WHY DON'T THE TIMES OF SUNRISE AND SUNSET MATCH?

My thanks to Peter Newman for suggesting this topic. During June, the time of sunrise gets earlier and earlier, pausing for a few days around June 17th, after which it starts getting later again (Fig 1). The time of sunset does a similar thing. It gets later and later, pausing for a few days around June 26th, after which it starts getting earlier again. The longest day occurs around the midpoint between the earliest sunrise and the latest sunset, on June 21st.

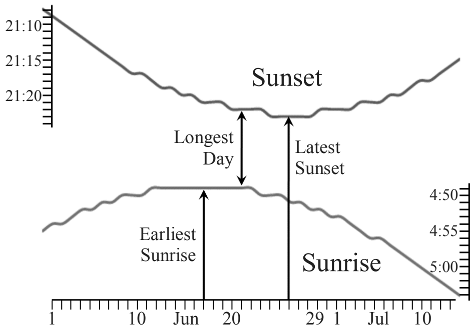

Fig 1: The times of sunrise and sunset during June and July

During December, the same thing happens in reverse, and to a greater extent: the earliest sunset is around December 13th, the latest sunrise around December 31st, and the shortest day between them, on December 21st (Fig 2).

The question I aim to answer in this article is, “Why don't the earliest sunrise, the latest sunset and the longest day all happen on the same day? Similarly, why don't the latest sunrise, the earliest sunset and the shortest day all happen together?”

The answer is to do with the speed that the earth moves in its orbit around the sun. If this speed was constant, sunrise and sunset would be in step. However, the speed of the earth in its orbit isn't constant—it speeds up during the winter, and slows down during the summer. The reason for this is that the shape of the earth's orbit is not a circle—it is an ellipse (the shape a rugby ball). However, the orbit isn't very far from being a circle—the closest and furthest distances from the sun are only 4% different, so the variation in speed is only slight, but it still causes the times of sunrise and sunset to be out of step.

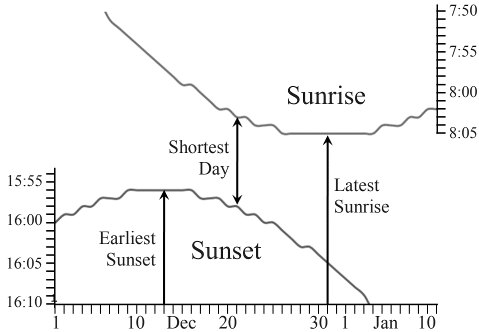

Fig 2: The times of sunrise and sunset during December and January

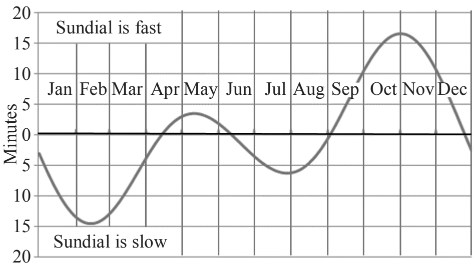

Fig 3: The difference between the time on a sundial and the time on a clock—known as the ‘equation of time’

If the speed was unvarying, the sun would be due south, and at its highest point in the sky, at noon (by the clock) every day. However, because the speed varies, the sun's highest point in the sky sometimes arrives early, and sometimes late. The effect of this is that the position of the sun, at its highest point, moves

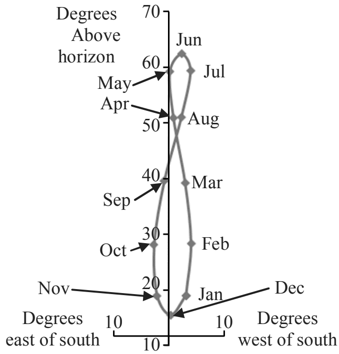

Fig 4: The 'analemma': the position of the sun in the sky at noon (by the clock) every day, in degrees above the horizon and degrees to the east or west of due south

to the left (east) and right (west) of due south, depending on the season. The difference from day-to-day is only a few seconds, but the differences accumulate from one day to the next, so that the maximum 'error' is more than 15 minutes. The difference between the time on the clock and time by the sun is known as the 'equation of time'.

The fact that there is such a difference causes a problem with sundials. Fig 3 shows the error in timekeeping for a 'simple' sundial. There are more advanced sundials which correct for this discrepancy, based on the actual date.

Because the axis of the earth is tilted, the position of the noonday sun is much higher in the sky in the summer than in the winter. Combined with the east-west motion, described above, the position of the sun at noon traces out a figure-of-eight in the sky—known as the "analemma" (Fig 4). If you look at old globes of the earth, they often show the analemma, usually in a blank spot in the Pacific Ocean. I have often wondered what this is—and now I know!

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