in the far east, where, as near Khiva, a summer of more than tropical heat is succeeded by a winter of Arctic rigour. In a very extreme degree the climate of Astrakhan contrasts with that of Fuegia, and yet the mean temperature of the two is about the same; but in the one the seasons are excessive, in the other the difference is but small. The difference in the products of the two countries is thus very great: on the one hand, plants requiring great heat, but able to withstand the cold, on the other plants of a more tender nature which can flourish with a very moderate amount of warmth; in the one grapes and corn, in the other fuchsias and veronicas.

In studying climate it is therefore necessary to observe not only the greatest heat and the greatest cold, but also the mean temperature. These can only be observed by means of thermometers, for personal feelings may be the effects of many other causes—of wind or evaporation, or state of health, or peculiarity of constitution, and are absolutely no index to the state of the air temperature.

The lecturer then proceeded to speak of the different kinds of thermometers, several of which were exhibited, and of the several stands for sheltering them. The Meteorological Society has decided positively in favour of the Stevenson stand, and directs its observers to record the temperature at 9 A.M. and 9 P.M., as well as the highest and lowest, as registered by the maximum and minimum thermometers. He then described some novel and ingenious contrivances for automatic registering, such as the "turn over" of Messrs. Negretti and Zambra, and the "chronothermometer" of Mr. Stanley, and concluded by pointing out that these instruments were but a means to an end, and that the study of climate was the study of nature in one of her most beautiful and most varied aspects.

Mr. Ley's lecture was on

Clouds and Weather Signs

The lecturer dwelt, in the first place, on the unsatisfactory condition of this portion of meteorology, as contrasted with those branches of the science in which instruments are employed. The great impediment to our progress arises from the fact that cloud-observation is, in large measure, an incommunicable art, requiring a special training of the eye. Specimens of the objects of study cannot be exhibited, neither is it possible, in illustration of the subject, to refer to types of cloud depicted in the well-known paintings of the best artists, because the latter, aiming at the production of atmospheric effects, employ the materials most easy to handle, which are commonly the least typical cloud-forms. The old classification and nomenclature of clouds is highly unsatisfactory, having been framed at a time when the relation of wind and weather to the distribution of barometric pressures was unknown; and with this relation the forms and movements of the clouds are intimately connected.

As regards configuration, clouds seem naturally divisible into two groups, those which arrange themselves in layers, whose vertical diameter is small as compared with its horizontal, and those which assume spherical or hemispherical shapes; and this division is related to certain physical conditions of the atmosphere and of the earth's surface beneath the cloud. It is, however, essential that we should possess some name or system of names to distinguish those clouds which are conveyed by the upper currents, and the term cirrus, with its compounds, must be more closely restricted to this class of clouds than has yet been done. From the use of weather-maps a new science of the winds has originated, on which all attempts at weather forecasting must be based. The movements of the upper clouds afford most valuable information concerning the distribution and movement of the areas of high and low barometric pressure. Rules by which this information may be interpreted, based in great measure on a former investigation by the lecturer,[1] are somewhat complex, and cannot well be given in a brief *résumé* like the present.[2] It may be sufficient to explain that in the front of an advancing barometric depression there usually extends a bank of the halo-producing cirro-stratus, the exterior edge of which is, roughly speaking, a parabola, the focus of which lies in the line about to be traversed by the centre of the depression. On the right-hand of the centre this bank or sheet is abruptly broken and is succeeded in the rear by local shower-clouds. On the left-hand the sky commonly continues overcast, but the cloud-plane gradually descends until little is to be seen but low stratus. A backing of the upper current takes place until after the centre of the depression has passed. In whatever direction a depression is advancing the same characteristic phenomena are observed. Thus changes in the clouds indicate to us probable alterations of wind and weather.

[1] "Relation between the Upper and Under Currents of the Atmosphere around Areas of Barometric Depression." *Quart. Journ.* of Met. Soc. vol. iii. p. 437.

