ASTRONOMICAL ANNUAL FOR 1898.—We have just received a copy of the sixty-fifth *Annual* of the Belgian Royal Observatory for 1898. The volume is similar in character to the many astronomical annuals published on the continent, giving in calendar form the most important astronomical events of the present year, and in addition geographical data referring chiefly to Belgium. Besides these there is a detailed description of the Royal Observatory at Uccle, together with the instruments and the observations made at the observatory in 1897.

SPECTRUM RESEARCHES OF η AQUILÆ.—Prof. A. Belopolsky has recently completed a new series of photographs in connection with the spectrum of η Aquilæ; and his paper on "Researches on the Spectrum of the Variable Star η Aquilæ" appears in the *Astrophysical Journal*, December 1897. In all, twelve photographs were taken corresponding to the different phases of brightness, and by an "iron comparison" on each photograph, it has been possible to determine the velocity of the system with respect to the sun.

The spectrum of η Aquilæ is remarkably like that of the variable star δ Cephei, belonging to a group of which γ Cygni is the type; therefore some of the principal iron lines contained in its spectrum have been utilised in making the measures.

From these measures, the author finds the motion of the system = – 1·85 geographical miles, and from the curve of velocities in the line of sight he concludes "that the times of minimum brightness and the times for which the velocity in the line of sight is zero do not coincide. For this reason the changes in the brightness of the star cannot be explained as the result of eclipses, and some other explanation must be sought." It is very remarkable that Prof. Belopolsky found this was also the case with the variable star δ Cephei.

A SIXTH edition of Mr. Thynne Lynn's handy little book on "Remarkable Comets" has just been published by Mr. Edward Stanford. The information in the book is completely up to date, even the observed return of Winnecke's comet, first seen on the present visit on January 2, being recorded. Encke's comet (period $3\frac{1}{3}$ years) may be expected shortly, and in the summer, Wolf's comet (period $6\frac{3}{4}$ years) should pay us a visit.

THE REFRACTION OF ELECTRIC WAVES.[1]

TWO years ago, Prof. Bose, in a communication to the Asiatic Society of Bengal, described some new devices for dealing with electric waves, which did much to bridge over the gulf between electric waves and light waves. One of these was the employment of nemalite, a fibrous variety of brucite, which has the valuable property of absorbing electric waves vibrating in a certain plane, and transmitting all waves at right angles to that plane. It thus could be made to do for electric radiation what a plate of tourmaline does for light, except that the directions of absorption and transmission are reversed. Nemalite is therefore a very convenient polariser and analyser of electric waves. Tourmaline also acts in the same manner (with planes reversed), but not to any extent comparable with the efficiency of nemalite. The apparatus was subsequently exhibited and worked before the Liverpool meeting of the British Association.

In the present papers, Prof. Bose describes some experiments on the refractive index of glass for electrical waves, carried out for the purpose of testing Maxwell's relation $K = \mu^2$, which maintains that the specific inductive capacity for any substance equals the square of its refractive index.

This relation, originally a purely theoretical deduction from an unproved theory, has been gradually verified as our experimental resources gained in power to grapple with the various difficulties involved in the measurements. In the first place, the specific inductive capacity is not a fixed number, but varies with the nature of the electric charge, whether stationary or alternating, and, if the latter, with the frequency of the alternations. Strictly speaking, Maxwell's relation only applies to the refractive index for waves of infinite length, and determinations of the optical refractive index, *i.e.* the index for electromagnetic waves of about 1/50,000th of an inch, do not bear upon the question. It is only the long invisible electromagnetic waves which can be properly used to test the relation.

TESTING MAXWELL'S RELATION.

The specific inductive capacity of glass has been assigned various values ranging from 2·7 to 9·8. The optical refractive index μ is about 1·5. Prof. Bose determined μ for electric vibrations of a frequency of about 10^{10} vibrations per second. The apparatus used is shown in the diagram.

It closely resembles an optical apparatus. The radiator, consisting of two platinum beads with a platinum sphere between them, and fed by an induction coil, is enclosed in the square box. The rays pass through the diaphragm P to the semi-cylinder C of the glass to be investigated. This semi-cylinder is turned until the rays are totally reflected by the back surface. They are detected by the receiver R, containing metallic filings, whose resistance is reduced by the impact of the waves. The shielding of the receiver from strong radiations is a matter of some difficulty. Prof. Bose says:—

"Another troublesome source of uncertainty is due to the action of the tube which encloses the receiver. When a slanting ray strikes the inner edge of the tube, it is reflected and thrown on to the delicate receiver. Unfortunately it is difficult to find a substance which is as absorbent for electric radiation as lamp-black is for light. Lamp-black in the case of electric radiation produces copious reflection. I have tried layers of metallic filings, powdered graphite, and other substances, but they all fail to produce complete absorption. The only thing which proved tolerably efficient for this purpose was a piece of thick blotting paper or cloth soaked in an electrolyte. A cardboard tube with an inner layer of soaked blotting paper is impervious to electric radiation, and the internal reflection, though not completely removed, is materially reduced. No reliance can, however, be placed on this expedient, when a very sensitive receiver is used.

