COMPREHENSIVE BIBLIOGRAPHY
OF ABSOLUTE GRAVITY AND
RELATED TOPICS

by H.D. Valliant
and N. Courtier

Internal Report 84-7

PUB.

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FOREWORD

This report is organized in two sections: the first constitutes a comprehensive bibliography of papers and reports in the field of absolute gravimetry. The second constitutes all available abstracts for the items included in the bibliography. A short introductory section, if available, is included in lieu of an abstract in cases where no abstracts were published.

Copies of all items in the list, except for those flagged with an "*", have been acquired and archived in an absolute gravity pamphlet file maintained by the Crustal Dynamics Section of the Gravity, Geothermics and Geodynamics Division of the Earth Physics Branch. It is intended that the maintainence of this file be an ongoing exercise with updated bibliographies produced from time-to-time as required.

SECTION 1

BIBLIOGRAPHY

ABSOLUTE GRAVITY BIBLIOGRAPHY

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Arnautov, G.P., Yu. D. Boulanger, G.D. Karner, S.N. Shcheglov. Absolute determination of gravity in Australia and Papua New Guinea during 1979. BMR J. Australian Geology & Geophys., 4, 383-393, 1979.

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Arnautov, G.P., E.P. Kalish, F.I. Kokoulin, V.P. Koronkevich, A.I. Lokhmatov, I.S. Malyshev, Yu. E. Nesterikhin, L.A. Petrashevich, M.G. Smirnov, Yu. F. Stus', and V.G. Tarasyuk. Measurements of the absolute acceleration due to gravity using a laser ballistic gravimeter, Sov. J. Quantum Electron., 9, 333-337, 1979.

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SECTION 2

ABSTRACTS

Anthony, D. Achievements in absolute gravity measuring accuracy, 1965 to present. Pan-American Institute of Geography and History. Washington, D.C. 1969.

ABSTRACT

A brief history of the status of absolute gravity measuring techniques prior to the application of laser technology and recent electronics is given. The various approaches toward high precision portable experiments are described with illustrations of results obtained by modern approaches.

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Alasia, F., L. Cannizzo, G. Cerutti, and I. Marson. Absolute gravity measurements: Experience with a transportable gravimeter. Metrologia, 18, 221-229, 1982.

ABSTRACT

A brief description is given of the apparatus for absolute gravity acceleration measurements that was constructed by the Istituto di Metrologia "G Colonnetti" - Torino - in cooperation with the Bureau International des Poids et Mesures. The paper supplies information on the use of the gravimeter in the past seven years, during which g measurements were made at 52 stations over the world, and analyses as well the causes of possible errors in the g measurements, while pointing out the methods adopted to eliminate their effects.

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Aranautov, G.P., Yu. D. Boulanger, E.N. Kalish, V.P. Koronkevitch, Yu. F. Stus, and V.G. Tarasyuk. "Gabl", an absolute free-fall laser gravitmeter, Metrologia, 19, 49-55, 1983.

ABSTRACT

A high-precision laser gravimeter for measuring the absolute value of gravitational acceleration by the free-fall method has been built in the Siberian Branch of the USSR Academy of Sciences (Novosibirsk). The use of a free-fall interferometer illuminated by a He-Ne laser stabilized by an iodine absorption cell ($^{127}I_2$) together with high-speed

counters and a rubidium frequency standard, plus constructive measures aimed at reducing the action of non-gravitational forces, provide an accuracy of measurements better than $10^{-7} m.s^{-2}$. In practice, the relative measurement error in g, as determined from convergence of the results of repeated measurements, is below 4 parts in 10^9 ($4 \times 10^{-8} m.s.^{-2}$).

The gravimeter is used for geophysical experiments and in the investigation of non-tidal variations of the Earth's gravitational field.

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Arnautov, G.P., Yu. D. Boulanger, G.D. Karner, S.N. Shcheglov. Absolute determination of gravity in Australia and Papua New Guinea during 1979. BMR J. Australian Geology & Geophys., 4, 383-393, 1979.

ABSTRACT

A cooperative survey between the Soviety Academy of Sciences and the Australian Bureau of Mineral Resources during 1979 successfully measured the acceleration due to gravity using an absolute apparatus at Sydney, Hobart, Alice Springs, Darwin and Perth in Australia and at Port Moresby in Papua, New Guinea. The measurements have a precision of about 6 µGal and an accuracy of about 15 µGal. Gravity ties for earlier stations allow comparisons with GAG-2 gravity meters, OVM pendulums and IGSN71 results. Gravity differences between cities are generally not significant at the 95 percent confidence level. Gravity differences at individual cities are also not significantly different from zero. The mean difference for all cities could be interpreted as having a component of secular variation of $\pm$ 3.3 $\pm$ 1.2 µGal/yr.

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Arnautov, G.P., Ye. N. Kalish, A. Kiviniemi, Yu. F. Stus, V.G. Tarasiuk, and S.N. Scheglov. Tetermination of absolute gravity values in Finland using laser ballistic gravimeter. Pub. Finnish Geodetic Inst., 97, 1-18, 1982.

(NO ABSTRACT)

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Arnautov, G.P., E.P. Kalish, F.I. Kokoulin, V.P. Koronkevich, A.I. Lokhmatov, I.S. Malyshev, Yu. E. Nesterikhin, L.A. Petrashevich, M.G. Smirnov, Yu. F. Stus', and V.G. Tarasyuk. Measurements of the absolute acceleration due to gravity using a laser ballistic gravimeter, Sov. J. Quantum Electron., 9, 333-337, 1979.

ABSTRACT

A unique device is described for highly accurate measurement of the absolute acceleration due to gravity using a ballistic method. Using stabilized lasers, a rubidium frequency standard, and a computer-controlled high-speed electronic counting system, it was possible to achieve a relative error of 4×10^{-9} with an output of 5000 measurements per twenty-four hours. Results are presented of determinations of the absolute acceleration due to gravity at international initial and reference gravimetric points and to investigate tidal and non-tidal (secular) variations in gravity.

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Arnautov, G.P., L.D. Gik, Ye. N. Kalish, I.S. Malyshev, Yu. S. Stus'. Papers on a laser ballistic gravimeter. Translated by Translation Division, Foreign Technology Division, WP. AFB. Ohio, 1974.

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Becker, M., E. Groten. Relative gravimeter measurements at the 1981 absolute gravimeter campaign in Paris-Sèvre, Instit. fur Physikalische Geodasie Technische Hochsschule, Darmstadt, 1982.

INTRODUCTION

In October and November 1981 the IAG-SSG 3.40 organized a simultaneous calibration of three absolute gravimeters at the Bureau International des Poids et Mesures in Sèvre (Boulanger et al., 1982). The objective of the relative gravimeter measurements was the determination of the gravity differences between the four sites A3, A4, A5, A6 and the fundament station A. In addition the gravity gradients at stations A3, A4, A5 and A6 were to be determined. For the measurements three Model-D and three Model-G gravimeters of LaCoste Romberg (LCR) were used. There were the instruments D14 and D21 operated by the "Institut fur Angewandte Geodasie" (IfAG), Frankfurt, G131 and G253 of the Defense Mapping Agency (DMA), Cheyenne (USA), G258 and D38 of the "Institut fur Physikalische Geodasie" (IPG), Darmstadt. The data processing of all observations was performed in the IPG.

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Bell, G.A., D.L. Gibbings, J.B. Patterson. An absolute determination of the gravitational acceleration at Sydney, Australia. Metrologia 9, 47-61, 1973.

ABSTRACT

An absolute determination of the acceleration due to gravity has been completed at the Australian National Standards Laboratory. The experiment was of the free rise-and-fall type using a corner-reflector as the moving body. The value of g obtained was 9.796720 $m.s^{-2}$, which is 138 $\mu m.s^{-2}$ below the value assigned to the site on the old Potsdam system. The estimated uncertainty of the result is $\pm$ 2 $\mu m.s^{-2}$ ($\pm$ 2 parts in 10^7).

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Beruff, R.B. Interim Gravity report: Western U.S. gravity ties. Unpublished, 1980.

(NO ABSTRACT)

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Boulanger, Yu. D., G. Aranautov, E. Kalish, Yu. Stus, and V. Tarasiuk. Determination of the absolute value of gravity in Singapore. IGB Bulletin D'Information, 42, I42-I59, 1978.

(NO ABSTRACT)

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Boulanger, J.D., G.P., Aranautov, and S.N. Scheglov. Results of comparison of absolute gravimeters, Sevres, 1981. (Unpublished and undated report).

(NO ABSTRACT)

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Bulanzhe, Yu. D., G.P. Arnautov, Ye. N. Kalish, V.P. Koronkevich, Yu. F. Stus', V.G. Tarasyuk, and S.N. Shcheglov. Results of the first international comparison of absolute gravity meters, Sévres, 1981.

ABSTRACT

Upon recommendation of the general assembly of the International Association of Geodesy (IAG), a comparison of absolute gravity meters of different designs built in different countries was conducted in 1981 at Sèvres. Two gravity meters from the United States and one from the USSR were compared simultaneously. Determinations of absolute gravity at Sèvres were made earlier with a Chinese instrument and somewhat later with French- and Italian-made instruments. It has been found that contemporary ballistic gravity meters have all approximately the same measurement accuracy with standard deviation of some 10 gal.

Coordination of all instruments made it possible to detect the displacement of the IGSN-71 system zero by approximately 50 gal.

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Cannizzo, G., G. Cerutti and I. Marson. Absolute gravity measurements in Europe, Il Nuovo Cimento, 1C, 1, 39-85, 1978.

SUMMARY

In 1976 and 1977, 25 absolute gravity measurements were carried out in 17 stations in Europe with the new transportable apparatus of the Istituto di Metrologia "G. Colonnetti", in order to improve the world gravity standard, to begin the study of the scale linearity along the line Hammerfest-Nairobi in IGSN71 and to establish new absolute references. The uncertainty of the measurements is of the order of 10 μGal, about 20 times better than the accuracy of IGSN71.

