Chapter 14.

On the aether or the subtle celestial air.

105. The whole of space that is left between the coarser bodies that are accessible to our senses, is filled with the subtle matter considered above, which therefore is called the aether or the subtle celestial air.

The space between the earth and the heavenly bodies is either totally empty, or it is filled with matter; those who are of the former opinion can not persist in this view, since they must concede that everything is at least filled with rays of light, a fact which alone is able to reject the empty space. But if this vast celestial space is filled with matter, then the latter must be uncommonly subtle, since the celestial bodies can move in it so freely that hardly the least trace of resistance can be noticed. From experience we know how large the resistance is that a body moving through air experiences, from which we can confidently conclude that this matter must be far subtler; also since air becomes thinner the higher one rises above the earth, it is very probable that eventually it loses itself entirely in that matter. For air consists partly of subtle and partly of coarse matter, which latter diminishes with increasing height, and eventually vanishes totally, so that in the end the whole space is filled solely by subtle matter. This subtle matter is called by Natural Scientists aether or the subtle celestial air, since it is there pure and without admixture of coarse matter; by contrast in bodies on earth it is never found other than mixed with coarse matter; the situation will be the same regarding the bodies that are found in the main bodies of the world. Thus the whole immense universe is filled with aether, or our subtle matter, the density of which must consequently be many thousand times smaller than the density of coarse matter, from which it also mainly differs by allowing itself to be compressed into a smaller space, and then to exert its spring force. But whether or not the aether and the universe have a limited size, is a question not to be decided here.

106. The subtle celestial air is in a forced state, and is compressed far beyond its natural density, for which reason it exerts everywhere an unusually strong spring force and compresses all bodies.

We have already shown that subtle matter must have a natural density, and can only be brought to and maintained in a higher degree of density by sufficiently large forces. Here we ask whether it exists in the world in its natural state, or whether its is in reality compressed, and tries to expand through its spring force. All processes in Nature from which we infer the existence of subtle celestial air, and that cannot be explained without it, show us that it must be compressed to a considerable degree and exerts a very large spring force. We only have to consider the velocity of light rays to make us ascribe to this matter a very high degree of compression together with incredible subtlety: for since there is no doubt that light rays are propagated through the aether in a similar manner as sound is through the air, there can be no doubt about this. It has been shown by irrefutable

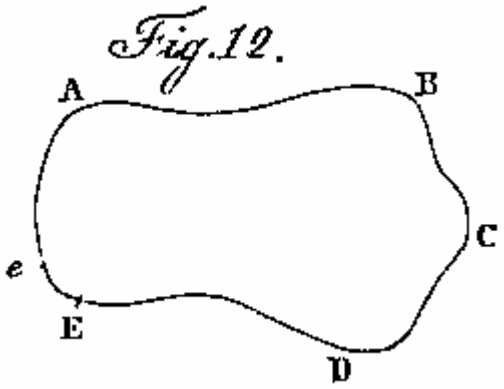
arguments that such movement must be the faster the greater the spring force of the matter in which the movement takes place, and the smaller its density. Since the velocity of light is many thousand times higher than that of sound, the spring force of the aether much be much stronger than that of air. It could be objected that the low density of the aether should be sufficient; however this must be associated with a spring force, from which a forced state arises. Other considerations such as the hardness of bodies and their spring force also lead us of necessity to a strong compression of the aether, so that this forced state is placed beyond all doubt. Since the aether possesses such a great force to expand, one will be anxious to know by what external forces this is kept within bounds; for if one considers the world as finite, and beyond it nothing but empty space, there would be nothing to prevent the aether from really expanding into it; otherwise one would have to picture the world as enclosed within a firm shell. But if one maintains the world to be infinitely large, then the difficulties concerning the actual expansion of the aether do not as yet seem to be removed. But such questions do not concern Natural Science, and we must be satisfied to examine those phenomena that have a direct influence on the processes in the world, without wishing to comprehend the divine work of creating and maintaining the world.

107. If the aether is to be at rest, then its spring force and its density must everywhere be the same; but if the density is greater at some place than at another, then it must expand from the former place to the latter and a movement must arise.

Since the aether is in a forced state, each of its parts tries to expand and to repel with its spring force all bodies around it that stand in the way of its expansion. If the surrounding bodies either exert no counter pressure, or a smaller one, it will in fact push these away and expand; but if these bodies resist with equal force from all sides, then the aether is kept in equilibrium and must remain in its state. But if the surrounding bodies press back with a larger force than the aether exerts to expand, then it will even be pushed back into a smaller space, until with increasing density its spring force becomes so great that it is able to withstand the inwards pressing force. In these cases, if a movement begins, it must be noted that once the parts of the aether have been set in motion, they can not suddenly stop when the spring force has come into equilibrium with the force pressing from outside, but the aether will, because of its persistence, either expand further or contract more, until its movement has been entirely braked by the resisting force, and since then its spring force will be smaller or greater than the force from outside, it will be set in motion anew. This makes abundantly clear that if the various parts of the aether do not have the same spring force, movement must develop amongst them, causing those with higher density to expand and the others to contract more; and because of persistence such movement must continue for some time. Therefore if the aether is to remain totally at rest, it is absolutely necessary that all its parts have the same spring pressure and the same density.

108. If the aether is at rest, then a body within it will be pressed from all sides with equal strength, and the forces acting on it will be in equilibrium such that they do not put the body into motion, unless it can be compressed, in which case it will be compressed by the aether into a smaller space.

