The Gravitational Constant may not be Constant: Correlation of Gravitational Constant Measurements with Ambient Gravitation

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ABSTRACT

There is a long history of measuring the gravitational constant starting with Henry Cavendish in the 1700's,[1], and in the last 15 years there has been a focused on refining the value with more modern technology, and precision instrumentation. Unfortunately the value is hard to pin down, and as the error bars of the various experiments at labs around the world get smaller the values are not the same and even the error bars are not overlapping. This paper evaluates the relation between the most precision measurements over the last 15 years, and the ambient gravitation at the location of the measurement. Although there may be some errors in the exact value of the ambient gravitation due to the exact location of the lab making the measurement, the errors are not significant enough to make a difference in the conclusion. **There is a definite relationship between the measured gravitational constant and the ambient value of the background gravitation.** This paper presents the data illustrating the correlation.

Introduction

There has been a significant effort over the last several to arrive to improve the accuracy of the gravitational constant. The results has been that labs around the world, have arrived at more precise numbers and reduced the error bars to a very few parts per million for the values. Unfortunately the values are not in agreement, and worse the error bars do not overlap.

It has occurred that there could be a relation of the value of G and the ambient gravitational level. Using Google maps [2], and the Bureau Gravimétrique

International database on the absolute gravitation levels [3], at the coordinate locations of the labs performing the measurements an evaluation of the relation can be evaluated. There may be some error in the gravitational levels but the error is small in relation to the value. The HUST gravity measurement in Wuhan China probably have the least confidence, because the measurements are taken in a lab laboratory is located inside Yu-Jia Mountain [4]. The area around Yuhan, however has a low background gravitational gradient, and the error is probably much less than 100 mgal. This error would not be significant.

From [4], the scatter in the values and error bars of the measurements can be noted.

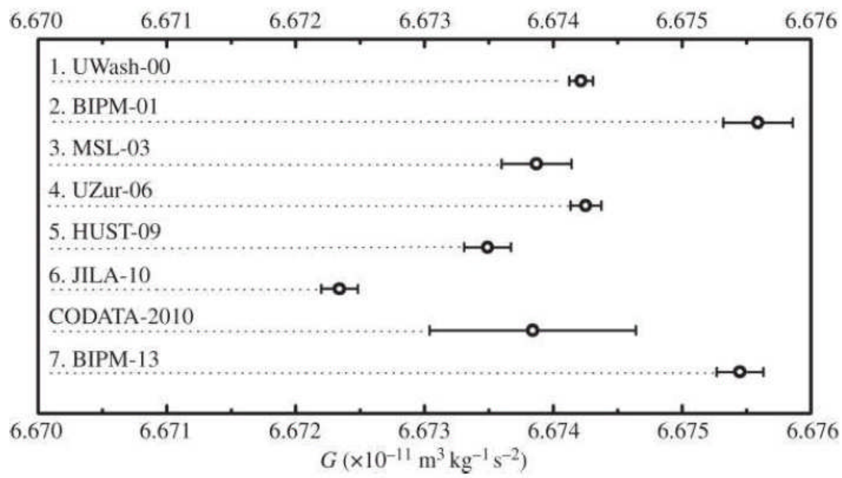

Fig 1. Chart from measurements with time-of-swing method at HUST [2]

Selection of data points

In order to evaluate the relation between the G measurements and the ambient gravitation, the data compiled by Vadim Milyukov [5] in **Appendix 1** was helpful. The most accurate data has been developed since 2000, and the last data point is from BIPM in 2013, which represents an upgrade to their previous value in 2001. The 6 selected points is inclusive of all measurements from 2000, -2013, with error bars of 40 parts per million or less. When there were improvements to the measurements, only the latest values are used.

Results

Transferring the coordinates of the lab location from Google maps [2] into the Bureau Gravimétrique International database [3] the values for the absolute gravitation background can be found and is included in **Table 1**.

Measurement Locations	Year	G e-11kg-1s	Error	ppm	Latitude	Longitude	Gravity M/sec^2	Elevation M
18 University of Colorado, Bolder	2010	6.672340	0.000140	21	40.0075810	-105.2659400	9.7960340	1655
17 HUST Wuhan, China	2009	6.673490	0.000180	26	30.5115927	114.4256175	9.7935370	37
14 St.Lab Meas.St.Lab, New Zealand	2003	6.673870	0.000270	40	-41.2346906	174.9175698	9.8028070	10
10 University of Washington	2000	6.674215	0.000092	14	47.6553351	-122.3035199	9.8072620	30
16 University of Zurich	2006	6.674252	0.000109	16	47.3743221	8.5509812	9.8052360	869
19 BIPM France	2013	6.675540	0.00016	25	48.8293390	2.2201170	9.8093570	35

Table 1 Selected data points including lab coordinates and Background Gravity.