[2] The lectures will shortly be published.

While the nimbus, which exists in the front of a depression, first makes its approach evident by changes in the higher cloud-strata, the process of nubification is the converse of this in those local showers which commonly occur on the right-hand and in the rear of a centre of depression, and therefore when the barometer is rising or just about to rise. These latter are developed in an upward direction through the formation of cumulus. The precipitation which occurs in them—always preceded by a change of appearance in the domes of cloud, which assume a soft and cirriform aspect—is attributed to the neutralisation of electricities as the summit of the cloud passes into a higher region; but there are important differences of appearance between those cumuli which are likely, and those which are unlikely, to undergo this transformation.

A physical explanation is given of the ordinary weather signs derived from the colours of the sky, from "visibility," and from unusual refraction. Attention is invited to some peculiar types of cloud, especially to a very elevated turreted stratus, often erroneously termed cirro-cumulus, occurring with high temperature on the south-western borders of anti-cyclones, a forerunner of thunderstorms. The formation of the low-level stratus and of the fog which usually prevails in our winter anti-cyclones, seems to be due to a downward movement of the air at a time when the earth's surface is colder than the atmosphere at a slight elevation above it.

In the course of this lecture sketches of some of the more definite varieties of cloud, with arrows indicating the direction of the currents, and a diagram showing the movements of the upper currents, and the prevailing cloud-types around areas of depression, were exhibited by the aid of the oxy-hydrogen lime-light.

THE MOTION OF A LUMINOUS SOURCE AS A TEST OF THE UNDULATORY THEORY OF LIGHT

1. ALTHOUGH the undulatory theory of light may now be considered as completely established, still any confirming test of a physical theory is in itself interesting as a fresh illustration of a natural truth. Considering how at one time crucial tests of this theory were sought after, it would appear perhaps rather an anomaly that attention should apparently not have been given to the effect attendant on the motion of a luminous source as a test between the two rival (undulatory and corpuscular) theories, and that more especially as the test would appear to be in principle a simple and decisive one. I should have considerable diffidence in directing attention to this point, but no record apparently exists of experiments proposed or attempted with this view. It might be said that the possible existence of practical difficulties in the way of carrying out the test may account for this; but then practical difficulties are seldom allowed to stand in the way, if a theoretic *principle* be correct; and, unless a thing were seriously proposed and discussed, no attempt would be made to surmount the difficulties that might exist in the way of carrying it out. Sir John Herschel, as far as he touches on this point, would appear to have had the idea that such a test between the two theories could not, *in principle*, be applicable; for he says ("Outlines of Astronomy," p. 214), speaking of the effect attendant on the motion of a luminous body, "The effect in question, which is *independent* of any theoretical views regarding the nature of light, ... &c." It is true he mentions afterwards, in a foot-note, a difference in the effect in the case of the two theories as regards the *velocity* of light, in the case of a luminous source moving directly towards or from the observer; but the following fundamental difference in the case of the two theories appears not to have been taken into account.

2. For the sake of precision we will take a special example. Suppose a luminous source with such an adjustment as to emit a parallel beam of light,[1] and let the luminous source be supposed put in motion in a direction at right angles to the path of the beam. Then on the basis of the corpuscular theory (according to which light consists of projected particles) since the particles or corpuscles, according to the laws of motion, partake necessarily of the motion of the body emitting them; so, therefore, if the corpuscular theory were true, the path of the emitted beam of light would be exactly the same in direction as if the luminous body were at rest. So, therefore, if we imagine a screen of the same breadth as the luminous beam to be placed at a distance, so that this screen is *exactly* illuminated when the luminous source is at rest, then (according to the corpuscular theory) this screen would also be *exactly* illuminated when both it and the luminous source were put in motion with equal velocities (in parallel paths) in the same direction.

