Chapter 19.

On Gravity and the Forces acting on Heavenly Bodies.

140. Gravity arises from the unequal pressure of the aether, which increases with increasing distance from the earth; therefore the bodies are more strongly pushed towards the earth than away from it, and the net excess of these pushing forces is the weight of the body.

Those who explain gravity by an attractive force of the earth, base their opinion mainly on the absence of any other demonstrable cause for this force. But since we have shown that all bodies are surrounded by aether, and are pressed by its elastic force, there is no need for us to seek the cause of gravity elsewhere. However if the pressure of the aether were the same everywhere, which would be a necessary condition for it to be in equilibrium, the bodies would be pressed equally from all directions, and would thus not be set in motion. But if we assume that the aether surrounding the earth is not in equilibrium, but that its pressure decreases the closer one approaches earth, then each body must experience on its upper surface a downward pressure that is greater than the upward pressure on its lower surface; in consequence the downward pressure will maintain the upper hand, and the body will really be pushed down by it, an effect we call gravity, whilst the downwards pushing force itself is called the weight of the body. We have already remarked that no coarse body can be significantly propelled by the impact of subtle matter, since the heavenly bodies experience no discernible resistance to their rapid motion through the aether; therefore the cause of gravity must be sought solely in the pressure of the aether. But if the pressure of the aether decreases closer to earth, then it can not be in equilibrium or at rest; all its particles must be pushed downwards equally strongly as coarse bodies, and a movement amongst them must arise in accordance with these forces. From this in turn it follows that if the aether around the earth is in motion, and this movement is the stronger the closer it is to the earth, then its pressure must become progressively smaller as earth is approached. Therefore if we only could explain why the aether is not in equilibrium in the neighborhood of the earth, but is put into motion, then we would have discovered the true origin of gravity.

141. Gravity acts on bodies only to the extent that they consist of coarse matter; and the weight of a body is the greater, the greater the space that is filled with coarse matter, that means: the weight of bodies is proportional to their true size.

The subtle matter contained in the open pores of bodies is in free communication with the external aether and takes no part in the movement of the body, for which reason it its distinguished from its proper matter. But that which is contained in the closed pores, does move with the body; however its quantity, as we have seen in the case of air, is so small, that it can more or less be neglected. It is therefore only necessary to consider the coarse particles, on which the aether acts with its pressure, and since each of them is pushed downwards, the weight of the body is given by the sum of all forces that act on the coarse

particles. But it is known from the nature of pressure in liquid matter that the force it exerts on a body is proportional to its size, and that its shape does not contribute to either an increase or a decrease of the force. Therefore every body is pushed downwards with a strength as if only its coarse matter were pressed together in a lump, the extent of which we have in the above called the true size of the body, to distinguish it from the apparent size, which also includes the pores. If we therefore denote by c^3 the true size of a body or the space that is only filled by its coarse matter, then this body is pushed downwards by the pressure of the aether with the same force as a cube of coarse matter, the side of which is c, or of any other shape of volume c^3. If we assume a column of base aa and height b, such that $aab=c^3$, then this column will have the same weight as the body. As stated, this follows from the theory of the pressure in liquid matter, where it is shown, that the entire force it exerts on a body is proportional to its size. Since weight is due to the pressure of the aether, it must likewise be proportional to the true size of a body, and a body that according to its coarse matter is twice as big, must have twice the weight.

142. Since experience teaches that the further a body is away from the centre of the earth, its weight is decreased in proportion to the square of the distance, then in order to explain this, the pressure of the aether towards the centre of the earth must decrease such that the decrease is inversely proportional to the distance.

