

IS THE EARTH FALLING INTO THE SUN?

*Wm. F. Rigge, S. J.



IT has often been said that no astronomer can be an atheist. The scale upon which the universe is built; the endless variety and the infinite number of the visible stars, all of which are self-luminous suns like our own; the conviction that the heavens must be filled by a vastly greater number of invisible and dark bodies forever concealed from our sight and our knowledge; and above all, the wonderful order and harmony prevailing throughout the entire universe, and the utter helplessness and nothingness of man in the presence of these stupendous bodies: all these are like the voices of a great multitude and like the sound of many waters, proclaiming aloud in unmistakable tones that the heavens declare the glory of the Lord and that the universe is the work of His hands.

To imagine that this glorious universe of stars should have sprung into being by chance, when we have never in all our years of experience seen anything whatever produced except by an adequate cause; to suppose that the wonderful harmony, the adaption and correlation of part to part, should have been a mere accident, when we know that no plant can grow, no animal can live, no material thing can be made except in a certain unalterable and limited manner; this is so utterly absurd and unreasonable that the idea must at once be rejected and repulsed as unworthy of a thinking being.

Out of the almost infinite variety of astronomical subjects that might be used to illustrate the Wisdom and Goodness of Almighty God, I have selected only one in this article, the earth's motion around the sun. We wish to some extent to study this

*Professor of Astronomy, College of Arts. Director of the Observatory.

motion, to see of what kind it is, and to know how long it will continue and whether it will ever change and work us harm. Some few mathematical notions must, of course, serve as a foundation for our study. But they will be made as untechnical as possible.

The earth moves round the sun in an ellipse with the sun in one of the foci. In order to understand the full meaning of these words, as well as all that I shall have to say concerning this ellipse, let us take two pins and stick them upright into a piece of cardboard. Let us next take a thread longer than the distance between the pins, and fasten one end to each of them. Then taking a lead pencil and extending the thread with it, let us move the pencil about as much as the thread will permit. The figure thus described will be an ellipse, the pins will be the foci, the point midway between them will be the center of the ellipse, and the straight line drawn through the pins and terminated by the ellipse, will be major axis and will be found to be exactly equal to the length of the thread.

The ratio of the distance between the foci to the length of the major axis, is called the eccentricity of the ellipse, and determines its shape. So long as this ratio is the same, the shape is the same. Thus, if we were to place the pins four-fifths as far apart as we did and use a thread of four-fifths the former length, we would get a smaller but exactly similar ellipse, so exactly similar in fact that if we were to take a photograph of the smaller ellipse at four-fifths the distance of the larger one, nobody could distinguish the pictures. On the other hand, if we change this ratio in either of its two possible ways, this similarity will be destroyed. For if we keep the pins in their places and change the length of the thread, that is, change the major axis, or if we use the same thread and change the distance between the pins, that is, alter the focal distance; the new ellipse thus generated will differ so much in shape from the original one that one has but to try the experiment to see the obvious result. An ellipse, therefore, has two constants, or two parameters, as mathematicians prefer to call them, the eccentricity which de-

termines its shape, and the major axis which determines its size.

In the ellipse which the earth describes about the sun, the sun occupies one of the foci, the other focus being vacant. Hence when the earth passes through that end of the major axis which is nearest the occupied focus, and is therefore nearest the sun, or in perihelion, it is nearer the sun by the distance between the two foci than it is at the other end of the major axis, or in aphelion. This variation of distance evidently depends upon the eccentricity of the ellipse. The eccentricity of the earth's orbit is 0.017, that is, if we take the major axis as 1000, the distance between the foci will be 17. In miles this means that for a mean distance (semi-major axis) of 92,897,000 miles the sun is about one and a half million miles away from the center, and that therefore the earth is about 3,000,000 miles nearer the sun on January 1 than it is on July 1. By mean distance we understand the mean or average of the perihelion and aphelion, or least and greatest, distances.

This variation of three million miles may at first appear to be very considerable, but it is small when compared to the 93 million in our distance from the sun. If we were to place our pins three-sixteenths of an inch apart and use a thread twice 93 sixteenths of an inch, that is of $11\frac{5}{8}$ inches in length, the ellipse thus drawn would be a correct representation of the earth's orbit, but would not be distinguishable from a true circle in which the sun is placed one and one-half sixteenths of an inch out of center.

