J. Astrophys. Astr. (2006) **27,** 439–441

Research Note

On New Limits of the Coefficient of Gravitation Shielding

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Received 2005 January 7; accepted 2006 November 3

Abstract. New limits of the shielding coefficients in the supposed phenomenon of gravitation shielding have recently become available. The new values are briefly reviewed and discussed in order to update the state of art since some new limits for gravitation shielding are not necessarily the lowest ones which, instead, are those of interest when planning new experimental research or studying theoretically the possible effects of gravitation shielding.

Key words. Gravitation—shielding—lower limits.

In the theory of the supposed gravitation shielding Bottlinger (1912) suggested that a gravitational ray l of intensity g be weakened after crossing a layer of material with density δ according to the law

$$g = g_0 \exp\left(-\lambda \int_l \delta dl\right) \tag{1}$$

where λ is the so called shielding coefficient. The experiment made so far allows us to assume that $\lambda < 10^{-14}\,\mathrm{g}^{-1}\,\mathrm{cm}^2$ and for layer thickness and density sufficiently small, we may then write

$$g = g_0\left(1 - \lambda \int_l \delta dl\right). \tag{2}$$

A straight-forward method to verify the reality of the phenomenon or to estimate λ is to measure the weakening of a gravitational ray caused by the crossing of a layer of known density and thickness. The first physicists who investigated this phenomenon and estimated λ, followed this path.

Many experiments have been made to verify the existence of gravitation shielding; a description of experiments made with a couple of horizontal pendulums and gravimeters may be found in Caputo (1977), articles with reviews may be found in the more recent book edited by Edwards (2002). A review of conventional explanations of anomalous observations of presumed shielding made during solar eclipses is in the recent paper by Duif (2004).

To enhance the scope of this note we quote the experiments of Majorana (1919, 1920) who made a series of laboratory experiments performed with very refined techniques seeking to observe the variation of weight of a 1.3 kg lead sphere when it was screened from the effect of Earth's gravitational field with other masses. As screen he used a 114 kg mercury cylinder, then a 9.8 kg lead cube which completely surrounded the sphere.

From the results of these experiments Majorana (1919, 1920) was induced to state that the shielding effect existed. One experiment made with the mercury cylinder as shield led to conclude that $\lambda = 7\ 10^{-12}$, while the experiments made with the lead cube concluded that $\lambda = 2\ 10^{-12}$.

Following the publication of the results of Majorana's experiments, Russel (1921) showed that if we accept that the outer layers of celestial bodies shield the inner layers then the inertial mass of the planets would not be proportional to their gravitational mass and consequently, the motion of celestial bodies should differ notably from what is observed in reality. According to Russel (1921) this would condition the value of λ to be smaller than the values given by Majorana by a factor of 10^{-4}.

We consider here the three methods used for the detection of the gravitation absorption: using the Moon as a screen, using the Earth as a screen and observing the Moon motion fluctuations. Concerning the method in which the Moon is used as a screen it is of interest that the experimental limit set for λ by Slichter *et al.* (1965) with observations, taken with a La Coste tidal gravimeter during the solar eclipse of February 15, 1961 is $\lambda = 8.3\ 10^{-16}$. During the same eclipse of February 15, 1961, from the data of the Great Horizontal pendulums of the Grotta Gigante in Trieste (Marussi 1960), Caputo (1962) set the limit $\lambda < 6\ 10^{-16}$.

In a recent experiment, Yang & Wang (2002) observed possible gravity variation with a La Coste gravimeter during the total solar eclipse of March 9, 1997, and concluded that "no significant anomaly during the very solar eclipse was found. However, there are two gravity anomaly valleys with near symmetrical decrease of about 6–7 μgal at first contact and at last contact."

This interesting result was discussed by the authors in great detail and they concluded that the data set an upper limit for the existence of gravitation shielding. According to the formula (2) the anomaly recorded by Yang & Wang (2002), taking into account the elevation of the Sun at the time of the eclipse, would lead to an upper limit of λ to about $3\ 10^{-14}$ (Yang & Wang 2002). We note that Yang & Wang (2002) used a gravimeter less sensitive by one order of magnitude than that used by Slichter *et al.* (1965) who obtained a lower limit for λ.

Results similar to that of Yang & Wang (2002) are obtained also from the data of Mishra & Rao (1997) who observed the solar eclipse of October 24, 1995 at Dhoraji with a gravimeter similar to that used by Slichter *et al.* (1965).

The method using the Earth as a screen was introduced by Harrison (1963) who used tidal gravimeters observation and found $\lambda < 10^{-15}$. A better result is that of Unnikrishnan *et al.* (2002) with $\lambda < 2\ 10^{-17}$ who used the same method and analyzed 11,000 minutes of data taken by Wang *et al.* (2000) with a gravimeter during the 1997 total eclipse in China.