Plotting the values of the measured values of the gravitational constant against the ambient gravitational values shows a definite correlation. **Figure 2** is a plot of all the data in **Table 1**, with the trend line for all the data.

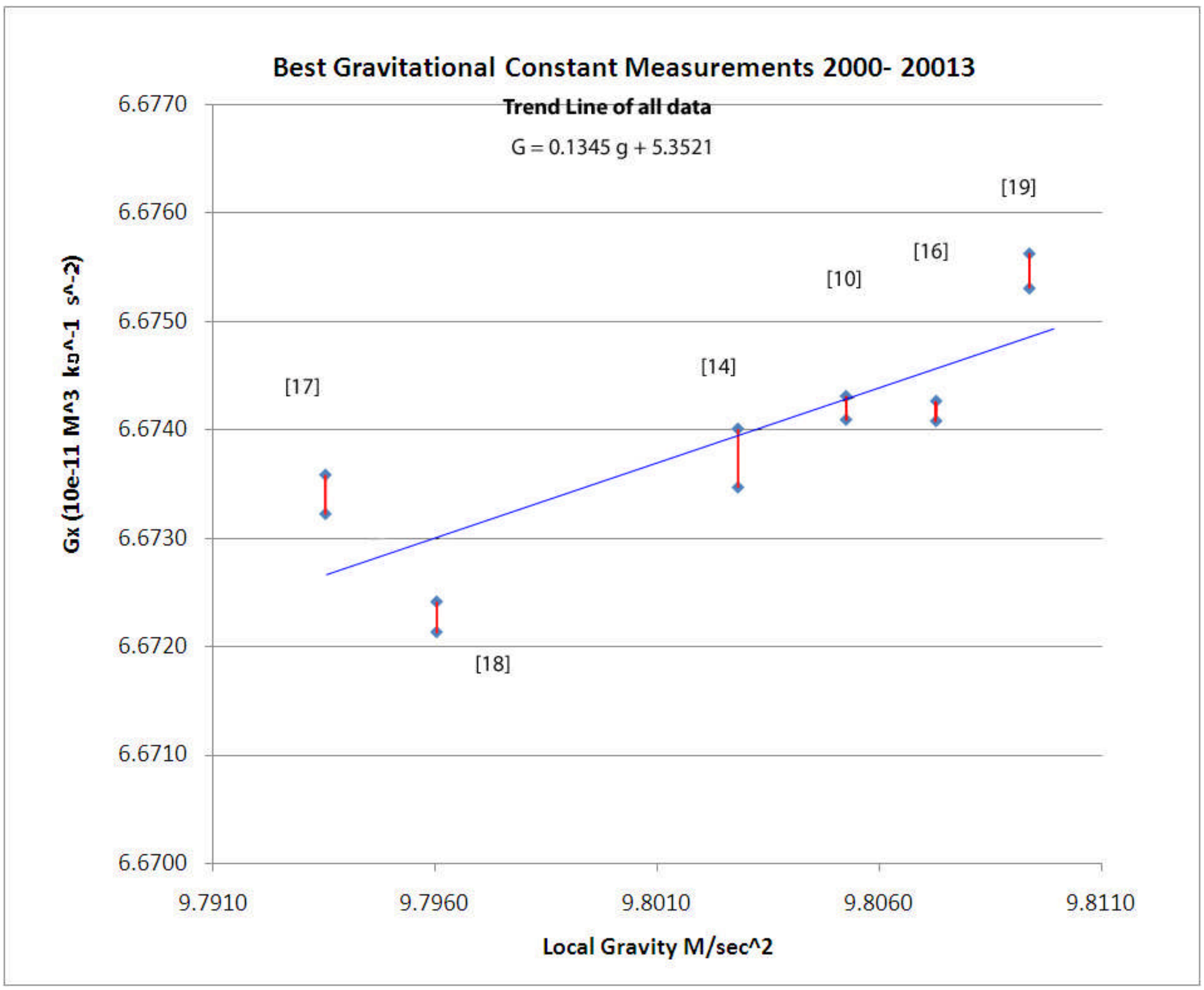

Fig. 2. The Gravitational constant measured vs. the local gravity.

The data points have been meticulously measured by researchers, and selected here to represent the best available data, so there is not a justification for discounting any of the data points. The trend line

$$G = (0.1345 + 5.3521) \times 10e-11 \ M^3 kg^{-1} s^{-2}$$

is the relation between the Gravitational Constant and the average of all the best data. It is certain that there is a relation.

Outlying points could be neglected to come up with a minimum and maximum value of the slope, and is somewhat artificial, but since there does appear to be outliers, the following are shown for illustration.

