certainly appears as if his value were to lie wholly in his private actual attainment, and not in a union by love and faith with a universe greater than himself.

"Religion, from this point of view, rather than the negation, is, in truth, the school or apprenticeship of the moral will. A school from which no spirit will ever believe itself discharged which does not hold its day's work to be finished, and which feels its life as an unceasing progress in learning what it is to create one's own personality." These are the concluding words of the book, and I am not perfectly sure of their import. But I suppose it to be that religion is the sense of imperfection and defect which urges forward the finite spirit, and that it does not, or not appreciably, involve the sense of peace in unity with the whole through faith and will, which to us seems fundamental to religion, and just to be wanting to morality. Yet we can understand in some degree from the author's emphasis on the "We" of the group-mind how it is possible for him to refer, as it seems, the very universe itself to the creative fact of our will and the process of our cognition.

BERNARD BOSANQUET.

The Foundations of Einstein's Theory of Gravitation. By ERWIN FREUNDLICH. Preface by A. EINSTEIN. Authorised English Translation by H. L. BROSE, M.A. Introduction by H. H. TURNER, D.Sc., F.R.S. Cambridge University Press. Pp. xvi, 60.

This pamphlet is worthy of the numerous and eminent fairy godfathers who have stood sponsor for it. Herr Freundlich wrote it; Einstein gave it his *imprimatur*; Mr. Brose became acquainted with it while interned in Germany, and (not having heard, presumably, that the Allied scientists had officially determined that German science was merely an inferior imitation of their own brilliantly original discoveries) determined to translate it. Prof. Turner and Prof. Eddington (who cannot plead the excuse of ignorance) encouraged Mr. Brose; and the former provided an excellent introduction. The result is the best account of the new theory, for the purpose of the general reader, that has yet appeared. Prof. Eddington's *Report* is of course considerably more detailed, but there is much in it that can hardly be understood by anyone who is not pretty familiar with mathematical physics. Herr Freundlich's pamphlet should be intelligible to any educated reader, whilst at the same time it is full and accurate and not in the least 'popular' in the bad sense of the word. The translation seems to have been thoroughly well done, and Mr. Brose is to be congratulated on his work.

The following points may be of special interest to readers of MIND. (i) The author lays special stress on the work of Riemann on manifolds, and points out how Einstein's theory is a development of ideas thrown out by Riemann. (ii) He points out that the equations of the special theory of relativity might have been deduced from simple and almost self-evident considerations without reference to the velocity of light. It follows from these that there must be *some* velocity which will be reckoned to be the same in magnitude by all observers in uniform relative motion. That this velocity is *finite*, and is in fact that of light *in vacuo*, is an additional empirical fact established by the Michelsen-Morley experiment. These statements may be compared with Prof. Whitehead's results in his *Principles of Natural Knowledge*. (iii) He shows very clearly how the new theory fastens on the two weak points in the Newtonian mechanics—absolute motion, and the unexplained identity of inertial and gravitational

mass—and successfully avoids the first and clears up the second. It thus avoids the one great objection to Newton's mechanics, and synthesises the two principles which immortalise his name—the laws of motion and the law of gravitation. Lastly (iv) Herr Freundlich makes great play with two epistemological principles, which he regards as lying at the base of Einstein's theory and as furnishing a kind of limiting condition to which any satisfactory physical theory must conform. As they both seem to me somewhat doubtful, it may be worth while to say a few words about them.

The two principles are the denial of action at a distance, and the demand that 'only those things are to be regarded as being in causal connexion which are capable of being actually observed'. The first is supposed to show that the law of gravitation, as stated, cannot be ultimate, because, in the formula $\frac{d^2r_1}{dt^2} = \gamma\frac{m_2}{(r_2 - r_1)^2}$, we have a *finite* distance, $r_2 - r_1$, on the right-hand side. 'The distances between points which are at *finite* distances from one another, must not occur in these laws, but only those between points infinitely near to one another.' The second is supposed, both by Herr Freundlich and by Einstein himself, to be the motive for getting rid of absolute space, time, and motion in the statement of the laws of nature.

The following criticisms suggest themselves at once. (i) If space be continuous there are no points 'infinitely near one another'; and therefore the first principle cannot be fulfilled. (ii) Even if there were infinitesimal distances they certainly are not the distances that can be observed, and therefore to regard purely differential laws as ultimate involves a breach of the second principle. (iii) It is rather unfortunate to insist on the absolute necessity of such laws at a time when pure mathematics is rapidly developing, in the theory of integral equations, methods that enable us to deal with integrated laws; when physics, in the theory of Quanta, is moving rather in the direction of discreteness; and when certain philosophers, such as Russell, are developing the notion that the continuity of nature is a logical construction, and that the ultimate data are of finite magnitude. (iv) The second epistemological principle seems to me, as I have argued elsewhere, to have very little in its favour, if taken as anything more than a methodological postulate. Physics certainly cannot get on if it confines itself to what actually can be observed. On the other hand, anything that could exist is in principle *observable*, *i.e.*, if we had the right kind of senses we could observe it. The fact that we should need a greater modification in our senses to enable us to perceive points of absolute space, if there be such things, than to enable us to perceive electrons, if there be such things, is surely epistemologically quite irrelevant. Naturally we ought to avoid postulating unobservable entities if we can do without them, and Einstein has at length shown that we can do without absolute space, time, and motion in mechanics. But the real objection to them has always been, not simply that they were unobservable, but that they did nothing. Electrons and molecules are postulated as causes and their properties can be determined with more and more accuracy from their observable effects. The laws of mechanics profess to *analyse* all motions; absolute space, time, etc., were merely parameters that simplified the analysis; and it was always clear in principle that they must somehow be dispensable.

C. D. Broad.