The Venus Transit 2004 (VT-2004) Programme

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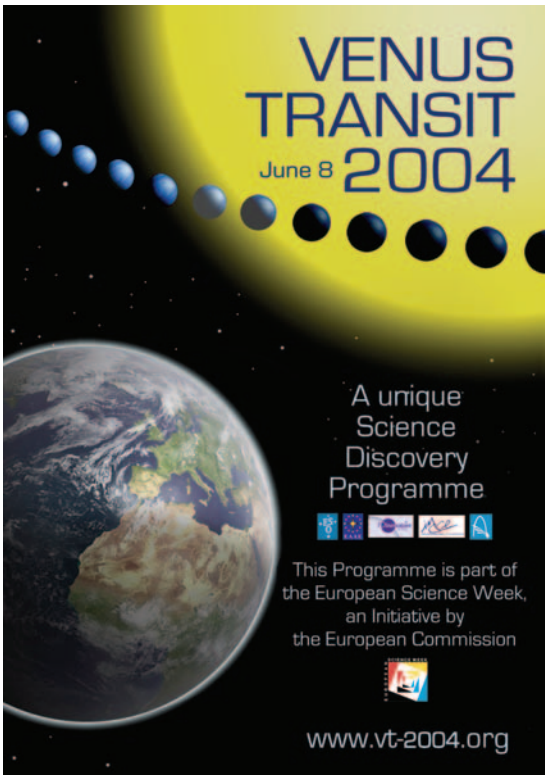
Why did Captain Cook travel to Tahiti? How big is the Solar System? How is it possible to detect Earth-sized planets in orbit around other stars? And how is it possible to participate actively, together with many other people on other continents, in an extremely rare celestial event - one that has never been seen before by any person now alive?

These and others are questions that the ambitious "VT-2004" programme tries to answer.

On June 8, 2004, Venus - the Earth's sister planet - will pass in front of the Sun. This event, a 'transit', is extremely rare - the last one occurred in 1882, 122 years ago. Easily observable in Europe, Asia, Africa and Australia, it is likely to attract the attention of millions of people on these continents and, indeed, all over the world.

The European Southern Observatory (ESO), in collaboration with the European Association for Astronomy Education (EAAE), the Institut de Mécanique Céleste et de Calcul des Éphémérides (IMCCE) and the Observatoire de Paris in France, as well as the Astronomical Institute of the Academy of Sciences of the Czech Republic has therefore set-up the Venus Transit 2004 (VT-2004) programme with support of the European Commission, within the framework of the European Science and Technology Week.

VT-2004 takes advantage of this extraordinary celestial event to expose the public - in a well-considered, interactive and exciting way - to a number of fundamental issues at the crucial interface between society and basic science.



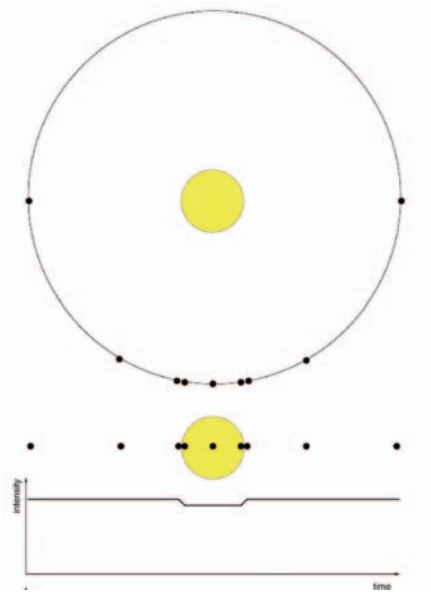
Main objectives of the VT-2004 programme

A key intention is to introduce (and "sensitise") the public to various issues of general interest, with the Venus Transit and related issues as a natural starting point:

