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Sunrise and sunset times near the dates of the equinoxes and solstices

The astronomical seasons are defined to begin on the dates of the equinoxes and solstices which occur on or about March 21 (vernal equinox), June 21 (summer solstice), September 21 (autumnal equinox) and December 21 (winter solstice).

The term "equinox" implies that the day and night are of equal length, but tables of sunrise and sunset times show that the dates when the period of daylight is exactly twelve hours do not correspond to the dates of the equinoxes. For example, in London in 1986 the interval between sunrise and sunset is twelve hours on March 18 and September 26 whereas the equinoxes occur on March 20 and September 23. The reasons for this discrepancy are, firstly, that sunrise and sunset tables are calculated for the rising and setting of the Sun's upper edge rather than its centre, and, secondly, that the refraction (or bending) of the sunlight by the Earth's atmosphere is taken into account. The result of these two factors is that at the calculated instant of rising or setting the Sun's centre is $0^{\circ} 50'$ below the horizontal plane rather than exactly in it; thus the twelve-hour day occurs before the vernal equinox (due to the northward progression of the Sun at this time) and after the autumnal equinox (due to its motion southwards). If the rising and setting were computed for the Sun's centre exactly in the horizontal plane (neglecting refraction) then the twelve-hour days would coincide with the equinoxes.

At the solstices the Sun "stands still" in its motion northwards and southwards in the sky, that is, the Sun's altitude above the horizon at noon is at its maximum (summer solstice) or minimum (winter solstice). At these times another apparent paradox occurs. The summer and winter solstices coincide with the dates of the longest and shortest days respectively but they do not correspond to the dates when the Sun begins to rise later and set earlier in summer or when the Sun begins to rise earlier and set later in winter. For example, in London in 1986 the earliest and latest sunrises are on June 17 and December 31 respectively, the latest and earliest sunsets are on June 25 and December 12, and the solstices themselves occur on June 21 and December 22.

The reason why these three pairs of dates do not coincide lies in the fact that at certain times of the year the interval between the noons (when the Sun is due south) on successive days is slightly greater than twenty-four hours of clock time, and at other times of the year slightly less, the differences cancelling one another out over the whole year. This effect is caused by a combination of the eccentricity (or non-circularity) of the Earth's orbit around the Sun and the inclination of its equator to its orbit plane. Near the summer and winter solstices the interval between successive noons is about thirteen and thirty seconds respectively greater than twenty-four hours and, since this difference is greater than that between successive sunrise and set times, it gives rise to the staggered effect of the earliest sunrise or set, the solstice, and the latest sunrise or set. The effect is more pronounced in December than in June due to the larger daily difference from twenty-four hours. If the interval between successive noons was always exactly twenty-four hours the solstices would then coincide with the earliest and latest sunrises and sunsets.

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