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Cerutti, G., L. Cannizzo, A. Sakuma, and J. Hostache. A transportable apparatus for absolute gravity measurements. VDI Berichte, 212, 1974.

INTRODUCTION

Since 1968, the construction of a transportable apparatus for absolute gravity measurements has been continued at the IMGC Torino, with the technical assistance of the BIPM, Sèvres.

The aims of this work are threefold: i) improvement in accuracy of the standards of force in terms of the primary standard of mass, ii) creation of new absolute gravity stations including the calibration of the International Gravity Net, iii) study on the evolution of the gravity field due to secular effect and tectonic motions by means of periodical gravity ties by the transportable absolute apparatus.

A first preliminary result was recently obtained by this apparatus, transported to the BIPM and installed on a pier where the value of "g" is already known. The mean value of 25 measurements of g (about one hour) was in agreement to within $\pm$ 0.02 mGal with the value obtained by a fixed apparatus of the BIPM.

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Clark, J.S. An absolute determination of the acceleration due to Gravity. Phil. Trans. Roy. Soc. London, Ser. A. 238, 65-123, 1940.

INTRODUCTION

Recent advances in the precision obtainable in length and time measurements have made it possible to determine the absolute value of the acceleration due to gravity with greater accuracy than has hitherto been possible.

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Cook, A.H. Recent developments in the absolute measurement of gravity, Bulletin Geodesique, 44, 34-59, 1957.

SUMMARY

The reasons for attempting to measure the value of gravity absolutely to better than one part in one million are briefly discussed and the following methods of measurement are reviewed: the reversible pendulum, the long pendulum, the method using the form of the surface of a rotating fluid and methods involving the free motion of a body under gravity. The effects of a number of perturbing forces are discussed in some detail. The results obtained to date are summarized but it is premature to attempt a critical review of them.

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Cook, A.H. The absolute determination of the acceleration due to gravity. Metrologia, 1, 3, 1965.

ABSTRACT

The place of absolute measurements of gravity in the system of fundamental constants of physics and celestial mechanics is discussed and the history of absolute determinations is summarized. Two classes of methods are mainly used at present, the reversible pendulum and the free-motion experiment. The principles of these methods are discussed in detail, particular attention being given to the definition of experimental parameters and to perturbing effects. The results so far obtained are described and experiments still in progress are mentioned. Three of the completed determinations are in Europe - at Leningrad

(reversible pendulum), Teddington (reversible pendulum) and at Sèvres (free-fall of line standard) and three are in N. America - at Washington (reversible pendulum), at Ottawa (free-fall of graduated scale) and at Princeton (free-fall of interferometer component). Comparisons between the results can only be made through measurements of the differences of gravity between the six sites and the problems of obtaining reliable differential results are indicated. It appears that the N. American results are more scattered than the European ones and that they differ from them by more than 2 mgal, an apparently significant amount. It is most likely that the differential measurements have systematic errors but there is a great need for further absolute measurements, especially in North America, to confirm or invalidate this conclusion.

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Cook, A.H. The experimental determination of the constant of gravitation. NBS Spec. Pub. 343, 475-483, 1971.

ABSTRACT

This paper reviews the principal determinations of the constant of gravitation from the work of Cavendish to that of Heyl. The main sources of error are discussed and the reasons for the poor precision of all work so far done are considered. Brief mention is made of the new determination by Beams and his collaborators now in progress at the University of Virginia, and the plans for a new determination at Trieste by A.H. Cook and A. Marussi are described.

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Cook, A.H. Report on absolute measurements of gravity. National Physical Laboratory, Standards Division. Intl. Assoc. of Geodesy Section IV (circa 1960).

(NO ABSTRACT)

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Cook, A.H. A new absolute determination of the acceleration due to gravity at the National Physical Laboratory, England. Phil. Trans. Roy. Soc. London, Ser. A., 261, 211-252, 1967.

ABSTRACT

A new absolute determination of the acceleration due to gravity at the National Physical Laboratory has been made by timing the symmetrical free motion of a body moving under the attraction of gravity; it is the first time this method has been used. The moving body was a glass ball and it was timed at its passage across two horizontal planes by the flashes of light that it produced when it passed between two horizontal slits which served to define each plane optically, the ball focusing light from one of the slits, which was illuminated, upon the other slit which had a photomultiplier placed behind it. The separation of the two planes defined by the pairs of slits was measured interferometrically and referred directly to the international wavelength definition of the metre, while the time intervals were measured in terms of the atomic unit of time scale A1. The value of gravity as reduced to the British Fundamental Gravity Station in the NPL is:

981181.75 mgal, s.d. 0.13 mgal (1 mgal = 10^{-5}m/s^2)

Systematic errors, are believed to be very small; this is particularly true of the error due to air resistance. The main contribution to the observed scatter of the results comes from microseismic disturbances.

The new result is 1.4 mgal less than that obtained at the fundamental station by J.S. Clark (1939) using a reversible pendulum. It is very close to the mean of a number of recent absolute determinations by other methods, but this may not be very significant because the uncertainties of those determinations and of the comparisons between the sites at which they were made and the present site are not less than 5 times the standard deviation of the new result.

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Cook, A.H., J.A. Hammond. The acceleration due to gravity at the National Physics Laboratory, England. Metrologia, 5, 4, 141-142, 1969.

(NO ABSTRACT)

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Dryden, H.L. A reexamination of the Potsdam Absolute Determination of Gravity. J. Res. NBS 29, 303-314, 1942.

ABSTRACT

Recent absolute determinations of the acceleration of gravity differ from the generally accepted Potsdam value by amounts considerably greater than the probable error assigned to that value by the Potsdam investigators. The discrepancy is due in large part to an adjustment made with the intent of correcting for certain systematic errors. The adjustment was probably not warranted. If this adjustment is not made, the Potsdam result is about 12 parts per million less than the commonly accepted value as compared with 14 and 20 parts per million less as found in the recent absolute determinations. The best value of g for general use when accurate absolute values are needed is probably obtained by reducing the local value in the Potsdam system by about 15 parts per million. The Subcommittee on Gravity of the National Research Council Committee on Fundamental Physical Constants has recommended a reduction of 17 parts per million.

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Egorov, K.N. Methods of determining the absolute value of gravity by interference measurements of a free-fall length. Izvestia Geophys. Ser. 9, 1348-1356, 1963.

ABSTRACT

It is shown that the absolute value of the acceleration of gravity g cannot be determined with the required accuracy by the well-known methods used. In view of this, a description is given of two new methods proposed and theoretically justified by the author for determining this value with an error up to $\pm$ 0.1 mgal. The methods are based on the automatic calculation, during the free fall of a body (mirror), of equal path segments and time intervals which are multiples of the length of the path and periodic time intervals, whose values are known with limited accuracy.

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Faller, J.E. Super spring, Dimensions/NBS, (Sept.), 25-26, 1979

ABSTRACT

Isolation of scientific apparatus from vibrations and mechanical disturbances is a long-standing experimental problem. In 1895, C.V. Boys, the eminent British physicist, complained that street traffic hampered his attempts to determind Newton's gravitational constant. Since that time gravitational and high precision experiments have become considerably more sophisticated, but mechancial isolation for many of these experiments still represents a problem. Physicists at the Joint Institute for Laboratory Astrophysics (operated by NBS and the University of Colorado) have developed a new type of device--the so-called "supper spring"--to provide that mechancial isolation.

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Faller, J.E., R.L. Rinker and M.A. Zumberg. Plans for the development of a portable absolute gravimeter: a tool for studying non-tidal variations in gravity. Boll. di Geofisica Teorica ed Applicata, 80, 355-362, 1978.

SUMMARY

The availability of a few parts in 10^9 absolute gravimeter would impact large areas of geodynamics as well as having possible application to earthquake prediction. The use of such an instrument in combination with classical leveling or extraterrestrially determined height data would also yield information on internal mass motions. The plans for development of such an instrument at JILA using the method of free-fall are discussed.

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Faller, J.E., R.L. Rinker, and M.A. Zumberge. Progress on the development of a portable gravimeter. IGB Bulletin D'Information, 44, 1979.

ABSTRACT

At the Joint Institute for Laboratory Astrophysics we are developing an absolute gravimeter using the method of free-fall. Our goal is to

divise an easily portable apparatus that has a 1-3 μgal sensitivity and which requires less than half a day per measurement (including set up) to obtain that accuracy. Significant progress toward this goal has been made.

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Faller, J.E., R.L. Rinker and M.A. Zumberge. Plans for the development of a portable absolute gravimeter with a few parts in 10 to the 9 accuracy, Tectonophysics, 52, 107-116, 1979.

ABSTRACT

Successful development of a few parts in 10^9 portable g apparatus (which corresponds to a height sensitivity of about 1 cm) would have an impact on large areas of geodynamics as well as having possible application to earthquake prediction. Furthermore, the use of such an instrument in combination with classical levelling or extraterrestrially determined height data would yield information on internal mass motions. The plans for the development of such an instrument at JILA using the method of free fall will be given. The proposed interferometric method uses one element of an optical interferometer as the dropped object. Recent work has resulted in substantial progress towards the development of a new type of long-period (T 60 sec) suspension for isolating the reference mirror (corner cube) in the interferometer. Improvements here over the isolation methods previously available, together with state-of-the-art timing and interferometric techniques, are expected to make it possible to achieve a few parts in 10^9 accuracy with a field-type instrument.

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Faller, J.E. Little g - an introduction to dropping things. Promise and plans for the JILA gravimeter. Proc. Intl. Symp. on precision measurement and gravity experiment. Taipei, China, 1983.

(NO ABSTRACT)

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Faller, J.E. An absolute interferometric determination of the acceleration of gravity. Ph.D. Thesis. Princeton Univ. 108 pp., 1963.

