

ART. L.—*On Gravitation in Gaseous Nebulae*; by FRANCIS E. NIPHER.

THIS subject has received attention of late through the work of Dr. See, who has rediscovered the law announced by Ritter in 1878. According to Ritter, if  $R$  be the radius of a spherical mass of gas of cosmical dimensions, and  $T$  its temperature, the product  $TR = \text{constant}$ . As Ritter announced, the heat capacity of such a gravitating mass is negative. If heat leaves the gas, it contracts and becomes warmer. Dr. C. M. Woodward has recently published a paper\* in which he deals with the conditions of equilibrium in such a mass, and he deduced the equation for the mass of the central core of a gravitating spherical nebula

$$M = \frac{2CT_0 r}{K}$$

Here  $C$  is the constant for the gas, and  $M$  is the mass internal to any radius  $r$ .  $K$  is the gravitation constant and  $T_0$  is the constant temperature of the mass. Woodward admits that if such a mass could be contracted, its temperature would rise, but he denies that gravitation is competent to contract the gas, and even concludes that such a nebula cannot lose heat by radiation.

The present writer, in the succeeding number of the Transactions, has shown that such contraction is possible; and that when  $T$  is made variable in the above formula, the value of Ritter's constant is determined by that equation, in terms of the gravitation constant, the constant for the gas, and the mass  $M$  internal to  $r$ .

This equation is then applied to a cosmical mass of hydrogen. What must be the physical condition in order that a central mass or core, having a radius equal to that of the sun, should contain a mass equal to that of the sun. The conditions of the problem determine  $r$ ,  $C$  and  $M$ ; and  $K$  being known, the value of  $T$  turns out to be 20,000,000 degrees centigrade. The pressure at the surface of this sphere is computed, and it is found to be  $3.706 \times 10^{14}$  dynes per square centimeter, or 366,000,000 atmospheres. The average density of the spherical mass, which is three times the density at the surface of the hydrogen sun, is about 7 per cent less than the average density of the sun itself. The pressure at a distance of 92 million miles from the center of mass is found to be about 0.4 of an atmosphere.

\* Trans. Acad. of Sci. of St. Louis, vol. ix, No. 3.

The equations show that the same pressures and densities would hold for any other perfect gas. In fact, the above equation shows that if  $r$  and  $M$  are fixed, the product  $TC$  must be constant for all gases. This carries with it the conclusion shown by the other equations, that the average density of such a solar mass is independent of the nature of the gas. This is a matter of great significance, when taken in connection with the fact that the real density of the sun is only slightly greater than the density of the hypothetical hydrogen sun.

The real condition around our sun is, that increasing opacity to radiation as one goes to levels of smaller radius, has retained the heat within the dense nucleus. The rarefied external parts of the solar nebula have parted with their heat and the temperature throughout the mass has ceased to be uniform. Interplanetary pressures have been abolished. Hydrogen would solidify at a distance of 92 million miles from our sun if away from any large mass of matter. And this obliteration of cosmical pressure has almost wholly compensated the fall in temperature of the sun from 20 millions at least to perhaps 10,000 degrees.

The fact that a gaseous mass can apparently contract itself, and heat up in some such way as it would do if it were compressed by the action of some external system, is obviously of profound significance. The clue that it seems to give concerning the nature of gravitation is well worthy of the most serious attention. Is not gravitation the action upon matter of a system wholly external to matter?