at the bottom of the Rhone valley, and will to-morrow be sweeping over the Rhine, or *vice versa*, according to the direction in which the surface wind blows. Hence Dr. Hann's observations, however valuable otherwise, can have only small bearing on the question of the cause of cyclones and anticyclones.

FRANZ A. VELSCHOW, C.E.

Jones Point, N.Y., June 2.

On the Determination of Parallax by the Spectroscope.

IN the winter of 1883–84 it occurred to the writer that the spectroscope might be made use of in the determination of the parallaxes of certain double stars. As there were no data at hand that would allow a numerical example to be worked out, the method was not published at the time, but was withheld until such data should be available. Recently my attention was drawn to the systematic measures carried on at Greenwich since 1876; and, although these are very unsatisfactory on account of their large probable error, it may be of interest to apply them to an actual parallax determination.

The method about to be proposed is based upon the well known fact that the positions of the lines in a star's spectrum depend not only upon the substances to which these lines are due, but also upon the velocity of the star's motion in the direction of the line of sight. So far as the writer can see, it is applicable only to double stars; and it may be made use of in two different forms, the first of which is applicable when both components of the star are bright enough to be observed spectroscopically, and the second when only one component is bright enough to be so observed.

In the first case, both components being bright, let S be the one to which the orbit is referred, and let C be the companion; ω is the angle that the tangent at C makes with $C\,S$, and θ the angle that it makes with the line of sight. V_0 is the velocity with which S is receding from the earth at a given moment, and V_1 is the velocity with which C is receding at the same moment, both being expressed in miles per second. The orbital velocity of C at this moment we will call v, the unit of length being that length which subtends an angle of one second at the star's distance from the earth. If π is the parallax of the star (supposed unknown), and D is the radius of the earth's orbit, v can be expressed in miles per second by multiplying it by $\frac{D}{\pi}$. Expressing it in this manner, we have

$$(V_0 - V_1) = v \,.\, \frac{D}{\pi} \,.\, \cos\theta \qquad (1)$$

But

$$v = \frac{2\,A}{p\ r\ \sin\omega} \qquad (2)$$

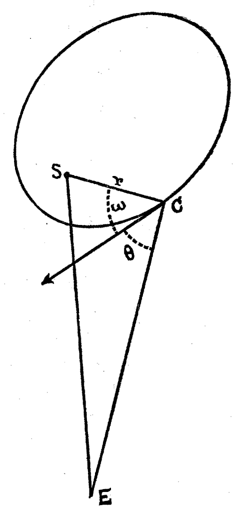
where p is the period of the star in seconds of time, r is the radius vector of the component in seconds of arc, and A is the area of the orbit, the unit of length being the same as in the case of v. Substitution in (1) gives us

$$(V_0 - V_1) = \frac{2\,A\ D\cos\theta}{p\ r\ \sin\omega} \cdot \frac{1}{\pi} \qquad (3)$$

The first member of this equation is to be observed by the spectroscope, and the co-efficient of the second member is to be computed from the elements of the star's orbit. The only quantity remaining is the parallax of the star, which is found by simple division. If it is desired to make a number of observations at different times, and combine the whole by the method of least squares, the normal equation will be, of course, $[a^2]x=[al]$, equation (3) being now of the form $ax=l$.

Undoubtedly the best way to determine the absolute term in equation (3) is to photograph the spectra of both stars on the same plate, and measure the intervals between the corresponding lines in the two. The probable error of a determination so made will be less than if V_0 and V_1 were measured separately and their difference taken. I do not find that this has been done in the case of any star whose orbit is known; but that the lines in the spectrum of a double star can be so photographed and measured, at least in certain cases, is well shown by Professor Pickering's recent work on *Beta Aurigæ* and *Zeta Ursæ Majoris*, which stars were not known to be double until the spectroscope showed them to be so. It is true that the proximity of the components of these stars, and their consequent short periods, make the measurement particularly easy in these cases; yet I trust that it is not unreasonable to hope that measures may be made on other stars sufficiently good to afford us some idea of their parallax.

