A shadow over Oxie
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An October 2003 amateur observation of HD 209458b

Anders Nyholm
Rymdgymnasiet
Kiruna, Sweden

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Abstract

This paper describes a photometry observation by an amateur astronomer of a transit of the extrasolar planet HD 209458b across its star on the 26th of October 2003. A description of the telescope, CCD imager, software and method used is provided. The preparations leading to the transit observation are described, along with a chronology. The results of the observation (in the form of a time-magnitude diagram) is reproduced, investigated and discussed. It is concluded that the HD 209458b transit most probably was observed.
A number of less successful attempts at observing HD 209458b transits in August and October 2003 are also described.
A general introduction describes the development in astronomy leading to observations of extrasolar planets in general and amateur observations of extrasolar planets in particular.

Contents

1. Introduction

This paper, about a photometric observation of a transit of the extrasolar planet HD 209458b, is the result of work carried out between March 2003 and April 2004[1]. I (the author) am currently going through the last year out of three at *Rymdteknikprogrammet* ("the Space Technology Program") at *Rymdgymnasiet* ("The Upper Secondary School of Space Technology") in Kiruna, Sweden. Rymdgymnasiet is a pre-university school oriented towards space technology with a curriculum calling for a deeper study of a subject of personal choice to be carried out during the final year, and it is in this context that I have carried out this work. The curriculum also calls for a specific problem in the form of a question to be formulated for the project. To comply I formulated the following question: *"Is it possible for me to observe the planet orbiting the star HD 209458 using the equipment available at the Tycho Brahe Observatory in Oxie, Sweden?"*

2. Background

2.1 Transit pre-history: Mercury and Venus

Transits have been of great scientific importance throughout the history of telescopic astronomy. The transits of Mercury across the solar disc provided opportunities to make precise measurements of its position, which were useful when the orbit of the planet was to be determined. The examination of transit data which Urbain Le Verrier carried out in the 1850s revealed that the perihelion of the orbit of Mercury moves slightly more than one is led to expect by the Newtonian theory of gravitation.

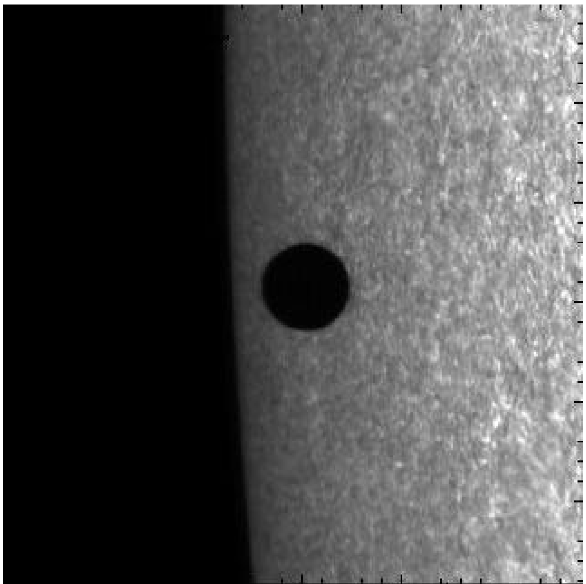

FIG. 2.1 The transit of Mercury on the 7th of May 2003, in an image obtained with the Swedish 1-m Solar Telescope. Image courtesy of The Royal Swedish Academy of Sciences.

Even though various explanations were put forward in the years that followed the discovery (such as the existence of a planet inside the orbit of Mercury causing the perturbations), the problem was finally solved in 1915 when Albert Einstein used his general theory of relativity to explain the perihelion problem (Wallenquist 1975). The transits of Mercury thus indirectly provided an opportunity for Einstein to test the general theory of relativity.

[1] A preliminary summary of the material in this paper was presented by Adrian Mach on behalf of the author at the meeting of the Astronomical Society Tycho Brahe on the 6th of November 2003 in Malmö, published in the newsletter Systema Solaris no. 1-04 (February 2004) and presented by the author at a meeting at the Tycho Brahe Observatory in Oxie on the 4th of April 2004.

The transits of Venus across the disc of the Sun have not been less important than the transits of Mercury.
While the transits of Mercury provided an opportunity to test an important theory of physics, the transits of Venus enabled astronomers to determine the distance between the Sun and the Earth. James Gregory proposed using the transits of Mercury and Venus to determine the Sun-Earth distance, and the method was refined by Edmond Halley who showed that the transits of Venus would give the best results. The method is based on the fact that observers on two widely separated locations on the Earth see Venus follow different paths across the solar disc, and if the angular distance between the two paths of Venus and the actual distance between the observers on the Earth are known geometry and the laws of Kepler gives the Sun-Earth distance (Doggett 1992).
The transits of 1761 and 1769 were observed from various locations across the Earth, but the method did not provide the accuracy expected (the values obtained in 1761 of the Sun-Earth distance ranged from 83% to 102% of the modern value). The 18th century Venus transits, nevertheless, were the first occasions on which large-scale international cooperation between astronomers took place.
The observations of the transit in 1874 represented a considerable improvement, yielding values ranging from 99% to 100.5% of the modern value (Doggett 1992).
Although other, more precise, methods have become available to determine the Sun-Earth distance since the 18th and 19th centuries the transits of Venus were good opportunities to determine the distance between the Earth and the Sun.

In recent years transit observations have also proved to be a most powerful tool in the study of extrasolar planets, and these particular transits are the topic of this paper.

2.2 Extrasolar planets: a brief history

The possibility that planets are orbiting stars other than the Sun has been considered for thousands of years. The philosopher Epicurus, who lived in the fourth and third centuries B.C., claimed that other worlds existed and thereby meant that other planets like the Earth capable of harbouring life should exist elsewhere (Flammarion 1867). Another thinker who claimed that other planets like the Earth existed was Giordano Bruno, who was condemned as a heretic by the Catholic Church in Rome and executed (Croswell 1997). Even though Epicurus and Bruno rightly can be regarded as pioneers in the field of extrasolar planet astronomy, it should be noted that they reached their conclusions on philosophic and theological rather than scientific grounds.
The first known observational attempt to detect planets at other stars was made in the 17th century by Christiaan Huygens, who did not succeed due to the limitations of his equipment (Schneider 1999).
These early examples aside, extrasolar planet astronomy can be said to have started around 1940 with the pioneering astrometry efforts by Strand and van de Kamp.
In 1943 Strand claimed that a third companion, with a mass of 16 Jupiter masses, is present in the 61 Cygni (PPM 86047) binary system (Strand 1943). This claim was based on photographic observations of 61 Cygni, which revealed a slight perturbation in the motions of the visible components indicating the existence of a third component. However, the claims of Strand were never sustained.
During the years 1938-1962 van de Kamp acquired over 2,000 photographic plates of Barnard's star (HIP 87937), which indicated that the proper motion of the star showed a wobble (Bell 1997). van de Kamp considered this motion to be caused by a planet with a mass of 1.7 Jupiter masses and a period of 25 years. van de Kamp later proposed a new model (van de Kamp 1982), in which two planets orbited Barnard's star. The results could not be reproduced, and the conclusions of van de Kamp were probably affected by errors in the acquisition and reduction of data.

Planets at other stars are difficult to detect, since they generally do not emit any intrinsic radiation. All detection techniques in use today are indirect and rely on influences by the planet on its parent star. The detection technique that so far have proved to be the most fruitful in the search for extrasolar planets is the Doppler spectroscopy technique, and it was also the method used when the first planets outside the solar system (whose existence could be positively confirmed) was discovered.

The Doppler spectroscopy technique is based on the fact that a planet orbiting a star does not orbit the star itself. Instead, both the star and the planet orbit a common centre of mass. However, since the mass of a star usually widely exceeds the mass of a planet, the common centre of mass (called the barycentre) lies inside the star, and this gives the impression that the planet orbits the star directly.
The narrow orbit of a star around the barycentre of a star-planet system gives an observer the impression that the star wobbles slightly. As the star moves towards the observer the light emitted by the star becomes slightly blue-shifted while the light becomes slightly red-shifted when the star moves away from the observer. These changes can be detected spectroscopically, and the orbital period, the semi-major axis and a minimum value of the mass of a planet orbiting a star can be inferred from them.

