reached by using a very wide aperture in proportion to the focal length, such as a ratio of one to two, and by making the negative sufficiently small, thus increasing the contrast. The present camera, as made up by the writer, has a lens of one inch aperture and two inches focus, achromatic, strongly convex outside and plane toward the plate. The exposure has been from eight to twenty minutes, and equally good results have been obtained from ortho-

chromatic and from slower plates, such as Seed 26. The development universally has been hydrokinone, with bromide, a cool developer, and a time never under fifteen, or at least twelve minutes.



FIG. 1.—ZODIACAL LIGHT IN PISCES AND ARIES, FEB. 12, 1915.



FIG. 2.—ZODIACAL LIGHT IN ARIES, TAURUS AND GEMINI, MARCH 17, 1915.



FIG. 3.—ZODIACAL LIGHT IN ARIES, TAURUS AND GEMINI, APRIL 8, 1915.



FIG. 4.—ZODIACAL LIGHT IN TAURUS AND GEMINI, MAY 4, 1915.

The first success obtained along these lines was in 1901, of which some description was given in *Popular Astronomy*, 1901; in *Publication of Astronomical Society of the Pacific*, 13, 47, 1901; and in *A.B.C. of Astronomy*, by Mrs. H. Periam Hawkins, as a

frontispiece, and in *Knowledge*, June, 1914. All the photographs here shown were made during the present year, and none have been previously published.



FIG. 5. — COUNTERGLOW ON BETA VIRGINIS, MARCH 17, 1915.

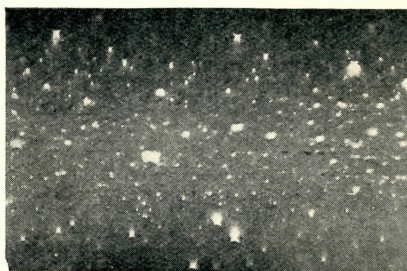
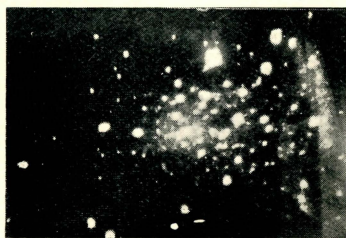
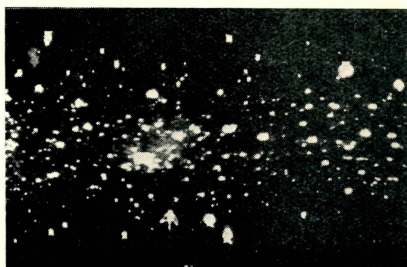


FIG. 6. — COUNTERGLOW BETWEEN SPICA AND THETA VIRGINIS, APRIL 8, 1915.



Second Problem: Correcting Defects of Illumination.—In the foregoing photographs the impression was made directly on a flat plate. Under such circumstances there is concentration of light toward the centre, because any point in the centre of the plate receives light from the entire lens at close range, but marginal points receive light from the lens on a slant, and at greater distance, and the amount of light is much diminished. It is evident that the concentration of light at the centre interferes with the accuracy of results, because it enhances any object on that part of the plate, and gives false contrasts between the part of the photograph in the centre and the part on the edge. Therefore, this defect is liable to interfere with true photographs of the zodiacal light or counter-glow. Two processes have been used to correct this. The first correction is made by building a panoram camera in which a film is curved around a semicircle and a focal diaphragm passes across the front of the film by clock-work, rotating the lens with it. Cameras of that type have long been in use, but a special one was made by the exhibitor, with lens rotating two degrees per minute. The width of the focal diaphragm is seventeen millimetres, giving an approximate twelve minute exposure. By this device the illumination in the direction of the length of the film becomes constant. The illumination across the film is subject to the diminution as before. [This half correction was used in producing the pictures here exhibited, except the first, in which a flat plate was used without correction.] Correction across the film was successfully made too late in the season to obtain photographs of the zodiacal light by its means. It consists simply in changing the outlines of the focal diaphragm into a parabolic curve, so that the edges shall obtain a longer time exposure than the centre. In this way nearly full compensation may be made for erroneous distribution of light, and the views obtained are almost entirely free from such errors.

Third Problem: Intensification of Slight Contrasts.—The third complete step in the photography of large, faint objects like zodiacal light and counter-glow, consists in intensification properly applied, by which immense gain is made in contrasts.

The photography of faint, small objects, with large contrasts like stars, is accomplished by giving very long exposures. The photography of faint, large objects with small contrasts is accomplished by many exposures at the same time. Upon each individual negative the effect is invisible or very uncertain, but by combining the negatives one on top of the other so that light passes through the entire series, the small effects of each accumulate until the object is easily seen. This method of photographing faint contrasts is the equivalent of averaging a number of independent observations of any quantity, and should be credited with the same kind of value. It is believed by the author that this method opens up new lines of investigation, and may be applied to photometric work with very accurate results, and without the extreme delicacy of manipulation required by such apparatus as the photo-electric cell.

The panoram camera made by the author had three exactly similar lenses rotated by the same clock, so that three films were in every case obtained. If necessary, two, three, or four sets of three each were taken one right after the other. When the object was photographed nearer the horizon, or near the Milky Way, it was found necessary to increase the number of original negatives. In one case, at least, as many as twelve were used. For printing purposes these were carefully glued together.

A similar method of intensification was applied also in the reproduction of the counterglow photographs. From the six or twelve original negatives placed together, three to six glass positives were made. These were in turn glued together and parallel light passed through them, producing a final negative. In this way the photographs of the counterglow have been reproduced with contrast entirely sufficient and even overdone. In each picture of the counterglow here exhibited a print is shown from the six or more original negatives, and then from the intensified negative of the same. In that way one can judge of the process of intensification.

Defects.—In Fig. 1 exhibited the panoram camera was mounted on a telescope which ran by clock-work, and the star images are good considering the immensely wide angle used in the lens. It was found, however, that the air was too greatly illuminated by the city lights at that point, and the camera was taken out beyond the edge of the town and mounted on a telescope which was moved by hand; hence, in nearly all these photographs the star images are very large and without proper shape. This is a matter which will be easily corrected by using a proper mounting.

The panoram effect gives a remarkable area of sky covered at one time. Several photographs covered one hundred degrees in length and twenty-five degrees in width very satisfactorily. The poorer margins bring the total width up to nearly fifty degrees, the scale used throughout is 1.2 degrees per millimetre.

In the sequence of zodiacal light pictures, the straightness of light up from the horizon may be seen in the early views of February and March, and in its more inclined position in the pictures of April and May.