

SUGGESTIONS FOR NEW PHOTOELECTRIC OBSERVATIONS OF THE ZODIACAL LIGHT AND THE COUNTERGLOW

by

P. SWINGS

Institut d'Astrophysique, Liège

All the investigations of the upper atmosphere assume tacitly that the earth's atmosphere has an approximately spherical symmetry. Yet many people have, at one time or another, thought that molecules in the highest atmospheric layers of the earth may be subject to radiation pressure or to some kind of electromagnetic force, and may form some sort of a « tail ». This would appear, for example, to be true for the N_2^+ ions : we know from the spectra of comet tails that the N_2^+ molecule has a high f -value and a long life in the radiation field of the sun. The N_2^+ molecule which is present in the earth's atmosphere should thus be sensitive to radiation pressure, or to whatever other physical mechanism such as prevails in comets.

To be sure, the situation in the earth's atmosphere differs from that in comets. A cometary molecule will be shot out into the tail if the radiation pressure (or any other repulsive force) is superior to the solar attraction. In the case of the earth, the forces acting upon the mole-

cule are a repulsive one centered at the sun and a gravitational pull due mainly to the earth. The forces of repulsion and attraction are not directed along the same straight line as they are in the case of comets. Numerically, the selective radiation pressure near the earth is smaller than gravity: this appears clearly from all the investigations, including the recent work by N. B. Divari⁽¹⁾. However it is well known that radiation pressure alone does not suffice to interpret all comet tail phenomena, and that Biermann has recently discussed possible electromagnetic mechanisms in comet tails. Pending a theoretical discussion of the trajectories of molecules high up in the atmosphere which would include the directional effects of radiation pressure and gravity, and electromagnetic phenomena, more or less similar to those in comets, it does not seem unreasonable to think of an asymmetric structure of the earth's atmosphere, similar, although on a much smaller scale, to comet tails.

On this basis, the recent investigations of the zodiacal light and the counter glow, by various Russian astronomers, under the leadership of V.G. Fessenkov, present a definite interest. I shall of course give here neither a history of the early observations nor a critical survey of the tentative explanations of the zodiacal light and counter glow. Both the zodiacal light and the counter glow have usually been considered as cosmic phenomena, which have nothing to do with our atmosphere. As stated by O. Struve⁽²⁾ who recently described new observations of the counter glow: « It has been thought for a

⁽¹⁾ *Russian A.J.*, 27, 351, 1950.

⁽²⁾ *Sky and Telescope*, 10, 216, 1951.

long time that the counter glow consists of small meteoric particles which, according to H. Gyldeń and F. R. Moulton, have a tendency to linger at points in their orbits that lie along the line joining the sun and earth. These particles remain for some time in the vicinity of opposition, and then gradually disappear within the diffuse interplanetary medium that constitutes the zodiacal light.». However this meteoric hypothesis for the counter glow has been challenged by N. D. Misseyev⁽¹⁾ who believes that it is untenable. In order that a cloud of meteoric matter remain in space in a direction opposite to the sun, strict geometrical and dynamical conditions must be fulfilled. It should be noted that, in the meteoric theory, the counter glow should have a purely solar spectrum.

The Russian investigators, especially V. G. Fessenkov⁽²⁾, M. G. Karimov⁽³⁾, D. A. Rozhkovski⁽⁴⁾ and N. B. Divari⁽⁵⁾ conclude from their recent visual and photographic observations that there is a terrestrial component of the zodiacal light, and that the counter glow is of terrestrial origin. The basic part of the zodiacal light would be due to scattering of light by solid matter in the interplanetary space; but there is also a part due to the terrestrial atmosphere. According to the Russian observers:

« The outer, most extended layers of the terrestrial atmosphere are not symmetrical with respect to the earth's surface, are not spherical in shape, are markedly

⁽¹⁾ *Russian A. J.*, 15, n° 15, 1938.

⁽²⁾ V.G. Fessenkov, *Russian A. J.*, 26, 344, 1949; 27, 89, 1950.

⁽³⁾ M.G. Karimov, *ibid.*, 27, 97, 1950.

⁽⁴⁾ D.A. Rozhkovski, *ibid.*, 27, 34, 1950.

⁽⁵⁾ N.B. Divari, *ibid.*, 26, 355, 1949.

deformed and stretch far from the earth in the plane of the ecliptic.

» In the direction of the sun, the outer layers of the terrestrial atmosphere form a kind of coma which may be represented by the surface of an ellipsoid of revolution, flattened in the direction of the pole of the ecliptic, or conceivably by an elliptic paraboloid stretched out for one or two thousand kilometers. In the direction opposite the sun, these outer layers become a long gaseous tail situated entirely in the plane of the ecliptic and widening in the shape of a cone with an angle between the generatrices of about 8-10°. The density of matter decreases rather slowly in this cone, being about halved for each 4.7 radii of the terrestrial globe ».

