which they form part will be coincident. If the second impulse take place when the particle is at A, the two sets of vibrations or waves to which they belong will have a difference of phase (*i.e.* the first will be in advance of the second) equal to one-fourth of a vibration or one-fourth of a wave-length. If the second impulse take place when the particle is at O on its way to B, the difference of phase will be half; if when it is at B the difference will be three-fourths of a wave-length.

The particle being at O, and subject to two simultaneous impulses of equal strength, one in the direction of A, the other in that of C, must move as much in the direction of C as in that of A, that is, it must move in a straight line equally inclined to both, namely O E in the same figure. And inasmuch as the two impulses in no way impede one another, the particle will move in each direction as far as it would have done if the other had not taken place. In other words, if we draw a square about O with its sides at distance equal to O A or O B, the extent of the vibration will be represented by O E where E is a corner of the square. The complete vibration will then be represented by the diagonal E F in the same way as it was by the line A B in the first instance. If the impulse had been communicated at the instant of passage through O on the way to B, it is clear that a similar train of reasoning would have shown that the vibration would have been in the other diagonal G H. We conclude, therefore, that if two sets of rectilinear vibrations, or plane waves, at right angles to one another combine, then when they are coincident they will produce a rectilinear vibration, or wave, whose plane is equally inclined to the two, and lying in the direction towards which the motions are simultaneously directed. In the figure this is represented by the dexter diagonal. When the two sets of waves have a difference of phase equal to half a wave length, their combination gives rise to a wave represented in the figure by the sinister diagonal.

Suppose now that the second impulse is communicated at the instant when the particle is at A; in other words, that the two sets of waves have a difference of phase equal to one-fourth of a wave-length. At that instant the particle will have no velocity in the direction of A B (for convenience, say eastwards), and will consequently begin to move in the direction of the second impulse, say northwards. But as time goes on the particle will have an increasing velocity westwards and a diminishing velocity northwards, it will therefore move in a curve which gradually and uniformly bends, until when it has reached its greatest distance northwards it will be moving wholly westwards. And as the motion not only will be the same in each quadrant, but would be the same even if the directions of the impulses were reversed, it is clear that the curvature of the path will be the same throughout, that is to say, if two sets of waves of the same magnitude in planes perpendicular to one another, and with a difference of phase equal to one-fourth of a wave-length combine, they will produce a wave with circular vibrations.

If the second impulse be given when the particle arrives at B, that is, if the waves have a difference of phase equal to three-fourths of a wave-length, similar considerations will show that the motion will be circular, but in the opposite direction.

Suppose, therefore, that we allow plane-polarised light to fall upon a plate of doubly refracting crystal cut perpendicularly to the axis in the case of a uniaxal crystal, or in the case of a biaxal to the plane containing the two axes, say a plate of mica which splits easily in that direction; then the vibrations will, as before explained, be resolved in two directions, at right angles to one another. And further, if the original directions of vibration be equally inclined to the new directions, *i.e.*, if it be inclined at 45° to them, the amount or extent of vibration resolved in each direction will be equal. Further, if the thickness of the plate be such as to produce retardation or difference of phase equal to a quarter of a wave, or an odd number of quarter wave-lengths, for the particular ray under consideration; then the two sets of vibrations on emerging from the mica plate will recombine, and in accordance with the reasoning given above, they will form a circular vibration, left-handed or right-handed according as the retardation amounts to an integral number of three-quarter wave-lengths or not.

