

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/45908334>

# Precise Measurement of Gravity Variations During a Total Solar Eclipse

Article in *Physical Review D* · March 2010

DOI: 10.1103/PhysRevD.82.041101 · Source: arXiv

---

CITATIONS

41

---

READS

960

6 authors, including:



Xin-She Yang

Middlesex University, UK

584 PUBLICATIONS 72,402 CITATIONS

SEE PROFILE

# Precise Measurement of Gravity Variations During A Total Solar Eclipse

Qian-shen Wang<sup>1)</sup>, Xin-she Yang<sup>2)\*</sup>;  
Chuan-zhen Wu<sup>1)</sup> Hong-gang Guo<sup>1)</sup>, Hong-chen Liu<sup>1)</sup>, Chang-chai Hua<sup>1)</sup>

- 1) Institute of Geophysics, Chinese Academy of Sciences, Beijing 100101, P R China.  
2) Department of Applied Mathematics, University of Leeds, Leeds LS2 9JT, England.

March 26, 2010

## Abstract

The variations of gravity were measured with a high precision LaCoste-Romberg D gravimeter during a total solar eclipse to investigate the effect of solar eclipse on the gravitational field. The observed anomaly ( $7.0 \pm 2.7$ )  $\times 10^{-8}$  m/s<sup>2</sup> during the eclipse implies that there may be a shielding property of gravitation.

PACS numbers: 04.80.C, 95.10.G, 91.10, 04.80.N

**Citation Detail:** , *Phys. Rev. D* **62**, 041101(R), (2000).

## 1 INTRODUCTION

Although gravitation may has the property of shielding in theories, it is very difficulty to test the possible effect experimentally. If gravitation were carried by particles, a mass between two bodies could partially shield each of them from the gravity of the other. Anomalies can be expected in the motions of certain artificial Earth satellites during eclipse seasons that behave like shielding of the Sun's gravity as suggested by VanFlandern [1]. The possible existence of gravitational shielding and gravitational-wave absorption [2] and some theoretical analysis of a weak shielding of the gravitational interaction by a disk of high temperature superconducting materials have been investigated [3,4,5]. An experiment of electrically charged pendulum [6] was carried out during an eclipse to test the Saxl's effect [7] although there was no noticeable effect observed. Some related work were reviewed by Gillies [8].

If there were gravitational shielding, it would expect that the effect shall be only significant during an eclipse when gravity of the Sun may be shieldly slightly by the moon so that the gravity on the Earth may fluctuate accordingly, however such effect may be extremely small even if it would exist. The present work was thus motivated to test the possible effect of gravitational shielding during the total solar eclipse with a high precision modern gravimeter.

## 2 EXPERIMENT

To investigate the effect of possible gravitational shielding, we conducted a precise measurement of the vertical gravity variations during a total eclipse of the Sun on 9 March 1997 in China. The observation

---

\*Corresponding author

and measurement during the total eclipse were carried out in Moho, Helongjiang province, China with the global position  $\phi = 53^{\circ}29'20''\text{N}$  and  $\lambda = 122^{\circ}20'30''\text{E}$ , which lies in the center of the shadow of the totality during the eclipse. The parameters of the total eclipse are: sunrise at 06:20:00 (local time), first contact at 08:03:29, second contact at 09:08:18, third contact at 09:11:04, and fourth contact at 10:19:50. The duration of totality of the solar eclipse is 2 mins and 46 seconds. The angular height of the Sun during the totality is  $21^{\circ}$ .

A very high-accurate LaCoste-Romberg D gravimeter (L & R D-122) was used to measure the variations of vertical gravitational acceleration with a high precision of  $2 \sim 3 \times 10^{-8} \text{ m/s}^2$  or  $2 \sim 3 \mu\text{gal}$ . The equipment was kept in a constant temperature with  $\pm 1^{\circ}\text{C}$  inside an undisturbed room. The output signal of the gravity variation from the gravimeter was automatically collected by a PC. The surrounding environment (within 200 meters) was kept undisturbed during the whole process of recording data so that there was no man-made gravitational disturbance (e.g., gravity disturbance due to the movement of people conducting the experiment).

The gravimeter (LaCoste-Romberg D) was very stable and had been used for various field survey as well as daily record of tidal force for several years. However, in order to ensure the accuracy of the measurement, the gravimeter was installed well earlier before the eclipse. The gravimeter reading was tested for several times to simulate real time recording. The real-time recording began at 15:00 in the afternoon on 5 March 1997, and go on continuously until 15:00 on 12 March 1997. The sampling reading interval is 1 minutes. The sampling was increased near the eclipse. The data reading was recorded at a rate of 2 reading every minute from 06:00 am to 12:30pm and at a higher sampling rate of 1 reading per second during the eclipse from 08:00am to 10:30am.

### 3 RESULTS AND DISCUSSIONS

The vertical gravitational acceleration measured consists of several components: 1) gravitational forces due to the Earth, the Sun and the Moon, and 2) the earth's rotation. The former includes the static gravity by the Earth and the tidal force by the Sun and the Moon due to changes of moving positions. The tidal component can be calculated theoretically with a precision of  $1 \mu\text{gal}$  or  $1 \times 10^{-8} \text{ m/s}^2$ , which is a routine practice in geophysics.