ABSTRACT

A free-fall determination of the acceleration of gravity has been made using one element of an optical interferometer as the falling object. A rotation insensitive mirror is dropped approximately ten centimeters and generates three sets of white light fringes as it falls. The times between the occurrence of these fringes are measured electronically. The spacing of the white light fringes is measured interferometrically and is continuously monitorable. The r.m.s. accuracy of the experiment is 7 parts in 10^7. This work serves to point out again the necessity of adopting a new relative standard of "g" differing from the value on the Potsdam system by more than 10 parts per million. The value obtained from "g" at the surface of the pier in Room 130 Palmer Laboratory is 980.1604 ± 0.0007 cm/sec^2. This value transferred to the gravity site in Guyot Hall would 980.1626 cm/sec^2; and finally the Palmer value transferred to the Washington Geophysics Laboratory (using a Washington-Princeton difference of .0770 cm/sec^2*) would be 980.0856 cm/sec^2.

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Faller, J.E. Results of an absolute determination of the acceleration of gravity. JGR, 70, 4035-4038, 1965.

ABSTRACT

The acceleration of gravity has been determined by using one element of an optical interferometer as a freely falling object. A rotation-insensitive mirror was dropped approximately 10 cm and generated three sets of white light fringes as it fell. The time between the occurrence of these fringes were measured electronically. The spacing of the white light fringes was measured interferometrically and was continuously monitorable. The rms accuracy of the experiment is 7 parts 10^7. This work serves to demonstrate again the Potsdam error of more than 10 ppm. The value obtained for g at the surface of the pier in room 130, Palmer Physical Laboratory, Princeton University, is 980 ± 0.0007 gals. This value transferred to the gravity site in Guyot Hall, Princeton University, would be 980.1626 gals; and finally the Palmer value transferred to the Washington Geophysics Laboratory Laboratory (using a Washington-Princeton difference of 0.0770 gals) would be 980.0856 gals.

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Faller, J.E. Precision measurement of the acceleration of gravity. Science, 158, 60-67, 1967.

ABSTRACT

Measurements of g have always made maximum use of the available technology in measurement of length and time.

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Faller, J.E. and Hammond, J.A. A new portable absolute gravity instrument. Bulletin d'Information No. 35, Bureau Gravimetrique International, I43-I48, 1974.

ABSTRACT

The main feature of the new design is that the freely falling reflector is enclosed in a small evacuated chamber which falls along with the reflector. These both fall in a larger vacuum chamber but since the air which comes in contact with the falling object is falling with essentially the acceleration of gravity, air resistance effects are negligible.

The electronics system will make digital time measurements between a large number (50 to 500) of interference fringes and will thus make independent measurements of g and the gravity gradient as well as detect seismic motions occurring during the fall of the object. The digital data will be processed immediately by an on-line process and control mini-computer.

The instrument will utilize a laser whose output is stabilized on an Iodine absorption line giving a contribution to the uncertainty from the wavelength of the light of only ±0.001 mGal. The absence of magnetic materials will remove a rather large source of uncertainty which existed with the original instrument.

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Faller, J.E., Y.G. Guo, J. Gschwind, T.M. Niebauer, R.L. Rinker, J. Xue. The JILA portable absolute gravity apparatus. JILA, Boulder, Colo., 1982.

ABSTRACT

At the Joint Institute for Laboratory Astrophysics, we have developed a new and highly portable absolute gravity apparatus based on the principles of free-fall laser interferometry. A primary concern over the past several years has been the detection, understanding, and elimination of systematic errors. In the Spring of 1982, we used this instrument to carry out a survey at twelve sites in the United States. Over a period of eight weeks, the instrument was driven a distance of nearly 20,000 km to sites in California, New Mexico, Colorado, Wyoming, Maryland, and Massachusetts. The time required to carry out a measurement at each location was typically one day. Over the next several years, our intention is to see absolute gravity measurements become both usable and used in the field. To this end, and in the context of cooperative research programs with a number of scientific institutes throughout the world, we are building additional instruments (incorporating further refinements) which are to be used for geodetic, geophysical, geological, and tectonic studies. With these new instruments we expect to improve (perhaps by a factor of two) on the 6-10 μgal accuracy of our present instrument. Today one can make absolute gravity measurements as accurately as - possibly even more accurately than - one can make relative measurements. Given reasonable success with the new instruments in the field, the last years of the century should see absolute gravity measurement mature both as a new geodetic data type and as a useful geophysical tool.

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Faller, J.E., Y.G. Guo, M.A. Zumberge. Determination of absolute gravity. Proc. 42^{nd} meeting ACSM-ASP, 63-74, undated.

ABSTRACT

The status of absolute gravimetry is discussed. A new and easily portable apparatus which has been developed at JILA for the absolute determination of the acceleration of gravity is described. Laboratory tests of this new instrument indicate a measurement accuracy of 6 parts in 10^9 is achieved. This corresponds to an equivalent height sensitivity of about 2 cm.

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Faller, J.E., Y.G. Guo, R.L. Rinker, M.A. Zumberge. Advanced absolute gravity determination. Jila, Boulder, Colo., undated.

ABSTRACT

During the past twenty years, a number of absolute gravimeters based on laser interferometry have been developed. At the Joint Institute for Laboratory Astrophysics (JILA) we have recently designed and built a new highly-portable absolute gravity apparatus based on these principles for the purpose of surveying tectonically interesting regions. The status of this new instrument and our future plans for it as well as the general status of absolute gravity determinations will be discussed.

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Faller, J.E. and J.A. Hammond. A laser-interferometer system for the absolute determination of the acceleration of gravity. AFCRL-70-0163 March 3, 1970.

ABSTRACT

The acceleration due to gravity at a particular site is an important quantity for several purposes. It contributes to the general knowledge about the earth's gravity field and provides a calibration point for geodetic (relative) gravity meters. Its value comes into the determinations of several fundamental constants because of the definition of the ampere being based on the force between two wires with current flowing in them. The local acceleration of gravity together with a standard mass provides the most precisely known force in a laboratory. Precise measurements of g over extended periods of time with a drift-free instrument could possibly demonstrate long period effects of a geophysical or cosmological origin. A new instrument for the measurement of this important physical quantity has been built and its design and construction together with the results obtained with it are discussed in this thesis.

The apparatus consists of a coner-cube interferometer in which one of the reflectors falls freely under the acceleration of gravity. This gives rise to fringes which may be counted providing a measurement of the distance fallen directly in terms of the wavelength of light. A stabilized He-Ne laser provides the required coherence and brightness to achieve high quality fringes over a one meter dropping distance. The stabilized wavelength of the laser has been measured with an accuracy of ± 2 parts in 10^8. The time base is a standard frequency oscillator which is compared with one of the 60 kHz standard radio broadcasts (WWVB). The timing accuracy achieved is $\pm$ 2nsec. A vertical seismometer is used to provide an inertial platform for supporting the

stationary corner-cube. The drop-to-drop scatter is less than 1 part in 10^7 and the consistency of 1/2 hour (50 drops) data sets is better than ±3 parts in 10^8. Non-gravity forces and systematic effects due to them and other factors have been carefully accounted for and the final results have a precision (70% confidence level or standard deviation) of ±5 parts in 10^8.

The instrument is portable and has been used to measure the local acceleration of gravity at a number international sites. Among these are: The National Bureau of Standards, Washington, D.C. (Gaithersburg site); The National Physical Laboratory, Teddington, England and The Bureau International des Poids et Mesures, Sèvres, France. The results obtained at these sites are:

Site	g (mgal)	Potsdam correction (mgal)
NBS (NBS-3)	980 102.40 ±0.06	-13.76
NPL (Bushy House)	981 181.935±0.05	-13.60
BIPM (Sèvres A)	980 925.965±0.05	-13.80

The differences between these values and those for the same sites in the Potsdam System of gravity values (Potsdam correction = g(Potsdam) - g (measured)) demonstrate two facts: 1) The International system of gravity values should be adjusted to reflect these corrections which have been verified by many experimenters and, 2) The relative transfers between different sites which establish their relationship to the Potsdam system cannot generally be accepted with greater than ±0.1 or ±0.2 mgal precision.

A step in the direction of statement (2) above was taken by the Comite International des Poids et Mesures at its October 1968 session in recommending that as of 1 January 1969, g(Potsdam) be reduced by 14 mgal thus defining a revised Potsdam system in better agreement with modern absolute measurements. While this correction may be adequate for those interested in absolute g with a precision of ±0.5 mgal (for instance) and experimenter interested in his local value of g to a precision of the order of ±0.10mgal (one part in 10^7) must check very carefully the transfer value from his site to the site of an absolute measurement of the appropriate accuracy and precision.

The results are compared with those of other recent absolute measurements made at or near these sites and thus provide the first such "on site" comparisons of absolute instruments with each other. In addition to these three sites, six other sites have been visited with the instrument. Those sites are: Wesleyan University, Middletown, Connecticut; Air Force Cambridge Research Laboratories, Bedford, Massachusetts; The Institute of Geophysics, University of Alaska, Fairbanks, Alaska; Universdad Nationale, Bogota, Columbia; The University of Denver, Denver, Colorado.

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Faller, J.E., R.L. Rinker, M.A. Zumberge. Absolute gravity as a reconnaissance tool for vertical height changes and for studying density changes. JILA, Boulder Colo., undated.

ABSTRACT

A major effort is under way to develop a highly portable absolute gravimeter having an accuracy of 3 μgal or better, an accuracy which translates into a height sensitivity of about 1 cm. Significant progress toward this end has been made. The instrument uses the method of free fall and consists basically of four parts: a drag free dropping chamber, a long period isolation device, a stabilized laser, and the necessary timing electronics. The size and weight of these units is such that the apparatus can be easily handled and assembled by a single person. The expected measurement time required at any given site is about one hour. Since the instrument's gravity measurements are based on secondary length and time standards it is inherently drift free and we believe field use of it will significantly advance the study of tectonic processes, including vertical height changes.