- **The basis of the measurement of the Universe:** For centuries, it was not possible for humankind to know the distance of the planets, the Sun and the stars from the Earth: all celestial bodies appeared to be located on the same "celestial sphere". The ignorance of these distances or their large uncertainty, led to a wrong appraisal of the distances in the Universe and hence to wrong models for our world. After the modelling of the Solar System by Copernicus, Tycho Brahe, Galileo and Kepler, it was possible to deduce the distances in the Solar System from the knowledge of the distance from the Earth to only one planet. Rare transits of Venus in front of the Sun provided unique opportunities to measure the Earth-Venus distance by observing the event from several different sites in the world. From this, all other distances in the Solar System could then be deduced and, from that, the distances to stars by trigonometry. These measurements were made mainly during the 18th century, often under very dramatic conditions but, also as the forerunners of European scientific collaboration, as fundamental scientific projects. It is the stated goal of the VT-2004 programme to have such measurements remade by today's students, pupils of high schools, amateur astronomers, and interested laypeople, for educational purposes, helping them, through thorough and didactic, yet exciting, preparations of the event, to understand how the Universe was first measured.

- **The uncertainty of scientific measurements:** From the knowledge of the historical aspects of Venus transit observations, the public may appreciate the uncertainties of the different measurements performed at different epochs. Furthermore, the individual action of each participant in the VT-2004 Observing Campaign will allow considerations about the uncertainty of his/her own measurement. Thanks to the individual timing of the different phases of the Venus transit, and the connection to a powerful resource centre, each participant will be able to compare their values with those of other contributors and with the theoretical ones, and thus obtain an appreciation of the personal accuracy achieved and the associated consequences.

- **Extra-solar planet research:** Nowadays, the simple observation of the transit of a planet in front of the Sun will not entail novel and useful scientific observations since radars have replaced such distance measurements, achieving much higher precision (now at the level of one metre!). However, transits of exo-planets in front of stars other than the Sun constitute similar events, difficult to observe, but one of the best current opportunities to detect the presence of small exoplanets around other stars. In fact, the transit method is probably - for the next decade at least - the only method to



Variations in stellar brightness and velocity, caused by an orbiting exoplanet that transits the disk of its central star. Consecutive positions of the planet in its (circular) orbit are marked by black dots, with the motion from left to right.

detect Earth-sized planets around stars other than the Sun. And as such, the transit method may ultimately lead to the discovery of other habitable worlds. The VT-2004 programme introduces this highly exciting topic.

- **Scientific methods and international collaboration:** Simultaneous observations of the same transit event by observers from different locations are required to measure the solar "parallax" (the angle under which one Earth radius is seen from the Sun). It is inversely proportional to the Earth-Sun distance and therefore allows the true value of this fundamental cosmic distance, known as the "Astronomical Unit" to be deduced. In the same manner that the ancient scientific campaigns for the observation of this event enabled the first measures of this distance to be obtained (which, however, were not all equally accurate), the present, wide VT-2004 Observing Campaign is being co-ordinated with new tools, demonstrating how coordination and international collaboration may be a powerful lever in science. A modern approach is proposed, e.g., by using GPS devices for the localisation of the observation sites and by network communications, thereby illustrating the progress from numerous local observations via data pooling towards the determination of a fundamental value.

- **The stellar nature of the Sun**: Participants will need to rehearse their observations before the Venus transit and they will obviously observe the Sun in detail (VT-2004 will ensure that safety issues will figure prominently!). They will discover the very active nature of our central star, with sunspots, flares and prominences appearing and disappearing. This will generate interest in the physical nature of the Sun, to be supported by comprehensive educational material. Another aspect is the way the solar activity affects our daily lives, with natural phenomena such as auroras and the associated impact on satellites and communications. This will also be a fine opportunity to introduce and further develop the theme that the Sun is our nearest star and as such allows us to understand other stars in the Universe.

- **Invite the public to approach the history of sciences:** In spite of the fact that the Venus Transit event is rare, and in the context of our scientific and technological capabilities today is absolutely unique, the historical background is extremely rich. Only a few such events have been observed since the 17th century when the knowledge of the planetary motions became sufficiently good enough to permit the prediction of such events. Johannes Kepler first predicted planetary transits in front of the Sun in the 1620's, and Pierre Gassendi was the first to observe a transit from Paris in 1631. During the 18th and 19th centuries, Venus transits in front of the Sun were a welcome opportunity for European scientists from several countries to join efforts in order to obtain an improved estimate of the fundamental Astronomical Unit. This objective was very important since that one measurement would then allow the astronomers to deduce the size of the entire Solar System (from the observed planetary motions and Kepler's Laws). Halley, Delisle and la Hire, in particular, tried to establish the best methods to predict and observe the first and last contacts of Mercury or Venus with the Solar limb and to get the most accurate value of the Astronomical Unit. The history of Solar System science and therefore the astronomical progress are thus closely related to these historical collaborations, organised to obtain basic data from the observations of these events.