3. This, however, will not be the case if the undulatory theory be true, for it is a known fact that waves emitted in a medium do not partake of the motion of the body emitting them. For when once a wave has left the body, the wave is dependent solely on the medium for its propagation and is not influenced by the motion of the body one way or the other. It follows, therefore, that in the case of a moving luminous source emitting waves transversely to its path, the waves forming the parallel beam will be left behind, or will not partake of the motion of the luminous source. The waves will form a slanting track of light which will no longer strike *exactly* the opposed distant screen, but will fall somewhat to the rear of it. The luminous beam which, when the screen and source were at rest, was exactly eclipsed or intercepted by the screen, will (when the screen and source are in motion) commence to escape behind the edge of the screen, or the eclipse will no longer be total.

4. Here, therefore, we should have in principle a simple and decisive test between the two theories, provided insuperable practical difficulties do not stand in the way of carrying it out (for which object probably various methods would suggest themselves).

In order to contrast further the different effects that would be produced in the case of the two theories (corpuscular and undulatory), we may consider various possible cases of relative motion, also the effect when the beam is received directly in a telescope, or in the eye. We have already considered the case where the beam is observed objectively (by the use of a screen), which we may call *Case I.*

5. *Case II.*—We may now consider the case when a telescope[2] is used. We will take the above example of a luminous source in motion, emitting a parallel beam of light at right angles to its path, and we will imagine that this beam is received in a distant *stationary* telescope, placed normal to the path of the moving luminous source, so that the beam flashes down the axis of the telescope at the instant of the passage of the luminous source. Then we have to compare the effects produced in the case of the undulatory and corpuscular theories. On the undulatory theory, waves emitted by a luminous source do not partake of the motion of the source, so that at the instant when the wave of the beam (singling out a particular wave) flashes down the axis of the telescope at the moment of passage of the luminous source, the source will have already moved on a distance from the point where the wave left it, this distance representing that traversed by it during the time the light took to pass from the source to the telescope; and the source is therefore seen out of its true position by precisely that amount. This is perfectly evident, and the correction for this error in the estimate of position (of the value above indicated) constitutes the well-known "equation of light."

6. We have now to consider what takes place on the corpuscular theory. Here the projected corpuscles will partake of the motion of the source. Singling out, therefore, one of the corpuscles that flashes down the axis of the telescope at the instant of the passage of the luminous source; this corpuscle will possess the transverse velocity of the source that emitted it, and therefore the corpuscle will not pass straight down the axis of the stationary telescope, but in its passage will deviate laterally from that axis. The telescope would accordingly have to be inclined in order that the corpuscle might pass along the axis. This deviation of the corpuscle from the axis of the telescope will cause the luminous source to be viewed out of its true position, and it is easily seen that this visual error in the estimate of the position of the source on the corpuscular theory is precisely the same in amount as the previous error (due to a different cause) on the undulatory theory. Indeed, the error on the corpuscular theory is simply a case of "aberration" due to the relative motion of the telescope and light), and the correction for it, according to known principles, is the same as the other correction on the undulatory theory, termed "equation of light.'" It is a remarkable fact, therefore, that though the path of the light in its transit is very different in the case of the two theories, the visual error in the estimate of the position of the object is the *same*, so that this error cannot itself serve as a test between the two theories. There is, however, one marked distinction between the two theories; for while on the undulatory theory a position of the telescope *normal* to the path of the moving luminous source, causes the flash of the beam to pass down the axis of the telescope; on the corpuscular theory, on the other hand, the telescope has to be *inclined* in order that the flash of the beam may pass down its axis. Here, therefore, we have a definite physical effect serving as a point of distinction between the two theories.