« The gaseous tail of the earth is somewhat bent with respect to its radius vector in a manner similar to that observed in the tails of comets of the first type. »

Such conclusions would be of great importance in aerophysics if they were substantiated, since they would require a revision of certain of our ideas on the geometrical, physical and chemical structures of the atmosphere.

The Russian investigations are based on numerous observations which seem to have been carefully reduced and discussed, although certain corrections appear to have been made erroneously. For example, the correction for the night sky emission component at various zenith distances is always based on an assumed height of 250 Km for the emitting layers (all radiations!). This is not by any means certain. How this error affects the Russian results has not been ascertained. The Russian observations are often made in integrated light; through numerical calculations these are reduced to monochromatic

radiation. However, such reductions are sometimes uncertain or even unreliable. It would be much safer to carry out the photometry in specific regions.

Considering the success of the recent observations of the night airglow with photoelectric photometers I would like to suggest that an attack on the problem of the zodiacal light and counter glow be planned with photoelectric photometers. For such work the solid angle covered in the photometer should be made as small as possible. In his observations Divari used an angle of 4°: this should be a maximum. All measures at low galactic latitudes should be excluded; the twilight should be avoided carefully.

Here are topics which should, I believe, be considered :

(a) The isophotes of the counter glow should be obtained in the emission lines of [O I] and Na, as well as in the continuum (1). Do the emission lines of the night airglow really strengthen in the counter glow, by an amount of 10 to 15 % (while the continuum is not appreciably enhanced), as Karimov states? A line emission of the counter glow, similar to the night airglow, would indeed be hard to understand in the case of a very tenuous tail of the earth. How does the brightness vary along the two axes of the oval? The Russian observers state that, in the position West of the meridian, a gradual widening of the isophotes toward the west takes place, while the eastern part remains sharply outlined: photoelectric isophotes would reveal whether the eastern and western

(1) Of course these isophotes should be corrected carefully for the superimposed luminosity of atmospheric and galactic origin, including the effect of tropospheric scattering of the integral brightness of the stars.

parts of the counter glow oval are equally sharply outlined or not.

(b) The variation of the isophotes in the course of the night and of the year is important. Do the isophotes vary symmetrically or not, with respect to midnight; do they exhibit rapid changes or not; how do they compare on different nights? Is there some correspondence with the luminosity of the night sky? Is the counter glow definitely brighter in the spring than in the fall?

(c) Photoelectric observations should be used to study the widening of the zodiacal strip and of the counter glow in the west? Fessenkov has described in detail the « false zodiacal light » (1).

(d) Is the photometric center of the counter glow really shifted by about 3 to 5°, to the west of the antisuon? Is the shift the same for different radiations? This is directly related to the tilt of the gaseous tail of the earth. Is the axis of the counter glow oval exactly along the ecliptic, or tilted as some of the Russian observers (but not all) state?

(e) It is important to devote new photoelectric observations to the question of a possible parallactic motion of

(1) This is a weakly luminous cone in the western part of the sky, which is similar in outline to the ordinary bright zodiacal light (which is visible at the same time, in the east, forming the same angle with the horizon). The faint cone is visible only for a short time (about 1 hr.), some 2-2½ hrs before sunrise. When the ordinary zodiacal light is already considerably above the horizon, and the counter glow is noticeably sinking toward the west and is about 40°-45° in altitude, the zodiacal strip widens conspicuously, forming a faintly luminous cone. At the vertex of this cone is visible the oval counter glow spot. The false zodiacal light seems to be connected with the western part of the sky only. This modification of the counter glow always occurs when the counter glow reaches a certain position.

the counter glow. Rojkovsky finds from photographs a periodic daily motion of the center of the counter glow leading to a diurnal parallax of 3.5 degrees. This would correspond to a distance of about half that of the moon. All previous observers who had attempted to find a diurnal parallax of the counter glow had reached negative results.

(f) The isophotes of the zodiacal light in different atomic lines and in the continuum should be compared, for detection of possible differences in the intensity decreases north and south of the ecliptic.

The intensifications of the green and red lines of [O II] in the zodiacal strip reported by the Russian observers should be compared. Does the D-line really behave in an erratic way?

On the basis of such material, the whole problem of the zodiacal light and of the counter glow could be re-discussed thoroughly. The results of the Russian observers are indeed striking, and deserve to be examined critically, on account of their importance in aerophysiscs as well as in astrophysics. Photoelectric observers, like Roach and Barbier, have already a wealth of material which, while not planned for zodiacal light studies, may be used fruitfully in this field. The solid angle in their photometers may, however, be a little too large. From preliminary examination of his material Roach does not seem to favor a terrestrial origin of the counter glow (1).

(1) Private communication.

The excellent pioneering work of Elvey (¹), followed by the extensive observations of Elvey and Roach, seem to point in the same direction. I think that a concerted attack on this problem should be planned.

(¹) In 1932, Elvey, on the basis of his photoelectric observations, had already mentioned that the counter glow changed in form and position.