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Solid Earth Discussions

Interactive comment on "Measurement of absolute gravity acceleration in Firenze" *by* M. de Angelis et al.

M. de Angelis et al.

deangelis@fi.infn.it

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We very much welcome the constructive comments of Referee. A specific response to each point is included below.

1) WE tried to solve for the vertical gravity gradient using the data from the FG5 gravimeter. The attempt gave an error of 30% and we can conclude that it remained unsuccessful. We think that the paragraph from line 25 page 52 till line 9 page 53 can be delated. In this paragraph we explain how we tried to elaborated data from the FG5 absolute gravimeter to solve the vertical gravity gradient. As a consequence figure 4 is no more necessary and can be deleted.

2) We have measured indeed the gravity gradient with the atom interferometer gra-

diometer and more thorough explanation of this can be added. Thus we wish to replace the sentence on lines 21-24 on page 52 with the following sentences:

"The data are least-squares fit to a function that uses a known a priori vertical gravity gradient in a fourth order equation of motion (see Niabauer 1995). If the drop length is 20 cm and the vertical gravity gradient equals the free air gradient (3,09 microGal/cm), then a 1% gradient estimate error introduces a 0,2 microGal error in the absolute gravity estimate. The gradient at the measurement location has been measured by the atom interferometer instrument (Lamporesi et al. (2006)) and it agrees with the commonly used standard free air value of the gradient within 1%."

Contribution on uncertainty (0,2 microGal) due to the gravity gradient can be added in the error budget of Table 2.

Laser, Barometer and Clock contributions to the uncertainty are described in our paper on page 54 line 3-10. For the standard FG5 instruments they are explained in the cited Nieabauer 1995 paper and in the technical note available on the site of the FG5 manufacturer. In any case we assume the uncertainty contribution listed in the processing report of the specific measurement run and we have reported them in Table 2. We have missed to specify in the text the uncertainty due to barometric contribution, that we would like to add using the following sentence before the dot on line 7 on page 54: "and a contribution to the uncertainty of the gravity acceleration of +/- 1microGal"

3) Our wish is to repeat if necessary the FG5 measurements at the same site. As a consequence we are interested in evaluating all possible signals that change with time. Source masses for the Newtonian constant experiment will be removed in the future and positions of the optical tables may also change due to experimental needs. And so will their effect on gravity acceleration at the site of the FG5.

Sentences on lines 15-19 on page 54 'During the measurements ...at both laboratories'

can be changed as following: "During the measurements the rooms were occupied

by optical tables and room 67 by the source masses for the Newtonian constant experiment. Their positions may change in the future, and so will their effect on gravity acceleration at the site of the FG5. Our wish is to repeat if necessary the FG5 measurements at the same site, that has been marked, and will be used in the future. As a consequence we are interested in evaluating all possible signals that change with time. This is a good reason to calculate the contribution of the nearby mass distribution of the optical tables and source masses at the FG5 site for the two laboratories as shown in Fig. 5. This correction is less than 1 μGal at both laboratories. An accurate gravity field description of the laboratories as given in Merlet et al. 2008 and Baumann et al. 2009 is beyond the aim of this paper and could be suitable if a comparison or transfer of the absolute measurement of g at the level of 1microGal is needed."

We wish to add the following reference to the Bibliography: Merlet S., et al. : "Microgravity investigations for the LNE watt balance project" Metrologia 45, 265-274 (2008). Baumann H., et al. : "Evaluation of the local value of the earth gravity field in the context of the new definition of the kilogramm" Metrologia 46, 178-186 (2009)

4) We agree that for the FG5 instrument seismic noise is not a problem after measuring for 12-24h and considering that the reference mirror of the instrument is isolated from vibrations with the super-spring. This may not be the case for the atom interferometer sensors (see Peters et al. Metrologia 2001), that are operating in the same site, and moreover if the noise of the site is higher than the High-Noise-Model reference curves (Peterson 1993). In fact the site is located within an industrial area and we do not know a priori the acoustic noise which is an important point for the measuring limits of our atom sensors. We have compared rms of the measured g value taken with FG5 against the rms of the vertical acceleration of ground taken with the seismometer (see attached figure) showing correlation between the two.

Thus we wish to add the following sentence at the end of paragraph 2.2: "Seismic noise is not a problem for the FG5 instrument after measuring for 12-24h and considering that the reference mirror of the instruments is isolated from vibrations with a 'super-

spring'. This may not be the case for the atom interferometer sensors (see Peters et al. Metrologia 2011), that are operating in the same site, and moreover if the seismic noise of the site is higher than the High-Noise-Model reference curves (Peterson 1993). In fact the site is located within an industrial area and we do not know a priori the acoustic noise and may become an impending point for the measuring performances of the atom sensors. We have compared rms of the measured g value taken with FG5 against the rms of the vertical acceleration of ground taken with the seismometer (see attached figure) showing correlation between the two."

We also wish to add to the paper the figure in attach with the following caption: "Fig. Standard deviation of the measured g values in 50-drops sets taken with FG5 (above) against the rms of the vertical acceleration of ground taken with the seismometer (below). the two instruments are located in the same laboratory and their measurements last for about 24-hour. The rms of the acceleration of ground is calculated from acquisitions taken in the same 500s time interval of the FG5 acquisition sets. The plot shows correlation between the two and a lower noise central part during the night."

We wish to add to the Bibliography the following reference to the Bibliography: Peters A., Chung K.Y., Chu S. High-precision gravity measurements using atom interferometry Metrologia, 2001, 38, n°1, 25-61

5) We agree that discussion about the value measured 20 years ago can be deleted –> sentences 'As far as we know ... directly in our laboratories' of line 10-21 on page 49 .

6) We agree with the refereee that the comparison between atom and FG5 gravimeters may be interesting but the atom experiements are not devoted to an absolute g measurement. Nevertheless their performance in measuring g is an index of the stability of the atom probe as explained in the introduction.

Interactive comment on Solid Earth Discuss., 3, 43, 2011.

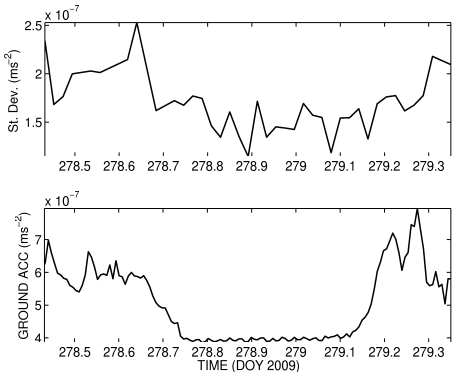
x 10^-7
2.5
2
1.5
St. Dev. (ms^-2)
278.5 278.6 278.7 278.8 278.9 279 279.1 279.2 279.3
x 10^-7
7
6
5
4
GROUND ACC (ms^-2)
278.5 278.6 278.7 278.8 278.9 279 279.1 279.2 279.3
TIME (DOY 2009)

Fig. 1.