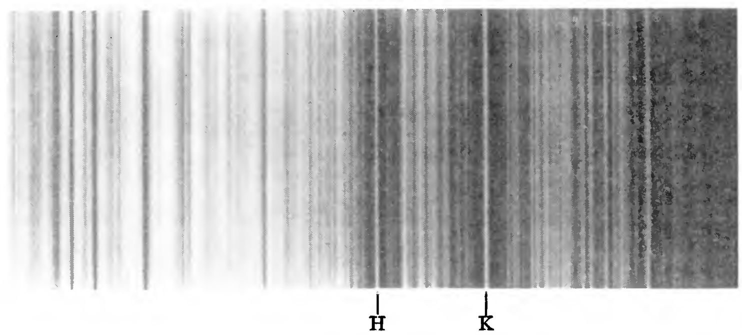
Minor Contributions and Notes

ON THE REVERSAL OF THE CALCIUM LINES H AND K IN STELLAR SPECTRA

During the year 1900 G. Eberhard and H. Ludendorff at the request of H. C. Vogel made photographs of stellar spectra with the small spectrograph D, which were intended particularly for the study of the ultra-violet. In the visible part of the spectrum these plates were very strongly overexposed. Eberhard found on such a plate of *Arcturus* that the K line of calcium shows a sharp reversal, that is, a calcium emission takes place in the middle of the absorption line just as one observes it in a disturbed region of the solar surface. As the absorption in the broad calcium line is very strong and the emission rather weak, the reversal is visible only on a plate in which the continuous spectrum in the neighborhood of the H and K lines is strongly overexposed. Further observations of this same phenomenon have recently been made by Schwarzschild with an objective-prism. On the plates of the *Hyades*, referred to in the preceding paper, taken with the U.V. Zeiss triplet and U.V. objective-prism (150 mm aperture, 1500 mm focus, dispersion 10 mm between H_γ and K) are found strongly exposed spectra of *Aldebaran*, which likewise show reversal of the K line and, although more weakly, a reversal of H. Similar exposures on α *Aurigae* and α *Ursae Majoris* failed to show reversal; neither did exposures on α *Orionis* and α *Cassiopeiae* show it. In the case of the last two it is perhaps true that the exposure was not sufficiently strong. An exposure of one hour on β *Geminorum* with the objective-prism showed no reversal, but on the same plate a neighboring star, σ *Geminorum*, shows extraordinarily bright, sharp emission lines in the middle of the absorption lines.

Although a mere examination of the spectra makes it very probable that one is dealing with a real emission phenomenon and not merely with a vacant space in the continuous spectrum, it seems advisable to investigate the relation of this line to calcium by a determination of its wave-length. In the following the results of such measures are given as differences in radial velocity. The reversals were compared with 7 to 10 of the neighboring star lines due to *Fe* and *Al*.



Spectrum of *σ Geminorum* taken with the Zeiss triplet and U.V. objective-prism, 1913, March 9. Enlarged and broadened about 12 times.

α Boötis

Great Refractor. Spectrograph III with short camera. Slit-width 0.10 mm, width of spectrum 0.05 mm. February 23, 1913. Exposure 30^{m}

H −3 km/sec., K +6 km/sec.

α Boötis

Zeiss triplet with objective-prism. Width of spectrum 0.2 mm. April 23, 1912. Two exposures of 14^{m} and 7^{m}. The mean of both taken.

H +5 km/sec., K +5 km/sec.

α Tauri

The same apparatus. January 14, 1912. One exposure of 30^{m}. January 1, 1913. Two exposures of about 30^{m} each. Mean of all three.

H −3 km/sec., K +3 km/sec.

σ Geminorum

The same apparatus. March 9, 1913 and March 12, 1913. Each exposure about 60^{m}. Mean of the two.

H −6 km/sec., K −7 km/sec.

Since in the vicinity of H and K 1 μ equals 1.2 km/sec. with the spectrograph and 2.6 km/sec. with the objective-prism, the above numbers probably only mean that the wave-lengths of the reversals agree within errors of measurement with the wave-lengths of the H and K lines. The brightness of the H and K reversals in the case of σ *Geminorum* is so great that their blackening of the plate equals that of the brightest part of the continuous spectrum between H and K. The width of the emission line amounts to about one Å.U. on the plate taken March 12. On account of the unsteadiness of the air and the pointing error this is not a measure of the width of the line, which presumably is small, but only indicates the strength of the radiation. In the case of *Aldebaran* it is shown, by a comparison of its spectrum with that of other stars in the *Hyades* photographed on the same plate, that the brightness of the reversal with an equal width is relative to the continuous spectrum about three magnitudes weaker than that of σ *Geminorum*. *Arcturus* shows a slightly stronger reversal than *Aldebaran*. K is stronger than H in all the three stars. In a high-dispersion spectrum of the sun a very fine, weak reversal of the K line is seen all over its surface. In a detached region of disturbance the reversal reaches a strength as great as in σ *Geminorum*. In order to get an idea of the average strength of emission of the sun compared with that of the star, the spectrum of diffuse skylight was photographed with the same dispersion on March 14, 1913. The spectrum of diffused skylight of course corresponds to the average spectrum of the sun. This plate showed no sign of reversal of the H and K lines. From this we conclude that the emission is much stronger in these stars than in the sun.

The following general remarks may be added. Reversals of lines in stellar spectra are not rare. The reversals found here are interesting in that they take place in stars whose spectra are similar to that of the sun and therefore more comprehensible to us. The same kind of eruptive activity that appears in sun-spots, flocculi, and prominences, we probably also have to deal with in *Arcturus* and *Aldebaran* and in a very greatly magnified scale in σ *Geminorum*. This agrees with Adams'[1] result for *Arcturus*, viz.,

[1] *Astrophysical Journal*, **24**, 69, 1906.

its absorption lines show the transition from the normal solar spectrum to the spot spectrum.

Two problems arise in this connection. It remains to be shown whether the emission lines of the star have a possible variation in intensity analogous to the sun-spot period. It is known as a result of the investigations of Deslandres[1] and of St. John[2] that the centers of the calcium emission of the sun have a radial outward motion of 1 km per second. A more accurate determination of the wave-lengths of the calcium emission of the stars should prove whether or not a greater total intensity of emission is accompanied by a greater velocity of ascent.

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ON THE RADIAL VELOCITY OF *63 TAURI*

For the determination of radial velocities by means of the objective-prism E. C. Pickering has proposed the method of making two exposures of a star field on the same plate, reversing the prism 180° between the exposures. The distances of corresponding lines in the two spectra of each star then depend upon its radial velocity, and the measurement of these distances makes it possible to obtain the radial velocity after the lines have been identified, and the necessary reduction constants have been applied.

Instead of determining the radial velocity itself, the problem may be limited to finding variation in radial velocity by means of a comparison of two plates with such double exposures. Let the linear distance for a star on the first plate equal s, on a second equal s', then the difference $s'-s$ at once measures the change in radial velocity of the star if the observing conditions were absolutely identical. The inevitable changes in these conditions have the result that to the effect of the radial velocity is added that of a linear function of the rectangular co-ordinates x, y of the star. For the measured distances $s'-s$ we have equations of the form $s'-s=\alpha+\beta x+\gamma y+\Delta(s'-s)$, in which α, β, γ are plate-constants depending upon the observing conditions and in which the only remaining

[1] *Comptes rendus*, 1905, 381. [2] *Astrophysical Journal*, **32**, 36, 1910.