present note. It may be mentioned that the low altitude of the nova made the observations difficult. In determining the color equation I made the simple assumption that the stars are all reddened to the same extent by differential extinction. If this assumption is unjustified, complications are introduced by the Purkinje effect and by differential extinction.

HARVARD COLLEGE OBSERVATORY.

A Simple Method of Determining the Date of the Equinox

By C. C. WYLIE

In an earlier paper,[1] it was pointed out that the diurnal path of a shadow on a level surface is a conic section, if one neglects curvature of the Earth, refraction, and the change in the declination of the Sun in a single day. If the Sun is below the horizon for part of the day, the path is a hyperbola. During our summer months the Sun is well to the north near rising and setting, and the hyperbolas formed by the shadow each day are concave to the south. During our winter months, when the Sun rises and sets to the south, the shadows are thrown to the north, and the hyperbolas formed by the paths of these shadows are concave to the north. At either equinox the Sun is in the plane of the equator, and the hyperbolas are changing from concave one way to concave the other. The diurnal path of a shadow, or of a spot of sunlight, is a straight line lying east and west at that time.

If the Sun just touches the horizon at midnight, the diurnal path is a parabola. If the Sun is above the horizon throughout the twenty-four hours, the diurnal path is an ellipse. At either pole, when the Sun is above the horizon, the diurnal path of the shadow is a circle.

The fact that, at either equinox, the Sun moves in the plane of the equator, means that the path of a shadow, or of a spot of sunlight made by light shining through a small hole, must move in the plane of the celestial equator that day. The intersection of that plane with another plane, either horizontal or vertical, is a straight line.

An interesting result is that the shadow of an east and west rail remains stationary throughout the day of the equinox. If a light snow occurs near March 21, that in the stationary shadow of the rail will melt more slowly than that in sunlight, and a conspicuous line of unmelted snow will remain for a time in the shadow. The illustration (Figure 1) shows this effect on an Iowa City street. If students are told about this, they will report many instances after a snowstorm near the spring equinox.

Early people fixed the date of the equinox from the rising due east

[1] "The Diurnal Path of a Shadow," POPULAR ASTRONOMY, Vol. 40, page 157; *Contributions of the University of Iowa Observatory*, Number 3, page 87.

and setting due west of the Sun. Temples were built to face the east, so that the priests, who regulated the calendar, could watch the east conveniently. By observing the path of a spot of sunlight, the date can be fixed quite easily. We have used a piece of rather heavy paper, pasted on a window at a height of about ten feet, and with a hole about half an inch in diameter, to make the spot of light. The following are some simple observations which students have found interesting.

1. Using an east or a west window, mark each day for some two hours the path of the spot of light on the floor. Note the day on which the path is most nearly an east and west line as indicated by the walls, or by grooves in the floor. This is a very simple observation, but if the building is not set with the points of the compass, the method will give an erroneous result.

2. Mark each day for some two hours the path of the spot of light on a blackboard on a wall running east and west, that is, a north wall in the Northern Hemisphere. Either an east or a west window can be used. Note the day on which the path is the most nearly horizontal. This is a simple method, but, if the blackboard is not set exactly east and west, some error will be introduced.

3. Mark each day, for some two hours in the forenoon, the path of a spot of light on the floor, using an east window. Then mark it for some two hours in the afternoon, using a west window in the same room or a nearby room in the same building. Measure carefully the direction, using the walls of the room or grooves in the floor. Note the date on which the direction in the afternoon is closest to the direction in the forenoon. That should be the date of the equinox. The accuracy of this method is not affected by the grooves or walls being out of an east and west line, since it fixes the date on which the path is a straight line.

4. Using a south window, mark the path of a spot of sunlight on the floor each day for some two hours, beginning about an hour before noon. Check the curvature of the paths with a yardstick or meter stick. The day on which the path is the closest to a straight line is the day of the equinox. This method is less accurate than Method 3, but it is the best for showing students that before the equinox the paths are hyperbolas concave one way, and after the equinox they are hyperbolas concave the other way.

5. Using an east window, mark the path of a spot of sunlight on a blackboard on a north wall for some two hours in the forenoon each day. Then using a west window, mark the path for some two hours in the afternoon. Measure the angle of rise or fall of the path. The day on which this angle is the same in the forenoon and afternoon is the day of the equinox. This fixes the date of the equinox, even if the blackboard is not due east and west, since it fixes the date on which the path is a straight line.

