What is the Physical Condition of Sun's Interior

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THE telescope reveals the Sun's exterior as of a mottled appearance, suggesting the idea of clouds. And the rapid changes that apparently take place at the Sun's bounding surface lend support to the view that what we see is of a volatile atmospheric nature. The spectroscope informs us that the Sun's exterior is composed of metallic and a few non-metallic substances in a gaseous state, chiefly iron, calcium and hydrogen. No doubt the formation is due to the partial condensation of the hot gases escaping upwards into the cooler regions at the surface. But the question as to the condition of the Sun's interior is a much more difficult one. W. Herschel held the truly extraordinary opinion that the interior of the Sun was a solid, and that the photosphere acting as a shield against the heat of the Sun's exterior, rendered the solid globe within fit for habitation! Since it has become recognized that the Sun's interior is at least as hot as its exterior, the view has generally prevailed that its interior must be composed of matter in a molten condition. It is, however, scarcely possible to regard the Sun's interior either as a solid or a liquid, for even at the cooler surface the most refractory metals are found in a gaseous state. It used to be thought that the enormous pressure that prevails towards the Sun's centre would reduce the gases to a liquid condition, since laboratory experiments proved that any gas can be liquified, if sufficient pressure be employed. But Andrews proved a few years ago that at certain critical temperatures gases resist liquification. Hence we cannot as yet tell what is the actual condition of the Sun's interior.

