daher, wie schon früher die Vorlesungen über die Wärme, so auch jetzt die vorliegenden Vorträge über den Schall unter ihrer besonderen Aufsicht übersetzen lassen, und die Druckbogen einer genauen Durchsicht unterzogen, damit auch die deutsche Bearbeitung den englischen Werken ihres Freundes Tyndall nach Form und Inhalt möglichst entspräche.—H. HELMHOLTZ, G. WIEDEMANN."

Prof. Tyndall's work, his account of Helmholtz's Theory of Dissonance included, having passed through the hands of Helmholtz himself, not only without protest or correction, but with the foregoing expression of opinion, it does not seem likely that any serious damage has been done.]

## Apparent Size of Celestial Objects

ABOUT fifteen years ago I was looking at Venus through a 40-inch telescope, Venus then being very near the Moon and of a crescent form, the line across the middle or widest part of the crescent being about one-tenth of the planet's diameter. It occurred to me to be a good opportunity to examine how far there was any reality in the estimate we form of the apparent size of celestial objects. Venus through the telescope, with a magnifying power (speaking from memory) of 135, looked about the size of an old guinea, *i.e.*, of a crescent cut off from that coin. The Moon, to my naked eye, appeared the size of a dessert plate. Having fixed their apparent dimensions in my mind, I adjusted the telescope so that with one eye I could see Venus through the telescope, and with the other the Moon without the telescope, and cause the images to overlap. I was greatly surprised to find that Venus instead of being about one-sixth of the diameter of the Moon was rather more than double its diameter, so that when the adjustment was made to bring the upper edge of the Moon coincident with the upper point of the crescent of Venus, the opposite edge of the Moon fell short of the middle of the crescent, a very palpable demonstration of the fallacy of guesses at size, when there are no means of comparison.

On another occasion a lady was looking at Jupiter through my telescope, and having first put on a power of 60 I changed it for one of 140. To my question, what difference she observed in the size of the planet, she answered, I see no difference in size, but a good deal in brightness. Here the area of the one image was more than five times that of the other.

The fallacy of guesses at size without objects of comparison is most strikingly shown in the ordinary expression of an ignorant observer looking at objects by day through a spy-glass. If you ask, as I have often done, a person unacquainted with optics whether he recognises any difference in size between an object, say a horse or a cow, seen with or without a telescope, he will always answer No, but it (the telescope) brings it much nearer. This, of course, is really an admission of increased magnitude, but the observer is unconscious of it; a horse to him is as big as a horse, no larger or smaller, whatever be the distance.

The assistance which may be derived from the degree of convergence of the optic axes alluded to by your correspondent "T. R." may be something when we know what the object is, or when it is moved to and fro, but if the object be unfamiliar, and there be no standard of comparison, I doubt whether any fair guess could be made.

Suppose all objects had never been seen but at one and the same distance, then an observer looking at a given object without any external standard of comparison, would probably make a fair guess at its size, for the picture on his retina would have a definite size, and his mind would estimate it by relation to other pictures of known objects which he had seen at other times; but as we see all the objects with which we are familiar at all degrees of distance, we have no standard of comparison for an image on the retina.

The common phantasmagoria effect where a figure appears to advance or recede from us though it really does not change its position, but its size is one of the many illusions produced by representing things as they are seen under certain circumstances which have become habitual, and habit interprets the vision. So if one lie on his back in a field, and throwing the head back, look at distant trees or houses, they will appear to be in the zenith, because when we ordinarily look at the zenith the head is thrown back.

Is the apparent size of the Sun or Moon, as expressed in common parlance, anything more than a reference to some standard which we have early adopted, and which, not having any means of rectifying, we assume. To me the Moon at an altitude of 45° is about 6 inches in diameter; when near the horizon, she is about a foot. If I look through a telescope of small magnifying power (say 10 or 12 diameters), so as to leave a fair margin in the field, the Moon is still 6 inches in diameter, though her visible area has really increased a hundred-fold.

Can we go further than to say, as has often been said, that all magnitude is relative, and that nothing is great or small except by comparison? W. R. GROVE.

115, Harley Street, April 4

## An After Dinner Experiment

SUPPOSE in the experiment of an ellipsoid or spheroid, referred to in my last letter, rolling between two parallel horizontal planes, we were to scratch on the rolling body the two equal similar and opposite closed curves (the *polhods* so-called), traced upon it by the successive axes of instantaneous solution; and suppose, further, that we were to cut away the two extreme segments marked off by those tracings, retaining only the barrel or middle portion, and were then to make this barrel roll under the action of friction upon its bounding curved edges between the two fixed planes as before, or, more generally, imagine a body of any form whatever bounded by and rolling under the action of friction upon these two edges between two parallel fixed planes; it is easy to see that, provided the centre of gravity and direction of the principal axes be not displaced, the law of the motion will depend only on the relative values of the principal moments of inertia of the body so rolling, in comparison with the relative values of the axes of the ellipsoid or spheroid to which the *polhods* or rolling edges appertain; and consequently, that, when a certain condition is satisfied between these two sets of ratios, the motion will be similar in all respects to that of a free body about its centre of gravity.

That condition (as shown in my memoir in the Philosophical Transactions) is, that the nine-membered determinant formed by the principal moments of inertia of the rolling body, the inverse squares and the inverse fourth powers of the axes of the ellipsoid or spheroid shall be equal to zero—a condition manifestly satisfied in the case of the spheroid, provided that two out of the three principal moments of inertia of the rolling solid are equal to one another.

My friend Mr. Froude, the well-known hydraulic engineer, with his wonted sagacity, lately drew my attention to the familiar experiment of making a wine-glass spin round and round on a table or table-cloth upon its base in a circle without slipping, believing that this phenomenon must have some connection with the motion referred to in my preceding letter to NATURE: an intuitive anticipation perfectly well founded on fact; for we need only to prevent the initial tendency of the centre of gravity to rise by pressing with a second fixed plane (say a rough plate or book-cover) on the top of the wine-glass, and we shall have an excellent representation of the free motion about their centre of gravity of that class of solids which have, so to say, a natural momental axis, *i.e.* (in the language of the schools) two of their principal moments of inertia equal. For greater brevity let me call solids of this class uniaxal solids. I suppose that the centre of gravity of the glass is midway between the top and bottom, and that the periphery of the base and of the rims are circles of equal radius. These circles will then correspond to *polhods* of a spheroid, conditioned by the angular magnitude and dip of the spinning glass; to determine from which two elements the ratio of the axes of the originally supposed but now superseded representative spheroid is a simple problem in conic sections; this being ascertained, the proportional values of the moments of inertia of the represented solid may be immediately inferred. The wine-glass itself belonging to the class of uniaxal bodies, the condition that ought to connect its moments of inertia with the axis of the representative spheroid (in order that the motion may proceed *pari passu* with that of a free body) is necessarily satisfied.

The conclusion which I draw from what precedes is briefly this—that a wine-glass equally wide at top and bottom, and with its centre of gravity midway down, spinning round upon its base and rim in an inclined position between two rough but level fixed horizontal surfaces, yields, so long as its *vis-viva* remains sensibly unaffected by disturbing causes, a perfect representation, both in space and time, of the motion of a free uniaxal solid, as *e.g.* a probate or oblate spheroid, or a square or equilateral prism or pyramid about its centre of gravity, and