It thus appears that a plate of mica which retards one of the sets of waves into which it divides an incident set by an odd multiple of quarter-wave lengths, affords a means of producing circular from plane polarisation. It remains to be shown that, with the same plate in different positions, right or left handed circular polarisation may be produced at pleasure. Suppose tbat the original vibrations are in the direction E F in the foregoing figure; the mica plate will resolve them into the two directions A B, C D, one of the rays, say the first, will be transmitted with greater velocity than the other, and the vibrations along C D will be one-fourth of a wave-length behind those along A B. This will correspond to the case discussed above, and will give rise to a circular vibration in a direction opposite to that of the hands of a clock. Suppose, however, that the plate be turned round through a right angle, so that the vibrations which are transmitted with greater velocity are placed parallel to C D, and those which are transmitted with lesser along A B. The ray whose vibrations are along A B will then be a quarter wave-length in advance, or, what comes to the same thing, they are three-quarters of a wave-length in rear of the others; and this condition of things produces, as explained before, a circular vibration in a direction the reverse of the former. It thus appears that the plate placed in one direction will convert plane into right-handed circular polarisation; and if turned round through a right angle from that position will convert plane into left-handed circular polarisation. A like change from right-handed to left-handed circular polarisation, or *vice-versâ*, may obviously be effected by turning the orginal plane of polarisation through a right angle; so that it shall lie between lines of concurrent instead of between lines of discordant motion.

W. SPOTTISWOODE

(*To be continued.*)

A COMPLETE SPECIMEN OF A PALÆOTHERIUM

FROM *La Nature* we learn that the palæontological collection of the Museum of Natural History of Paris has just been enriched by the addition of a new specimen of very great scientific interest, which is the entire skeleton of *Palæotherium magnum*, imbedded in a large block of gypsum and marl, the whole being exhibited in the anatomical department of the museum.

The *Palæotherium magnum*, whose name alone indicates its ancient existence, was first recorded by the great French naturalist Cuvier, in his celebrated "Recherches sur les Ossemens Fossiles." It is an animal which is entirely extinct, without any present representative. Individuals of the species must have been extremely abundant during the period that it existed. Modern zoologists place it among the Perissodactylates, that is to say, with the at present existing rhinoceros, tapir, and horse. It forms part of the fauna which is found abundantly embedded in the deposits of gypsum. All palæontological collections, even the most humble, have for a long time been provided with the remains, or more or less complete portions of this fossil form, but none have yet had the good fortune to obtain a complete skeleton.

The principal result of the examination of the new specimen which we are describing has been to show that until now very inexact notions have been entertained as to what this animal truly was when the proportions and general contour of the tapir were assigned to it, as was done even by Cuvier himself.

Far from being bulky and almost massive, as was thought, *Palæotherium magnum* is now evidently seen to be a very slender animal, with an extremely graceful carriage, with the neck longer than in the horse, and a general contour much on the same type as that of the Llama.

Without attempting a detailed study of its osteological structure, we may mention that *Palæotherium magnum* had a height a little less than that of a middle-sized horse. Three toes are found on each of the feet; the head, much like that of a tapir, had most probably also the rudiment of a trunk; the femur has a third trochanter; the dentary system is composed, in each jaw, of six incisors, two canines, and fourteen molars, these latter corresponding with the same teeth in the rhinoceros.

Palæotherium magnum, like its congeners, of which about a dozen species are at present known, was herbivorous, and without doubt lived in large herds. Its existence carries us back to that age of our earth which is termed the Eocene period, and it is in the middle of that period, which comprises the gypsum deposits or their geological equivalents, that its remains are discovered, as well as those of all the other species of the same genus.

PALÆOTHERIUM MAGNUM

Nevertheless it made its appearance even before the gypsum formation, its presence having been detected in the beds of coarse limestone, which are inferior to and therefore more ancient than that formation.

It is the plaster quarries of Montmartre, Pantin, and La Villette, near Paris, which have for a long time held the privilege of furnishing to palæontologists the numerous remains that are known of this fossil species. The Palæotherium, which forms the subject of this notice, was obtained from a plaster-quarry situated at Vitry-sur-Seine. It was, however, even a few days ago, as we see it to-day, exposed on one side, and on the other encrusted in its stony resting-place in the ceiling of a subterraneous gallery, a little more than four yards high. Only a few have visited it, although M. Fuchs, a civil engineer, the proprietor of the quarry where this magnificent specimen was found, offered to give it to the Museum.

The gift so generously offered was immediately accepted; and Prof. Gervais, with a scientific zeal which ought to be fully acknowledged, occupied himself with the direction of the important task of taking it intact to Paris.