When one of the components of a double star is so faint that its spectrum cannot be observed, it becomes necessary to modify the foregoing mode of procedure somewhat. Let S be the principal star, as before, and C the companion. Let V be the velocity of recession of the principal star, and V_0 the velocity of recession of the centre of gravity of the system (V_0 being appreciably constant for many centuries). Let a be the semi-axis major of the orbit of the companion, when referred to the principal star, and let a_1 be the semi-axis major of the smaller ellipse described on the heavens by the larger star, in consequence of its having a companion (this



may be determined by comparing the position of the principal star with smaller stars in the vicinity, not physically connected with it). Then we have the equation

$$V = V_0 + \frac{a_1}{a} \,.\, \frac{D}{\pi} \,.\, v \,.\, \cos\theta \qquad (4)$$

(this is obtained by resolving the velocity of the component along the line of sight, multiplying the result by $a_1 \div a$ to find the corresponding differential velocity of the principal star, and adding to the velocity of the centre of gravity of the system). Substituting in (4) the value of v as given in (2), we have

$$V = V_0 + \frac{a_1}{a} \,.\, \frac{2\,A\ D\cos\theta}{p\ r\ \sin\omega} \,.\, \frac{1}{\pi} \qquad (5)$$

This is the form of the observation equation. V is observed, at intervals, by the spectroscope, and corresponding values of the co-efficient of $\frac{1}{\pi}$ are computed. The normal equations are, then,

$$[p\ V] = [p]\ V_0 + [p\ F]\,x\,,$$
$$[p\ F\ V] = [p\ F]\ V_0 + [p\ F^2]\ x,$$

(5) being of the form $V = V_0 + F\,x$.

As already intimated, the writer has applied this method to a particular case, using the spectrum observations made at Greenwich since 1876, together with one measure obtained by Huggins in 1868. Sirius was selected for the purpose for several reasons. Its orbit is fairly well known, the spectrum observations on it cover an interval of twenty years, the period of the star is short, and various determinations of its parallax have already been made by the direct method. The elements of the star, according to Mr. J. E. Gore (*Monthly Notices of the Royal Astronomical Society* for June, 1889), are as follows:—

$T = 1896.47$	$\Omega = 49°\ 59'$ (1880.0)
$P = 58.47$	$i = 55°\ 23'$
$a = 8''.58$	$\gamma = 216°\ 18'$
$e = 0.4055$	$\mu = -6°.157$

It appears also, from Auwers's work, that the semi-axis major of the orbit that the principal star describes about the centre of gravity of the system is $a_1 = 2''.33$. Computing the co-efficients of $\frac{1}{\pi}$ for the thirteen years for which I have spectroscopic results, the following observation equations are obtained:—

No.	Equation.	Date.
(1)	$V_0 - 0.342 \frac{1}{\pi} = +29$	1868.1
(2)	$.447 \quad = +24$	1876.11
(3)	$.453 \quad = +12$	1877.16
(4)	$.456 \quad = +24$	1878.16
(5)	$.455 \quad = +16$	1880.18
(6)	$.450 \quad = +12$	1881.14
(7)	$.440 \quad = +16$	1882.21
(8)	$.426 \quad = -5$	1883.17
(9)	$.408 \quad = -20$	1884.11
(10)	$.384 \quad = -23$	1885.09
(11)	$.354 \quad = -24$	1886.00
(12)	$.311 \quad = +4$	1887.05
(13)	$.271 \quad = +35$	1887.82

Giving the weight unity to each of these, the following normal equations result:—

$$13\ V_0 - 5.2 \frac{1}{\pi} = +100$$

$$-5.2\ V_0 + 2.124 \frac{1}{\pi} = -39.86$$

Hence $\pi = 0''.34$.

The only direct determinations of the parallax of Sirius that I have at hand are those of Henderson and Peters (0''.150), Gyldén (0''.193), and Gill and Elkin (0''.39). The agreement between this last result and the one deduced above by the spectroscopic method is of course purely accidental, the Greenwich measures being too rough to furnish us with a result even passably good. It is to be hoped that measures may be made, with improved apparatus, that will enable us, in the course of time, to apply the spectroscopic method to a large number of double stars. Dr. Vogel's photographic measures, taken at Potsdam, are far superior to any thing else the writer has seen in this line, unless the Harvard College measures are excepted. They have a very small probable error, and the measures on Venus seem to indicate that his work is not materially affected by constant errors. As a matter of fact, constant errors are of no importance in deducing parallax by the spectroscope, since they affect V_0 only, and not π.

It is plain that the method set forth in this article is open to many objections. It is beset with difficulties, but it should not be discarded or lost sight of for that reason. The fact is, that we must either forever give up the effort to determine the distances to the more remote stars, or we must seek them by this method. Very few stars are near enough for us to measure their parallaxes directly; but the spectroscopic method is still applicable when there is no indication of parallax to the micrometer. The velocity of motion in the line of sight may be measured with equal ease, whether the star is near or remote; and the only limit to the power of the method lies in the increasing closeness of the double star as the distance grows greater, and the corresponding difficulty of determining the orbits. By photographing binary systems at intervals of a few years, and measuring distances and position angles on the negative, much better orbits might be computed than we have at present.

