

of the colours and on account of the ease with which the surface can be given a satisfactory polish.

It is clear from the observations mentioned above that the colours under discussion are in the nature of *diffraction effects* arising from a film which is not continuous, but has a close-grained structure. Interesting effects are observed when the surface of the illuminated plate is viewed through a nicol, the colour and intensity of the scattered, as well as of the regularly reflected, beams varying as the nicol is rotated about its axis. The most striking effect is obtained when the direction of observation is nearly parallel to the surface of the plate. The scattered light in this case is nearly completely polarised, and the colour of the regularly reflected light changes nearly to its complementary when the nicol is turned through 90° . The phenomena strongly recall to mind the observations of R. W. Wood on the colours of a frilled collodion film on a silvered surface, which have been discussed by the late Lord Rayleigh (*Phil. Mag.*, November, 1917), and it seems probable that the explanation of the phenomena will ultimately be found to be somewhat similar in the two cases.

C. V. RAMAN.

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October 11.

MR. MALLOCK has shown that the colour of the oxide film is an *intrinsic* property of the material of which it is composed and the material retains this property as it is gradually ground down from its original thickness to the vanishing point. Sir George Beilby's observations have confirmed this, and have further shown that the film is an aggregate in *open formation* through which oxygen molecules can penetrate to the metallic surface. For each temperature above the tempering range the thickness of the film is determined by the porosity of the aggregate to the oxygen molecules at that temperature. Direct experimental observations have shown the part played by *time of heating* at any given temperature. For example, at 275° C. a deep purple was reached in ten minutes, and this changed to blue from the margin inwards during a further period of twenty minutes. It was thus shown that the watchspring-blue, which could immediately be produced by a temperature of 300° C., could also be produced by heating at 275° for thirty minutes. Sir George Beilby's view is that the *intrinsic* colours of the films which are produced at different temperatures result from changes in molecular aggregation in relatively open formation of a similar nature to those which have been shown to occur in thin metal films, e.g. gold. This is referred to in his recently published volume entitled "Aggregation and Flow of Solids," sections 3 and 10.—ED. NATURE.

Some Terrestrial Experiments on Gravitation and Einstein's Theory.

THE object of this letter is to direct the attention of writers on Einstein's theory of gravitation to some recent experiments on the terrestrial aspects of gravitation which seem to have been overlooked, although they appear to be of great importance for the purpose of forming a just estimate of the correctness of Einstein's theory.

The first investigation referred to is that of Dr. P. E. Shaw on the effect of temperature on gravitational force (*Phil. Trans.*, 1916, A, vol. 216, pp. 349-92). On p. 390 Dr. Shaw writes:—"When a large mass attracts a small one, the gravitative force between them increases by about $1/500$ as the temperature of

the large mass rises from, say, 15° C. to 215° C." The only cause capable of producing this effect on the relativity theory seems to me to be the absorption of heat by the large mass (lead), amounting to 6 calories, or 2.5×10^8 ergs per gram, and resulting in a fractional increase of inertial mass of about 2.8×10^{-13} . We require 7000 million times this amount in order to account for Dr. Shaw's result on the hypothesis of the proportionality of the gravitative and inertial masses, which is one of the basal assumptions of Einstein's theory.

Another investigation is that of Majorana on the absorption of the gravitational flux (*Phil. Mag.*, vol. 6, No. 39, pp. 488-504, 1920), in which he finds, *inter alia*, that a lead ball weighed in *vacuo* loses 7.7×10^{-10} of its weight when it is surrounded symmetrically by 104 kg. of mercury. If the gravitational flux be assumed to be absorbed by the mercury according to an exponential law of density and thickness, the *quenching constant*, or factor of absorption, is found to be 6.73×10^{-13} per unit density and length. A possible interpretation is that the gravitational mass of a homogeneous sphere at an outside point is only a fraction of its inertial mass; according to Majorana, it is about one-third for the sun. If this interpretation be legitimate, the results of Majorana, like those of Shaw, lead to the conclusion that the gravitational and inertial masses are not proportional to one another in all circumstances.

G. A. SCHOTT.

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January 5.

British Scientific Instruments.

IN the timely and encouraging leader in NATURE of January 19, with which my experience is in entire agreement, there is a point of some importance to which reference is omitted. This is the practical question of cost. I would ask permission to draw a moral for application at the present time. Without expressing any opinion as to whether this cost could be reduced by improved methods of manufacture, I would direct attention to the fact that in the impoverished state of the finances of universities and similar bodies it is impossible adequately to equip their laboratories with costly apparatus.

The moral is this: *The most effective way in which Government intervention can assist British makers of scientific apparatus is to increase the grants to universities and to research in general.* It is impossible for individual workers to purchase expensive British instruments out of their own incomes, and until the resources of the laboratories in which they work are sufficiently increased it is an unjustifiable and foolish restriction to prevent their obtaining from abroad apparatus often admittedly inferior, but capable of good use. How many laboratories can afford to obtain Hilger optical apparatus or the Cambridge string galvanometer? It is further to be remembered that as science advances the instrumental equipment for continued pushing forward tends to become more elaborate, sensitive, and accurate, and necessarily of greater cost.

W. M. BAYLISS.

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Globular Lightning Discharge.

THE following is an account of what appears to have been a genuine case of globular electrical discharge observed by the sisters of one of my colleagues, the Misses Pitman, at Eastbourne on August 17 last. Authentic instances of this phenomenon are rare, and as the conditions which accompanied this particular

ball were observed with some care it seems desirable to put the case on record.