After making all these corrections, the difference left shown Figure 1) is the variation of vertical gravity during the eclipse due to some unknown effect, which may be a possible shielding effect of gravitation. The solid curve is the averaged values with a 10 minute window and the variation can be more clearly identified.

The variation around zero has an amplitude of  $\pm 3 \sim 4 \mu\text{gal}$ . The important and interesting anomaly is that there exists two regions with significant gravity decrease. One of such region occurred within about 30 mins around 07:30am with a maximum significant decrease of  $6.0 \pm 2.5 \mu\text{gal}$ , and another took place within 30 mins around 10:20am with a maximum change of  $7.0 \pm 2.7 \mu\text{gal}$ . The deviation is calculated by using the standard formulae in measurement data processing. If the solid curve is used for the calculation, the maximum changes shall be  $5.3 \pm 1.4 \mu\text{gal}$  at first contact and  $6.8 \pm 1.4 \mu\text{gal}$  at fourth contact, respectively. These two changes took place between first contact and fourth contact, and quite closely related to the timing of eclipse phases of first contact and fourth (last) contact.

Figure 2 shows the measured gravity variation in the week of the eclipse from 5 March 1997 to 12 March 1997. The significant variation during the eclipse on 9 March 1997 is also shown (detail see Figure 1). In plotting this figure, the data was averaged with a 10 minute moving window so that the curve is more smooth than the actual measured data and the signal looks more significant. We can see that the reading was quite stable before the eclipse and after the eclipse. The change during the eclipse is remarkable. Table I shows the number of data deviated from the average value with a total of 10,080 data. Please note that the actual number of data during the eclipse is much more than those listed this table (with a resampling rate of 1 reading per minute) because the sampling rate during the eclipse is much higher (1 reading per second).

The changes are quite significant and they are not the effect of temperature and pressure changes. According to the calibration precision of the LaCoste-Romberg gravimeter provided by the manu-

facturer, the variation of  $8^{\circ}\text{C}$  in temperature would lead to  $5\ \mu\text{gal}$  change in gravity reading. The actual temperature change in controlled room temperature during the eclipse is within  $\pm 1^{\circ}\text{C}$ , so the actual effect of temperature change is less than  $1\ \mu\text{gal}$ . The actual change in pressure during eclipse from 07:00am to 11:00am is about  $1\ \text{mmH}$  and the change is less than  $3\ \text{mmH}$  in that whole day. According to the manufacturer, the effect of actual pressure change on gravity reading shall much less than  $1\ \mu\text{gal}$ . Therefore, the actual noticeable changes of gravity during the eclipse may imply some extra-ordinary phenomenon associated with gravity such as the possible shielding effect of moon on the gravitational force of the Sun. In addition, another puzzle is that the anomalies of the gravity variations occurred at the first and last contact but not during the totality. This certainly requires more precise measurements in the future during totality of a solar eclipse.

Table I: Measured Data Distribution

Data deviation range ( $\mu\text{gal}$ )	Number of Data
$< 2$	9948
$\geq 2$	87
$\geq 4$	45

In summary, we have used the best available gravimeter, with a high precision of  $2 \sim 3\ \mu\text{gal}$ , to measure the variation of vertical gravity during the total eclipse on 9 March 1997. Although there was no noticeable changes around the totality during the solar eclipse, we have observed quite significant decrease in vertical gravity during the first contact and the last contact. This may imply the new property of gravitation, which certainly needs more high precision experiments to be conducted in the future especially during solar eclipse. Although the purpose of this short paper and the present work is not intended to prove the shielding effect of gravitation, however, we would be delighted if the present work can initiate more work on the possible new property of gravitation.

**Acknowledgement:** We would thank the referee(s) for their insightful comments which has greatly improved the manuscript, especially for the kind suggestion of averaging the data over the 10 minute interval. The work was supported by the National Natural Science Foundation of China. The authors are grateful to the help from the Moho geophysical station of Chinese Academy of Sciences.

## REFERENCES

1. T. VanFlandern, *Astrophys. Space Sci.*, **244**, 249 (1996).
2. V. Desabbata and C. Sivaram, *Nuovo Cimento*, **B 106**, 873 (1991).
3. G. Modanese, *Europhys. Lett.*, **35**, 413 (1996).
4. C. S. Unnikrishnan, *Physica*, **C 266**, 133 (1996).
5. E. Podkletnov and R. Nieminen, *Physica*, **C 203**, 441 (1992).
6. Y. C. Liu, X. S. Yang, T. R. Guan et al., *Phys. Lett.*, **A 244**, 1 (1998).
7. E. J. Saxl, *Nature*, **203**, 136 (1964).
8. G. T. Gillies, *Reports Prog. Phys.*, **60**, 151 (1997).