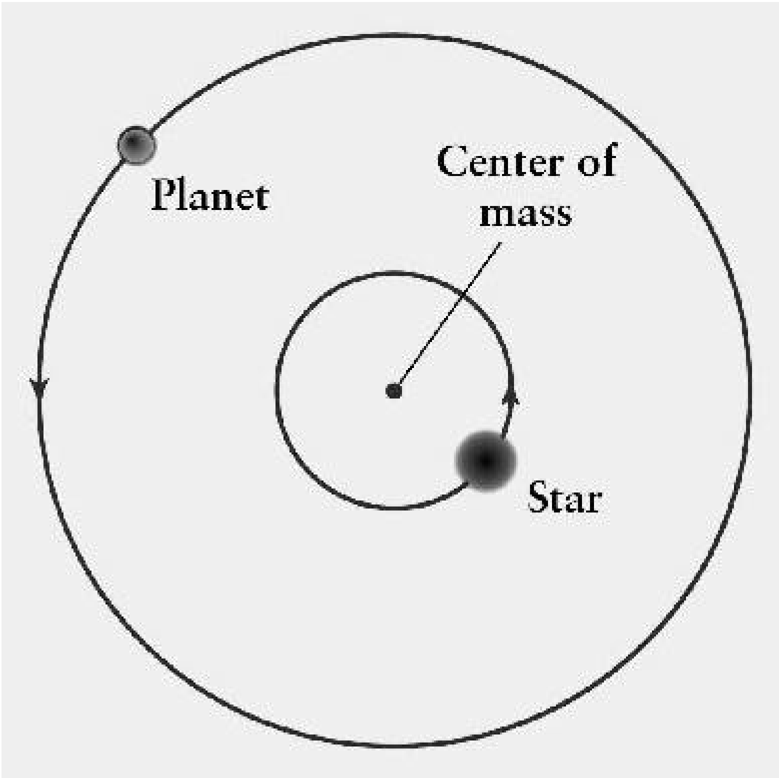

FIG. 2.2 A star-planet system with the centre of mass of the system indicated.

Timings of radio emission from the millisecond pulsar PSR 1257+12 made in 1991 by Wolszczan and Frail revealed a periodic shift in the signal received. This was interpreted as being due to the presence of two or possibly three planets in orbit around the pulsar (Wolszczan and Frail 1992).
This discovery was confirmed, and the planets orbiting PSR 1257+12 thus were the first planets to be found outside the solar system. Since the discovery the existence of the third planet has been confirmed, and the orbital and physical properties of the planets well established: their masses range from 0.02 to 4.3 Earth masses and their distance to the pulsar from 0.2 to 0.46 AU (Schneider 2003). A number of other pulsars have been studied with the same detection technique, but no other pulsar planets have been found.
In 1995 Mayor & Queloz (1995) announced that they had detected a planet orbiting 51 Pegasi (HD 217014, a G2V dwarf) using the Doppler spectroscopy technique. The results were confirmed by others, and thereby the first planet orbiting a sun-like star had been discovered. The planet has an orbit with a semi-major axis of 0.052 AU and a period of 4.2 days. M sin i for the planet is 0.47 Jupiter masses (Schneider 2004A).
Since the discoveries of the planets orbiting PSR 1257+12 and 51 Pegasi about 120 extrasolar planets have been discovered. They have orbits with semi-major axises ranging from 0.02 to 5.9 AU and eccentricities ranging from 0 to 0.93. M sin i for the detected planets lies between 0.00006 and 13.75 Jupiter masses (Schneider 2004C). Most of the planets have been found at sun-like stars, which is the type of stars that have been emphasized by the various planet search programmes.

The Doppler spectroscopy technique is, as mentioned above, currently the most widely used and the most fruitful extrasolar planet detection technique. There is however a number of other detection techniques available for detecting and observing extrasolar planets. One technique uses photometry.

2.3 Early photometry proposals

Struve (1952) was the first author to consider using the transits of extrasolar planets across their stars for observational purposes. He presented his idea at the end of a short paper about extrasolar planet detection techniques mainly dealing with the Doppler spectroscopy technique. He predicts the loss of starlight during a transit and also points out that the technique would be especially suitable for planets near their stars. Rosenblatt (1971) made a more detailed proposal for how photometry could be used to detect extrasolar planets, including estimates of the probability of transits, the photometric results, sources of errors and suggestions regarding data collection and analysis. Further proposals were made in the 1980s and early 1990s, as described by Deeg (2002).

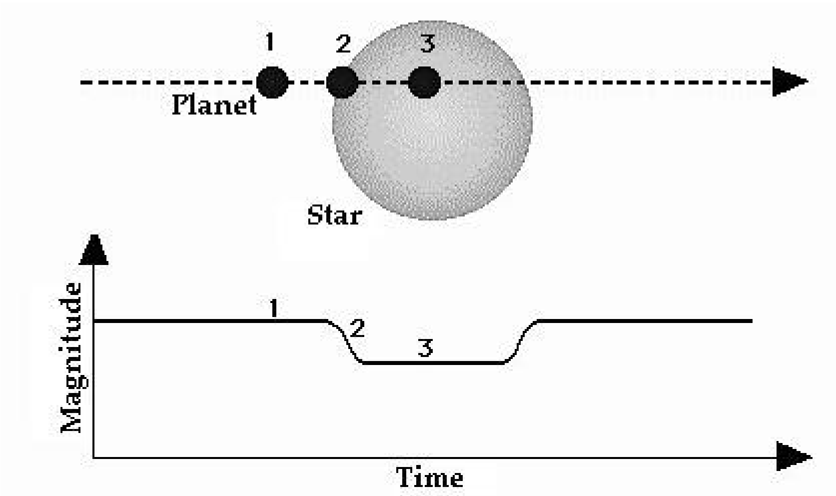

FIG. 2.3 A schematic illustration of a planet transiting its star, with the resulting time-magnitude diagram shown below.

2.4 HD 209458b: discovery and study

The planetary companion of HD 209458, which has been designated HD 209458b, was discovered in 1999 with the Doppler spectroscopy technique (IAU Circular No. 7307). The first transit was observed soon after the discovery (IAU Circular No. 7307), and the transiting nature of HD 209458b was soon confirmed by many observers (IAU Circular Nos. 7314, 7317 etc). The first observation of a transit by amateur astronomers was carried out at Nyrölä Observatory in Nyrölä, Finland, on the 16th of September 2000 (Jyväskylän Sirius 2002). A 0.4 m Schmidt-Cassegrain telescope with a CCD imager was used to make photometry measurements during the transit. Other amateurs soon followed, among them Gary, who made a transit observation in September 2002 (Gary 2002).
Discoveries concerning the composition and shape of the atmosphere of the planet have been made during 2001-2004 (Vidal-Madjar et al. 2004, Vidal-Madjar et al. 2003 & Charbonneau et al. 2001).

2.5 Stellar characteristics of HD 209458

HD 209458 (SAO 107623) is a G0V dwarf with m_V = 7.65 located in the constellation Pegasus, at right ascension 22h 3' 10.8" and declination +18° 53' 4" (epoch 2000.0)[2]. *Hipparcos* measurements gives a distance of 47 pc, which yields M_V = 4.29. Using *Hipparcos* data Prieto & Lambert (1999) estimate the mass, radius and effective temperature of HD 209458 to be 1.03 solar masses, 1.15 solar radii and 6025 K.
Spectroscopically, HD 209458 is similar to the Sun, as demonstrated by Henry et al. (2000).

[2] Data from SIMBAD (http://simbad.u-strasbg.fr/), May 2003.

2.6 Characteristics of HD 209458b

As described by Schneider (2004B), HD 209458b has an orbital period of 3.524738 ± 0.000015 days and an orbit with a semi-major axis of 0.045 AU. The eccentricity of the orbit is 0.0, and the orbit is inclined with 86.1 ± 0.1° with respect to the plane of an Earth-bound observer. M sin *i* for the planet is 0.69 ± 0.05 Jupiter masses, and the radius is 1.43 ± 0.04 Jupiter radii.
Oxygen and carbon (Vidal-Madjar et al. 2004) as well as sodium (Charbonneau et al. 2001) have been spectroscopically detected in the atmosphere of the planet. The atmosphere of the planet appears to be extended into space in a cometary way (Vidal-Madjar et al. 2003).
The presence of satellites of HD 209458b with masses exceeding 3 Earth masses has been ruled out, as pointed out by Charbonneau (2002).