The two ladies were sitting at table about 8 p.m., with the window open. It was raining heavily at the time, and there was no wind. Stormy clouds were about, but it was not unusually hot. Thunder and lightning at the same time were afterwards reported from London—a distance of, say, 50 miles—but there was no thunderstorm at Eastbourne. There had been no rain during the few preceding days. As one of the ladies took up a knife to cut bread the ball of light was seen to flash past the knife (without touching it) on to the table, travelling a distance of about 9 in. at an average height of about 3 in. from the table, but moving towards the latter.

When the ball touched the tablecloth it "went out with a spitting sound," leaving no mark or trace of any sort. Until it touched the cloth there was no sound, and the whole thing was over in such a "flash of time" that it was impossible to say how fast the ball travelled. There seems to have been an impression that the ball came from the direction of the open window, but it was only under dependable observation during its 9-in. path from the bread-knife to the tablecloth.

As to the appearance of the ball itself, it was "about the size of a pea, the light encircling it being about the size of a golf ball. The light was white and intensely bright, like electricity." "Too dazzling to see through."

A. P. CHATTOCK.

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Where did Terrestrial Life Begin?

FOR a long time now the idea has prevailed that life began in the sea or in the mud of the seashore, and many interesting articles have been written to describe the emigration of sea-creatures and water-creatures to the land, but there are some difficulties in the way of this theory which do not seem to have been noticed, and on broad general grounds it is, perhaps, more probable that life began on mountain-tops.

Life became possible on the earth only after it had cooled to a certain point, and surely that point was reached much sooner on hilltops than in the sea or on the seashore. It must be remembered that the sea when first formed would have a temperature of more than 100° C., since the condensation of volcanic steam must have taken place under a massive atmosphere of carbon dioxide. This heavy atmosphere would not only raise the boiling point of the sea, but would greatly retard its cooling, which would in any case be a very slow process, since the sea-bed would be hot and the sea deep, and a bad conductor. Would not the mountain-tops have become cool and habitable centuries before the temperature of the sea fell to 111° F. and became a fit abode of life? Further, it is almost certain that the first life was green chlorophyll-carrying cells which would require sunlight, and sunlight would pierce the heavy and cloudy atmosphere of steam and carbon dioxide, and would reach the hill-tops long before it reached sea-level.

For these reasons it seems that life is more likely to have made its first appearance on the mountain-top of the Polar regions than in sea-mud or seawater.

RONALD CAMPBELL MACFIE.

DR. MACFIE'S suggestion that life originated on the mountain summits is new, and entitled to careful consideration. If the early earth, when its atmosphere was laden with carbon dioxide and steam, had been windless, then the mountain summits would have

stood like islands above a sea of hot mist, and they would have been the only situations possible for the development of life; but as any wind would have at times submerged the mountain summits beneath the lower atmosphere, they would have been subject to violent fluctuations in temperature and moisture which would have been unfavourable to primitive life. It may be doubted whether life could have appeared on the earth until later, when the temperature and the atmosphere were more similar to those which have existed throughout all the time of which there are contemporary geological records as to climate and geographical conditions.

In the discussion on this question in a chapter of "The Making of the Earth" I laid stress on an equable environment as an essential condition for the development of Protobion, the most primitive form of life. If that view be sound, then life was not likely to have developed until a considerably later stage on the earth than that at which the conditions stated by Dr. Macfie would have held. His letter involves the issue whether the first life was semi-aquatic or terrestrial. On his assumption that it is "almost certain" that the first life consisted of cells containing chlorophyll it would certainly have begun on land. But such an organism would be more complex, and, therefore, probably later in development than some simple form of amœboid or mycetozoon, to which strong sunlight would have been less beneficial, and for which the unchanging environment on the muddy shores of a primeval lagoon would appear to be a more suitable medium than a mountain summit.

J. W. GREGORY.

Rainfall and Drainage at Rothamsted in 1921.

IN view of warnings that are being issued by various water companies that waste of water should be avoided, the rain and drainage figures of the Rothamsted Experimental Station for 1921 are of considerable interest and significance. The drainage gauges were built in Barnfield in 1870 by Lawes and Gilbert, and contain undisturbed soil which is kept bare; each gauge measures 1/1000 acre. The soil is a rather heavy loam with a reddish subsoil over chalk.

	Rainfall 1/1000 acre gauge. Inches.	Percolation.		
		Through 20 inches of soil. Inches.	Through 40 inches of soil. Inches.	Through 60 inches of soil. Inches.
For year 1921	16.093	5.766	5.984	5.479
Average for 50 years ...	28.692	14.834	15.482	14.659

The significance of these figures is that not merely is the rainfall and drainage the lowest since the records started, but that whereas in a normal year about 50 per cent. of the rainfall evaporates, during the past twelve months as much as 63 to 65 per cent. evaporated. This is partly accounted for by the excess of sunshine, which at this station amounted to 159 hours above the average, or about 26 minutes a day.

The number of days on which rain fell (0.01 in. or more) during the past twelve months is 119; this compares with an average for sixty-eight years of 174.

It is interesting to recall the fact that the year 1902, which hitherto gave the lowest percolation figures, was followed by the wettest year on our records, when the heavy rain-showers gave a drainage of 24 in.

W. D. CHRISTMAS.

Rothamsted Experimental Station, Harpenden,
January 16.