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Feng Yong-yuan, Zhang Guang-yuan, Li De-xi, Qui Xiao-mei, Zhou Jing-hua, Gao Jing-Lung, Huang Da-lun, Huang Cheng-qing, and Guo You-Guang. Transportable gravimeter for the absolute determination of gravity; Metrologia, 18, 139-143, 1982.

ABSTRACT

A transportable absolute gravimeter has been constructed at the National Institute of Metrology (NIM), which is based upon the principle of free fall through three stations. A cube-corner reflector dropped in a vacuum chamber forms an arm of an optical interferometer. The interference pattern produced by the motion of the falling object is converted to an electric signal. This is then processed by a special electronics system, so that the distances and the respective time intervals of the falling reflector as it passes each of the three stations are measured. The light source of the interferometer is a stabilized He-Ne laser. The time base is a rubidium frequency standard. The sources of error of the measurement and the uncertainty of the results are given. The effect of non-verticality of the laser beam is discussed. Some of the recent results including the comparison with A. Sakuma's gravimeter at the Bureau International des Poids et Mesures (BIPM) are presented. The accuracy achieved with this gravimeter is about 2×10^{-8}.

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Fischer, W., H.G. Kahle, and I. Marson. Absolute and relative gravity measurements in Switzerland with special emphasis on a new Swiss National Gravity Net (SNGN); Bulletin d'information, Bureau Gravimetrique International, 49, 38-49, 1981.

ABSTRACT

Absolute gravity measurements have been carried out between 1978 and 1980 at 7 stations in Switzerland with the transportable absolute gravity apparatus of the Istituto di Metrologia "G. Colonnetti", Torino.

Relative gravity measurements have been performed in Switzerland since 1962 in order to establish a new Swiss National Gravity Net. During the period 1975-1979, the gravimetric activities have been devoted to the completion of a new Bouguer gravity map of Switzerland. A special network connecting the 7 absolute sites and including the calibration line Interlaken - Jungfraujoch has been measured 1980-1981 in order to determine the scale of two LaCoste & Romberg G-gravimeters and one D-model. In addition, this network has allowed some valuable investigations on the periodic errors of the two G-meters in question.

Measurements of non-periodic secular gravity variation are planned in the Rhine valley near Chur and Sargans, where earlier investigations have shown a pronounced minimum of the isostatic anomalies as well as the highest uplift rates of the country. This project has been started in autumn 1981. It is intended to connect this gravity line with a similar profile (Munich - Verona) in the Brenner area, Austria, which has been established by the Bayerische Kommission fur die Internationale Erdmessung, Germany.

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Gibbings, D.L.H., J.B. Patterson and G.A. Bell. The absolute determination of the gravitational acceleration at Sydney, Australia. CSIRO Nat. Stand. Lab. Sydney, Australia, 469-474, undated.

ABSTRACT

An absolute measurement of the gravitational acceleration "g" has been made at the National Standards Laboratory, Chippendale, N.S.W., Australia.

The determination was made by studying the free motion of a body projected vertically upwards in a vacuum and the time between its initial and final passages through two horizontal planes of known vertical separation was measured.

The measured value of g at a point 1.2 metres above the floor in room B.37 of the National Standards Laboratory is

$9.7967134 \ m/s^2$.

The corresponding value at floor level at the BMR gravity station is

$9.796717 \ m/s^2$.

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Groten, E. Tidal corrections for absolute gravimetry. (Reference unknown).

ABSTRACT

Since accuracy of about ± 2 microgal is at hand reductions and corrections applied to gravimetric measurements should have accuracies of better than ± 1 microgal. Tidal reductions, if correctly applied, yield such accuracies. Consequences are discussed.

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Gschwind, J. Trip report. Absolute gravity measurements. Unpublished. 1982.

(NO ABSTRACT)

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Hammond, J. A. A laser-interferometer system for the absolute determination of the Acceleration of Gravity. JILA report #103. JILA, Boulder, Colorado, 1970.

ABSTRACT

The acceleration due to gravity at a particular site is an important quantity for several purposes. It contributes to the general knowledge about the earth's gravity field and provides a calibration point for geodetic (relative) gravity meters. Its value comes into the determinations of several fundamental constants because of the definition of the ampere being based on the force between two wires with current

flowing in them. The local acceleration of gravity together with a standard mass provides the most precisely known force in a laboratory. Precise measurements of g over extended periods of time with a drift-free instrument could possibly demonstrate long period effects of a geophysical or cosmological origin. A new instrument for the measurement of this important physical quantity has been built and its design and construction together with the results obtained with it are discussed in this thesis.

The apparatus consists of a coner-cube interferometer in which one of the reflectors falls freely under the acceleration of gravity. This gives rise to fringes which may be counted providing a measurement of the distance fallen directly in terms of the wavelength of light. A stabilized He-Ne laser provides the required coherence and brightness to achieve high quality fringes over a one meter dropping distance. The stabilized wavelength of the laser has been measured with an accuracy of ±2 parts in 10^8. The time base is a standard frequency oscillator which is compared with one of the 60 kHz standard radio broadcasts (WWVB). The timing accuracy achieved is ± 2nsec. A vertical seismometer is used to provide an inertial platform for supporting the stationary corner-cube. The drop-to-drop scatter is less than 1 part in 10^7 and the consistency of 1/2 hour (50 drops) data sets is better than ±3 parts in 10^8. Non-gravity forces and systematic effects due to them and other factors have been carefully accounted for and the final results have a precision (70% confidence level or standard deviation) of ±5 parts in 10^8.

The instrument is portable and has been used to measure the local acceleration of gravity at a number international sites. Among these are: The National Bureau of Standards, Washington, D.C. (Gaithersburg site); The National Physical Laboratory, Teddington, England and The Bureau International des Poids et Mesures, Sèvres, France. The results obtained at these sites are:

Site	g (mgal)	Potsdam correction (mgal)
NBS (NBS-3)	980 102.40 ±0.06	-13.76
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BIPM (Sèvres A)	980 925.965±0.05	-13.80

The differences between these values and those for the same sites in the Potsdam System of gravity values (Potsdam correction = g(Potsdam) - g (measured)) demonstrate two facts: 1) The International system of gravity values should be adjusted to reflect these corrections which have been verified by many experimenters and, 2) The relative transfers between different sites which establish their relationship to the Potsdam system cannot generally be accepted with greater than ±0.1 or ±0.2 mgal precision.

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Hammond, J.A., and J.E. Faller. Laser-interferometer system for the determination of the acceleration of gravity. IEEE Jour. of Quantum Electronics, QE-3, 11, 597-602, 1967.

ABSTRACT

A system is described for determining the acceleration or gravity using a stablized He-Ne laser as the light source in a Michelson-type interferometer which incorporates a freely falling corner reflector as one of its mirrors. The method effectively utilizes the most precise standards presently available for the measurement of length and time and is capable of an accuracy of better than 5 parts in 10^8.

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Hammond, J.A., and J.E. Faller. Results of absolute gravity determinations of a number of different sites. JGR, 76, 32, 7850-7854, 1971.

ABSTRACT

Absolute determinations of the acceleration of gravity using a free-falling laser-interferometer apparatus have been made at a number of sites. A rotation-insensitive mirror (corner cube) is dropped approximately 1 meter, and interference fringes are counted for two sequential periods of time. Fractional fringe counts are determined electronically. The rms accuracy of the measurements is approximately 5 parts in 10^8. The value obtained for g is given for eight different sites: National Bureau of Standards, Gaithersburg, Maryland; Wesleyan University, Middletown, Connecticut; Air Force Cambridge Research Laboratories, Hansco Field, Bedford, Massachusetts; Denver, Colorado; Fairbanks, Alsaka; Bogota, Columbia; Teddington, England; and the Bureau International des Poids et Mesures, Sèvres, France. The measurements were made between May 1968 and August 1969.

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Hammond, J. Absolute gravity measurements by the Air Force Geophysics Laboratory. Proc. 9th Int. Symp. on Earth Tides. New York, 1981.

ABSTRACT

The Air Force Geophysics Laboratory has made observations of absolute gravity at a number of locations in the United States during the last three years. Many of these measurements have been made at sites where comparison with other instruments has been possible. The instrument, employing a free fall technique, is described, and a discussion of the systematic corrections presented. The comparisons with other absolute measurement and the reproducibility of values with the AFGL system is discussed. The obtained results show that the accuracy of this instrument is 0.01 mgal.

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Hammond, J.A., and J.E. Faller. A laser-interferometer system for the absolute determination of the acceleration due to gravity. Proc. of the International Conference on Precision Measurement and Fundamental Constants. NBS Spec. Publ. 343, U.S. Govt. Printing Off. Washington, D.C. 457-463, 1971.

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ABSTRACT

A new and portable instrument for making an absolute determination of the acceleration due to gravity has been built. The design and construction of this apparatus together with the results obtained at eight different sites are discussed. The instrument consists of an optical interferometer illuminated by light from a stabilized He-Ne laser in which one of the mirrors, a corner cube reflector, freely falls a total distance of about one meter. The drop-to-drop scatter is less than 1 part in 10^7, and the uncertainties (70% confidence intervals) of the results obtained at most sites are less than ±5 parts in 10^8.

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Hammond, J.A. and R.I. Iliff. The AFGL absolute gravity program. Applications of Geodesy to Geodynamics, Proc. 9th GEOP Conf., Dept. of Geodetic Science Report No. 280, Ohio State Univ. Columbus, Ohio, 245-248, 1978.

