absorption coefficient must be less than the coefficient computed with the aid of the Klein-Nishina formula from the energy released in the process from which the radiation arises. Now the Bothe-Kolhörster experiments of about a year ago show that when the energies of the incident photons are sufficiently high, the beta rays released by Compton encounters do indeed become abnormally penetrating: so that it is to be expected that, for the cosmic rays produced by the formation of the heavier of the common elements like silicon and iron out of hydrogen, the observed absorption coefficients will be somewhat smaller than those computed from the energy available for their formation. This is precisely the behaviour which our cosmic ray depth-ionisation curve actually reveals. At the highest altitudes at which we have recently observed (14,000 ft.), the helium rays have reached equilibrium with their secondaries, and the observed and computed coefficients agree as they should. For the oxygen rays the observed coefficent is a little lower than the computed value —about 17 per cent lower; for the silicon rays still lower—about 30 per cent; and for the iron rays considerably lower still—about 60 per cent: all in beautiful qualitative agreement with the theoretical demands as outlined.

The foregoing results seem to point with much definiteness to the following conclusions:

1. The cosmic rays have their origin not in the stars but rather in interstellar space.

2. They are due to the building up in the depths of space of the commoner heavy elements out of hydrogen, which the spectroscopy of the heavens shows to be widely distributed through space. That helium and the common elements oxygen, nitrogen, carbon, and even sulphur, are also found between the stars is proved by Bowen's beautiful recent discovery that the 'nebulium lines' arise from these very elements.

3. These atom-building processes cannot take place under the conditions of temperature and pressure existing in the sun and stars, the heats of these bodies having to be maintained presumably by the atom-annihilating process postulated by Jeans and Eddington as taking place there.

4. All this says nothing at all about the second law of thermodynamics or the *Wärme-Tod*, but it does contain a bare suggestion that if atom formation out of hydrogen is taking place all through space, as it seems to be doing, it may be that the hydrogen is somehow being replenished there, too, from the only form of energy that we know to be all the time leaking out from the stars to interstellar space, namely, radiant energy. This has been speculatively suggested many times before, in order to allow the Creator to be continually on his job. Here is, perhaps, a little bit of *experimental* finger-pointing in that direction. But it is not at all proved or even perhaps necessarily suggested. If Sir James Jeans prefers to hold one view and I another on this question, no one can say us nay. The one thing of which we may all be quite sure is that neither of us *knows* anything about it. But for the continuous building up of the common elements out of hydrogen in the depths of interstellar space the cosmic rays furnish excellent experimental evidence. I am not unaware of the difficulties of finding an altogether satisfactory kinetic picture of how these events take place, but acceptable and demonstrable facts do not, in this twentieth century, seem to be disposed to wait on suitable mechanical pictures. Indeed, has not modern physics thrown the purely mechanistic view of the universe root and branch out of its house ?

Geodesy in India.

IN the British Empire at the present time, geodetic operations are mainly confined to Canada, India, and South Africa. The Dominion and the Union are working principally for the more pressing needs of development; in India, on the other hand, apart from the necessity for revision, more attention is being paid to the interpretation of results. The Great Trigonometrical Survey of India itself being long complete, triangulation is now being carried on in the outer zones—in Burma and on the Siamese frontier at the date of the last Geodetic Report.[1]

The main triangulation in 1928–29 was executed with Wild theodolites, which gave very good results when the instruments were working. Their axes, however, stiffened in the field, causing serious loss of time. Surveyors cannot adjust the instruments in the field, and even the mathematical instrument workshop in Calcutta found adjustment difficult, though mere oiling is simple if the method is known. It was intended to keep the older and heavier 12-inch theodolites at hand during the ensuing season, in case of further failures.

Precise levelling is perhaps the most economically important section of the revisionary geodetic work: of the new net of 16,000 miles proposed, nearly one-half was completed in 1929. Levelling on hilly circuits appears to show that the shorter sights thereon contribute to accuracy as against longer sights in flat country; experience in precise levelling has given revised results on hilly circuits in Ceylon which are practically as good as on the plains. Indian investigations show that error due to differential refraction on steep slopes is negligible, and the greater part of the errors of closure is believed to be due to changing length of the staves. The results of levelling must lie within limits of accidental and systematic error which are strictly defined; one notices that 55 per cent of one line was relevelled. On the several lines—not yet, of course, referred strictly to M.S.L.—the relative discrepancies between the new and the old measures do not ordinarily exceed 6 inches; but there are interesting exceptions. Thus there is evidence of a sinkage around Ambala of about an inch per decade, attributed to removal of water from wells. On the line between Sukkur and Hyderabad the results of much levelling have given measures so discordant that it has been decided to abandon the line. India has hitherto used wooden staves, and it is not stated if these have been rendered non-hygroscopic; change in length, which appears to have a diurnal range, being attributed to temperature. In any event, staves with invar strips were to be substituted.