As practically all of the earth's surface heat, and with it the support of our vegetable and animal life, comes to us from the sun, and as the amount we receive is less in the ratio of the square of the distance from the source of heat, it is evident that if either the eccentricity or the semi-major axis of the earth's orbit were to change considerably, our comfort, and even our very existence would be seriously threatened. A change in the semi-major axis, that is, in our mean or average distance from the sun, would give us, if it were diminished, so much heat as to scorch our vegetation, or if it were increased, not enough heat

to enable it to mature, in either case very effectively killing all life upon the globe. A change in the eccentricity, or in the

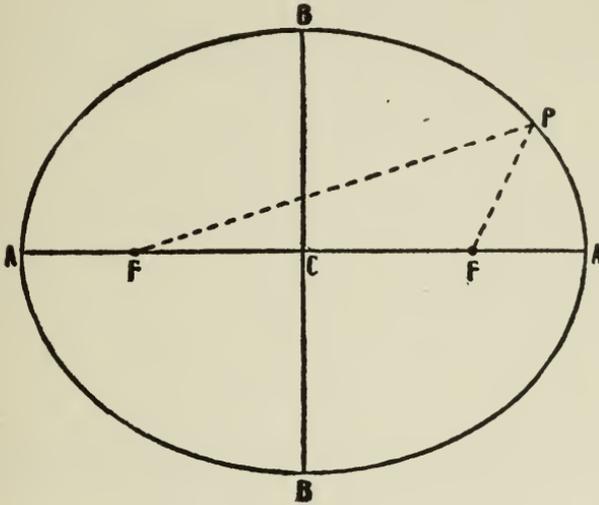


FIG. 1

F and F are the pins or the foci, FPF is the thread and P the pencil whose motion traces the ellipse. AA is the major axis, BB the minor axis, C the center, and the ratio of FF to AA or of CF to CA is the eccentricity which gives the ellipse its shape.

variation of our distance from the sun, would be equally ruinous to our existence, since it would subject us to unbearable extremes of heat and cold.

Here Divine Providence gives us a faint glimpse of Its Wisdom and of Its Goodness. The labors of the most expert mathematicians have demonstrated that, while the eccentricity and the mean distance are subject to variation, this variation is very small and requires long periods of time to pass from one extreme value to the other. Thus, the eccentricity of the earth's orbit is at present 0.017 and is so slowly diminishing that it will require about 24,000 years to reduce it to 0.003, and then the orbit will be almost a true circle, that is, the variation of our distance from the sun will be only about one-sixth of what it is at present, only one-half instead of three million miles. It will take 40,000 years more to bring back the eccentricity to 0.020, a little beyond its present value, and by that time there may

not be any living being on earth to be interested in the matter.

Our mean distance from the sun is entirely free from all secular disturbances, and while subject to slight periodic in-

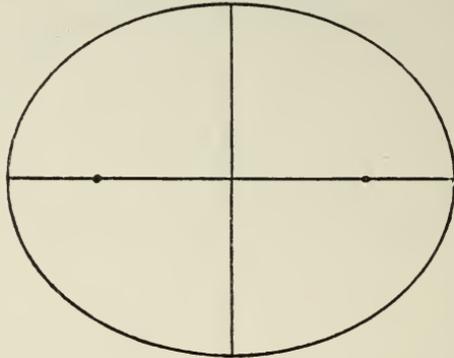


FIG. 2

In this ellipse the distance between the pins and the length of the thread are both four-fifths of those in Fig. 1, but the eccentricity, or the shape, is exactly the same.

equalities, is absolutely constant in the long run. The variation, if it existed, would betray itself at once in the length of the year, since the square of this time is proportional to the cube of the mean distance, according to Kepler's third law.

For this reason the earth can neither fall into the sun nor run away from it, but will move in practically its present orbit forever. A resisting medium in space would be the only thing that could retard the earth's movements and thus gradually force it down in an ever-narrowing spiral into the sun. We have the best of reasons for believing that this medium does not exist. For first, a resisting medium would be betrayed by the barometer, since it would cause perceptible condensation of the air on the forward or morning side of the earth, a rarefaction on the rear or evening side, and a preponderance of east winds at midnight and west winds at noon. Secondly it would long ago have brushed away our atmosphere altogether. Thirdly, it would offer a noticeable resistance to the motions of comets, some of which have passed so close to the sun that they must have almost grazed its surface, and not the least retardation in their motions has ever been observed. So true is this that

the solitary case of Encke's comet has been so thoroughly discussed, that no conclusions whatever can be drawn from its behavior.