7. *Case III.*—We will now take the case when *both* the luminous source and the distant observer are in motion, moving with equal velocities in parallel paths alongside each other in the same direction. Here on the corpuscular theory, in which case the corpuscles partake of the motion of the source, since the whole system therefore moves with equal velocity, the whole system will therefore be *relatively* at rest; so that the light will pass across and enter the telescope just as it would have done if everything were at rest, or there will be no peculiarity in the passage of the light whatever on the corpuscular theory. It is widely different on the undulatory theory, for here the beam of light passing between the source and the telescope will be left behind in the medium, and therefore in the first place, the moving telescope, in order to catch the parallel beam, will have to be placed back a certain distance in the rear; for since the light takes a slanting track between the source and telescope (the degree of slant depending on their common velocity), the telescope to intercept the light, can no longer be placed exactly *opposite* the luminous source. The distance the telescope will require to be placed back evidently must be equal to that traversed by it during the time the light takes to pass from the source to the telescope. Secondly, the light on the undulatory theory will suffer aberration in passing along the tube of the telescope, owing to the latter being in motion relatively to the light; no such aberration taking place on the corpuscular theory, since the corpuscles are moving at the same velocity as the telescope. Thirdly, on the undulatory theory, there will be a correction necessary, due to the motion of the luminous source ("equation of light"); such correction not being required on the corpuscular theory, since on that theory the light emitted partakes of the motion of

[1] We consider a *parallel* beam of light for simplicity, though it is not necessary to the principle.

[2] Of course the effect produced by aberration is the same with the eye alone as with a telescope, but we prefer to consider the latter, as its larger scale enables the effect to be visualised better.

the source. But it is a curious fact that the two errors occurring on the undulatory theory ("aberration" and "equation of light") happen precisely to counteract each other; so that therefore the luminous source is seen in its *true* position, *i.e.*, in the *same* position as by the corpuscular theory. The fact of the two errors compensating each other therefore prevents this occurrence of error from serving as a visual test between the two theories. There is, however, a distinct objective difference between the two theories in this case, as regards the *position* of the telescope (previously referred to); but before recurring to this, we may consider more closely the mode in which the above compensation of the two errors is brought about.

8. It is well known that the effect of the error termed "aberration" is to make the luminous source appear *forwards* of the position it occupied when the wave left it, and this by an absolute amount equal to that traversed by the telescope during the time the light took to pass from the source to the telescope. But from the fact that the luminous source is in motion, the latter *is* actually at the time of observation situated *forwards* of the position it occupied when the wave left it, and by precisely the above amount (since the source is moving at the same velocity as the telescope). Hence the two errors will precisely compensate each other, and the luminous source will be seen through the telescope in its true position, *i.e.*, in the *same* position as by the corpuscular theory. But it is important to note that on the undulatory theory, the telescope, in order to receive the parallel beam emitted by the luminous source, must be placed *not* opposite the source, but somewhat backwards, to make up for the slanting track of the beam attendant on the motion of the luminous source. On the corpuscular theory, on the other hand (where the track of the beam of light is *normal* to the line of motion of the source), the telescope must be placed *opposite* the source in order to catch the beam. The *position* of the telescope in the two cases therefore constitutes a distinct physical difference between the two theories, which might serve as a test.[1]

9. The above considerations may suffice to show in a simple manner that important differences exist in the effects attendant on the motion of a luminous source on the corpuscular and undulatory theories of light, and that these differences would be *in principle* capable (supposing practical difficulties surmounted) of constituting a simple and decisive test between the two theories.

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[1] The fact pointed out by Sir John Herschel in regard to the difference in the *velocity* of light on the undulatory and corpuscular theories, in the case of a luminous body moving directly towards or from the observer, would appear also to be worthy of remark. It is evident, for example, that in the case of a luminous body moving towards the observer, the velocity of light would *add* itself to that of the body on the corpuscular theory; but the velocity would be unaffected on the undulatory theory.