Heights are subject to orthometric and dynamic corrections, the former to take account of the non-parallelism of the equipotential surfaces at different altitudes, the latter to refer all heights to a standard equipotential surface of sea-level at a mean latitude, in India 24° north. The corrections are easily computed by formulæ, in which case they depend on theoretical, not observed, values of gravity. The Director of the Geodetic Branch, Dr. De Graaf Hunter, discusses the question of a rigorous investigation, and finds that the effect at Mussoorie, 7000 feet, is 0·7 ft.; he concludes that the severe labour involved in applying a rigorous correction is not justifiable in hilly country and is unnecessary in flat country, even though in strictness values derived by formula give heights in an unknown unit above an unknown datum.

India controls tide-gauges at forty eastern ports and issues predictions. An outstanding discrepancy in 1928 was 4·6 feet at Basrah on a certain date—not surprising at the mouth of great rivers and at the head of a great gulf. By arrangement with the Admiralty, the tide-tables will be extended to sixty-eight ports in the Indian Ocean, and they will be issued in cheaper form—sufficient evidence of the success of the Survey in deriving harmonic constants in a region where monsoons and unique tides must sometimes give rise to peculiar conditions.

It has been decided to re-map at least a portion of the Dependency on areas of conical orthomorphic projection; in such an immense area the change-over will be gradual. The areas proposed are 8° in latitude by 16° in longitude. In this matter South Africa and India represent extreme views, the former adopting a width of 2° as against 8° in India. At the bounding parallels the scale error is about 1/400, which will be reduced one-half by a scale factor. The magnitude of the scale error and, perhaps more particularly, the rapid change of scale at the bounding parallels will doubtless evoke criticism.

The Survey has constructed a mural base for standards of length. Such bases already exist at Sèvres and Teddington; yet the writer doubts if this is the best form of construction, even though the thermal expansion of the wall becomes fairly well known after some years.

In the course of the longitude campaign the variation of latitude was studied; the results appear to show a well-marked correlation with the moon's age, as already described in NATURE.[2] The mean longitude of Dehra Dûn as derived from the Bordeaux and Rugby signals in 1928–29 is 5 h. 12 m. 11·79 s., precisely the same as in the longitude campaign of 1926. A Shortt clock was installed this year to supplement the Riefler.

The most interesting portions of the Report deal with gravity and the geoid in India; it would be impossible to deal adequately in a short review with the wealth of material here provided. The Director reaffirms his conclusion that conditions of approximately perfect Hayford isostasy are not met with in peninsular India; but the interested reader must be referred to the Report itself for a description of the numerous investigations. Work with the Cambridge pendulum apparatus is being vigorously pursued, old values being revised and new stations added, with the object of having one station in every seventy-mile square.

The Survey of India has made remarkable contributions to geodesy in the past. It is doubtful if any single volume has approached in interest and instruction that of the year under review.

G. T. McC.

[1] Geodetic Report, Vol. 5, of the Survey of India. From Oct. 1, 1928, to Sept. 30, 1929. Published by order of Brigadier R. H. Thomas, Surveyor-General. 8vo., pp. 150+29 charts. (Dehra Dûn: Geodetic Branch Office, 1930.) 5*s*. 3*d*.

[2] Bomford, G., NATURE, June 8, 1929, vol. 123, p. 873.

Obituary.

THE death on Dec. 28 of Prof. Eugen Goldstein, head of the Astro-Physical Section of the Potsdam Observatory, removes an observer whose work on the phenomena which accompany the passage of electricity through rarefied gases is well known. He was born at Gleiwitz on Sept. 5, 1850, was educated at the Ratibor Gymnasium and the Universities of Breslau and Berlin. At Berlin he worked under Helmholtz at the electric discharge in vacuum tubes, and in 1876 his first paper on the subject appeared in the *Berliner Berichte*, and was followed for fifty years by a long series dealing with cathode and anode rays and the influence of magnetic fields and of the dimensions of the discharge tube on the character of the discharge. He maintained throughout that the luminous discs of the positive column were repetitions with decreased intensity of the cathode glow. His recent work was mainly on the complex discharge near the anode, but he is probably best known for his discovery of the anode or canal rays. He was awarded the Hughes Medal by the Royal Society in 1908.

WE regret to announce the following deaths:

Mr. R. G. Lunnon, lecturer in physics at Armstrong College, Newcastle.

Dr. A. P. Maudslay, president in 1911–12 of the Royal Anthropological Institute, who was well known for his investigations of Mayan and Aztec sites in Mexico and Central America, on Jan. 22, aged eighty-one years.

Mr. H. W. Monckton, sometime treasurer and several times vice-president of the Geological Society, and vice-president and treasurer of the Linnean Society up to the time of his death, on Jan. 14, aged seventy-four years.

Prof. C. Y. Wang, professor of pathology in the University of Hong-Kong, author of numerous papers on tuberculosis and other bacterial diseases, on Dec. 16, aged forty-two years.