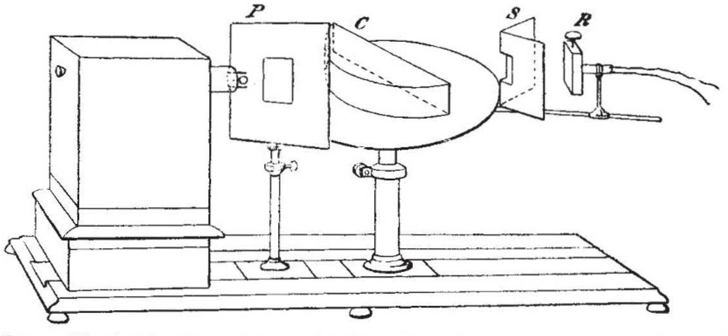

FIG. 1.—The electric refractometer: P, the plate with a diaphragm; C, the semi-cylinder of glass; S, the shield (only one shown in the diagram); R, the receiver.

"After repeated trials with different forms of receiving tubes, I found a form, to be described below, to obviate many of the difficulties. Instead of a continuous receiving tube, I made two doubly inclined shields, and placed them one behind the other, on the radial arm which carries the receiver. The first shield has a tolerably large aperture, the aperture of the second being somewhat smaller. The size of the aperture is determined by the wave-length of radiation used for the experiment. It will be seen from this arrangement, that the rays which are in the direction of the radial arm, can effectively reach the receiver, the slanting rays being successively reflected by the two shields. With this expedient, a great improvement was effected in obtaining a definite reading.

"When the deviated rays are convergent, the receiver is simply placed behind the shields, at the focus of the rays. But when the rays are parallel, the use of an objective (placed behind the first shield) gives very satisfactory results. As objectives I used ordinary glass lenses; knowing the index from my experiments, I was able to calculate the focal distance for the electric

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[1] Abstract of two papers communicated to the Royal Society by Prof. Jagadis Chunder Bose, M.A., D.Sc., Calcutta: "On the Determination of the Indices of Refraction of various Substances for the Electric Ray," and "On the Influence of the Thickness of Air-Space on Total Reflection of Electric Radiation."

ray. This is of course very different from the focal distance for the luminous rays. I at first used a lens of 6 cm. electric focal distance, but this did not improve matters sufficiently. I then used one with a longer focus, *i.e.* 13 cm., and this gave satisfactory results."

The value obtained for μ was 2·04, while the optical refractive index for the D line was 1·53. According to Maxwell's relation, the specific inductive capacity K should therefore be $4\cdot16 = \mu^2$, a value well within the extremes of 2·7 and 9·8 mentioned above. It is interesting to note that the refractive power of glass is higher for these electro-magnetic waves than for light, and that ordinary lenses must therefore converge these waves to a shorter focus. Hence the small dimensions of Bose's apparatus.

TOTAL REFLECTION OF ELECTRIC WAVES.

These and some of the earlier experiments were repeated with two semi-cylinders separated by an air-space, and the thickness of air necessary to produce total reflection was determined. In optics, a very thin film of air suffices. In the case of electro-magnetic waves as produced in the laboratory, the thickness is found to reckon by several millimetres.

Two semi-cylinders of glass, with a radius of 12·5 cm., were placed on the spectrometer circle. The plane faces were separated by a parallel air-space. The radiator was placed at the principal focus of one of the semi-cylinders; the rays emerged into the air-space as a parallel beam, and were focussed by the second semi-cylinder on the receiver placed opposite the radiator.

The two semi-cylinders were separated by an air-space 2 cm. in thickness; this thickness was found to be more than sufficient for total reflection. The experiments were commenced with an angle of incidence of 30° (slightly greater than the critical angle). The receiver, which was placed opposite the radiator, remained unaffected as long as the rays were totally reflected. But on gradually diminishing the thickness of air-space by bringing the second semi-cylinder nearer the first (always maintaining the plane surfaces of the semi-cylinders parallel), a critical thickness was reached when a small portion of the radiation began to be transmitted, the air-space just failing to produce total reflection. The *beginning* of transmission could easily be detected and the critical thickness of air determined with tolerable accuracy. The slight discrepancy in the different determinations was due to the unavoidable variation of the sensitiveness of the receiver. When the thickness of air was reduced to 14 mm. the receiver began occasionally to be affected, though rather feebly. But when the thickness was reduced to 13 mm. there was no uncertainty; a measurable, though small, portion of the radiation was now found to be always transmitted.