Imagine a body ABCDE (Fig.12), which is surrounded by aether on all sides.; but let the aether be in complete rest, so that, being equally dense everywhere, it will press on the body with equal strength from all sides. For if one imagines the whole surface of the body to be subdivided into equal elements such as *Ee*, then each element will experience the same pressure, directed perpendicularly to it. It can be shown from the rules of equilibrium that all these equal forces keep each other in equilibrium, and therefore can not alter the state of the body. But it can also be demonstrated clearly and without calculation, that the body experiences the same forces that an equal mass of aether of the same shape and size would experience in its position. But it has been shown that this mass of aether is in equilibrium with that surrounding it, and therefore would not be set into motion, provided it has the same density. If therefore the body can not be compressed, then it is in the same situation as an equally dense mass of aether, and will not be set in motion by the pressure of the surrounding aether. If it had been at rest, it will remain at rest forever, but if it had been in motion, it will continue this motion uniformly, and if the forces acting on it are sufficient, it will really be driven by them into a smaller space. But if the body does not permit compression, although it is soft and flexible, then its shape will not in the slightest be changed by the pressure, since an equal mass of aether also would not suffer a change in its shape.



109. But if the aether is not in equilibrium or is not equally dense everywhere, then a body in it will not be pressed equally from all sides, and will be set in motion in the direction into which the higher pressure drives.

If the pressure of the aether were equal from all sides, then, as we have seen, the body would not be set into motion, but the forces acting on it would compensate each other completely. If we now assume that the side AB (Fig.12) receives a higher pressure than the other sides of the body, then only a part of the forces acting on AB would be kept in equilibrium and compensated by the others, but the remaining part would act on the body just as if it alone were there. The situation will be as if the body were pressed only on side AB by a force equal to the excess. If there is nothing in the way of the body, this force will change its state. If it has been at rest, it will be set into motion, but if it has already been in

motion, then either its speed or its direction or both will be altered, depending on how the force is oriented with respect to its direction. It can therefore happen that a body moves in the aether with variable speed along a curve, even if it is surrounded by nothing but aether; for this nothing is required but that equilibrium is removed within the aether, and its spring force is different at different locations. It must without doubt be ascribed to such a cause that the planets and comets move at variable speed along curves in the aether, and it is only necessary to show how and why the aether has been placed out of equilibrium.

But if the body that is pressed on by the aether lies on an other body, that hinders its movement, then the latter will exert on it an equal pressure, which explains the cause of the weight of bodies, showing it to be the same as the cause of the movement of planets.

110.If the aether is not in equilibrium, and therefore finds itself in motion, then it acts on bodies suspended in it in two ways, namely through impact and through pressure. But the effect of the former on them is so small that it can be more or less neglected.

If the density and spring force of the aether is not everywhere the same, then the aether can not be in equilibrium, but a movement must of necessity arise between its parts, as was shown above. If therefore a body such as ABCDE (figure 12) is placed in it, then it experiences not only the pressure from all sides due to the spring force, that we have considered in the previous section, but the aether will also because of its movement impact on the body as a stream, and through that exert a particular force, that must be distinguished from the mere pressure. Apart from the velocity, the force of the impact is due mainly to the density of the aether; but since this is astonishingly small, its effect on a body of fairly high density cannot be noticeable; and we must assume the density of the aether to be very low, so that the movement of the planets experiences no significant resistance, although they move with very high speed. But although the impact of subtle matter is so very weak, the pressure it exerts can be very great, since this depends on the degree of compression. For we have above (§104) quoted a formula according to which, if it really applied, the aether would at a density = *nd* already exert an infinitely large spring force, however small the density might be. When therefore the aether is in motion and acts on the planets through impact as well as through pressure, then the former force is nevertheless to be neglected against the latter, and it is as if the aether were at rest and acted solely through the pressure. Against those who want to explain the movement of the planets through the pressure of a vortex, it is rightly objected that the impact due to such vortex movement would have to be very considerable compared to the pressure, and would have to change the effect of the latter totally. But this objection, which eliminates the vortices, does not apply to the action of the aether.

111. Since the aether exerts its pressure in all directions even in its smallest parts, we must regard it as a perfectly liquid matter, which in its nature is totally liquid even in its smallest parts, and does not include any solid particles.

We compare liquid matter and solid bodies, the difference between which is to be shown more clearly below. Here we say firstly that the aether is not a solid body, and therefore is not composed of solid bodies. The first is clear for reasons which have already been stated for the highly subtle essence of the aether; for that the celestial bodies can move through it without discernible resistance could not occur if it were a solid body; however subtle one might imagine it to be, the celestial bodies would have to break through it and render it into pieces. The most prominent characteristic of a liquid is that, the aether, being in a forced state, exerts its spring force in all directions, which can not occur in a solid body, so that the aether must be regarded as a perfect liquid; but this is shown even further by the fact that it penetrates into the smallest pores of the bodies and fills them. But most of all the liquidity of the aether is confirmed by the fact that all its parts can be compressed and subsequently expand again under their own force, whilst always completely filling their occupied space without leaving any pores between each other. This is a property that it is impossible for a solid body to have; for when such a body expands into a larger space, then this occurs only to the extant that the pores it contains become larger, and such an expansion will not increase its true size. But since the aether can expand or contract even in its smallest parts, without extension or contraction of pores, even the smallest parts can not be solid; and the essence of this subtle matter demands that all its particles, however small one may imagine them to be, are perfectly liquid. All these particles hang together on all sides; and since there are no ultimate particles that could be regarded as actual units, the question as to the shape of these particles does not arise. Imaginary parts however, such as exist only in the imagination, have any shape one wishes to assign to them; if I imagine cubic or spherical particles, then that is the shape they have.