Let the true size of a body, that we imagine as a column *aabb* (Fig.17), be c^3, with base areas $aa=bb=a^2$ and length $ab=b$, so that $a^2b=c^3$. Let the length of this body be oriented

Space for Figure 17.

towards the centre of the earth at a distance $CP=x$, for we regard the size of the body as negligible compared to this distance. If we call P the weight of this body at the surface of the earth, the half diameter of which we call r, then, according to experience, the force that drives the body towards the earth, when it is at distance $CP=x$, is equal to Prr/xx. To calculate this force, let us denote the pressure of the aether when at rest by the height h, and since at P its equilibrium is disturbed and its pressure is smaller than h, let it, at distance $CP=x$ be smaller by the force A/x and therefore be $h-A/x$, so that the diminution is in inverse ratio to the distance $CP=x$. Through this pressure the base aa is pushed away from C and the force due to this pressure will be $aa(h-A/x)$. The other base bb is at a distance further from C by the amount b, where the pressure of the aether is $h-A(/x+b)$; therefore the body is pushed towards C by the force $aa(h- A/(x+b))$. Since this is greater than the former, there results from both together a force that pushes the body towards C, having a magnitude

$$aa\left(h-\frac{A}{x+b}\right)-aa\left(h-\frac{A}{x}\right)=aa\left(\frac{A}{x}-\frac{A}{x+b}\right)=\frac{aabA}{x\left(x+b\right)}=\frac{Ac^3}{x\left(x+b\right)}.$$

But since b is negligible compared to x, the force pushing towards C is $\frac{Ac^3}{xx}$ and thus inversely proportional to the square of the distance from C; therefore if the body is on the surface of the earth, where $x=r$, then its weight will be $P = \frac{Ac^3}{rr}$, which thus is proportional to the true size of the body

143. The loss suffered by the elastic force of the aether in the vicinity of the earth is very great, and therefore the elastic force of the aether, when at rest, must be very much greater than that which through its pressure acts on bodies on earth.

The height h is to represent the elastic force of the aether in equilibrium, the height $h-A/x$ that which the aether exerts at distance $CP=x$ from the centre of the earth. Now we have seen that the thus arising force, which pushes a body of true size c^3 towards the earth, is Ac^3/xx, and if we take this body to be at the surface of the earth, then its weight will be Ac^3/rr, where r indicates the half diameter of the earth. In order to express the magnitude of this weight in a more convenient form for calculation, we want to express it in terms of an equally heavy mass of water, so that subsequently the height that determines the elastic force is expressed in terms of water, just as the elastic force of air is taken as equivalent to a water height of 32 feet. But a body of true size c^3 is heavier than a cube of gold of side c and therefore more than 19 times heavier than a cube of water of equal size. Therefore the weight of our body will be greater than $19c^3$ and consequently A will be greater than $19rr$. Let us put $A= 40rr$, then the elastic force of the aether at the surface of the earth will be $h - 40r$. Consequently the water height h, representing the pressure of the aether when in equilibrium, be much greater than the radius of the earth multiplied by 40, because its diminution on earth is already $40r$, i.e. approximately 700 million feet, compared to which the water height of 32 feet is negligible. The immense size of this pressure causes no small astonishment, however if gravity arises from the pressure of subtle matter, the conclusion is quite correct. If other phenomena in Nature require a smaller force, it follows that more than one kind of subtle matter must be assumed to exist in the world, thus by way of example we have already seen that air is distinguished from the aether, despite the fact that it is suspended in the latter and has similar properties.

144. Since experience shows that in an evacuated space all heavy bodies fall equally fast, the weight of each body must be proportional to its mass. But since the weight is also proportional to the true size, it follows that if the true size is the same, then there is also the same amount of coarse matter present.

It has already been shown above that if two bodies are to be imparted the same motion, then the forces must be proportional to their masses. But because, when there is no external resistance, all bodies fall equally fast, the downward acting force or gravity must be proportional to the mass. For this reason all explanations of gravity are eliminated that are derived from the impact of a subtle matter that streams onto the bodies, since the

magnitude of this impact depends on the shape of the bodies, since it is known from experience that however the shape of a body may be altered, it will keep the same weight. But if we derive gravity from the pressure of a subtle matter, then this must be proportional to the true size, i.e. to the space occupied by the proper or coarse matter; from which follows that the mass or quantity of coarse matter is proportional to the space it occupies. For the same reason it has already been determined above that all coarse matter is equally dense and that its density can not be altered by any means. The latter follows at once from the fact that the weight of a body always remains constant however its shape might be altered. This theorem, that establishes the nature of coarse matter, is only here fully illuminated and given the necessary proof, on which we have already based argument above. It is also automatically clear that this proof is not invalidated by the fact that up till now we have assumed the theorem to be true, since everything that was derived from it has no influence on the present conclusion. If one furthermore considers that the subtle matter, that produces gravity, does not in the least resist the movement of bodies, there can be no place for other explanations, such as have so far appeared.