Finally studying the fluctuations of the Moon motion Crawley *et al.* (1974) found $\lambda < 6.3\ 10^{-15}$. However, the most stringent limit on gravitation absorption, is that of Eckhard (1990) who, in a brief note, using the Laser ranging to the Moon data of Williams *et al.* (1976), gave what is now the best upper limit $\lambda < 2\ 10^{-21}$.

In conclusion, in the case of new research on gravitational shielding based on the use of the Moon or the Earth as screen and using gravimeters, considering the best results previously obtained for the coefficient of absorption and taking into account the elevation of the Sun, the instruments must be one order of magnitude more accurate than those previously used; moreover, considering the best result obtained by observing the anomalies in the Moon motion (Eckhardt 1990), we may not obtain better limits unless the gravimeters have an accuracy many orders of magnitude better than that of the instruments previously used.

References

Bottlinger, K.-F. 1912 Die Gravitationstheorie und die Bewegung des Mondes, Innauguraldiss, Univ. München, C. Troemer, Freiburg Br., 57.

Caputo, M. 1962 Un nuovo limite superiore per il coefficiente di assorbimento della gravitazione, Accademia Nazionale Lincei, Rendiconti della Classe di Scienze Fisiche, *Matematiche e Naturali*, **32(4)**, 509–515. Also, in English, in *http://www.space-time.info/gravianom/literaturelist.html*.

Caputo, M. 1977 Experiments concerning gravitational shielding, International Symposium on Experimental Gravitation, Pavia 1976, Atti dei Convegni Lincei, **34**, 193–211.

Crawley, R.-J., Woodward, J.-F., Yougrau, W. 1974 *Astronomische Nachrichten*, **295**, 203.

Duif, P.-C. 2004 A review of conventional explanations of anomalous observations during solar eclipses, *http://arxiv.org/ftp/gr-qc/papers/0408/0408023.pdf*.

Eckhardt, D.-H. 1990, Gravitational shielding, *Phys. Rev. D.*, **42(6)**, 2144–2145.

Edwards, M.-E. 2002, Pushing Gravity, Apeiron, Montreal.

Harrison, J.-C. 1963 A note on the paper "Earth-tide observations made during the International Geophysical Year", *J. Geophys. Res.*, **68(5)**, 1517–1519.

Majorana, Q. 1919, Sulla gravitazione, Accad. Nazionale Lincei, Rendiconti Classe Scienze Fis. *Mat. Naturali*, **2**, Papers: I, 165–174; II, 221–223; III, 313–317; IV, 416–427; V, 480–489.

Maiorana, Q. 1920, Sulla gravitazione, Accad. Nazionale Lincei, Rendiconti Classe Scienze Fis. *Mat. Naturali*, **1**, Papers VI, 23–32; VII, 90–100; VIII, 163–169; IX, 235–240.

Marussi, A. 1960 I primi risultati ottenuti nella stazione per lo studio delle maree della verticale della Grotta Gigante, *Bollettino di Geodesia e Scienze Affini*, **19(4)**, 645–667.

Mishra, D.-C., Rao, M.-B.-S. 1997, Temporal variation in gravity field during solar eclipse on 24 October, *Curr. Sci.*, **2**, 782.

Russel, H.-N. 1921, On Majorana's theory of gravitation, *Astrophys. J.*, **54**, 334–340.

Slichter, L.-B., Caputo, M., Hager, C.-L. 1965 An Experiment Concerning Gravitational Shielding, *J. Geophys. Res.*, **70(6)**, 1541–1551.

Unnikrishnan, C.-S., Mohapatra, A.-K., Gillies, G.-T. 2002 Anomalous gravity data during the 1997 total solar eclipse do not support gravitational shielding, *Phys. Rev. D.*, **63**, 062002.

Wang, Q.-S., Yang, X.-S, Wu, C.-Z., Liu, H.-C., Hua, C.-C. 2000, Precise measurement of gravity variation during a total solar eclipse, *Phys. Rev. D.*, **62**, 041101(R).

Williams, J.-G., Dicke, R.-H., Bender, P.-L., Alley, C.-O., Carter, W.-E., Currie, D.-G., Eckardt, D.-H., Faller, J.-E., Kaula, W.-M., Mulholland, J.-D., Plotkin, H.-H., Poultney, S.-K., Shelus, P.-J., Silverberg, E.-G., Sinclair, W.-S., Slade, M.-A., Wilkinson, D.-T. 1976, New Test of the Equivalence Principle from Lunar Laser Ranging, *Phys. Rev. Lett.*, **36**, 551–556.

Yang, X.-S., Wang, Q.-S. 2002 Gravity anomaly during the Mohe total solar eclipse and new constraint of gravitational shielding parameter, *Astrophys. Space Sci.*, **282**, 245–253.