3. Observations

3.1 Observatory, equipment and software

All the observations of HD 209458 described from here on were made by the author at *Tycho Brahe-observatoriet* ("The Tycho Brahe Observatory" or TBO) in Oxie, Sweden.
The observatory is located at latitude 55° 32' 35" North, longitude 13° 5' 10" East and 55 m above the sea level. It is situated on a hill inside the village of Oxie, but despite this and the proximity of the cities of Malmö and Lund the light pollution at the site is not very severe. TBO is run by *Astronomiska Sällskapet Tycho Brahe* ("The Astronomical Society Tycho Brahe" or ASTB).
The equipment used during the observations was a 0.35 m *Celestron C-14* Schmidt-Cassegrain telescope operated at f/5, mounted on an equatorial *Paramount 1100* mount and equipped with an *Apogee 7* CCD imager with a 512x512 pixel detector (giving a field of view of 19' x 19').
The software used was *TheSky* version 5 (1999) from Software Bisque (for controlling the telescope), *CCDSoft* version 4 (1999) from Software Bisque (for controlling the CCD imager and making photometry measurements) and the *Microsoft Excel* version 10 (2002) spreadsheet software for compiling the photometry measurements and for making diagrams. All the software mentioned runs in a *Microsoft Windows* environment.

3.2 Test observation of SAO 42275 on the 14th of April 2003

During 21.07 – 22.11 UT on the 14th of April 2003, 147 useful images of the low amplitude variable star SAO 42275 (HD 69242, CR Lyn) were obtained at TBO. The exposure time per image was 8 s, the telescope was focused and no filter was used. No flat fields were obtained. The temperature of the CCD was -20° C. The weather was somewhat hazy.
The purpose of the observation was to evaluate the photometric precision of the telescope and the CCD imager, and SAO 42275 was picked as a test object because its properties as a variable star (period 3.16 hours, amplitude 0.07 magnitudes)[3] are similar to the photometric properties of a HD 209458b transit.

3.3 Selection of candidate transits

The table of upcoming transits for HD 209458 prepared by Charbonneau (2003) was used to choose transits suitable for observation. The time separating two transits corresponds to the orbital period of HD 209458b (i.e. about 3.5 days), which means that two transits occur per week. Every other transit occurs during daytime for an Earth-based observer, which means that one transit per week can be observed. A transit lasts about 3 hours, which means that HD 209458 must be at a sufficient altitude for at least such a long time to allow an observation of a whole transit. This constraint, along with the geographical location of TBO, means that transit observations are only possible during August – October each year.
It should be noted that there are other extrasolar planets that are going through transits, apart from HD 209458b, but that the transits of HD 209458b are the only transits that are within reach for amateur astronomers.

[3] Data obtained from the BYU Variable Star Database (March 2003)

3.4 Test observation and transit observation attempts in August 2003

During 21.01 – 22.20 UT on the 17th of August 2003 114 useful images of HD 209458 were obtained at TBO. The exposure time per image was 6 s, the telescope was focused and no filter was used. No flat fields were obtained. The temperature of the CCD was -16° C. The sky was cloud-free and the seeing was good. The time for the observation on the 17th of August had been selected since no transit was underway at the time, and the purpose of the observation was to measure the photometric stability of HD 209458 when HD 209458b was not transiting. The telescope was moved at 21.58 UT in order to allow testing of SAO 107607 (HD 209346) as a reference star. SAO 107607 is located outside the field of view when HD 209458 is centred.

A transit occurred on the 20th of August 2003, with HD 209458 favourably placed as seen from TBO, but observations were not possible due to cloudy weather. Another suitable transit occurred on the 27th of August 2003, and the sky was cloud-free, but malfunctioning equipment prevented the observation from being carried out. No suitable transits took place in September.

3.5 Transit observation attempt on the 12th of October 2003

During 18.07 – 19.57 UT on the 12th of October 2003 181 useful images of HD 209458 were obtained at TBO. The exposure time per image was 2 s, the telescope was focused and no filter was used. No flat fields were obtained. The temperature of the CCD was -20° C. The sky was cloud-free and the seeing was good. At the time of the observation the author was in Kiruna, and the telescope at TBO was therefore controlled via the Internet. The purpose of the observation was to get a series of images of the transit that, according to Charbonneau (2003), was to occur 18.00 – 21.05 UT on the 12th of October.
The reason why the observation was aborted prematurely was hardware-related. The 0.35 m telescope is mounted in such a way that its mounting often collides with itself when it follows an object across the meridian. This occurred on the 12th of October, since HD 209458 crossed the meridian during the observation.

3.6 Transit observation attempt on the 26th of October 2003

During 19.55 – 23.59 UT on the 26th of October 2003 362 useful images of HD 209458 were obtained at TBO. The exposure time per image was 9 s, the telescope was slightly unfocused and no filter was used. The temperature of the CCD was -20° C. No flat fields were obtained. The sky was cloud-free, but became slightly hazy around 23 UT. The purpose of the observation was to get a series of images for a transit that, according to Charbonneau (2003), was to occur 20.24 – 23.28 UT on the 26th of October.

FIG. 3.1 An image of HD 209458 (the brightest star in the image) from the 26th of October 2003, obtained with the 0.35 m telescope at TBO. Exposure time 9 s.

4. Data reduction and results

4.1 General reduction method

CCDSoft allows photometry measurements to be made in CCD images, when the properties of the telescope used to obtain the images have been specified in the programme. The measurement process is straightforward, and involves specifying the magnitude of a chosen reference star whereupon the magnitude of the star to be measured is calculated by the program when the user marks that star. *CCDSoft* was, as mentioned before, used for all the photometry measurements described here.

A disadvantage of HD 209458 (when centred in a 19'x19' field of view) is the lack of nearby reference stars of comparable magnitude. The brightest stars nearby (with visual magnitudes around 11.3) were therefore chosen as reference stars, as a compromise. Data for each of them is given in table 4.1.

Table 4.1
Characteristics of the four reference stars used for photometry[4]

Provisional designation (as in Fig. 4.1)	GSC designation	Right ascension	Declination	Visual magnitude	Angular distance to HD 209458
A	1688:1903	22h 3' 7.5"	+18° 51' 34"	11.23	1' 41"
B	1688:1716	22h 3' 15.6"	+18° 55' 7"	11.62	2' 21"
C	1688:1864	22h 3' 28.4"	+18° 51' 54"	11.32	4' 19"
D	1688:1639	22h 2' 55"	+18° 46' 24"	11.18	7' 38"

The reference stars designated A, B and C was used for photometry in the images from the 12th of October, 2003. A, B, C and D were used in the images from the 26th of October. The reference star B (as mentioned in Table 4.1) and the reference star SAO 107607 (described in section 3.4) was used for the images from the 17th of August 2003.

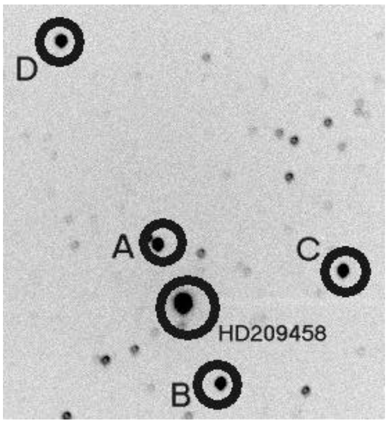

FIG. 4.1 Reference stars A-D in an image obtained
with the 0.35 m telescope at TBO on the 26th of October 2003.

The aim of the photometry measurements was to produce time-magnitude diagrams of HD 209458 in order to show how the brightness of the star changed over time. To accomplish this, the magnitude of HD 209458 was first measured using *n* reference stars, which gave *n* magnitude values per image. The arithmetic mean of these values was then calculated, in order to obtain one magnitude value per image.

$$\frac{m_1 + m_2 + \ldots + m_n}{n} = M \qquad (4.1)$$

In equation 4.1 the terms from m_1 to m_n represents the magnitude values for HD 209458 obtained using different reference stars. n is the number of magnitude values obtained and M is the arithmetic

[4] Table 4.1 is based on data from *TheSky* (1999). Right ascension and declination is given in epoch 2000.0.

mean of all the magnitude values. The calculation of a mean magnitude value for each image gives one magnitude value per image, instead of several "raw" values.
In order to make possible trends clearly visible in a time-magnitude diagram another calculation of arithmetic means was carried out, which involved calculating the arithmetic mean of magnitude values from 10 images at a time.

$$\frac{M_1 + M_2 + \ldots + M_{10}}{10} = M_{avg} \tag{4.2}$$

In equation 4.2 the terms from M_1 to M_{10} represent mean magnitudes from individual images. 10 is the number of images and M_{avg} is the arithmetic mean magnitude for the 10 images.
These two steps of mean value calculations brings the number of magnitude values to be plotted in the time-magnitude diagram down to a reasonable value, helps making instrumental errors in the data less conspicuous and helps making changes in magnitude over time visible.
In this case it has been of interest to measure a change in the brightness of HD 209458, rather than to determine a definitive value of its brightness. It is therefore unimportant that the values on the magnitude axises in the time-magnitude diagrams below differ from the common catalogue values for the apparent magnitude of HD 209458. This kind of photometry (differential photometry) to a certain extent compensates for changes in atmospheric transparency occurring during the observation.
It should be noted that the diagrams below were made with a Swedish version of *Microsoft Excel* and that the magnitude values therefore are given as "n,n" instead of "n.n" (e.g. 7,66 instead of 7.66, with a "," instead of a "." as a decimal point).

