agreement must hold, in all the experiments directed to detect the total motion, for the ballistic principle has been just introduced from Ritz for the purpose of extending the mechanical principle of relativity to all physical phenomena. This means that the ballistic theory is a *relativistic* one, like that of Einstein, with the two advantages of preserving classical mechanics and of explaining variable stars.

For the sake of completeness, it must be remembered that only in one event would the Michelson-Morley experiment trouble the ballistic theory, that is, only if in repeating the experiment with extra-terrestrial light the result were also negative. Of course, an astronomical light source is not dragged by the earth; light speed, therefore, on the ballistic theory should appear to a terrestrial observer different towards and normal to the motion. Thus, an effect should be expected. As a matter of fact, this experiment proposed by myself in 1912 (*Nuovo Cim.* vol. 3, p. 345, 1912; *Phys. Zeit.* vol. 13, p. 1129, 1912), and recently attempted (R. Tomaschek, *Ann. d. Phys.* 73, p. 105, 1924), cannot give a decisive result, for many difficulties increase when the light falls on a movable mirror, as I have already pointed out (*Ann. d. Phys.*, 75, p. 195, 1924).

In conclusion, ballistic theories are very promising, because they enable us to explain all the phenomena of classical optics and electromagnetism, including the deflexion of light rays near the sun, and they are also fruitful in explaining variable stars, while they finally reconcile both the undulatory and the quantum theories required by recent discoveries.

M. LA ROSA.

R. Università-Istituto Fisico, Palermo,
November 18.

### The Rare Gases of the Atmosphere.

ONE of the unsolved questions of geophysics is whether the earth's atmosphere is mainly primitive, or whether its constituents have for the most part been evolved from the interior of the earth since solidification. Dr. Aston's letter (NATURE, Nov. 29, p. 786) may help to answer this question. The tendency of a gravitating planet to collect heavier molecules to itself, and in certain circumstances to lose the lighter ones, would not by itself account for the rarity of the inert gases. Xenon and krypton have the highest molecular weights of all the atmospheric gases, and would therefore be the most abundant if this were the sole explanation. Possibly the ability of other elements to form stable solid and liquid compounds has co-operated. If so, we may contemplate a heated primitive earth surrounded by a tenuous atmosphere consisting largely of the rare gases as at present represented, with the possible exception of helium. The greater part of the atmosphere, the water, and perhaps the helium, would have been emitted from the interior in the course of the earth's development.

I am much indebted to the reviewer for his careful and kind notice, in NATURE of November 22, of my book "The Earth." He has, however, misunderstood me in regarding as a lower limit my estimate of 0·14 astronomical unit as the radius of the primitive sun, at the time of the tidal encounter. It is an upper limit, based on the fact that the sun would have been too cold to be gaseous if its size were any greater. I doubt whether any serious change will be necessitated by the sudden death of the giant and dwarf theory while my book was in the press, but cannot as yet be sure.

HAROLD JEFFREYS.

### The Temperature of Mars.

IN a recent paper (Pub. Ast. Soc. of the Pacific), Nicholson and Pettit calculate the temperature of the planet Mars, based on their radiation measures made at Mount Wilson. Most confidence is placed on measures made in the region 8 to 14$\mu$, by the use of filter screens, and an emissivity of unity is assumed for all wave-lengths. However, Mars, being probably composed of material not unlike the earth, would radiate more like sand or quartz than like a black body, and it can be calculated from curves given by Wood ("Physical Optics") and data given by Rosenthal (*Wied. Ann.* 68, p. 783), that the average ratio of the emissivity of quartz to that of a black body in the region 8 to 14$\mu$, is 0·819. The values of the emissivity of quartz given are far below that of a black body between 8 and 10$\mu$; they are nearly the same from 10 to 14$\mu$; the average ratio is taken.

It is believed that temperature calculations using this value for the emissivity, and the fourth power radiation law, will be more correct than when an emissivity of unity is assumed. For a given amount of received radiation, the temperature of the radiating body will be higher for a lower emissivity. Accordingly, the temperatures T given by Nicholson and Pettit have been recalculated by applying the method separately to each value of T.

$$\frac{T^4}{T_e^4} = 0{\cdot}819.$$

| | T. | $T_e$. |
|---|---|---|
| Centre, full phase . . | 280° absolute | 294° |
| Limb . . . . | 260° | 273° |
| Pole cap . . . . | 205° | 216° |
| Integrated disc . . | 250° | 263° |

CARL T. CHASE.

Norman Bridge Laboratory of Physics,
Pasadena, Cal., November 15.

### Low-Voltage Arc Spectra of Copper.

IN my letter which appeared in NATURE of October 4, p. 501, I reported work I had carried out on the low-voltage arc in copper vapour. I have since then succeeded in obtaining the line absorption of normal copper vapour. The lines which are certainly absorbed, and which, therefore, should be 1*s* combinations, are:

| | |
|---|---|
| 3247·55 | 2244·24 |
| 3273·97 | 2225·67 |
| 2492·14 | 2165·06 |
| 2441·63 | |

With slight uncertainty there are also the lines:

2181·68
2024·33

In addition, I find from combinations that 2178·91 should also be absorbed, but this is not sufficiently resolved from 2179·39 by the small spectrograph used.

By subtraction from the term 1*s*, the above lines give energy-levels which are all confirmed by combinations with other known terms of the copper arc spectrum. From the arc lines previously reported I have also calculated a number of other terms.

A paper is being written incorporating all these results. A. G. SHENSTONE.

University of Toronto,
Toronto, Canada, November 26.