Technical Papers

On Projection as a Possible Source of Apparent Color in Sunspots

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That sunspots occasionally show definite colors is a fact attested by numerous observers dating back at least to Messier (*4*), who in 1759 reported a deep brown color in the notable sunspot of that year. Many competent observers, however, have not conceded the objectivity of the observed colors and have ascribed them to illusions or to the secondary spectrum of objectives (*5*). The difficulty has been to account for them within the framework of accepted physical theories of the sun's constitution.

However the reconciliation is to be accomplished, such colors may be seen with reflectors as easily as with refractors, which fact greatly weakens the argument that they arise through the effects of the secondary spectrum. Moreover, two facts seem to suggest most strongly that some, if not all, of the observed colors are truly objective: 1) they are seen chiefly during maximum sunspot periods and are generally confined to the largest and most active class of spots; and 2) they are comparatively rare. Thus, of 6,169 individual sunspots observed by the writer at Baltimore in 1948, only 22 were found to be colored. It is not easy to see why, if the colors are illusionary, they should not be seen much more frequently.

Hitherto, the writer has been inclined to regard sunspot colors as being due to radiation from the spot in selective wavelengths (*1*); but while this may account for umbral colors, it is not easy to assign such a cause when the color is in the penumbra.

D. H. Menzel, in a letter to the writer referred to by Bartlett (*2*), suggests that color may also be due to the projection of chromospheric eruptions. A recent observation by the writer tends to confirm this view very strongly.

August 21, 1949, at 17h 24m, the writer observed a very large, irregular sunspot of F-1 type (Waldemeier classification) close to the equator in the northern hemisphere and almost on the solar meridian. The time given here is the mean time of observation, i.e., the mean of the sum resulting from the addition of the time when the observation began to the time when it ended. Actual times are given as follows:

At 17h 10m the penumbra was found to be normally grayish with little contrast. The umbra was certainly black. At 17h 29m the penumbra was observed to be red-violet and the umbra appeared brown. At 17h 32m the penumbra suddenly became a bright red-violet, showing marked contrast with the photosphere. At 17h 36m the penumbra was again grayish with little contrast and the umbra again looked black. Between 17h 32m and 17h 36m color in the penumbra was observed to fade and brighten alternately several times.

Although the writer had never seen this particular phenomenon before, it had been previously reported to him by at least two other observers on the writer's granulation program; and Walter L. Moore, observing with the 12.5-in. Clark reflector of the University of Louisville, had also reported colored areas in penumbrae, though the color had not been observed to fluctuate.

While observing this phenomenon, it occurred to the writer that the appearances corresponded very well to what might be expected from the passage over the spot of a chromospheric area of varying density—hence the fluctuations—in brightness inferior to the photosphere but superior to the penumbra and umbra. Thus, Menzel's suggestion of color by chromospheric projection appears to receive observational support.

In this connection an observation recently made at Climax may perhaps be confirmatory. In October 1948, the writer observed rapid changes of color (not merely fadings and darkenings) and other phenomena in a large sunspot. A telegram was sent to Walter Orr Roberts in charge of the High Altitude Observatory of Harvard at Climax, urging spectroscopic examination of this spot. In a letter to the writer (*3*), Roberts reported marked phenomena "directly over the region of the sunspot" and presumably within the chromosphere. There was also observed a brilliant emission in the yellow at the coronal line 5694 A. Since this activity took place above the spot, and therefore had a relatively dark background for projection, it seems quite possible that color effects might have been noticed which seemed to be in the spot itself.

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The Frequency of Beat of Sperm Tails

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Since Bidder (*1*) in 1895 estimated the vibrational frequency of choanocyte flagella, several methods of measuring the rate of ciliary beats have been devised, and a number of readings have been made on vibratile parts of protozoa, molluscs, vertebrates, and arthropods. Bidder's first approximation placed the rate at about 10 beats per sec, but he later (*2*) recorded 5 beats per sec in *Grantia*, giving at the same time the opinion that a healthy frequency ought to be closer to 20 beats per sec. Gray (*3*) measured beats of cilia and flagella, ranging

