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A new method for simultaneous determination of verticality and Eötvös effects in absolute gravimetry

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We present a new method for an accurate alignment of the verticality in absolute gravimeters with macroscopic objects that allows simultaneous determination of the Eötvös effect. The method is based on measurements of lateral motions of freely falling objects by a position sensitive detector and has been experimentally used for one FG5 and one FG5X gravimeter. As for the verticality effect, we show that the current method of verticality alignment by using the reflection off the geopotential surface placed outside the vacuum dropping chamber is insufficient and that systematic errors exceeding 1 μGal might be expected, as demonstrated for FG5X-251. On the other hand, the new method of verticality alignment based on minimizing the measured lateral accelerations allows to reduce systematic errors to about 0.1 μGal. Moreover, the measurements/underlying the alignment can be used for determination of the Eötvös effect that depends on the lateral velocity of the falling object in the east-west direction. The results for two FG5(X) gravimeters are presented, with Eötvös effects below 1 μGal that, however, cause biased gravity values so that relevant corrections should be applied. The method we are presenting does not allow to determine the verticality and Eötvös effects for particular drops in a measurement mode of a gravimeter. To do so, optical paths in the interferometer should have to be re-designed. Nevertheless, it is possible to determine both effects with a standard uncertainty better than 0.2 μGal using less than 50 drops carried out in a non-measurement mode.