- **Dissemination of information about the structure and movements in the Solar System:** Venus transits are very rare - only four events can be observed every 243 years. The first Venus transit was observed in 1639, the most recent one in 1882. The next will occur in 2012, but it will not be visible from Europe. The Moon and the planet Mercury also present transit events in front of the Sun. The Moon transits cause the well-known solar eclipses. Mercury transits are more frequent than Venus transits; during the 20th century, fourteen Mercury transits occurred. But their observation is very difficult since the apparent diameter of Mercury is only about 1/200th of that of the Sun. The Venus transits are very rare but are easily observable since the apparent diameter of Venus' disk is about 1/30th of that of the Sun. The

The 1882 Transit of Venus as Seen from Chile

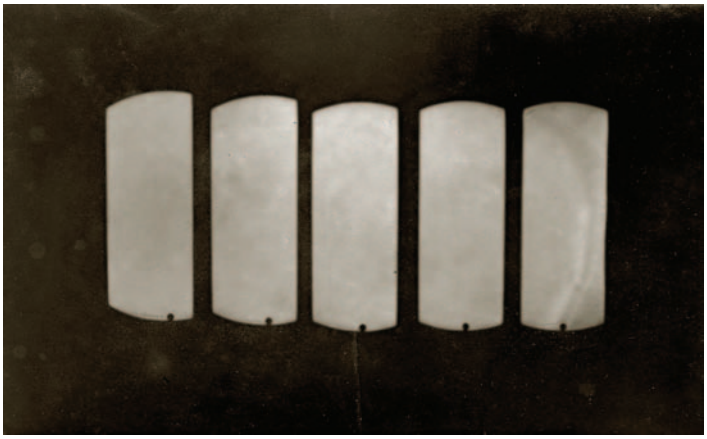
This year, on June 8, Venus will pass in front of the solar disc. The complete transit can be seen from Europe. Only 8 years later, on June 5, 2012, another Venus transit will be visible from Chile.

In the past, such transits were of crucial importance in measuring the size of the solar system and led to many expeditions to very remote places. These expeditions have been reported extensively and are even part of modern literature. References to expeditions to observe the 19th century transits are less frequently found in present-day literature than the more crucial and sometimes more tragic 18th century ones, since the results did not actually lead to a major improvement in the value of the astronomical unit.

What is noteworthy however is that the 19th century Venus transits were not only monitored by expeditions from the established astronomical "superpowers" France and England, as was the case in the 18th century, but by a bunch of "newcomers", like Austria, Belgium, Brazil, Denmark, Germany, Italy, Mexico, the Netherlands, Portugal, Russia, and the United States. And when it came to observing the 1882 transit from a good site in the southern hemisphere, Chile turned out to be an excellent choice. Word on this was also spread during an international conference on Venus transits held in Paris in early October, 1881. Among its participants was the former director of the Chilean National Observatory, Carlos Moesta. Astronomers from Belgium, Brazil, France, Germany and the United States spent a few weeks in or near Santiago and in Punta Arenas to observe the transit.

To know more about the various expeditions to Chile to observe the 1882 Venus Transit, read the article by Dr. Hilmar Duerbeck on the vt-2004 web site:
http://www.vt-2004.org/Background/Infol2/EIS-F7.html

understanding of these events implies detailed and accurate knowledge of orbital dynamics, as these celestial events only occur in particular configurations: when the orbital nodes of the Venus orbit are located near the Sun-Earth axis.



The Venus Transit observed in 1874. On this series of rare historical photos, the black disk of Venus is seen at the bottom, near the solar limb (credit: IMCCE).

Public participation

The VT-2004 programme is establishing wide international networks of individuals (including school teachers and their students, amateur astronomers, interested laypeople, etc.) and educational institutions (astronomical observatories, planetaria, science centres, etc.). It encourages real-time measurements of one of the most fundamental astronomical parameters, the distance from the Earth to the Sun.