ABSTRACT

A brief discussion of the AFGL's program in absolute gravity is presented. Support of outside work and in-house studies relating to gravity instrumentation are discussed. A description of the current transportable system is included and the latest results are presented. These results show good agreement with measurements at the AFGL site by an Italian system and with previous measurements by Hammond and Faller. The accuracy obtained by the transportable apparatus is better than 0.1 $\mu msec^2$ (10 μgal) and agreement with previous measurements is within the combined uncertainties of the measurements. The instrument will be used extensively for field measurements in 1979.

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Hammond, J.A., R.L. Illif, and R.W. Sands. New techniques for absolute gravity measurements. AFGRL-TR-83-0016, Air Force Geophysics Laboratory, Hanscom AFB, Mass., 1-12, 1983.

ABSTRACT

Since the international conference on precision measurement and fundamental constants, a number of new techniques have been put into practice at the Air Force Geophysics Laboratory (AFGL) in a transportable system for measuring the acceleration of gravity. The system in use at the present incorporates an earlier vacuum chamber with some modifications and includes new electronics, data analysis, and optical subsystems. Along the way new techniques have been incorporated with have resulted in several improvements to the overall operation of the system. The electronics now produce time measurements at a large number of points (500) during the free fall of the object. These time values are analyzed with a least squares fit to a second-order polynomial to obtain the average acceleration. The correction for air resistance is now made by monitoring the pressure and making a correction based on extrapolation from near atmospheric pressure (7×10^{-2}Pa) to the low operating pressure (3×10^{-5}Pa). The use of an Iodine-stabilized laser as a reference for the length measurement has significantly reduced the uncertainty due to the wavelength of the Lamb-dip stabilized laser.

Since that time support has been given to the development of a second generation instrument which used a chamber-in-a-chamber technique. This system produced reasonably good data, but several effects presented

problems which encouraged us to reevaluate the previous system. We decided to modify the first generation system to use the superior electronics which were developed for the second generation system. Thus, at the beginning of 1978 the assembly of the current system was started. Most of the "New Techniques" which we will discuss in this report are the result of innovations first put into operation with the second generation system. The electronics system developed by the Joint Institute for Laboratory Astrophysics (JILA) with AFGL support performed multiple time measurements during the fall of the object, and these time measurements were used to compute gravity 'g'. This is in contrast to the three-position technique used in the first generation systems.

When the decision to use the mechanical parts of the first generation system was made, it was concluded that the reduction of the height of the chamber by about 0.5 m would not only simplify the transportation and operation of the system but would not reduce the precision. The first data obtained with this new system has been described earlier. There was reasonably good agreement between the new measurements and previous measurements at the AFGL site.

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Hanada, H., T. Tsubokawa, M. Ooe, and I. Tsubokawa. Absolute determination of gravity with transportable apparatus. Proc. IAG. Tokyo, 1982.

ABSTRACT

We have developed a transportable absolute gravimeter (Tsubokawa type) and recently obtained preliminary results at Mizusawa. A cat's eye falls about 30 cm in vacuum and a Michelson interferometer, which is illuminated by an iodine stabilized He-Ne- laser, measures its falling distance every 1 ms. Timing signals are synchronized with a rubidium frequency standard. The dropping mechanism is designed so as to realize the non-rotating free fall. The arithmetic mean of the measurement is consistent with that obtained by the station type apparatus at Mizusawa.

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Haubrich, R.A., J.C. Rose, and G.P. Wollard. A method for the measurement of absolute gravity. Trans. AGU, 39, 27-34, 1958.

ABSTRACT

The greatest difficulty in measurements of absolute gravity with either pendulums or falling bodies is the distance determination. It is proposed to avoid the distance measurement in a falling-body experiment by determining g in terms of c, the velocity of light. A pulse of light is directed up toward and reflected from a falling ball. The reflected light pulse, upon being detected by a photomultiplier, initiates a new pulse. A pulse recycle oscillator is thus set up whose frequency is a function of the position of the ball. By measuring the frequency for three successive time intervals, g may be determined in units of c independent of the time and position at the release of the ball.

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Humphrey, C.L. Analysis of the free fall experiment. AJP, 41, 965-968, 1973.

ABSTRACT

Five methods found in the literature for analyzing the data obtained in the classical free fall experiment are compared to a method proposed by this author. Statistical analysis is used to show that the author's method, a correct application of the method of differences, yields a more precise mean value of acceleration. Experimental results verify the statistical predictions.

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Inouye, Tadaeo, Tomiji Kitsunezaki, Osamu Senda and Koichi Ando. A determination of the acceleration due to gravity at Kakioka, Japan. Nat. Res. Lab. of Metrology, Itabashi, Tokyo, Japan, undated.

ABSTRACT

This measurement is based on the free-fall method using a 1 metre graduated scale. The obtained value of gravity is 9.79961 m/s^2 with the assigned error of 1.0 X $10^{-5} m/s^2$. This value is 15.3 X 10^{-5} m/s^2 smaller than the value based on the Potsdam system.

From analysis of the observational data, it was found that some of the experiments were affected by microscisms.

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Jeffreys, H. On the absolute measurement of gravity. Monthly notices, Roy. Astro. Soc., Geophysical Supp. 5, 398-408, 1949.

ABSTRACT

A simplified method is given for finding the corrections for bending and stretching of a pendulum used for making an absolute determination of gravity. It appears that the correction given by Clark is incorrect and that the value of g for Teddington consequently needs an increase of about 1.7 mgal. Examination of several minor corrections mentioned by Heyl and Cook for the Washington determination shows that they mount up and that the value given by these authors also needs an increase of about 1.5 mgal. When taken in conjunction with the relative determination by Bullard and Browne, the revised values give a discrepancy of 4.7±1.6 mgal., which is large enough to need attention. An independent determination is desirable.

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Jeudy, L.M.A. Changes in absolute gravity of environmental origin. EPB Internal Report, GGG, 83-12, 1983.

ABSTRACT

Changes in the absolute determination of gravity at the Bureau Internationale des Poids et Mesures (BIPM) in Sèvres (near Paris), France over a period of four years (August 1967 - July 1971) are anlayzed in terms of correlation with changes of other environmental variable such as local atmospheric pressure, water table level, variation of latitude and Earth rotation rate. The present study proves a significant correlation with atmospheric pressure (-0.7 ± 0.5 μGal/mb) and with UTO length of day variation (-10. ± 5. μGal/ms, where the error bounds are 2σ units). In both cases the correlation significance is estimated by a variance ratio F test where the actually published standard errors and deduced covariances have been taken into account. The same test is used to prove the non-correlation with latitude variation (due to polar motion) and water table level changes (River Seine water level). The results are discussed and elastic homogeneous incompressible earth hypotheses are envisaged.

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Jeudy, L.M.A. Absolute determination of gravity from free-fall measurements using spectral analysis and least squares fit. EPB unpublished report, 1984.

ABSTRACT

A practical and accurate (within 10^{-4}nm) free-fall formula is derived for the purpose of determining absolute gravity from free-fall measurements using least squares fit. Small correcting terms for air resistance and Coriolis force (Eotvos effect) are taken into account. A procedure using spectral analysis, least squares fit and variance-ratio significance F test eliminates non-random noise and computes gravity. The present study shows from real data that perturbing frequencies may create systematic errors up to 50 ±Gal. A method of computing an average set of data is suggested and the problem of computer expenses is considered.

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Jeudy, L.M.A. Coriolis corrections for free fall absolute gravity measurements. EPB, Undated draft manuscript.

ABSTRACT

Considering an ideal case, the rigourous laws of motion are derived for a freely falling object in a rotating gravitational field taking into account Coriolis forces. The corresponding corrections for the measured gravity as obtained from free fall absolute gravimeters are derived. In the case of symmetric free fall, the correction amounts to -1.4 μgal for typical numerical values corresponding to Sakuma's gravimeter at BIPM (Bureau International des Poids et Mesures). In the case of single free fall, the correction amounts to +0.43 μgal.

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Jeudy, L.M.A. Spectral analysis of Free Fall Measurements and determination of Absolute Gravity, EPB Undated draft manuscript.

ABSTRACT

Equations of free fall, accounting for Coriolis forces and constant gravity gradients, are derived by application of the principles of Classical Mechanics (Goldstein, 1980). Least squares spectral analysis

(Vanicek, 1971), removal of the non-random noise, correction of the original time series and least squares fit of a polynomial of degree four to the corrected time series are proposed.

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Jeudy, L.M.A. Report on the absolute determination of gravity from free fall measurements. EPB Internal Report GGG 83-4, 1982.

ABSTRACT

First I would like to make a brief account of the results of the first International Calibration of Absolute Gravimeters held in Sèvres (France) at BIPM (October, November 1981). In the second part of the present report I gave a short explanation of my data analysis method. The mathematical details can be found in the preliminary version of a joint paper (in preparation) by myself and R.I. Iliff.

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Jeudy L.M.A. Practical formulae for free fall absolute gravity and gravity gradient measurement. IGB, Bulletin d'information, 49, 180-199, 1981.

ABSTRACT

Equations of free fall, accounting for Coriolis forces and constant vertical gravity gradient, are derived by application of the principles of Classical Mechanics (Goldstein, 1980). A least squares fitting of the observed height of the falling body to a polynomial in time is proposed. Formulae for computing gravity and gravity gradient from the ploynomial coefficients are estabilished.

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Kahle, H.G., P.J. Cagienard, St. Mueller, I. Marson, F. Chaperon, and F. Alasia. Absolute schweremessungen in der schweiz als basis fur geodynamische untersuchungen zur aktuellen alpentektonik, Vermessung, Photogrammetrie, Kulturtechnik 7/81, 221-203, 1981.

ABSTRACT

Le développement des gravimètres absolus transportables à haute précision vers la fin des années soixante-dix a permis d'étudier les mouvements verticaux de la croûte à l'aide des résultats des mesures absolues. Cet article donne une vue d'ensemble sur les fondements de la techniques des mesures gravimétriques et l'application à la solution des problèmes géodynamiques. L'exemple des Aples suisses montre la collaboration interdisciplinaire entre la Géodésie et la Géophysique.