4.2 Reductions and results for SAO 42275 (14^{th} of April 2003)

Other reference stars than those listed in table 4.1 were used when photometry measurements were made for SAO 42275, but the same "double mean" method was used to reduce the measurements. Three reference stars were used, which totally gave 3 (reference stars) x 147 (images) = 441 magnitude values, which were reduced to 14 magnitude values with the "double mean" method. A time-magnitude diagram (not reproduced here) was obtained, showing a total change in magnitude of approximately 0.03. That the observation covered less time than a complete period of variation probably explains why this value is less than the amplitude given in section 3.2.

4.3 Reductions and results for HD 209458 (17^{th} of August 2003)

Two reference stars were used when photometry measurements were made for HD 209458 on the 17^{th} of August 2003: B (listed in table 4.1) and SAO 107607 (with a visual magnitude of 8.32). Reference star B was used in the images obtained 21.01 – 21.58 UT and gave 80 magnitude values, which were reduced to 8 values by calculating the arithmetic mean of the magnitudes in blocks of 10 values. A time-magnitude diagram (not reproduced here) was obtained for this period, showing a total change in magnitude of approximately 0.012.
SAO 107607 was used as a reference star in the images obtained during 21.58 – 22.20 UT, and gave 34 magnitude values, which were reduced to 3 values by calculating the arithmetic mean of the magnitudes in blocks of 10 values. When arranged in a time-magnitude diagram they showed a total change in magnitude of approximately 0.011.

4.4 Reductions and results for HD 209458 (12^{th} of October 2003)

The reference stars A, B and C was used when photometry measurements were made for HD 209458 on the 12^{th} of October 2003. This totally gave 3 (reference stars) x 181 (images) = 543 magnitude values, which were reduced to 16 magnitude values with the "double mean" method. The time-magnitude diagram obtained is reproduced in figure 4.2. It should be noted that the y-axis on this diagram (showing magnitude) has been inverted, so that a falling curve in the diagram corresponds to a decreasing brightness.

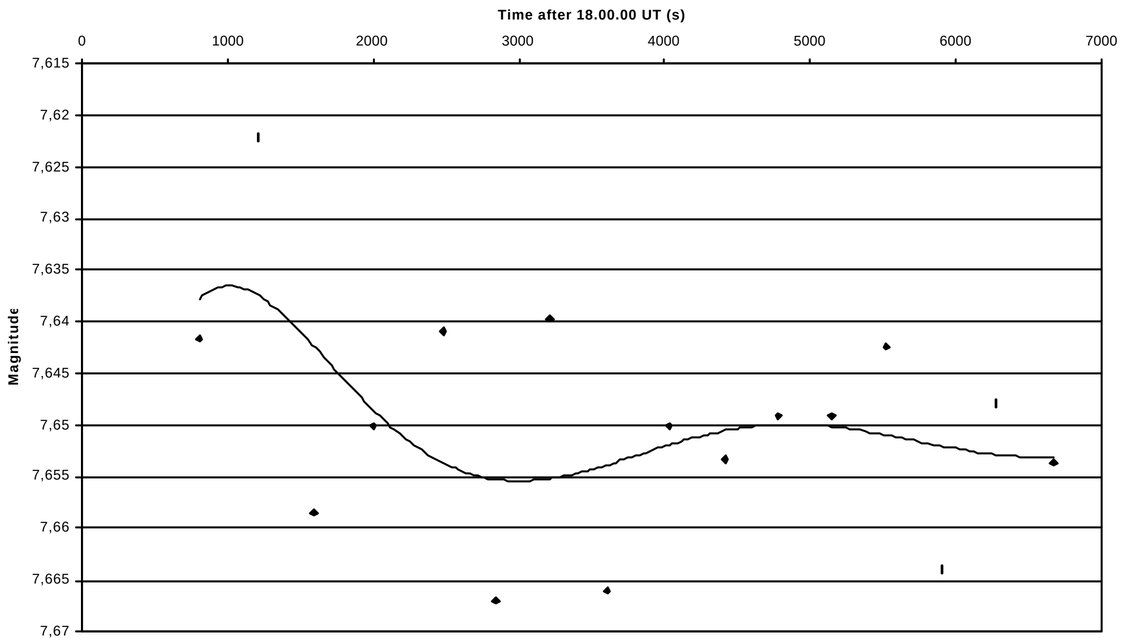

FIG. 4.2 Time-magnitude diagram for HD 209458 on the 12th of October 2003, showing ”double mean” magnitude values based on measurements from 3 reference stars.

The total magnitude change shown by the diagram is approximately 7.635 – 7.655 = 0.02.

4.5 Reductions and results for HD 209458 (26th of October 2003)

The reference stars A, B, C and D was used when photometry measurements were made for HD 209458 on the 26th of October 2003. This totally gave 4 (reference stars) x 362 (images) = 1448 magnitude values, which were reduced to 36 magnitude values with the “double mean” method. The time-magnitude diagram obtained is reproduced in figure 4.3. The magnitude-axis in this diagram is inverted, like in figure 4.2.

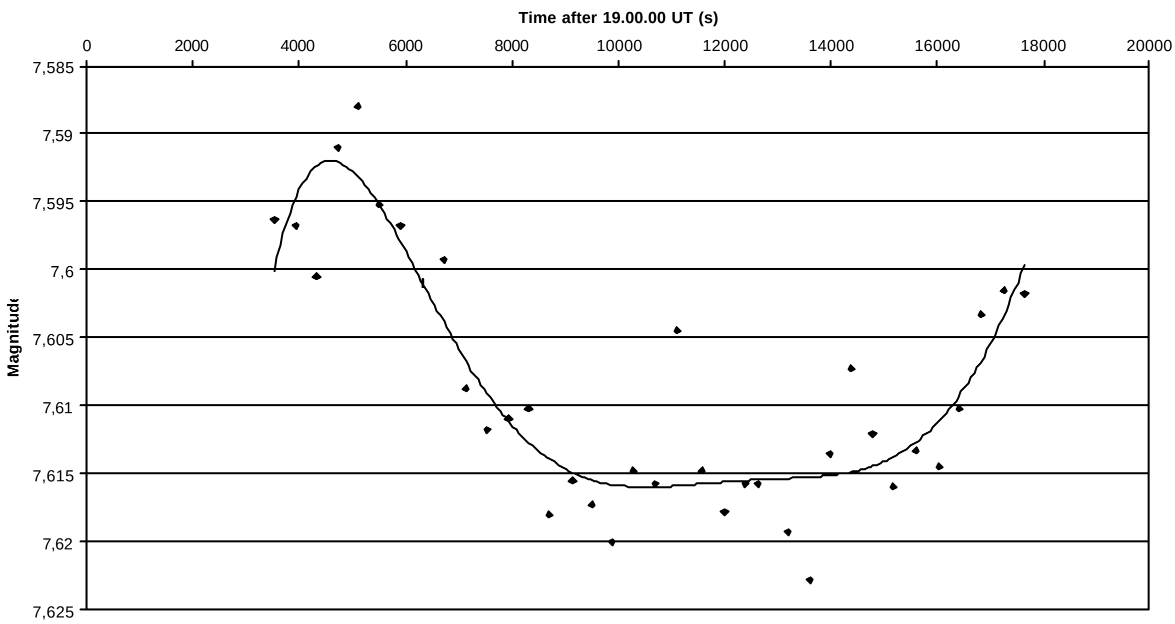

FIG. 4.3 Time-magnitude diagram for HD 209458 on the 26th of October 2003, showing ”double mean” magnitude values based on measurements from 4 reference stars.

The total magnitude change shown by the diagram is approximately 7.615 – 7.595 = 0.02.

5. Interpretation

5.1 Interpretation of the results from the 12th of October 2003

According to Charbonneau (2003), first contact of the HD 209458b transit of the 12th of October 2003 was to take place between 1207 s before and 1292 s after 18.00.00 UT. At approximately 1000 s after 18.00.00 UT a slight decrease in brightness can be seen in the time-magnitude diagram (figure 4.2). Since the observation was aborted prematurely (see section 3.5) nothing can be said about the end of the transit.