VT-2004 also explains the relation of the Venus transit to a highly visible front-line research area, the search for extra-solar planets. The transit method is the only one, which, in the near future, has the potential to discover Earth-size planets in orbit around other stars and thus, possibly, alien habitable worlds. It promotes web-encounters and international collaboration throughout Europe as well as in Africa and Asia, stimulating observations of this rare celestial event, with debates via the Internet and the opportunity to add local observational contributions to a large, common database.

The VT-2004 programme is centred on the delivery of detailed explanations in most European languages of all aspects (scientific, technical, historical, etc.) of the transit event itself as well as its implications for the search for life. It is based on the active involvement of the media, students and teachers and amateur astronomers in order to spread this information as widely as possible and to ensure the highest return and common benefit.

A video contest with interesting prizes is also being launched in the framework of the VT-2004 programme. Everybody with a video camera and who participates in observations of the transit is invited to produce a short film (not exceeding 8 min) that documents their preparations for the transit and the actual observations, conveying the personal impressions of the event itself and those of being part of the programme. The winners will be selected by a professional jury - and they will be invited to present their videos at the VT-2004 "Final Event", a 2-day meeting in November 2004 in a European capital, with the possibility of winning one of the top prizes. As explained below, this meeting will also host expert dicussions about the many aspects of the unique VT-2004 public educational programme.

The Internet is the main vector of interaction, with a central website now being developed at: www.vt-2004.org. It comprises extensive background information, recommendations for active participation by individuals and groups, and also offers profound insight into the many interesting facets of this celestial phenomenon. There is also a VT-2004 Web Forum, as well as numerous links to organisations (observatories, planetaria, science centres, amateur clubs and associations, etc.) which are members of the wide VT-2004 Network. Educationally oriented organisations that plan activities in connection with the Venus Transit are welcome to join this network - registration details will be found at the corresponding webpages.

In order to promote the Venus transit and provide information about the opportunities for participation in the various countries and geographical regions, a number of VT-2004 National Nodes have been established. They collaborate closely with the organisers of the programme and constitute the main contact points for the media in the corresponding countries.

The VT-2004 website also contains an art gallery with drawings made by children.

Observations of the transit

On Tuesday, June 8, 2004, via the central VT-2004 display, all interested parties may follow in real-time the majestic progress of Venus' black disc across the solar surface, covering the distance from limb to limb in a little less than 6 hours. Live images (and possibly, videos) from leading (solar) observatories will be made available with very high throughput, involving a large number of mirror sites all over the world. In Europe, this transit happens during the morning of that day.

Moreover, observational data from a large number of observers in Europe and on other continents will be collected within the framework of the VT-2004 Observing Campaign in near-real time. This is the modern reenactment of a famous historical observation which was used by observers in the 17th, 18th and 19th centuries to measure the distance between the Earth and the Sun. A running estimate of the resulting value of this distance will be provided, illustrating this most fundamental step towards the cosmological distance scale and the determination of the size of the Universe.

The observations by the public required for this project will naturally lead to observations of the Sun itself and the discovery that our central star is far from being a quiet and boring lamp in the sky but rather a complex and highly interesting celestial body.

Evaluation of the implications

In addition to activities around the Venus Transit itself, the organisers also aim at evaluating in gross terms the sociological impact of such a very rare astronomical event and the way it is perceived in the different countries. Because the programme provides a field test for the execution of large-scale public activities relating to a particular scientific event with strong operational constraints (including the requirement to act in real-time as the scientific event progresses), the organisers expect to gather valuable experience for future continent-wide activities involving the same mechanisms and carried out under similar conditions.

The VT-2004 Final Event will bring together the main participants in this project from many different European countries. It will serve to discuss the project and its impact, identifying possible differences from country to country and showing how it is possible to share good practices in the future. The outcome of this rare celestial event and the overall experience from this unique public education project will clearly be of very wide interest, not just in the field of astronomy.

More information is available at the VT-2004 website (www.vt-2004.org). The organisers of the VT-2004 programme may be contacted via *vt-2004@eso.org*.