Recording the observations in Universal Time

When Venus crosses the Sun, we need to note the times of the contacts between Venus and the Sun, at the beginning and at the end of the transit as is explained in the sheet "What needs to be observed and what measurements should be made when Venus crosses the Sun". Having identified the type of event to be observed, let us see how to record it.

Why record the observation?

As explained in the sheet "The purpose of observing the transit of Venus", the many observations carried out at various places on the Earth will provide us with the required information. All the observations will be gathered to estimate the distance between the Earth and Venus. In order to combine the observations, it is essential to measure the events using ***the same time scale.*** The scale adopted for all observers will be Universal Time (abbreviated UT).

What is Universal Time?

Civil time as shown on our watches is ultimately derived from the rotation of the Earth and the daily passage of the Sun across the sky. Local noon or midday occurs when the Sun is at its highest position in the sky. But the Sun does not move evenly across the sky because the Earth's orbit is an ellipse and the Earth's axis is tilted. Therefore we use the concept of a fictitious body, *the mean sun*, which crosses the sky at a uniform rate above the Earth's equator. We can establish a universal time scale by relating events to the passage of the mean sun relative to the Prime Meridian of Greenwich at zero longitude.

- Each day begins at midnight (00.00hours) and lasts 24 hours or 86400 seconds
- The Earth's surface is divided into 24 time zones in each of which civil time differs from Greenwich Time by an integral number of hours. When it is noon (12.00hours) at Greenwich, it is 12.00hours plus (or minus) N hours in the countries situated at N time zones east (or west) of Greenwich.

As the Earth's rate of rotation is gradually slowing due to tidal friction, the duration of the second (and hence civil time) is now defined in terms of precise oscillations of cesium atoms. This time standard is known as "Co-ordinated Universal Time" (abbreviated UTC) and is accurate to about one-billionth of a second per day. In order that UTC does not differ by more than 0.9sec. from the time defined by the Earth's rotation, a one-second change called a "leap-second" is introduced into UTC. This happens about once every year to a year and a half. This means that occasionally a day lasts one second longer than 24 hours to take account of the slowing of the Earth's rotation.

How can Universal Time be obtained?

In general, we do not obtain Universal Time directly, but we can readily obtain our country's civil time, a time which differs by a whole number of hours from Universal Time. Civil time can be easily accessed by phone thanks to the speaking clock. Some radio stations like Frankfurt and Rugby broadcast Universal Time; commercial clocks can be synchronised to these signals. GPS receivers can also provide Universal Time.

What precision is needed?

Equipped with a clock adjusted to Universal Time, or differing from it by an integral number of hours, we are ready to time each event when Venus crosses the Sun. The time should be estimated immediately the event takes place and should be recorded to the nearest second. This will be the precision of the observation. A higher degree of accuracy (noting the time to one tenth of a second) is much more difficult to reach: the simple reflex of looking at the clock, giving a signal or pressing a button lasts more than a tenth of a second. Moreover, the event to be timed is difficult to distinguish and it will last more than several seconds. A precision of one second is more than adequate but one minute is not sufficient. So we will record the event to the nearest second of time. If several people observe at the same time, each should not be influenced by the observations of the others. It is normal that neighbouring observers do not record a phenomenon at the same moment since observing methods may differ. Statistical methods will be able to decide between observers. Averaging over a very great number of observers will make it possible to obtain a result more precise than each individual measurement.

To record an observation

If you record your observation with a video camera or a webcam, for example, timing will be easier. First of all, try to record on each image the hour, the minute and the second of Universal Time or civil time (or record a speaking clock on the sound track). If this is not possible, note the difference between the recorded time and Universal Time with a precision better than a second. If each image is timed accurately, it will be easy to interpolate the times of the images to obtain the time of contact.

Conclusion

Be careful to ensure the quality of your observation: obtain Universal Time and carefully note your observation without being influenced by your neighbour or by the predicted time! Idealy, record your observation with a well defined time standard linked to Universal Time. Use the observation sheet giving the procedure to be followed to record the observation.