The detected magnitude change (approximately 0.02) corresponds to what have been observed by others (see table 5.1), but the overall trend shown in the diagram is rather indistinct. This probably has to do with the focusing of the telescope (see discussion in section 5.2).

5.2 Interpretation of the results from the 26th of October 2003

According to Charbonneau (2003), first contact of the HD 209458b transit of the 26th of October was to take place between 3807 and 6333 s after 19.00.00 UT. At approximately 5500 s after 19.00.00 UT a beginning decrease in brightness can be seen in the time-magnitude diagram (figure 4.3). This decrease continues until about 8500 s, whereupon the brightness stabilises.

According to Charbonneau (2003) last contact was to take place between 14862 and 17388 s after 19.00.00 UT. An increase of brightness takes place between approximately 15000 and 18000 s after 19.00.00 UT. The brightness trend for this transit observation is considerably more distinct than for the observation from the 12th of October.

The photometric transit depth (i.e. the total magnitude change) as observed during various HD 209458b transits by different observers are presented in table 5.1, along with the value obtained by the author on the 26th of October. The value obtained by the author agrees well with the results of other observers.

Table 5.1
Photometric transit depth (comparison with other observers)

Observer and date	Observed transit depth (magnitudes)	Reference
The author, 26-Oct-2003	0.02	- (see figure 4.3)
Gary, 12-Aug-2002	0.0155 ± 0.0022	Gary 2002
The Nyrölä group, 16-Sep-2000	0.02	Jyväskylän Sirius 2002
Gonzalez, 22-Nov-1999	0.028	IAU Circular 7317
Rebolo et al., 18-Nov-1999	0.023 ± 0.005	IAU Circular 7314
Henry et al., 8-Nov-1999	0.017 ± 0.002	Henry et al. 2000

A note about the focus of the telescope should be made, since the telescope was differently focused on the two observing nights. While the telescope was in focus on the 12th of October, it was intentionally slightly out of focus on the 26th. The apparent diameter of HD 209458 in the CCD images from the 12th of October was about 10 pixels, whereas it was about 12 pixels in the images from the 26th.

The telescope was slightly defocused on the 26th in order to catch more photons from HD 209458 and from the reference stars. The light of a star is concentrated on comparatively few pixels on a CCD detector when a telescope is well focused, and this makes it easy to detect dim objects with short exposure times, but this takes place at the cost of capturing few photons.

When a telescope is less well focused, longer exposure times are required to detect dim objects, but more photons are captured. In this particular case, where the reference stars used to measure the magnitude of HD 209458 are considerably fainter that HD 209458, it was important to capture as many photons as possible. Another important reason for defocusing the telescope was to avoid saturation of the CCD during the comparatively long exposures necessary to capture as many photons as possible.

The combination of a slightly unfocused telescope and a long exposure time per image (9 s) on the 26th of October, compared to a focused telescope and a short exposure time per image (2 s) on the 12th of October probably explains the indistinct appearance of the time-magnitude diagram for the 12th, compared to the more well-pronounced appearance of the time-magnitude diagram for the 26th.

6. Conclusions

The indistinct appearance of the time-magnitude diagram for the 12th of October makes it hard to conclude whether a transit was observed or not, but the coincidence in time between the decrease in brightness at beginning of the observation and the predicted time for HD 209458b ingress in combination with the magnitude change (which corresponds to what has been observed by others) probably indicates that the beginning of a transit was detected (albeit weakly). The observation was aborted prematurely due to reasons already discussed.

The coincidence between the predicted and observed ingress and egress times for the transit on the 26th of October and the magnitude change (which corresponds to values obtained by other observers) indicates, together with the distinct appearance of the time-magnitude diagram, that a whole HD 209458b transit was observed.
It appears that a time-magnitude signature revealing a HD 209458b transit can be extracted from CCD images that have not been flat fielded, such as the ones used in this case.
The answer to the original question (*"Is it possible for me to observe the planet orbiting the star HD 209458 using the equipment available at the Tycho Brahe Observatory in Oxie, Sweden?")* is "Yes.".

7. A personal perspective

Slightly more than a decade ago no astronomer had observed any extrasolar planets with any certainty, but now they are within reach for amateurs. This was perhaps the most important source of inspiration when I decided to try to observe HD 209458b. That the observation could be done at an observatory named after, and located only about 50 km from the birthplace of, Tyge Brahe was also an incentive.

Neither professional nor amateur astronomers should be concerned with such small-minded conceptions as "country" and "nationality", but it does not hurt that the observation described above most probably makes me the first Swede and the first Scanian to observe a planet outside the solar system.

Even though amateurs always have been able to contribute to the science of astronomy, the gap between professionals and amateurs in terms of equipment was quite large during most of the 20th century. The advanced work carried out by many amateur astronomers today suggests that this gap in some respects have been bridged, and that astronomy of today in a certain sense can be compared to astronomy of the 19th century, when amateurs still could do research on par with professionals.
It is impossible to gain an idea about the state of extrasolar planet astronomy in general, and extrasolar planet amateur astronomy in particular, in ten or twenty years time. But, considering what has been done so far, not expecting the unimaginable would be unfair to discoveries and discoverers yet to come.

8. Summary

The observations of transits of Mercury and Venus across the Sun in the 18th and 19th centuries proved valuable for proving the general theory of relativity and for determining the Sun-Earth distance, respectively.
The existence of planets orbiting other stars have been imagined during at least the last two thousand years, but it was not until 1991, when a number of planets orbiting a pulsar was found, that their

existence could be observationally confirmed. The first planet orbiting a Sun-like star was detected in 1995, and HD 209458b was discovered in 1999.
Struve (1952) was the first to suggest observations of extrasolar planet transits with photometry, and various further proposals about this method of observation was made throughout the last half of the 20th century. The first transit observation (of HD 209458b) was made in 1999, and the first amateur observation of a transit was made in 2000.

All the observations of HD 209458 by the author were made at *Tycho Brahe-observatoriet* ("The Tycho Brahe Observatory), in Oxie outside Malmö, Sweden. An equatorially mounted, 0.35 m f/5 Schmidt-Cassegrain telescope with a 512x512 pixel CCD imager was used for all observations. A series of images of the low amplitude variable star SAO 42275 was obtained in April 2003, in order to evaluate the photometric abilities of the equipment. The first series of images of HD 209458 was obtained on the 17th of August 2003, when no transit was taking place, to measure the photometric stability of HD 209458 when no transit was taking place. Two opportunities to observe a transit at the end of August 2003 could not be utilized due to cloudy weather and malfunctioning equipment.
An attempt to observe the transit taking place on the 12th of October 2003 was aborted prematurely due to an equipment malfunction. A complete series of images was taken during the time predicted for the transit of the 26th of October 2003. Photometry measurements in the images from the 12th and 26th of October in October – December 2003 revealed that a transit possibly was detected on the 12th of October and almost certainly was detected on the 26th.

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Appendix 1

The following table presents all the magnitude measurements of HD 209458 from the series of images obtained on the 12th of October 2003. The left column gives the time for each of the measurements, counted in s after 18.00.00 UT. The three remaining columns gives the magnitude values for HD 209458 obtained using the reference stars A, B and C (see table 4.1 in the main text).