While at work on the numerical example in this article, I have endeavored to find out whether others have not worked at this same problem. My attention has been called to several papers that apparently relate to it, though I have been unable to gain access to more than two of them, and then only for a moment, so that I could give them only a hasty examination. The first paper that I find reference to was by C. Dufour, the title being "Utilisation de l'analyse spectrale pour déterminer la distance de certaines étoiles doubles" (Lausanne, Bulletin des séances de la Société vaudoise des sciences naturelles, vol. xiii., 1874, p. 452). The second paper, by Edward C. Pickering, is entitled "Dimensions of the Fixed Stars, with Especial Reference to Binaries and Variables of the Algol Type," and is in the "Proceedings of the American Academy of Arts and Sciences," 1880, vol. xvi. This paper, as its title indicates, relates more particularly to the dimensions of stellar systems than to their parallaxes. The third paper was read before the Royal Irish Academy on May 24, 1886, by Arthur A. Rambaut, the title being "On the Possibility of determining the Distance of a Double Star by Measures of the Relative Velocities of the Components in the Line of Sight." The method here proposed is not applicable unless both components are bright enough to be observed spectroscopically. It appears to be identical with what I have called the "first method." Finally, Herr J. Palisa published an article on the subject while the present one was in preparation, entitled "Ueber die Bestimmung der Parallaxe von Doppelsternen" (*Astr. Nach.*, No. 2,941, Dec. 12, 1889). I have not seen this paper, but I understand that in it he refers to a dissertation by one Hans Homann, the title of which is "Beitrage zur Untersuchung der Sternbewegung," which presumably touches upon the same subject. A. D. RISTEEN.

Hartford, Conn., June 13.

Temperature in Storms.

IN the "Smithsonian Report for 1865," beginning at p. 340, there is a detailed account of a balloon ascension at Paris on July 27, 1850, during a severe storm of rain with some strong wind gusts. The most interesting point is the severity of the cold encountered, the temperature falling to —39° C. at an elevation of seven thousand metres. It is stated that at the beginning of the ascent "a deluge of rain was falling," which shows that it must have been made near the centre of precipitation, if not at the exact storm-centre. It would seem that these observations are confirmatory of those noted by Dr. Hann, to which reference is made by Professor Davis in *Science* for May 30. M. A. VEEDER.

Lyons, N.Y., June 9.

BOOK-REVIEWS.

The Criminal. By HAVELOCK ELLIS. London, Walter Scott; New York, Scribner & Welford. 12°. $1.25.

MR. ELLIS, the editor of this promising series of scientific monographs, has contributed to it in this volume a well-planned and ably executed *résumé* of modern criminology. So little of this science has hitherto been accessible in English, that this compilation is especially timely. It is an outcome of a pedantic and unscientific view of crime, that we are obliged to speak and accustomed to think of all persons liable to punishment as criminals. There are certain very well marked distinctions between classes of criminals, that should be generally recognized. There is the criminal by passion, the insane criminal, the occasional criminal, the instinctive criminal, the habitual criminal, the professional criminal. While the existence of some of these is rather the crime of the society that breeds them, others are distinctly diseased forms of humanity, which we must study in order to understand and to treat. It is the biological, sociological, and psychological study of the criminal classes, so vigorously pursued in Italy and other countries of Europe, that is described in the present volume. On the physical side, the shape of the cranium, the tendency to asymmetry, the peculiarities of face, the details of the ear, nose, and so on, anomalies of the hair and pigmentation, hereditary characteristics, motor inertia and sensory insensibility, fondness for tattooing, and the like,—these characteristics have been made the subjects of special monographs, and in many cases class distinctions between the criminal and his more normal fellow-being have been successfully laid down. While it is not yet possible to describe accurately and briefly the results of these methods of study, and still less so to apply them to individual cases, enough has been done to indicate that all kinds of abnormalities are more common among criminals than among normal people, and to give interesting glimpses into the nature of these differences. These physical differences are connected with and lead up to moral and intellectual differences, and the studies of the two have advanced together. The moral obtuseness, the lack of sympathy, the selfish and thoughtless satisfaction of sudden and strong impulses, the keen cleverness in certain limited directions but general stupidity in every thing else, the emotional