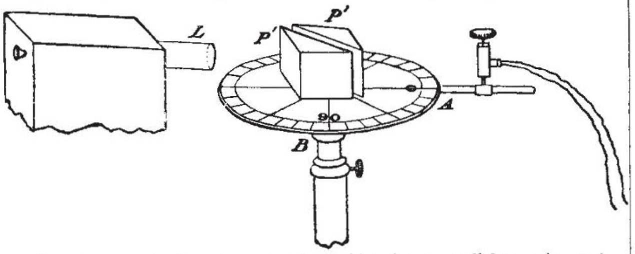

FIG. 2.—L is the lens to render the incident beam parallel; P, P', are the right-angled isosceles prisms; A and B are the two positions of the receiver. The receiver-tube is not shown in the diagram.

With an angle of incidence of 60° the minimum thickness for total reflection was found to be between 7·6 mm. and 7·2 mm. The minimum effective thickness is thus seen to undergo a diminution with the increase of the angle of incidence.

The author also determined the influence of wave-length, using three different radiators.

The following method of experimenting was adopted as offering some special advantages. If a cube of glass be interposed between the radiator and the receiver placed opposite to each other, the radiation striking one face perpendicularly would be transmitted across the opposite face without deviation and cause a response in the receiver. If the cube be now cut across a diagonal, two right-angled isosceles prisms will be obtained. If these two prisms were now separated slightly, keeping the two hypothenuses parallel, the incident radiation would be divided into two portions, of which one portion is transmitted, while the other portion is reflected by the air film in a direction at right angles to that of the incident ray, the angle of incidence at the air-space being always 45°. The transmitted and the reflected portions would be complementary to each other. When the receiver is placed opposite to the radiator, in the A position, the action on the receiver will be due to the transmitted portion; but when the receiver is placed at 90°, or in the B position, the action on the receiver will be due to the reflected portion. The advantage of this method is that the two observations for transmission and reflection can be successively taken in a very short time, during which the sensitiveness of the receiver is not likely to undergo any great change. In practice three readings are taken in succession, the first and the third being taken, say, for transmission and the second for reflection.

When the prisms are separated by a thickness of air-space greater than the minimum thickness for total reflection, the rays are wholly reflected, there being no response of the receiver in position A, but strong action in position B. As the thickness is gradually decreased below the critical thickness, the rays begin to be transmitted. The transmitted portion goes on increasing with the diminution of the thickness of air-space, there being a corresponding diminution of the reflected component of the radiation. When the thickness of the air-space is reduced to about 0·3 mm., no reflected portion can be detected even when the receiver is made extremely sensitive. The reflected component is thus practically reduced to zero, the radiation being now entirely transmitted; the two prisms, in spite of the breach due to the air-space, are electro-optically continuous. This is the case only when the two prisms are made of the same substance. If the second prism be made of sulphur, or of any other substance which has either a lower or a higher refractive index, there is always found a reflected portion even when the two prisms are in contact.

The results obtained show that the effective thickness of the air-film increases with the wave-length. This was to be expected, since at very small wave-lengths, such as those of ordinary light, the thickness required for total reflection becomes very small. The brilliant reflection in the crack of a pane of glass is a familiar example.

PALÆOLITHIC MAN.[1]

IN the address of last year the evidence for the existence of man in the Tertiary period was reviewed, and although some of the evidence was very cogent, yet in no case did it amount to a proof, such as is necessarily demanded before so great an antiquity can be accepted for the human race. On the other hand, the presence of man in Quaternary times has long since been proved by the presence of many undoubted flint implements, in cave and river deposits of Pleistocene age and in relation with the bones of the mammoth and other extinct mammalia.

But other questions have now to be answered. What were the physical and intellectual peculiarities of the men who made the palæolithic implements? Have any parts of his skeleton yet been found?

Human bones and skeletons, more or less imperfect, supposed to be of Pleistocene age, have often been recorded both in this country and also on the continent of Europe; but a close investigation has, in most cases, proved them to be of much more recent origin, or has shown that there were very grave doubts as to their authenticity.

Much has been done to eliminate the doubtful records by such writers as Prof. Boyd Dawkins, M. Gabriel de Mortillet, and MM. Fraipont and Lohest; and consequently it is only necessary, at the present time, to consider the more important of these discoveries, and especially those which have been made within the last ten or fifteen years.

The famous Canstadt skull, described by Jaeger in 1835, is of uncertain origin, for when the mammalian remains, with which it was supposed to have been associated, were first described in the year 1700, no mention was made of this skull, and it is therefore by no means certain that it was associated with these extinct mammals. A new interest is awakened in this and some other of the earlier and unauthenticated remains of man by the discovery, within the last twelve years, of very similar skulls which are accepted as of palæolithic age. The skull discovered by M. Faudel in 1865, at Eguisheim on the Lower Rhine, is not unlike that from Canstadt, and is generally believed to be of

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[1] Abstract of Presidential Address to the Geologists' Association, delivered at the Annual Meeting, February 4, by Mr. E. T. Newton, F.R.S.