Time (s, from 18.00.00 UT)	Reference star A	Reference star B	Reference star C
460	7.66	7.72	7.62
688	7.61	7.67	7.57
743	7.68	7.64	7.54
776	7.67	7.72	7.62
809	7.61	7.7	7.56
842	7.7	7.77	7.66
876	7.63	7.65	7.59
922	7.68	7.71	7.53
962	7.62	7.65	7.57
994	7.64	7.69	7.57
1029	7.63	7.66	7.57
1062	7.67	7.68	7.64
1094	7.65	7.7	7.57
1140	7.6	7.66	7.57
1179	7.65	7.68	7.57
1213	7.6	7.63	7.51
1248	7.63	7.63	7.57
1280	7.63	7.69	7.57
1312	7.61	7.65	7.56
1346	7.63	7.66	7.59
1379	7.63	7.66	7.58
1411	7.71	7.72	7.66
1444	7.62	7.63	7.57
1476	7.64	7.64	7.58
1520	7.63	7.67	7.59
1560	7.7	7.75	7.64
1593	7.63	7.67	7.59
1625	7.65	7.66	7.57
1659	7.75	7.77	7.68
1691	7.63	7.66	7.58
1724	7.68	7.72	7.64
1756	7.72	7.74	7.64
1788	7.65	7.66	7.56
1822	7.64	7.67	7.59
1853	7.65	7.67	7.57
1888	7.69	7.71	7.63
1922	7.64	7.71	7.61
1954	7.72	7.72	7.65
1986	7.6	7.64	7.58
2134	7.63	7.74	7.58
2167	7.75	7.67	7.71
2201	7.63	7.67	7.6
2246	7.64	7.69	7.58
2285	7.67	7.68	7.61
2319	7.62	7.66	7.57
2384	7.7	7.73	7.65
2419	7.64	7.67	7.6
2451	7.66	7.73	7.64
2483	7.61	7.67	7.6
2515	7.64	7.64	7.57
2547	7.62	7.68	7.57
2581	7.61	7.65	7.58
2614	7.67	7.71	7.63
2648	7.63	7.66	7.58
2680	7.72	7.73	7.65
2713	7.62	7.67	7.58
2745	7.78	7.79	7.73
2777	7.67	7.69	7.62
2809	7.64	7.68	7.62
2841	7.72	7.76	7.69
2872	7.64	7.67	7.6
2906	7.62	7.67	7.59
2937	7.64	7.68	7.59
2971	7.64	7.67	7.57
3003	7.68	7.73	7.66
3047	7.69	7.7	7.62
3087	7.66	7.68	7.58
3120	7.63	7.65	7.58
3153	7.64	7.66	7.59
3185	7.65	7.65	7.59
3186	7.63	7.66	7.58
3248	7.61	7.64	7.59
3281	7.71	7.74	7.65
3314	7.66	7.67	7.63
3348	7.64	7.65	7.58
3391	7.62	7.67	7.61
3430	7.65	7.67	7.61
3463	7.78	7.8	7.74
3496	7.65	7.64	7.6
3530	7.65	7.66	7.59
3564	7.64	7.68	7.62
3596	7.63	7.68	7.6
3626	7.7	7.74	7.65
3662	7.68	7.68	7.58

3706	7.64	7.67	7.59
3758	7.72	7.74	7.68
3798	7.69	7.69	7.64
3842	7.64	7.65	7.59
3893	7.65	7.68	7.6
3932	7.64	7.66	7.58
3966	7.64	7.65	7.61
4000	7.68	7.71	7.67
4033	7.64	7.67	7.59
4066	7.63	7.67	7.62
4099	7.64	7.67	7.58
4130	7.68	7.74	7.65
4163	7.69	7.71	7.6
4195	7.68	7.71	7.63
4229	7.64	7.69	7.61
4262	7.65	7.7	7.63
4293	7.64	7.68	7.59
4338	7.64	7.68	7.61
4388	7.64	7.66	7.59
4426	7.68	7.69	7.63
4458	7.65	7.68	7.59
4490	7.62	7.68	7.59
4523	7.67	7.68	7.57
4555	7.64	7.68	7.62
4587	7.76	7.76	7.72
4619	7.64	7.7	7.64
4652	7.64	7.69	7.59
4684	7.68	7.7	7.64
4716	7.64	7.67	7.61
4748	7.64	7.67	7.62
4780	7.65	7.68	7.61
4812	7.65	7.68	7.62
4843	7.62	7.66	7.59
4874	7.71	7.71	7.65
4906	7.64	7.67	7.6
4938	7.65	7.66	7.6
4971	7.67	7.66	7.61
5004	7.62	7.68	7.61
5035	7.64	7.67	7.61
5067	7.69	7.65	7.63
5109	7.7	7.72	7.66
5159	7.64	7.66	7.62
5197	7.65	7.72	7.61
5227	7.66	7.66	7.6
5259	7.64	7.67	7.63
5292	7.64	7.68	7.6
5325	7.62	7.7	7.6
5356	7.65	7.67	7.62
5389	7.65	7.68	7.59
5420	7.67	7.71	7.65
5454	7.63	7.68	7.61
5486	7.64	7.69	7.6
5520	7.64	7.69	7.6
5551	7.64	7.68	7.61
5586	7.62	7.65	7.59
5617	7.66	7.69	7.61
5651	7.63	7.65	7.58
5685	7.65	7.67	7.6
5729	7.67	7.65	7.62
5769	7.75	7.77	7.71
5803	7.64	7.66	7.62
5836	7.66	7.71	7.63
5869	7.65	7.68	7.62
5902	7.66	7.69	7.62
5936	7.65	7.67	7.61
5969	7.66	7.7	7.64
6001	7.66	7.67	7.6
6035	7.72	7.71	7.68
6068	7.66	7.68	7.59
6100	7.68	7.67	7.63
6134	7.65	7.67	7.6
6167	7.65	7.69	7.59
6200	7.65	7.68	7.63
6235	7.7	7.71	7.66
6269	7.63	7.67	7.62
6302	7.65	7.66	7.61
6337	7.65	7.69	7.63
6371	7.6	7.66	7.6
6414	7.62	7.68	7.62
6453	7.62	7.69	7.62
6497	7.69	7.71	7.65
6525	7.69	7.7	7.63
6567	7.66	7.68	7.61
6599	7.7	7.71	7.65
6631	7.62	7.67	7.6
6665	7.64	7.68	7.63
6696	7.65	7.68	7.59
6730	7.66	7.69	7.61
6763	7.63	7.68	7.61
6797	7.64	7.67	7.61
6830	7.64	7.68	7.61
6864	7.64	7.7	7.63
6896	7.63	7.65	7.58
6940	7.66	7.69	7.63
6979	7.67	7.7	7.65
7012	7.63	7.7	7.61
7046	7.63	7.66	7.6

Appendix 2

The following table presents all the magnitude measurements of HD 209458 from the series of images obtained on the 26th of October 2003. The left column gives the time for each of the measurements, counted in s after 19.00.00 UT. The four remaining columns gives the magnitude values for HD 209458 obtained using the reference stars A, B, C and D (see table 4.1 in the main text).

Time (s, from 19.00.00 UT)	Reference star A	Reference star B	Reference star C	Reference star D
3355	7.62	7.64	7.61	7.56
3394	7.59	7.64	7.61	7.54
3433	7.61	7.64	7.61	7.47
3472	7.62	7.66	7.61	7.55
3511	7.59	7.64	7.6	7.53
3550	7.59	7.63	7.61	7.56
3588	7.59	7.65	7.61	7.56
3627	7.59	7.62	7.6	7.56
3666	7.57	7.64	7.57	7.55
3705	7.63	7.63	7.61	7.54
3744	7.61	7.61	7.59	7.55
3783	7.6	7.63	7.59	7.53
3822	7.61	7.66	7.61	7.57
3860	7.61	7.64	7.6	7.53
3899	7.63	7.63	7.62	7.56
3956	7.68	7.6	7.58	7.55
3995	7.58	7.64	7.57	7.55
4034	7.6	7.61	7.58	7.54
4073	7.59	7.64	7.6	7.56
4112	7.62	7.64	7.6	7.56
4151	7.6	7.63	7.61	7.58
4189	7.6	7.65	7.6	7.56
4228	7.58	7.65	7.59	7.56
4267	7.57	7.63	7.6	7.55
4306	7.58	7.64	7.61	7.57
4345	7.61	7.64	7.59	7.53
4402	7.59	7.63	7.61	7.57
4440	7.61	7.64	7.62	7.58
4479	7.59	7.64	7.61	7.54
4519	7.64	7.64	7.6	7.58
4558	7.59	7.6	7.61	7.55
4597	7.62	7.65	7.62	7.52
4636	7.61	7.66	7.61	7.52
4675	7.56	7.66	7.63	7.51
4714	7.58	7.64	7.62	7.52
4753	7.61	7.65	7.61	7.52
4791	7.6	7.63	7.59	7.51
4830	7.6	7.65	7.61	7.54
4869	7.56	7.65	7.57	7.48
4908	7.59	7.65	7.61	7.53
4947	7.57	7.64	7.61	7.52
4986	7.59	7.64	7.58	7.51
5025	7.56	7.63	7.61	7.52
5063	7.58	7.64	7.63	7.54
5102	7.58	7.65	7.58	7.52
5141	7.61	7.63	7.61	7.52
5180	7.59	7.65	7.62	7.51
5219	7.62	7.66	7.58	7.51
5258	7.58	7.64	7.58	7.53
5219	7.6	7.64	7.61	7.53
5335	7.64	7.67	7.61	7.55
5374	7.58	7.65	7.62	7.53
5413	7.58	7.67	7.61	7.54
5452	7.58	7.65	7.58	7.49
5491	7.61	7.65	7.61	7.52
5530	7.6	7.65	7.61	7.54
5569	7.59	7.66	7.56	7.52
5608	7.6	7.65	7.62	7.53
5646	7.59	7.65	7.62	7.53
5685	7.56	7.64	7.61	7.54
5724	7.6	7.67	7.6	7.53
5763	7.6	7.61	7.58	7.52
5802	7.57	7.66	7.61	7.55
5841	7.59	7.64	7.59	7.52
5879	7.56	7.65	7.59	7.52
5918	7.6	7.65	7.62	7.54
5957	7.6	7.66	7.62	7.55
5996	7.61	7.69	7.62	7.57
6035	7.59	7.67	7.59	7.54
6092	7.61	7.65	7.6	7.53
6149	7.57	7.64	7.62	7.55
6188	7.63	7.65	7.61	7.53
6227	7.62	7.65	7.65	7.55
6265	7.59	7.64	7.62	7.54
6304	7.59	7.64	7.59	7.52
6343	7.58	7.65	7.62	7.54
6382	7.62	7.65	7.62	7.54
6421	7.61	7.64	7.61	7.54
6460	7.6	7.67	7.61	7.51
6499	7.61	7.68	7.61	7.53
6538	7.55	7.67	7.61	7.51
6576	7.62	7.67	7.61	7.53
6615	7.59	7.67	7.61	7.51
6654	7.61	7.67	7.6	7.53