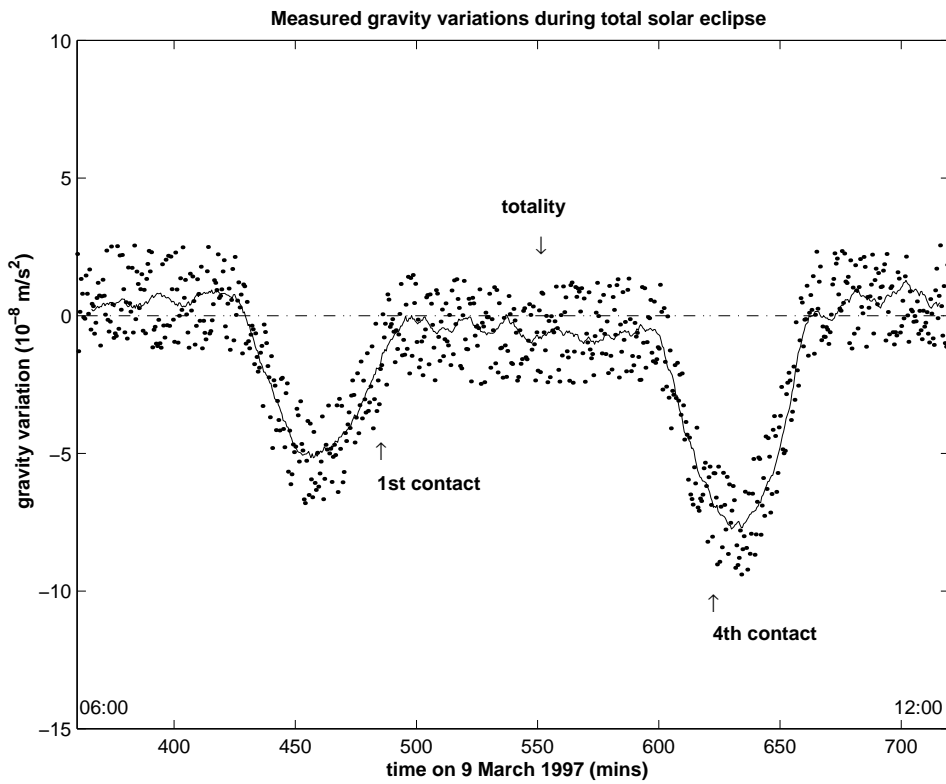


Figure 1: Variations of vertical gravity measured during the total solar eclipse on 9 March 1997. The solid curve is the averaged variation over a moving 10-minute window. Two regions of gravity anomaly during the eclipse were observed, which may be the effect of gravitational shielding.

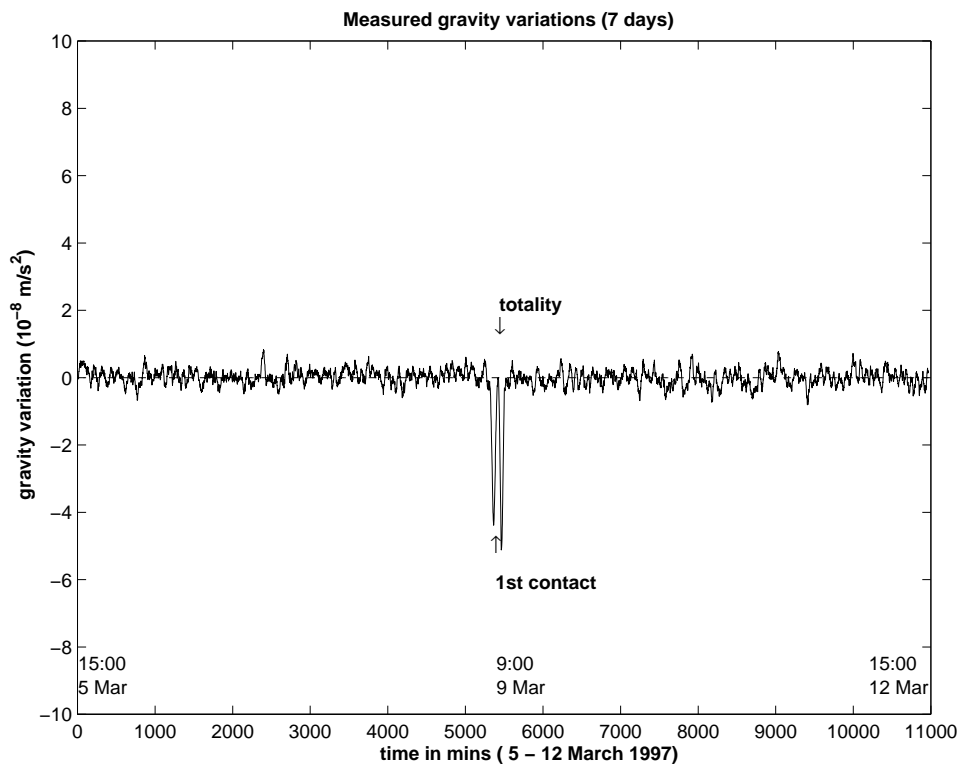


Figure 2: Measured variations of vertical gravity measured during the whole week from 5 March to 12 March 1997. Significant change was observed during the eclipse on 9 March 1997, which is shown in more detail in Figure 1.