from 5 per min for *Noctiluca* to 1200 for a sponge choanocyte, though the lower frequency has been questioned by Lowndes (*10*). Gray (*4, 5*), using a mechanical stroboscope combined with a motion picture camera, later established a rate of 5–16 vibrations per sec in cilia from the gills of the mussel. An electric spark of a duration less than 0.0001 sec was used with a shutterless camera by Jennison and Bunker (*7*) to record movement of the cilia of clam gills. Hammond (*6*) measured the beat of cilia of several protozoa by means of a shuttered stroboscope and found, at 20°–24° C, a range from 6 or 8 per sec for *Vorticella* up to 42 per sec for *Stentor*. Lucas and Douglas (*11*) by direct observation with continuous light counted 2.2–5.2 beats per sec in cilia of a turtle's trachea. Lowndes (*8–10*) photographed moving flagella with a high speed motion picture camera which exposed 60 frames a sec with an exposure of 1/8000 sec, and recorded frequencies of about 7–12 beats per sec in several flagellates. Pease and Kitching (*12*), in a study of the effects of hydrostatic pressure on ciliary speed, used a variable speed, slotted, rotating disk similar to that used by most previous investigators. They reported that the cilia of mussel gills generally beat between 600 and 700 times per min. Except for Lowndes (*8*), who studied the sperms of an ostracod, apparently no investigator has measured the rate of flagellar vibration of sperms.

In the present study, human sperms were mounted in spermatic fluid at a temperature of 32° C and observed in dark field, illuminated by stroboscopic light.[1] The instrument used furnishes an intense light of very short duration, and can be simply and instantly regulated to produce flashes from 600 to 14,500 times per min. If the frequency of the flashes is the same as the frequency of the beat of the tail, one apparently motionless tail is visible. If the frequency of the flashes is twice that of the tail, there are apparently two tails. If the flash frequency is half that of the tail, then again one tail appears, but this rate will not be confused with the rate which obtains when flash and tail frequencies are the same if one bears in mind that, in the latter case, doubling of the flash frequency produces a double tail image.

Unlike most flagellated cells, the sperm cell does not move forward at a steady rate. Further, the tail does not beat with a simple harmonic motion. The sperm progresses in irregular jerks, each burst of speed lasting less than a second. It is during the moment of greater speed that the frequency of the vibrating tail can be determined, while between spurts of speed, the cell moves more slowly and the beat of the tail is so slow that I could not measure it stroboscopically. There is no perfectly rhythmic alternation of the periods of slow and fast beat, nor is there complete uniformity of behavior from cell to cell. Many cells cannot be "stopped" with stroboscopic light because they seem to be altering their speed so often that it is impossible to tune in on any frequency. The lowest flash frequency at which a single image could be observed was 14–16 per sec. With 25–28 flashes per sec, visibility improved because flickering was minimized, but during the moments when the tails were "stopped" they appeared double, due to the fact that the light was flashing twice during each period of vibration. The figures given are the extremes of a number of readings. That the double frequency is not exactly twice the single is probably due partly to inaccuracy of the method and partly to the fact that different cells were used for each reading, since I was not able to follow any single sperm long enough to make two readings on it.

It is interesting to find that the tails of human sperm cells have a frequency of beat which is rather close to that of the cilia or flagella of clam gills or monads; but such a result is to be expected, since, in spite of the fact that these various cells are far separated in organic history, they are still of so much the same order of magnitude that the surprise would have come if they had proved to move at radically different speeds.

[1] General Radio Company, Cambridge, Massachusetts.

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Action of Carboxypeptidase Toward Peptides Containing Unnatural Aromatic Amino Acids[1]

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Since β-2-thienylalanine has been found to inhibit the growth of certain organisms through interference with the metabolism of its analogue, phenylalanine (*2, 3*), it seemed of interest to prepare peptides containing this and other unnatural aromatic amino acids, and to determine whether these peptide analogues would be antagonistic to the action of isolated proteolytic enzyme systems, as well as to the growth of microorganisms.

Carboxypeptidase from beef pancreas was selected as the enzyme to use in this study because it displays maximum activity toward substrates derived from aromatic amino acids, and because it can be isolated readily in pure form. Carbobenzoxyglycylphenylalanine (I) is hydrolyzed by carboxypeptidase more readily than any other synthetic peptide, and its racemate has been suggested as

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