About the middle of March, 1940, pieces of heavy paper, about

10 x 12 inches and each with a hole about half an inch in diameter, were fastened to some windows of our office building about 10 feet above the floor level for a test of these methods of dating the equinox. Sunlight shining through the small hole made an elliptical spot of light on the floor of the room. In this building the floors are cement, and the center

FIGURE 1

STATIONARY EAST AND WEST SHADOW ON DAY OF EQUINOX. NOTICE THE LINE OF UNMELTED SNOW.

of the elliptical spot could be marked closely with chalk by drawing approximately the major and minor axes of the ellipse and writing the hour and minute beside the mark. The grooves in the floor lie approximately in an east and west direction. An east window from which the spot of light fell on the floor was used, and also a west window from which the spot of light fell on the floor. With these, the date of the equinox was fixed by Method 1 and Method 3. A second west window was used from which the spot of light fell on a blackboard on a north wall. With this window, the date was fixed by Method 2. A smaller piece of paper was fixed to a south window from which the spot of light fell on the floor, but this was in another office, and as we did not want to bother the occupants of that office too much, no real measures were made. The path from this south window was marked on a few occasions, however. The use of the south window is Method 4. No east window from which the spot of light fell on a blackboard was available, so a test of Method 5 could not be made.

The path of the spot of light was marked on March 18, March 19, March 20, and March 21, although clouds interfered some on March 21. As the Sun moves across the sky from east to west, the spot of sunlight on the floor or on the blackboard moves eastward throughout the day. On the afternoon of March 18, the spot of sunlight on the blackboard rose about 4 inches between 2:00 P.M. and 4:00 P.M. On the forenoon of March 19, the spot of sunlight on the floor deviated to the south, as it moved to the east. On the afternoon of that day, the spot of light on the floor deviated to the north as it moved to the east. On the forenoon of March 20, the spot of light on the floor moved one inch to the north while moving 95 inches to the east. On the afternoon of that day, the spot of light on the floor moved one inch to the north while moving 85 inches to the east; the spot of light on the blackboard rose 11/16 inch in 142 inches of eastward motion. On the forenoon of March 21, clouds interfered, but the spot of light on the floor deviated to the north about ⅛ inch while moving to the east 25 inches. On the afternoon of that day, the spot of light on the floor moved practically parallel to the groove in the floor. On the same afternoon the spot of sunlight on the blackboard moved nearly horizontally, but dropped between ½ and ¾ of an inch in 14 feet of eastward motion.

Let us now fix the date of the equinox by Method 1, using the east window. On the forenoon of March 19, the spot of sunlight on the floor deviated to the south, and on the forenoon of March 20, it moved nearly parallel to the groove, but deviated a little to the north. This indicated that the equinox occurred between the forenoon of March 19 and the forenoon of March 20, but closer to the second date. Using the same method, and the afternoon observations, the spot of sunlight moved a little to the north on the afternoon of March 20 and practically parallel to the groove on the afternoon of March 21. This indicated that the

equinox occurred on March 21. The discrepancy between the forenoon and afternoon results indicates that the building is not set exactly with the points of the compass, but averaging these observations, one would assume that the Sun reached the equinox on March 20.

Let us now consider Method 2. The spot of sunlight falling on the blackboard from a west window rose rather rapidly on the afternoon of March 18, rose some on the afternoon of March 20, and dropped a little on the afternoon of March 21. This indicates that the Sun reached the equinox on March 21. This result is in agreement with the result from the spot of sunlight falling on the floor from a west window, and no doubt is slightly in error because the building is not set exactly with the points of the compass.

Let us now fix the date of the equinox by Method 3. On the forenoon of March 19, the spot of sunlight on the floor deviated to the south, and on the afternoon of the same day it deviated to the north. This indicated that the path was a hyperbola concave to the north, and that the Sun had not reached the equinox. On the forenoon of March 20, the spot of sunlight on the floor deviated about one inch to the north in 95 inches of eastward motion. On the afternoon of the same day it deviated one inch to the north in 85 inches of eastward motion. Since it deviated more rapidly in the afternoon than in the forenoon, the path was not exactly a straight line, but a hyperbola and still concave to the north. This indicated that it was still winter at Iowa City local noon. On March 21, in the forenoon the spot of light deviated to the north about ⅛ inch in 25 inches of eastward motion, and in the afternoon it moved practically parallel to the groove in the floor. This indicated that the path was a hyperbola concave to the south and that at Iowa City local noon the Sun had passed the equinox. From the observations of March 20 and March 21, it appeared that the Sun reached the equinox between noon March 20 and noon March 21, Iowa City time, but closer to noon March 20. In reality, the Sun reached the equinox in 1940 at 12:24 P.M., Central Standard Time, March 20, so the result of Method 3 was essentially correct.

Teachers report considerable interest in Method 1 and Method 4 as home assignments, to be worked on the week-end nearest the equinox, weather permitting. Method 3, in general, has been used only where the teacher can supervise the observations, and see that the measurements are made with some care. Methods 2 and 5 require a blackboard, and so are worked usually at school. This year, the Sun reaches the equinox on Sunday, March 21, so if the weather is clear, interested students can verify for themselves that the path of a spot of light on the floor is a straight line lying in an east and west direction. Such students should be reminded that with War time, noon comes at about one o'clock, instead of at about twelve o'clock. Forenoon, noon, and afternoon observations should be planned accordingly.

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