GEOGRAPHICAL NOTES

THE Paris Geographical Society held last Friday its annual December meeting, at its hotel, under the presidency of Admiral La Roncière le Nourry. The report of the progress of geography was read by M. Maunoir, the secretary. M. de Ujfalvy delivered an address on the region of Central Asia which he visited, and which may be termed the extreme frontiers of the Russian empire, and which are just now attracting so much notice. This traveller will soon come to London to give the same address before the Royal Geographical Society. His exploration was made at the expense of the French Government. On the following Saturday a banquet took place at the Continental Hotel. The usual toasts were given. After dinner M. de Lesseps, who is very likely to be nominated president of the Society for 1879, at the April meeting, gave some account of his visit to Tunis with Capt. Roudaire, in order to investigate the conditions of the creation of the new Saharan Sea. M. de Lesseps described the whole scheme as being easily practicable for a sum of not more than 60,000,000 of francs. He said that the French extension telegraph system was extending all over Tunis and Tripoli, and that Arabs were accustomed to follow the telegraphic line as their camels travelled at a quicker rate when following its track. He intimated that the Egyptian telegraphic system was extending to the equator, and that he advised M. Cochery, the Director of French Postal Telegraphy, to extend it all over Sahara up to Senegal.

PETERMANN'S *Mittheilungen* (for so it will continue to be named) for December contains a long and careful account of Chartography at the Paris Exhibition; Dr. Carl Martin contributes a paper, based on Chilian sources, on the Chonos Archipelago, which is accompanied by a map. An excellent paper on the present condition of Afghanistan (with map), is contributed by Herr F. von Stein. This number, besides the usual table of contents to the volume, contains a complete alphabetically arranged index to Dr. Behm's useful monthly summaries.

WE have received a specimen of the first number of one of those stupendous geographical works of which the French are so fond, and the best example of which is Elisée Reclus' "Géographie Universelle." Indeed, the new work announced seems to have pretty much the same object as that of Reclus, though the method is different. The new work is to be issued by the Librarie des Connaissances Utiles, and the author is M. Charles Hertz. Its title is "La Géographie Contemporaine d'après les Voyageurs, les Émigrants, les Colons, les Commerçants." It will consist of ten series of from three to five volumes each. We trust the publishers will find subscribers patient enough to wait for the end. There will be from 600 to 800 maps and hundreds of illustrations, and the work will be issued in weekly parts. We calculate it will take fifteen years to complete. Judging from the specimen, a good deal of narrative and adventure will be introduced into the work, and that it will be at least as entertaining as instructive. The first series will deal with polar and maritime expeditions, the second with Africa, the third with Asia, the fourth with Australia, and the fifth with means of communication, geographical societies, &c. The other five series will be devoted to a description of the nations of European origin and their enterprises over the globe. It is a grand scheme.

DR. THOLOZAN, physician to the Shah of Persia, is organising a scientific exploration of the province of Khuzistan, the southern province of Persia. The expedition will start from Bassorah on February 1 next.

NOTES

THE Corporation of the City of London having determined to identify themselves with the movement by the Livery Companies of London for the advancement of technical education, on Thursday last elected the following to serve on the Board of Governors of "The City and Guilds of London Institute for the Advancement of Technical Education":—The Lord Mayor *ex officio*; the Recorder, *ex officio*; Aldermen: Sir Thomas Dakin, Knt.; Sir Robert W. Carden, Knt.; Mr. William Lawrence; Sir Francis W. Truscott, Knt.; Sir Wm. A. Rose, Knt., F.R.S.L., F.R.G.S.; Simeon C. Hadley; Common Council: Mr. Joseph Beck, F.R.A.S.; Mr. W. Bassingham; Mr. J. L. Shuter, F.R.A.S.; Sir C. Reed, Knt., LL.D., F.S.A., Dep.; Mr. George Shaw; Mr. J. Edmeston; H. Lowman Taylor, J.P., Dep.; S. E. Atkins, Dep.; Sir Jno. Bennett, Knt.; Mr. Henry Greene; Mr. John Faulkner; Mr. Thomas Waller.