145. Just as the elastic force of the aether is reduced around the earth, it is similarly reduced around the sun and every other heavenly body, and with respect to every heavenly body this reduction is inversely proportional to the distance from its centre.

On this rests the general law discovered by the great Newton, with which the movement of all heavenly bodies can be determined; for the movement of every heavenly body is such as if it were constantly driven towards all others by forces which decrease in the same proportion as the square of their distances increases. Since these forces also depend on the mass and consequently the true size of the bodies, these must also originate from the non-equal ness of the pressure of the aether; for, approaching every heavenly body, the elastic force of the aether must suffer a diminution, that is inversely proportional to its distance from it. If therefore, as before, we express the elastic force of the aether, where it is in complete equilibrium, by the height h, then at a place where the distance from the centre is z, the pressure of the aether will be given by the height $h - A/z$, where the numerator of the fraction, A, will for the case of the earth have a particular constant value. If at this place there is a body, the true size of which is c^3, then this will be driven towards the sun by a force which is Ac^3/zz, i.e. it will be inversely proportional to the square of the distance from the sun. If we consider apart from the sun another heavenly body from which the above place is at a distance y, then the elastic force of the aether will also suffer through this a diminution and the height through which the latter is given at this place will be $h - A/x - B/y$. If one now takes into account all heavenly bodies, and denotes their distance from a place by the letters z,y,x,v etc. then at this place the elastic force of the aether is given by

$$h - A/z - B/y - C/x - D/v - \text{etc.}$$

and the effect of this pressure on a body at this place will be such as if it were pulled towards all heavenly bodies by forces that are inversely proportional to the square of the distances of it from them. As regards the numbers A,B,C,D etc. we can still remark that they are in the ratio of the masses of the heavenly bodies to which they refer.

146. Everything therefore depends on finding the reason why the elastic force is reduced by every heavenly body, and why this reduction is on the one hand proportional to the mass of the heavenly body, and on the other is inversely proportional to the distance from it.

Let the symbols α,β,γ, δ,φ,τ,μ,η express the masses of the heavenly bodies they represent.[1] If we now consider a place from which the distances to these bodies are *D*α, *D*β, *D*γ, *D*δ etc. then the elastic force of the aether will be given at this place as

$$h - m\alpha / D\alpha - m\beta / D\beta - m\gamma / D\gamma - m\delta / D\delta - \text{etc.},$$

where *m* indicates a certain constant quantity, that can be determined from the above mentioned case relating to earth; for we will have that $m\alpha = 40rr$ and therefore $m = 40rr/\alpha$, where *r* is the radius of the earth. Therefore if only we could determine the reason for the decrease in the elastic force of the aether, then we would have a complete explanation of all forces by which the heavenly bodies are driven. Although we have to stop here and hardly can hope ever to find the cause of the diminution of the elastic force of the aether, it is easier to resign to this than to merely maintain that all bodies are by their nature endowed with a force to attract each other. For since one can not even form an understandable concept of this attraction, one can by way of contrast at least understand how it is possible that the elastic force of a liquid matter is reduced, and one also understands that this can occur in a way that is in accordance with the laws of Nature. But everything depends on two questions: firstly, why the pressure of the aether is reduced by a coarse body within it? and secondly why this reduction becomes larger the closer one approaches the body? The reason for this must manifestly be sought in the coarse matter of which the body consists, and the coarse matter must cause in the aether a movement that disturbs the equilibrium. If one has got that far, then it is easy to show that in this way the pressure of the aether must be reduced.

[1] The original uses the conventional astrological symbols for Earth, Mars, Venus, etc. which are not available to the translator. Greek letters are used instead, with α referring to earth.