The Climate of the Planet Mars

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IT has become the fashion now-a-days to speak of the climate of Mars as worse than arctic in character, and its surface as a succession of "bleak arid deserts over which the rays of the Sun would seem to struggle in vain to mitigate the blasting chill of the attenuated air." Let us look into the question of Mars' climate a little more closely. There is little doubt but that if our Earth were removed to the same distance from the Sun as Mars, all our oceans, equatorial as well as arctic, would be eternally ice-bound. But the polar ice-caps of Mars never extend to lower latitudes than do those of the Earth, and in summer recede even further towards the pole. It has, therefore, sometimes been claimed that the temperature on Mars may for certain reasons be even higher than the Earth's. We will first discuss (*omnibus paribus*) what should be the fall of temperature as compared with the Earth's, due to enhanced distance from the Sun. Since Mars is roughly one and a half times the distance of the Earth (and radiated heat varies as the sub-duplicate ratio of the distance), the heat at Mars should be four-ninths of that at the Earth. The heat at various zones of the same globe varies as the incidence of the Sun's rays. It can be calculated that an equally wide zone at 63° latitude will have an area four-ninths of that at the equator. Further, owing to its obliquity to the heat rays, the heat received per unit area would also be reduced by about four-ninths. Thus the temperature at Mars' equator, accounted for solely by distance, is equal to that of the Earth at latitude 63°, or of Iceland and Greenland. Now for many reasons it appears that Mars' climate must be much less rigorous than this estimate, namely, that even at its equator it has the same temperature as at the Earth at 63° latitude. How then can we modify this estimate by other considerations? We cannot suppose a greater outward flow of heat from Mars' interior. For Mars was in all probability developed anterior to the Earth, and again being a smaller body its heat would have radiated more rapidly than the Earth's. Moreover, heat flowing outwards is a practically negligible quantity in the determination of surface temperature. The only good reason that can be alleged for supposing a higher temperature on Mars' surface is the principle of selective absorption. Thus, whilst the interposition of a pane of transparent glass will scarcely affect the temperature of the Sun's rays, upon a thermometer, it will greatly reduce the temperature of heat rays proceeding from a fire-place in a room. Indeed a glass screen in this case is almost as effective as an opaque screen. The cause of this is doubtless due to the particular property of the rays emanating from the source, and the rapidity of the vibration of the ether of space. Again, a hot-house will greatly exceed the temperature of the outside air (owing to this principle of selective absorption), for the Sun's rays will easily penetrate the glass roof, but the essentially different kind of rays radiated back from the plants will not be able to penetrate the glass again and escape. Many gases and especially water vapour act much in the same way as glass. By a series of accurate experiments Tyndall has shown that water vapour can retain and prevent the escape of as much as ten per cent. of the Sun's heat rays. Herein then lies the cause, which may in the matter of temperature compensate for Mars' greater distance, namely, that the water-vapour there is so profuse, that it effectually prevents the escape of the small amount of heat received from the Sun, and hence the temperature on the surface may be maintained at a high standard. Both the low intensity of gravitation on Mars, and the almost certain extreme tenuity of its atmosphere, are favourable to the existence of very large quantities of water-vapour. Evaporation continues until the vapour of water has been formed, such that it should (independently of any other atmosphere present) produce such a density in the vapour at the surface, as would prevent further evaporation. And since surface gravity on Mars is only two-fifths that on the Earth, the quantity of water on Mars may be two and a half times proportionately greater than on the Earth. Again, evaporation would take place more rapidly in the attenuated atmosphere of Mars, and hence the loss of vapour due to condensation would be more quickly restored. We will now turn our attention to the effect gases may produce in raising Mars' surface temperature. It is known that above about eight miles high, the temperature of the Earth's atmosphere is constant at—47° centigrade. And assuming that the atmosphere of Mars presents the same order of conditions, we can estimate the gases that could be retained, and those that must inevitably escape from the planet Mars. Jeans has proved that at a temperature of—175° hydrogen will certainly be retained, whilst at—65° it will certainly be lost. The same conditions hold good for helium at—81° and—136° respectively, and for water-vapour at 599° and 1,583°. Hence if we suppose (for the sake of argument) the isothermal stratum of the Martian atmosphere to possess approximately the same temperature as the Earth's, hydrogen would have escaped but not only water-vapour but even helium would have been retained. If, however, the isothermal stratum be colder than the Earth's, the chief result would be the depression of gases and especially carbonic acid gases towards the lower strata. And this would have a very important effect upon the general climate and its consequences. It is now universally admitted that even a small proportionate increase in the amount of carbonic acid for a unit volume of air, will produce a very powerful effect in raising the temperature. For, next to water-vapour, carbonic acid gas is the most potent retainer and absorber of the Sun's rays. Hence there will be a great elevation of temperature, and vegetation will be very luxuriant. Water containing large quantities of carbonic acid will act powerfully upon the silicates and other minerals, and cause a rapid formation of carbonates. Again, the carbonic acid issuing from Mars' interior will further increase the temperature. Hence we maintain (as against the now generally received opinion that the climate of Mars is more than arctic) that, on the contrary, it is nowhere too cold to prevent the chemical reactions of carbonic acid in solution, or to arrest the development of the most luxurious vegetation upon the greater part of the Martian surface. And at the same time, the amount of carbonic acid it is necessary to assume as existing on Mars (in order thus to greatly raise the temperature of its climate) would not be so great as to be at all injurious to animal life, even supposing it were of the same type as the terrestrial.

The Rotational Motion of the Orion Nebula

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A RESUME of the results of the new application of the "Method of interferences" to the study of the Orion Nebula may be found interesting. The method has been applied by the astronomers Buisson, Fabry and Bourget. By its means the radial velocity of various parts of the nebula can be measured. The line H gamma in the spectrum has been specially chosen for examination, because it exists also in the spectrum of the nebula. The position of this line was compared with that of its comparison spectrum in the laboratory. It has thus been found that the radial velocity of the nebula varies from point to point, and on an average it is about 9 miles per second. The region surrounding the Trapezium rotates in an almost opposite direction to that of our Sun. And in general it may be said that whilst the outer Sp. region recedes from us at about 3 miles a second, the Sf. region approaches us at about the same rate. It can be readily gathered from the above statements that its rotational movement is very irregular. It may be described very roughly as rotating from S.E. to N.W. Further, both the atomic weight and the temperature of the nebula can be found by this same method.