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Kanngieser E., W. Torge, and H.G. Wenzel. Direct comparison of absolute and relative gravity measurements in the Federal Republic of Germany and Northwestern Europe. 8th meeting Int. Grav. Comm. 1978.

SUMMARY

Relative gravity measurements in the Federal Republic of Germany (FRG) 1978 and in the region of the North-West European Lowland Levelling (NWELL) 1976 give average differences of $\pm 8*10^{-8}$ ms^{-2} between the adjusted gravity values from relative measurements, and the absolute values observed with the transportable apparatus of the Istituto di Metrologia "G. Colonnetti", Torino. So both systems seem to be compatible with the $10*10^{-8}$ ms^{-2} accuracy level.

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Kiviniemi, A. High precision measurements for study in the secular variations in gravity in Finland. Publication of the Finnish Geodetic Institute No. 78, Helsinki, 68, 1974.

(NO ABSTRACT)

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Kukkamaki, T.J., and Hytonen. Two hundred meter pendulum. XII General Assembly of IUGG. 1960.

(NO ABSTRACT)

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Lambeck, K. Temporal variations of rotational origin in the absolute value of gravity. Studia Geoph et Geod. 17, 269-271, 1973.

SUMMARY

When correcting precise gravity measurements for polar motion, the Earth's rotational deformation must be considered, as this will increase the correction based on a rigid Earth by about 15%. Conversely the gravity observations can be used to estimate the Love numbers h_2 and k_2 at the chandler frequency.

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Lambert, A. and R.K. McConnell. The need for an absolute gravity appartus in the Gravity Division. Internal Report 74-1, Earth Physics Branch, EMR. 1974.

(NO ABSTRACT)

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Levallois, J.J. Quelques consequences geophysiques des nouvelles methodes de haute precision de mesures absolues de g. Bull. Geod., 99, 111-112, 1971.

(NO ABSTRACT)

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Lin, Hong-chu, and De-xi Li. Developments and research trends in the measurement of absolute gravity. Acta Geophysica Sinica, 25, 6, 554-560, 1982.

ABSTRACT

This article describes developments in absolute gravimeters and absolute gravimetry, presents the results of international comparisons in absolute gravimetry over the last decade or so, and analyzes and discusses trends in the measurement of absolute gravity with reference to research projects in countries that are ahead in this field.

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Marson, I., and F. Alasia. Absolute gravity measurements in the United States of America; AFGL-TR-78-0126, Air Force Geophysics Laboratory, Hanscom AFB, 1978.

(NO ABSTRACT)

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Marson, I., and F. Alasia. Absolute gravity measurements in the United States of America; AFGL-TR-80-0052, Air Force Geophysics Laboratory, Hanscom AFB, 1980.

(NO ABSTRACT)

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Marson, I. and C. Morelli. First order gravity net in Italy. Presented at the 8th meeting of IGC, 1978.

SUMMARY

Results of a new first order gravity net performed in Italy in 1977 are presented. Four La Coste-Romberg Mod. G., one Mod. D meters, 49 base stations and 758 ties have been used. Five absolute stations (accuracy

± 10 μGal) have been included in the net. The standard error of the final g value is within the limits 6-22 μGal. The 1955 First Order Net data have been converted in the new Net (accuracy ± 100 μGal). Comparison with IGSN71 shows an agreement within the accuracy limits of the World Gravity Net (± 100 μGal).

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Marson, I. and F. Alasia. Absolute measurements of the gravity acceleration in the United States of America. Boll. di Geodesia e Scienze Affini, 2, 285-304, 1979.

SUMMARY

The present paper reports the results of a gravity survey made in autumn 1977 with the I.M.G.C. Absolute Gravity Meter in U.S.A.

Absolute measurements have been made at Bedford, Denver, Bismarck, Alamogordo, San Francisco, Miami. The mean error has been ± 10 μGal (1). The agreement with respect to the IGSN71 is within the accuracy limits of the net.

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Marson, I., Kahle, H.G., Mueller, St., Chaperon, F. and F. Alasia. Absolute Gravity Measurements in Switzerland: Definition of a base network for Geodynamic Investigations and for the Swiss Fundamental Gravity Net. Bulletin Geodesique, 55, 203-217, 1981.

ABSTRACT

Results of two absolute gravity surveys performed in Switzerland between 1978 and 1979 are presented and discussed in the framework of the uplift history of the Swiss Alps. Five absolute stations have been established as a contribution to the Swiss fundamental gravity net as well as to geodynamic investigations on the Alpine uplift. Two sites (Interlaken-Jungfraujoch) form the end points of a calibration line for field gravimeters. The gravity range of this line amounts to 605 x $10^{-5} ms^{-2}$ (=605 mgal). It can be traversed in a relatively short time interval of less than 3 hours. Two other sites (Brig and Chur) are located in the area of the most negative gravity anomalies and highest uplift rates encountered in Switzerland. They serve as reference stations for a more extended gravity net for studying non-periodic secular gravity variations associated with the Alpine uplift.

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McConnell, R.K. Absolute Gravity Requirements in Canada. Update to Internal Report 74-1, Earth Physics Branch, E.M.R., 1979.

(NO ABSTRACT)

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Medi, E. Un metodo per la misura assuluta dell accelerazione de gravita: Il rotogravimeteo. Annali di Geofisica, VII, 4, 437-490. 1954.

Summary

A method is discussed for an absolute measurement of the constant of gravity. This method is based on the form taken by a liquid set in rotation around an axis parallel to the direction of the acceleration of gravity at the place of observation.

By measuring the focal distance of the revolution paraboloid thus obtained, and the period of rotation of the system, it is possible to obtain a value for g. There are no temperature effects with this method measurement, and further sources of errors, normally present in other methods, are eliminated.

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Morelli, C. Gravita assoluta: Stato attuale e necessita metrologiche. Boll. di Geodesia e Scienze Affini, 4, 685-691, 1960.

(NO ABSTRACT)

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Morelli, C. IGSN71: The international gravity standardization net 1971. Bureau Central De L'Association Internationale De Geodesie 19, rue Auber-75009 Paris, 1971. (EPB Library QB334.I61).

INTRODUCTION

Up to the present time relative gravity measurements were referred to a single absolute reference value determined by Kuknen and Furtwangler at Potsdam in 1906 by reversible pendulum experiments. This value (981 274. ± 3 mGal) compared with later measurements (reversible pendulum and free fall experiments) at various laboratories appeared to be too large by about 12 to 16 mGal.

The employment of modern technology for absolute measurements resulted in significant improvements during the 1960's. The utilization of new concepts (symmetrical experiments), white light and laser interferometers and modern nanosecond time counters increased measuring precision to the order of μ Gals and considerably reduced the systematic errors in the experiments. The transportable experiments (Hammond, Faller, 1971) permitted, for the first time, direct comparisons of various methods at the same site.

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Murata, I., A transportable apparatus for absolute measurement of gravity; Bul. of the Earthquake Research Inst., 53, 49-130, 1978.

ABSTRACT

A transportable apparatus for an absolute measurement of gravity has been constructed for the purpose of detecting secular variations of gravity. First of all, the significance of the absolute measurement of gravity is outlined in this paper.

The principle of measurement adopted here is the simple free fall, on the basis of the well-known relation between falling distance, falling time and acceleration of gravity. Using a cat's eye as a falling object, a Michelson interferometer measures the falling distance comparatively with the wavelength of a He-Ne laser light. Interference fringes for 30 cm falling distance are continuously recorded on a recording film with 1 ms sampling intervals which are accurately controlled by a frequency standard. Phase angles of interference fringes at every 1 ms interval are taken into consideration but direct counting of the number of interference fringes is unneccessary in the present apparatus. The method of data processing, in which the falling distance is counted from time to time on phase angle data, is one of the distinct features of the present apparatus, and proves to be very effective in both detecting details of falling motion and simplifying the apparatus. Furthermore, we describe

disturbing factors such as the inaccuracy in wavelength of laser light, the vertical gradient of gravity, residual gas and incompleteness of the optical character of a falling object.

Secondly, the result of experimental observations at the Matsushiro Seismological Observatory is reported. The gravity value obtained from twenty-one test drops is as follows:

g_{OBS}= 979 770.131±0.010 mGal.

This is very close to the corresponding value derived from that of the Matsushiro First-order Gravity Station of the Geographical Survey Institute:

g_{DRV} = 979 770.19±0.1 mGal.

The main sources of standard error of a single drop of 0.038mGal have been estimated as the inaccurate setting of the wavelength of laser light and microtremors. Inaccuracy in wavelength causes a 0.020 mGal error, but it will be overcome by introducing an iodine saturated absorption stabilized He-Ne laser with an accuracy in wavelength of $1X10^{-9}$. Microtremor effect on gravity amounts to about 0.026mGal, but can be minimized by monitoring ground vibrations with a seismometer. It is concluded that the high efficiency and the practicability of the present apparatus have been confirmed through the experiment and the data analyses.

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Newton, R.R. Experimental evidence for a secular decrease in the gravitational constant G. JGR, Vol. 73, 12, 3765-3771, 1968.

ABSTRACT

This paper combines data from a variety of sources relating to changes in the earth's spin for the purpose of estimating changes in the earth's polar moment of inertia C and in the gravitational constant G. The changes in C and G cannot be inferred with confidence until an important question in lunar theory is resolved and until certain types of measurement are improved. Plausible assumptions lead to the tentative conclusion that C is increasing and that G is decreasing at rates of the order of 1 part in 10^8 per century. These estimates agree to order of magnitude with the rate of upward transport of material at the mid-ocean ridges.

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Ooe, M., T. Suzuki, T. Tsubokawa, H. Hanada. Absolute measurement of the gravitational acceleration of Mizusawa. Proc. 9th Int. Symp. on Earth Tides, New York, 1981.