6693	7.59	7.68	7.59	7.53
6732	7.6	7.67	7.62	7.54
6771	7.59	7.68	7.6	7.53
6810	7.61	7.66	7.62	7.53
6849	7.61	7.68	7.62	7.54
6906	7.57	7.65	7.59	7.51
6963	7.64	7.67	7.64	7.54
7001	7.63	7.65	7.63	7.57
7040	7.65	7.66	7.61	7.53
7079	7.6	7.65	7.63	7.56
7118	7.6	7.64	7.62	7.53
7157	7.57	7.66	7.62	7.54
7196	7.61	7.65	7.59	7.55
7235	7.63	7.65	7.63	7.54
7274	7.58	7.65	7.63	7.54
7312	7.62	7.66	7.63	7.55
7369	7.65	7.66	7.64	7.55
7408	7.57	7.65	7.62	7.53
7447	7.56	7.66	7.64	7.54
7486	7.65	7.66	7.63	7.57
7525	7.65	7.61	7.61	7.55
7564	7.63	7.66	7.63	7.57
7603	7.65	7.66	7.6	7.53
7641	7.61	7.67	7.64	7.53
7680	7.61	7.66	7.63	7.57
7719	7.61	7.66	7.61	7.54
7758	7.61	7.66	7.64	7.54
7797	7.58	7.65	7.64	7.56
7836	7.61	7.66	7.61	7.54
7875	7.61	7.66	7.6	7.53
7914	7.71	7.67	7.62	7.53
7952	7.63	7.65	7.61	7.53
7991	7.6	7.66	7.61	7.54
8030	7.65	7.68	7.64	7.56
8069	7.61	7.65	7.61	7.53
8108	7.62	7.67	7.63	7.53
8147	7.63	7.67	7.63	7.55
8186	7.71	7.67	7.63	7.52
8224	7.6	7.67	7.62	7.52
8263	7.61	7.65	7.6	7.54
8302	7.61	7.66	7.59	7.55
8341	7.57	7.66	7.63	7.52
8380	7.62	7.64	7.62	7.57
8419	7.59	7.66	7.63	7.53
8458	7.62	7.66	7.63	7.56
8496	7.63	7.65	7.65	7.54
8535	7.63	7.67	7.62	7.55
8574	7.65	7.67	7.64	7.56
8613	7.64	7.69	7.63	7.54
8652	7.63	7.67	7.64	7.58
8709	7.59	7.66	7.58	7.53
8748	7.63	7.67	7.64	7.55

8787	7.58	7.66	7.61	7.53
8826	7.61	7.69	7.64	7.57
8864	7.64	7.67	7.61	7.52
8902	7.67	7.65	7.64	7.57
8941	7.65	7.66	7.65	7.58
8980	7.59	7.65	7.6	7.51
9019	7.6	7.67	7.63	7.53
9058	7.65	7.66	7.64	7.56
9097	7.63	7.66	7.62	7.55
9136	7.66	7.68	7.6	7.52
9175	7.59	7.67	7.63	7.52
9213	7.64	7.68	7.64	7.57
9552	7.59	7.66	7.61	7.56
9291	7.63	7.67	7.64	7.57
9330	7.63	7.68	7.63	7.55
9369	7.6	7.65	7.62	7.53
9408	7.59	7.67	7.61	7.55
9447	7.61	7.67	7.63	7.55
9485	7.62	7.66	7.63	7.53
9524	7.62	7.67	7.62	7.53
9563	7.63	7.67	7.64	7.57
9602	7.63	7.66	7.62	7.55
9641	7.6	7.67	7.63	7.57
9680	7.64	7.73	7.65	7.58
9719	7.59	7.67	7.63	7.53
9757	7.61	7.66	7.64	7.56
9796	7.65	7.68	7.66	7.58
9835	7.66	7.67	7.64	7.57
9874	7.7	7.67	7.64	7.59
9913	7.61	7.68	7.63	7.56
9952	7.62	7.66	7.62	7.56
9991	7.6	7.66	7.64	7.54
10029	7.59	7.66	7.6	7.55
10068	7.6	7.67	7.63	7.52
10107	7.6	7.69	7.63	7.54
10146	7.59	7.68	7.63	7.55
10185	7.63	7.69	7.62	7.55
10224	7.58	7.67	7.63	7.53
10263	7.59	7.69	7.63	7.56
10302	7.63	7.67	7.63	7.54
10340	7.64	7.68	7.62	7.54
10379	7.58	7.67	7.63	7.57
10436	7.62	7.68	7.61	7.55
10475	7.62	7.66	7.62	7.55
10514	7.61	7.65	7.61	7.55
10571	7.63	7.67	7.64	7.54
10610	7.64	7.69	7.64	7.56
10649	7.61	7.67	7.59	7.55
10688	7.61	7.66	7.63	7.53
10727	7.62	7.67	7.62	7.54
10765	7.71	7.68	7.64	7.58
10804	7.61	7.67	7.61	7.53

10843	7.59	7.66	7.62	7.55
10882	7.6	7.68	7.63	7.54
10921	7.58	7.67	7.61	7.54
10960	7.58	7.67	7.6	7.55
10999	7.61	7.69	7.64	7.55
11037	7.57	7.65	7.6	7.49
11076	7.66	7.65	7.63	7.56
11133	7.6	7.67	7.61	7.53
11190	7.59	7.66	7.56	7.53
11229	7.63	7.68	7.62	7.54
11268	7.6	7.68	7.64	7.54
11307	7.59	7.67	7.61	7.53
11364	7.6	7.66	7.63	7.52
11421	7.64	7.68	7.63	7.56
11478	7.66	7.67	7.59	7.54
11535	7.63	7.68	7.63	7.56
11574	7.59	7.66	7.63	7.56
11613	7.61	7.66	7.62	7.54
11652	7.65	7.66	7.64	7.56
11691	7.59	7.68	7.62	7.52
11730	7.6	7.68	7.64	7.55
11768	7.61	7.67	7.62	7.55
11807	7.61	7.67	7.63	7.57
11864	7.62	7.69	7.64	7.55
11903	7.6	7.68	7.63	7.55
11942	7.64	7.67	7.63	7.55
11981	7.59	7.66	7.63	7.53
12020	7.6	7.69	7.64	7.54
12059	7.63	7.68	7.64	7.56
12098	7.63	7.67	7.63	7.54
12137	7.62	7.68	7.61	7.55
12175	7.65	7.67	7.62	7.52
12214	7.64	7.68	7.64	7.57
12253	7.67	7.67	7.61	7.57
12292	7.6	7.68	7.62	7.54
12331	7.58	7.66	7.63	7.55
12370	7.62	7.66	7.62	7.55
12427	7.62	7.67	7.64	7.56
12466	7.59	7.66	7.61	7.54
12505	7.59	7.66	7.61	7.52
12543	7.62	7.68	7.63	7.56
12582	7.65	7.67	7.63	7.56
12621	7.64	7.66	7.62	7.57
12660	7.61	7.66	7.62	7.56
12717	7.61	7.69	7.6	7.56
12756	7.59	7.68	7.6	7.55
12795	7.62	7.68	7.61	7.54
11034	7.59	7.66	7.59	7.57
12873	7.62	7.67	7.62	7.57
12911	7.66	7.67	7.63	7.59
12950	7.59	7.67	7.61	7.58
12989	7.63	7.67	7.62	7.55