Designating Outliers

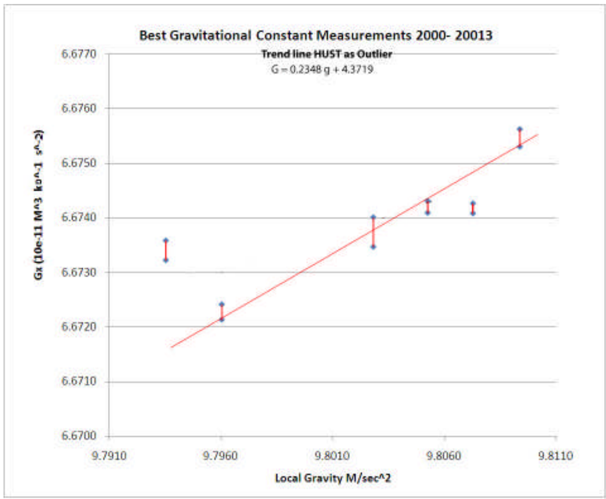

Figure 3. Trend line with HUST data neglected.
G = (0.2348g + 4.3719) x 10e-11

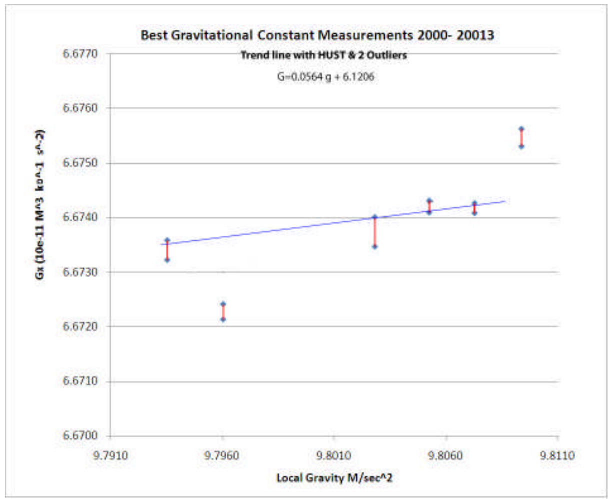

Figure 4 Trend line with Univ Bolder & BIPM neglected.
G = (0.0564g + 6.1206) x 10e-11

Note that there is quite a range in the slope of the correlation depending on the data neglected. In all cases, however the data definitely correlates with there being a relation between the ambient gravitation and the Gravitational constant.

Whether this relation is the result of some overlooked factor in the measurements or is a statement that the Gravitational constant is not a constant, cannot be determined from the data.

The physical aspects of a variable Gravitational Constant are actually a little more difficult to discern than expected. The absolute value of G has no implications in most orbital mechanics, and the value only represents the estimate of the mass of astrophysical bodies compared to the earth.

The variable value of G may have implications in dark energy and MOND theories, but until such relations are reliably defined, it would be difficult to make judgments. An accurate measurement of G in free space that may be done by the LISA Pathfinder would be very helpful in evaluating this relationship.

Conclusion

The most notable observation of this paper is that either there is a misunderstanding and misestimating of the errors associated with the measurements or the gravitational constant is not constant, and the value of G is related to the value of the gravitational potential at the location the measurement is made.

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Appendix 1

Measurement Locations	Year	G e-11kg-1s	Error	ppm	Latitude	Longitude	Gravity M/sec^2	Elevation M
1 Nat. Bur. of Stand., Washngton	1942	6.672000	0.004100	615	39.1400400	-77.2185060	9.8010320	125
2 Metrol. Nationale,France	1972	6.671400	0.000600	90	48.8292710	2.2950370	9.8093500	34
3 Moscow University USSR	1979	6.674500	0.000800	120	55.7039349	37.5286695	9.8151710	157
4 Nat. Bur. of Stand., Washington	1982	6.672600	0.000500	75	39.1400400	-77.2185060	9.8010320	125
5 Techn. Bundesanstalt, Germany	1995	6.715400	0.000600	90	52.2964842	10.4631555	9.8125280	72
6 Committee Standards, Moscow	1996	6.672900	0.000500	75	55.7558260	37.6173000	9.8152360	151
7 Los Alamos National Lab, USA	1997	6.674000	0.000700	105	35.8440582	-106.2871620	9.9710310	2230
8 HUST Wuhan, China	1999	6.669900	0.000700	105	30.5115927	114.4256175	9.7935370	37
9 Meas.St.Lab, New Zealnd	1999	6.674200	0.000700	105	-41.2346906	174.9175698	9.8028070	10
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12 University of Zurich	2002	6.674070	0.000220	33	47.3743221	8.5509812	9.8052390	869
13 University Wuppertal, Germany	2002	6.674220	0.000980	150	51.2450000	7.1495000	9.8116000	175
14 St.LabMeas.St.Lab, New Zealnd	2003	6.673870	0.000270	40	-41.2346906	174.9175698	9.8028070	10
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http://www.saske.sk/FFK2012/sites/www.saske.sk.FFK2012/files/Milyukov_FFK2012_0.pdf

* added to Milyukov database [6]

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[13] Kleinevoß University of Wuppertal	University Wuppertal, Germany
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