ABSTRACT

Absolute measurements of the acceleration due to gravity have been made at the International Latitude Observatory of Mizusawa. The experiment was that of the free rise and fall (Sakuma type) apparatus using a corner-reflector as the moving object. Efforts were made to establish an apparatus which works with a high repeatability adopting a Xe arc lamp (continuous lighting) as a white-light source. The tidal variation of gravity was observed with 30 absolute measurements, for the period from June 10 to 1, 1981. An average value of "g" is 9801465.13 $\mu m.s^{-2}$ after corrections of the earth tide, etc. were applied. The estimated uncertainty (SD) is 0.06 $\mu m.s^{-2}$ or 6 µgal.

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Ooe, M., T. Suzuki, H. Hanada, T. Tsubokawa, K. Hosoyama. Implementation of the free rise and fall (Sakuma type) apparatus for the absolute measurement of gravity and obtained values at Mizusawa. IAG, Tokyo, 1982.

ABSTRACT

Absolute measurements of the acceleration due to gravity have been made at the International Latitude Observatory of Mizusawa. The experiment was given by the free rise-and-fall (Sakuma type) apparatus. Calibrations have been made for the length of the etalon and stability of the measurement has been increased. Gravity values were obtained for the two periods 10 June to 16 June 1981 and 20 April to 1 May 1982. Average values for the former and for the latter period are 9801465.07 ± 0.06 $\mu m/s^2$ and 9801465.03 ±0.14 μms^2 , respectively, after corrections of known effects. These values are larger by about 1.50 $\mu m/s^2$ than an asigned value referring to the IGSN'71 system.

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Ooe, M., H. Hanada. Physical simulation of effects of the atmospheric pressure and the ground water upon gravitational acceleration and crustal deformation. Proc. Int. Latit. Obs. Mizusawa, 21, 1982 (in Japanese).

ABSTRACT

High sensitive observations of geophysical phenomena, such as gravitational acceleration and crustal tilts and strains, are considerably affected by the environments. In this paper, the effect of the atmospheric pressure and the ground water upon gravitational acceleration and crustal strains are quantitatively estimated. The effects of the atmospheric pressure upon gravitational acceleration consist of two parts, namely, Newtonian attraction and crustal deformation. We calculate the both effects. The crustal deformation due to the atmospheric pressure changes is estimated by using Green's function for Gutenberg-Bullen's model given by W. E. Farrell. It is supposed in our calculation that the effect of atmospheric pressure on ocean floor is isostatically compensated. Calculations show that the effect of atmospheric pressure upon gravitational acceleration in Mizusawa is about -0.36μgal/mbar, which is consistent with the observations. The effect of atmospheric pressure upon crustal strain is also calculated and the results are compared with the observations made at the Esashi Earth Tide Station. In addition, calculations show that the atmospheric pressure can generate crustal tilt of order 10^{-8} rad in coastal region, which is comparable to tidal tilts. Correction of the effect of ground water level changes is essential for absolute gravimetry, because the seasonal changes in ground water level amount to 2 or 3 meters in Mizusawa, which would generate gravity changes of several micro gals.

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Preston-Thomas, L.G., Turnbull, E. Green, T.M. Dauphinee, S. and S.N. Kalra. An absolute measurement of the acceleration due to gravity at Ottawa. Can. J. Phys. Vol. 38, 824-852, 1960.

ABSTRACT

An apparatus for determining the absolute value of gravity by measuring the distances through which a rule falls in discrete time intervals is described. From the data associated with 64 drops with two non-magnetic stainless steel rules in vacuum, a value of g at the absolute gravity station at Ottawa of 980.6132 cm sec^{-2} with a possible error of ±0.0015 cm sec^{-2} has been obtained. This value is 13.7±2.0 milligal less than the Potsdam value at that position.

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Rinker, R.L., and J.E. Faller. A long period vibration isolator. Joint Institute for Laboratory Astrophysics, National Bureau of Standards and University of Colorado, Boulder, Colorado. (Undated circa 1981).

ABSTRACT

We have devised a new mechanical isolating device which we call a "super spring." The super spring isolator makes use of the fact that a mass suspended by a long spring is effectively isolated (from vibrations) for all frequencies higher than the system's natural resonance. We have developed a method of electronically terminating a 30 cm-long spring in such a way that the mass suspended from it behaves as if the spring were one kilometer or longer in length. This permits us to provide isolation for frequencies as low as 0.02 Hz. We will discuss the principle, the results of shake-table tests, and the implications of this technique for measurement science.

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Rinker, R.L. Super spring - A new type of low frequency vibration isolator. Ph.D. Thesis, Univ. of Colorado, 1983.

(NO ABSTRACT)

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Romaniuk, V.A. Measurement of the absolute value of acceleration due to Gravity (Theory). Academy of the Sciences U.S.S.R., Unpublished translation, 1975.

(NO ABSTRACT)

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Sakuma, A. Etat actuel de la nouvelle determination absolue de la pesanteur au Bureau International des Poids et Mesures, Int. Bull. Geodesique, No. 69, 249-260, 1963.

RÉSUMÉ

L'état actuel des études préliminaires d'une mesure absolue de g au B.I.P.M. basée sur le principe de la "méthode des deux stations" (1) est résumé dans cette note.

Une précision de g plus élevée que celle qui a été obtenue jusqu'à présent, est espérée à cause des avantages des mesures symétriques dans cette méthode et des observations interférentielles des passages d'un corps lancé (un trièdre formé de trois miroirs orthogonaux) à des stations fixes.

Nous envisageons qu'une précision de g de l'ordre de 0,1 mgal sera réalisable avec cette méthode.

SUMMARY

In this note, the present stage is outlined in the preparations for an absolute determination of gravity at B.I.P.M., based on the principle of "La méthode des deux stations" (1) (or so called "The up and down motion method").

It is expected that a value of g of greater accuracy than previous measurements will be obtained, due to the use of the symmetrical measurements by this principle and the use of the interferometric observations of the passage of the projected body (a corner cube reflector) in free fall across fixed horizontal stations.

It seems probable that an accuracy of the order of 0.1 mgal will be obtained by this method.

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Sakuma, A. Observations experimentales de la constance de la pesanteur au Bureau International des Poids et Mesures, IGC, 159-163, 1970.

ABSTRACT

Une première station permanente de gravimétrie absolue vient d'être constituée an B.I.P.M. Cet appareil a été mis en oeuvre après dix ans d'études, dont les trois dernières années ont été consacrées à la

recherche des causes eventuelles d'erreurs systématiques et à l'amélioration de la précision de la mesure de g.

Ce gravimètre absolu possède à l'heure actuelle une sensibilité et une exactitude de mesure supèrieure à 3µGal (3 x 10^{-9} g) et en conséquence la perturbation de g due à l'effet luni-solaire peut être nettement déterminée.

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Sakuma, A. Une tendance de la variation de la pesanteur observee au Bureau International des Poids et Mesures, Sevres, France. IGB Bulletin d'Information, 27, I33-I35, 1971.

(NO ABSTRACT)

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Sakuma, A. Absolute Gravity Measurements. IGB Bulletin d'Information, 35, I39-I42, 1974.

(NO ABSTRACT)

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Sakuma, A. A permanent station for the absolute determination of gravity approaching one micro-gal accuracy. Proc. Intl. Symp. on the Earth's Gravitational Field and Secular Variations in Position; Dept. of Geodesy, Univ. New South Wales, Sydney, 674-684, 1974.

ABSTRACT

This paper describes the first permanent station for the absolute determination of gravity at the International Bureau of Weight and Measures. The station presently consists of an absolute apparatus of a few micro-Gal accuracy based on a symmetrical free rise and fall observation of a corner reflector in vacuum. Periodic determinations of g by the apparatus permits one to monitor the small variations of g arising from the Earth tide and various geophysical causes including the secular effects. The principal sources of errors in the apparatus are discussed and it is predicted that a final accuracy of 1 µgal can be obtained by

the symmetric free rise and fall principle, provided that the local Earth tide and the vertical gradient of g are measured with sufficient accuracy. A tendency of the secular variation of g of the order of 10 μGal per year is reported. An Earth tide recording gravimeter and a transportable absolute gravity apparatus, both of which have recently been completed at this station, are also described.

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Sakuma, A. Recent developments in the absolute measurement of gravitational acceleration. Proceedings of the International Conference on Precision Measurement and Fundamental Constants, NBS Spec., Publ. 343. U.S. Govt. Printing Office, Washington, D.C., 447-456, 1971.

ABSTRACT

Metrological and geophysical applications of the absolute determination of gravitational acceleration are described and recent work is reviewed. Practical absolute measurements are still restricted to two conventional methods, the pendulum and the free motion experiment. The precision of recent measurements by free motion methods is a few parts in 10^9 (1 μgal), two orders of magnitude better than that of absolute determinations prior to 1966. Realization of transportable absolute apparatus is proceeding in several laboratories. The first portable apparatus has recently contributed to the establishment of several new absolute sites (0.1 mgal or better) in North America and also to mutual verification of the accuracy of measurements at two existing absolute sites: NPL in Teddington and BIPM in Sèvres. Agreement to better than 0.1 mgal was obtained between these three absolute determinations. It is therefore believed that there are now no significant systematic errors in the determination of the absolute gravitational acceleration in North America and Europe. Perturbing effects in gravity measurement are analyzed.

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Sakuma, A. Report on absolute measurement of gravity. Bulletin d'Information No. 35, Bureau Gravimetrique International, I39-I42, 1974.

INTRODUCTION

The absolute measurements of gravity, carried out up to the end of the last decade, obtained accuracies of 0.1 mGal or better (Cook 1967, Sakuma 1968, Hammond 1970). These results have been adopted to establish the International Gravity Standardization Net 1971 (I.G.S.N 71) (Morelli et al. 1974). Presently this net covers over 1800 world-wide stations where the local absolute values of gravity are believed to be accurate to at least 0.1 mGal.