Hence, as both the eccentricity and the semi-major axis of this earth's orbital ellipse do not change to an extent that

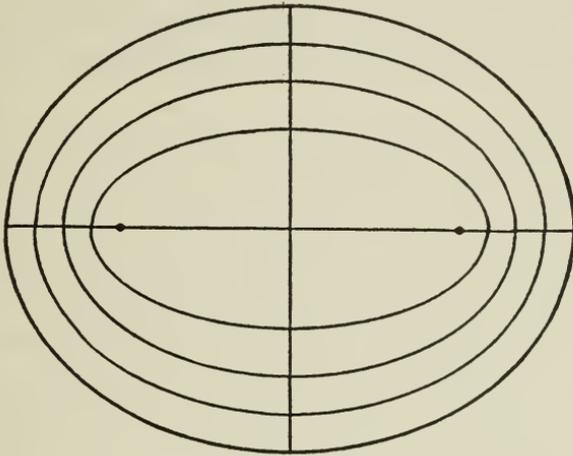


FIG. .3

In these ellipses the focal distance is the same as in Fig. 1, but the major axes (or the lengths of the thread) are not the same, the eccentricities (or the shapes) are entirely different.

can be perceived by any but professional astronomers, the comfort of the human race is secured for all time, and we need have no fear about the future, much less therefore about the present. And lest the present value of the eccentricity, which brings about a variation of 3 out of 93 million miles in our distance from the sun, should cause us any anxiety, Providence has so arranged matters that we are nearest the sun on January 1, and farthest away on July 1, just as we would wish to be. And if we object that this is true only for the northern hemisphere and must have the opposite effect in the southern, since that will be nearest the sun in summer and farthest away in winter, Providence has again wonderfully come to the rescue by putting very much more water in the southern hemisphere than in the northern, and we know that water is an excellent equalizer of temperature.

The major axis of the earth's orbital ellipse prolonged to the heavens is called its line of apsides, and is swinging around at a rate that will carry it completely around in a circle in 108,000 years. This would be illustrated by turning an ellipse slowly round its center. In the same way the plane of the ecliptic in which the earth is moving, is also slowly shifting. But both of these things are of no consequence, since nothing whatever depends upon them, and no one but an astronomer will ever know of the change.

Another item of importance to the well-being of the human race on earth, is the constancy of the seasons. We know that the seasons are caused by the fact that as the earth revolves about the sun, its axis is inclined to the plane of its orbit and remains sensibly parallel to itself that is, points always to the same star. This axis can, and does, vary its position, however, in two ways or directions: first by nutation, an up-and-down-motion, as it might be called, which changes the inclination of the axis and brings the sun into higher or lower latitudes and thus widens or narrows the torrid zone; and secondly by precession, a sidewise motion, by which the axis is merely pointed to another star. If the inclination of the earth's axis were to become very much less than it is at present, the torrid and frigid zones would become very narrow, and the temperate zones very wide. At first sight this might seem to be an advantage, but it would in reality be a great evil, since it would confine the heat of the torrid zone within a narrow belt and thus scorch its vegetation to death, and it would spread the heat of the temperate zones over a wider area and thus lower their average temperature too much to allow their vegetation to ripen. On the other hand a much greater inclination of the earth's axis would widen and thus cool the torrid zone, and would in the temperate zones make the extremes of summer heat and winter cold too great for the endurance of plants and animals and the comfort of the human race.

For these reasons an Allwise Providence has confined the variations of the inclination of the earth's axis within very nar-

row limits, so narrow indeed that the zones of the earth can expand and contract only 70 miles on either side of their mean or average boundary. To lessen the effect of even this narrow variation, the time required is enormous, since it will take about 15,000 years to reduce the present obliquity three quarters of a degree, that is, about 50 miles on the earth. Thus, our trade winds, ocean currents, and general circulation of air and water and consequent distribution of heat, will forever keep their present cycles.