13028	7.63	7.67	7.63	7.56
13067	7.62	7.69	7.6	7.56
13106	7.62	7.68	7.62	7.57
13145	7.63	7.68	7.6	7.56
13184	7.63	7.67	7.6	7.58
13222	7.66	7.68	7.61	7.57
13261	7.62	7.68	7.62	7.57
13300	7.62	7.68	7.63	7.56
13339	7.58	7.68	7.62	7.52
13378	7.64	7.64	7.61	7.58
13417	7.64	7.68	7.63	7.57
13456	7.62	7.68	7.62	7.57
13495	7.61	7.68	7.63	7.56
13533	7.63	7.66	7.63	7.57
13590	7.64	7.66	7.63	7.58
13629	7.62	7.64	7.58	7.56
13668	7.67	7.68	7.62	7.58
13707	7.61	7.67	7.6	7.58
13746	7.68	7.69	7.62	7.59
13785	7.58	7.69	7.62	7.54
13824	7.59	7.69	7.59	7.57
13863	7.62	7.68	7.63	7.59
13902	7.71	7.69	7.63	7.58
13940	7.59	7.68	7.6	7.53
13979	7.66	7.68	7.63	7.54
14018	7.59	7.68	7.63	7.55
14057	7.58	7.66	7.6	7.53
14096	7.57	7.67	7.61	7.55
14135	7.66	7.67	7.59	7.53
14174	7.6	7.66	7.59	7.54
14212	7.6	7.66	7.61	7.55
14251	7.6	7.67	7.6	7.55
14290	7.6	7.68	7.6	7.55
14329	7.57	7.64	7.59	7.52
14368	7.62	7.67	7.63	7.57
14407	7.6	7.65	7.6	7.56
14446	7.62	7.64	7.6	7.56
14503	7.66	7.63	7.62	7.59
14541	7.64	7.66	7.62	7.58
14580	7.56	7.66	7.61	7.55
14619	7.58	7.65	7.6	7.56
14658	7.6	7.68	7.63	7.56
14697	7.64	7.67	7.61	7.57
14736	7.62	7.67	7.61	7.55
14775	7.57	7.67	7.61	7.57
14813	7.6	7.67	7.61	7.54
14852	7.61	7.65	7.62	7.58
14891	7.59	7.71	7.61	7.55
14930	7.63	7.68	7.61	7.58
14969	7.59	7.7	7.6	7.53
15008	7.63	7.67	7.63	7.59
15047	7.59	7.68	7.59	7.56

15086	7.58	7.68	7.6	7.57
15124	7.62	7.67	7.6	7.56
15163	7.63	7.65	7.61	7.56
15202	7.62	7.67	7.62	7.57
15241	7.66	7.67	7.64	7.6
15280	7.63	7.66	7.62	7.57
15337	7.59	7.66	7.62	7.57
15376	7.56	7.66	7.61	7.57
15415	7.63	7.67	7.61	7.57
15454	7.57	7.68	7.65	7.53
15492	7.62	7.69	7.63	7.59
15531	7.58	7.67	7.61	7.56
15570	7.57	7.68	7.63	7.55
15609	7.59	7.69	7.56	7.55
15648	7.6	7.67	7.59	7.58
15687	7.63	7.69	7.59	7.57
15726	7.6	7.68	7.64	7.58
15821	7.57	7.7	7.59	7.57
15860	7.61	7.65	7.61	7.58
15899	7.64	7.69	7.6	7.6
15938	7.65	7.62	7.62	7.57
15977	7.61	7.64	7.58	7.55
16016	7.64	7.68	7.62	7.54
16055	7.58	7.68	7.59	7.56
16093	7.62	7.7	7.63	7.57
16131	7.61	7.67	7.64	7.55
16170	7.59	7.66	7.61	7.54
16209	7.61	7.68	7.63	7.56
16248	7.59	7.65	7.59	7.55
16287	7.54	7.71	7.56	7.54
16326	7.64	7.66	7.6	7.54
16365	7.56	7.7	7.61	7.56
16403	7.57	7.68	7.61	7.56
16443	7.62	7.69	7.63	7.57
16482	7.64	7.68	7.64	7.59
16520	7.66	7.69	7.64	7.58
16559	7.57	7.66	7.58	7.55
16598	7.57	7.7	7.61	7.52
16637	7.57	7.66	7.62	7.54
16676	7.56	7.69	7.63	7.56
16715	7.53	7.65	7.59	7.51
16772	7.59	7.68	7.59	7.52
16811	7.58	7.69	7.59	7.54
16850	7.6	7.7	7.61	7.58
16927	7.61	7.73	7.65	7.56
16966	7.59	7.7	7.62	7.57
17005	7.54	7.71	7.62	7.55
17044	7.56	7.65	7.58	7.51
17083	7.54	7.67	7.62	7.52
17122	7.53	7.69	7.62	7.52
17161	7.56	7.7	7.62	7.53
17200	7.61	7.69	7.65	7.57

17238	7.59	7.68	7.62	7.55
17277	7.56	7.67	7.59	7.52
17316	7.54	7.69	7.61	7.52
17355	7.56	7.68	7.6	7.56
17394	7.6	7.69	7.61	7.56
17433	7.57	7.68	7.61	7.56
17472	7.59	7.71	7.61	7.55
17511	7.56	7.66	7.58	7.52
17549	7.61	7.71	7.62	7.58
17588	7.57	7.68	7.62	7.54
17627	7.58	7.67	7.61	7.56
17666	7.59	7.65	7.59	7.54
17705	7.53	7.69	7.63	7.52
17744	7.56	7.67	7.58	7.56
17783	7.56	7.68	7.6	7.55
17840	7.58	7.67	7.61	7.58
17878	7.57	7.69	7.62	7.54
17917	7.57	7.7	7.59	7.57
17956	7.68	7.69	7.62	7.55
17995	7.54	7.68	7.6	7.55

Appendix 3: Informal chronology based on the diary of the author

January 2001: Read about the transit observation of the Nyrölä group in Sky & Telescope.

April 2002: Began to think about making a transit observation myself at TBO.

January 2003: Began searching for suitable transits to observe.

February – March 2003: Wrote a brief paper in Swedish, as a school exercise, called *Att observera HD209458b med enkel utrustning* ("Observing HD209458b with simple equipment"), in which the HD 209458b observations of other amateur astronomers were described, along with a plan for making an observation.

14th of April 2003: Made a test observation of SAO 42275 at TBO.

24th of April 2003: Spoke at the meeting of the ASTB in Malmö, and briefly described my plan to try to observe HD 209458b.

End of April 2003: Photometry measurements in the SAO 42275 images.

End of June 2003: Photometry measurements in the SAO 42275 images.

Beginning of August 2003: Made detailed plans for upcoming HD 209458b transits and made photometry measurements in the SAO 42275 images.

17th of August 2003: Made a test observation of HD 209458, without any transit taking place.

19th of August 2003: Received the images from the 17th via mail on a CD-R. Photometry measurements.

20th of August 2003: Transit. No observation because of cloudy weather.

27th of August 2003: Transit. No observation because of malfunctioning equipment.

Beginning of September 2003: Began searching for suitable transits to observe in October.

20th of September 2003: Made a test connection between the computer to be used in Kiruna and TBO.

12th of October 2003: Transit. Partially observed. Equipment at TBO controlled via the Internet.

16th – 20th of October 2003: Photometry measurements in the HD 209458 images from the 12th of October.

26th of October 2003: Transit. Complete set of images, for the whole transit.

Beginning of November 2003: Photometry measurements in the images from the 26th of October.

6th of November 2003: Adrian Mach presents the preliminary results of the observation from the 26th of October at the meeting of the ASTB in Malmö.

End of November 2003: Photometry measurements in the images from the 26th of October and improvement of the time-magnitude diagram.

Beginning of December 2003: Some media attention concerning the HD 209458b observation (e.g. an article in the daily *Sydsvenska Dagbladet*), due to a press release issued by the ASTB.

January 2004: Wrote an informal article about my HD 209458b observation for *Systema Solaris* (the newsletter of the Solar System Section of the Swedish Amateur Astronomer's Society).

February 2004: Informal HD 209458b article published in *Systema Solaris*.

April 2004: Wrote this paper.