In such circumstances, the activities of the absolute measurements of gravity during the three years since the last General Assembly of the I.U.G.G. can be classified into three fields:

1) Establishment and maintenance of permanent stations (Sèvres, Mizusawa) where one micro-gal accuracy may be obtained in the future (Sakuma 1973).

2) Construction of transportable absolute apparatus with 10 μgal final accuracy (Faller - Hammond 1974, Sakuma et al, 1974, Tsubokawa et al, 1974) aimed at the maintenance and improvement of the I.G.S.N. 71 and at other applications in geophysics and metrology.

3) Achievement of absolute measurements of gravity by various methods started long before the establishment of the I.G.S.N. 71 (Schuler et al. 1971, Hytonen 1972, Bell et al. 1973). Because of their accuracies of 0.1 mGal or less, these experiments have served to confirm the validity of the I.G.S.N. 71.

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Tate, D.R. Acceleration due to Gravity at the National Bureau of Standards. NBS Monograph 107, June 1968.

ABSTRACT

A determination of the absolute value of the acceleration due to gravity was completed in June 1965 at the National Bureau of Standards near Gaithersburg, Maryland. The determination resulted in a value of 980.1018 centimeters per second squared for a reference point on the first floor of the Engineering Mechanics Building. The result was published in The Journal of Research of the National Bureau of Standards, Vol. 70C, No.

2, Engineering and Instrumentation, page 149, April - June 1966. The present paper describes in detail the apparatus and the techniques employed and presents the summarized data from which the value was derived.

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Tate, D.R. Absolute Value of g at the National Bureau of Standards. Journal of Research NBS, 70C, No. 2, June 1966.

ABSTRACT

A determination of the absolute value of the acceleration due to gravity has been completed at the National Bureau of Standards near Gaithersburg, Maryland. The value, reduced to a gravity meter station on the floor of the site is 9.801018 m/s^2 with a standard deviation of 0.3 X 10^{-5} m/s^2. The absolute value, which is 13.2 X 10^{-5} m/s^2 (13.2 milligals) less than the corresponding Potsdam value, is in general agreement with other recent absolute determinations.

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Tate, D.R. Absolute value of g at the National Bureau of Standards. Bulletin #14 of the IGB, 1966.

(NO ABSTRACT)

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Tate, D.R. Gravity measurements and the Standards Laboratory, NBS. U.S. Tech. Note 491, 1969.

ABSTRACT

The local value of the acceleration due to gravity is a fundamental datum for almost every standards laboratory as it, together with accurate standards of mass, is the basis for the standards involving force. Instruments used as standards in this area include precise deadweight piston gages, deadweight calibrators for force transducers, liquid manometers, and earth field accelerometer calibrators. The practical realization of the absolute ampere and the absolute volt require a

knowledge of force. This paper presents the basic information about how gravity measurements are made and outlines procedures for obtaining a suitable value for a given location. It also gives a brief discussion of the background and meaning of the term "standard gravity", and its applicaton in the computation of forces in units of the pound-force and the kilogram-force.

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Terrien, J. News from the Bureau International des Poids et Mesures. Metrologia 5, 68, 1969.

INTRODUCTION

The B.I.P.M. was extremely active as a center for international coorperation in scientific metrology during September and October 1968, when seven international meetings dealing with various fields achieved important agreements or decisions. The following were some of the fields covered.

Electrical Measurements: more accurate and uniform d.c. standards, more accurate value of the gyromagnetic ratio of the proton, new intercomparisons of radiofrequency quantities.

Nuclear Physics: α-energy standards to be redetermined.
Time Scales: improvement of UCT discussed.
Temperature: the International Practical Temperature Scale of 1968 supersedes that of 1948-1960; better accuracy and extension towards lower temperatures.

Mechanics: internationally agreed correction to the Potsdam System of the acceleration due to gravity.

Units: meaning of "Système International d'Unités" to be reconsidered.

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Thulin, A. Determination Absolue de g au pavillion de Breteuil par la methode de la chute d'une regle divisee. Ann. Geophys. 16, 105-127, 1960.

RÉSUMÉ

Des mesures de l'accélération due à la pesanteur, effectuées au moyen, de la cinématographie ultra-rapide dune règle divisée tombant en chute libre dans une enceinte évancuée à 5.10^{-5} mm Hg, ont donné comme résultant 980 928,0 ± 1 mgals pour la station gravimétrique Sévres A située dans les laboratories du Bureau International des Poids et Mesures à Sèvres (S.-et-O.), France.

Dans le système de Postdam, la valeur généralement admise pour ce même lieu est de 980 940,0 mgals.

Le nouveau résultat est en parfait accord avec des déterminations récentes employant des pendules réversibles et montre, encore une fois, la nécessité de réviser les valeurs dites de Postdam.

SUMMARY

Absolute gravity measurements using high-speed cinematography of a graduated scale that falls freely in a chamber evacuated to 5.10^{-5}mm Hg have given as a result 980 928.0 ± 1 mgals for the gravity station Sèvres A situated in the Laboratory building of the Bureau International des Poids et Mesures at Sèvres (S.-et-O.) France.

The Potsdam value generally admitted for the same point is 980 940.8 mgals.

The new result is in fair accordance with other recent reversible pendulum determinations and confirms once more the necessity for revising the Potsdam values.

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Volet, C. L'intensite de la pesanteur determinee par l'observation de la chute d'un corps comptes. Academie des sciences 224, 1815-1816, 1947.

(NO ABSTRACT)

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Zumberge, M.A. A Portable Apparatus for the Absolute Measurement of the Earth's Gravity. Ph.D. Thesis, University of Colorado, Boulder, Colorado, 1981.

(NO ABSTRACT)

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Zumberge, M.A., J.E. Faller. A portable apparatus for absolute measurements of the earth's gravity. JILA, NBS and University of Colorado, Boulder, Colorado. (Undated).

ABSTRACT

We have developed a new and portable apparatus for making absolute measurements of the acceleration due to the Earth's gravity. We use the method of free fall, and interferometrically determine the acceleration of a freely falling corner cube. In the design and development of this instrument, particular attention was paid to those aspects which would affect its performance in the field. The resulting instrument, we believe, provides a viable new tool for the study of tectonic motions. The system is very small; it can be transported in a small van and requires only two hours for assembly. A high rate of data acquisition is available; if necessary, a single measurement can be made every two seconds. Further, we have made a concerted effort to detect and (we hope) eliminate systematic errors. The results of extensive tests indicate that the achievable accuracy is about six parts in 10^9 of g. This instrument therefore provides a sensitivity to vertical motions (e.g. of the earth's crust) as small as 2 cm.

The basic principle (see Fig.1) of the instrument's operation is the same as has been used successfully in several other absolute gravity meters (1-7). One arm of a Michelson interferometer is terminated by a corner cube retroreflector which is allowed to be freely accelerated by the Earth's gravity, and the times of occurrence of certain interferometer fringes are measured and used to calculate the acceleration of this falling object (8,9). A new type (Zeeman) of stabilized laser (10), used as the light source in the interferometer, provides the length standard while an atomic (rubidium) frequency standard provides the time standard.

Two aspects of this instrument account for its ability to achieve high accuracy without sacrificing small size and, hence, ease of portability. First, a new dropping mechanism has been developed which eliminates several sources of systematic errors while providing a rapid means of repeatedly releasing the dropping object. Second, a synthesized long-period isolation device is used to greatly decrease the instrument's sensitivity to ground vibrations. This avoids the large drop-to-drop scatter that would otherwise result from our comparatively short dropping

length (20 cm) - a consequence of the instrument's small size - and also allows us to obtain data during times of increased microseismic activity. Some of the details of the dropping mechanism, the long period isolator, and other parts of the instrument, as well as the results of measurements made to date, are discussed below.

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Zumberge, M.A., J.E. Faller, R.L. Rinker. A new, portable absolute gravimeter. JILA, NBS and University of Colorado, Boulder, Colorado. (Undated).

ABSTRACT

We report on the performance of a new and easily portable apparatus for the absolute measurement of the acceleration of gravity. Rapid acquisition of data and high accuracy result form the use of a drag-free dropping chamber that descends with the falling object whose acceleration is measured interferometrically. Preliminary results indicate an absolute accuracy of 6 parts in 10^9.

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Zumberge, M.A., Rinker, R.L. and Faller, J.E. A portable apparatus for the absolute measurement of the earth's gravity; Metrologia, 18, 145-152, 1982.

ABSTRACT

We have developed a new and portable apparatus for making absolute measurements of the acceleration due to the Earth's gravity. We use the method of free fall, and interferometrically determine the acceleration of a freely falling cube corner. In the design and development of this instrument, particular attention was paid to those aspects which would affect its performance in the field. The resulting instrument, we believe, provides a viable new tool for the study of tectonic motions. The system is very small; it can be transported in a small van and requires only two hours for assembly. A high rate of data acquisition is available; if necessary, a single measurement can be made every two seconds. Further, we have made a concerted effort to detect and (we hope) eliminate systematic errors. The results of extensive tests indicate that

the achievable accuracy for g is about six parts in 10^9. This instrument therefore provides a sensitivity to vertical motions (e.g., of the Earth's crust) as small as 2 cm.

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Zumberge, M.A., Faller, J.E. and Gschwind, J. Results from a U.S. absolute gravity survey. JGR, 88, B9, 7495-7502, 1983.

ABSTRACT

Using the recently completed JILA absolute gravity meter, we made an absolute gravity survey which covered twelve sites in the United States. Over a period of eight weeks, the instrument was driven a total distance of nearly 20,000 km to sites in California, New Mexico, Colorado, Wyoming, Maryland and Massachusetts. The time spent in carrying out a measurement at a single location was typically one day. A measurement accuracy of around 1×10^{-7} m/s^2 (10 μgal) is believed to have been obtained at each of the sites.

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