On the other hand the sidewise shifting of the earth's axis caused by precession, which merely gives us another pole

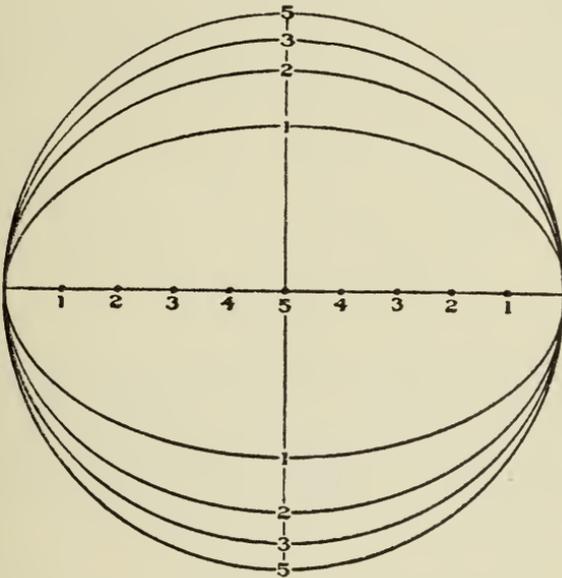


FIG. 4

In these ellipses the major axis (or the length of the thread) is the same, but as the focal distances are different, the eccentricities (or the shapes) are also different. When the two foci coincide at the center 5, the ellipse becomes a circle. The ellipse which has the foci 4,4, has its minor axis only 2 per cent shorter than its major axis and is too close to the circumscribing circle 5 to be drawn on the diagram.

star, without affecting the earth in any other way, is not confined to any limits whatever, but moves the celestial pole round in a complete circle in a period of 25,800 years.

All that has been said about the constancy or variation of the elements of the earth's orbit, applies equally to the orbits of all planets except the asteroids, which are at best only large rocks, and about whose motions nobody is concerned. The solar system, therefore, is most wisely built, and built to endure forever. It has probably existed for ages long before the advent

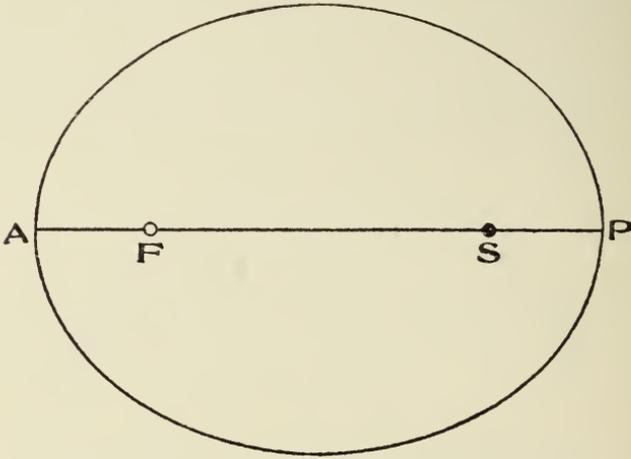


FIG. 5

This ellipse represents to some extent the orbit of a planet around the sun. S is the sun, F is the other and empty focus, P the perihelion or point of nearest approach, and A the aphelion or point of greatest distance. In the ellipse actually given the eccentricity is 0.6000. In the earth's orbit the eccentricity is 0.017, and when drawn correctly to scale, the distance between F and S would be less than the thickness of the lines in the figure, and the ellipse would appear to be a perfect circle.

of man, and will most probably endure for as many more long after the human race has ceased to exist. When the end of the world will come is not given to man to know, not even the Angels of heaven know it, no one but the Son of Man. Science does not know it, does not know of any end. Is this not a wonderful confirmation of our Lord's words?

How then is it that those elements in the earth's orbit upon whose constancy we are so dependent for our comfort and even for our very existence, should vary within such narrow limits that unprofessional men would never detect the variation, and

on the other hand, those elements whose variation does not at all affect us, should have no limit set to their variation? How is it except that we are in the hands of a kind Providence who has our best interests at heart in this life as well as in the next. True science helps our faith, for both have the same Author. And the facts stated in this article have all the greater value and trustworthiness in that they have been established by the labors of the best astronomers and mathematicians, who were actuated by the sole motive of knowing the actual state of affairs, and not by any love for religion or aversion from it. For this reason no true scientist can be an atheist, and least of all the astronomer who has so many and astounding proofs of God's power and wisdom and goodness.

