# 6. Measurement of UFF Violation with Li/C/ Pb Compared to Al

**Abstract:** A measurement of the simultaneous fall of seven solid chemical elements is performed in a vacuum from a height of 110 meters. Fall distance differences were observed relative to Al due to acceleration differences up to $\Delta a_{Al,Li}/a_{Al} \approx 0.045(1)$ % which explain the non-equivalence of and the inertial mass $m^i_j$ and gravitational mass $m^g_j$. The result confirms $m^i_j = m^g_j(1-\Delta^{MD}_j/f)$ with a factor $f = 6.7(4)$ whereby $\Delta^{MD}_j$ is the relative mass defect of isotopes, measured with mass spectrometers. A composition dependency of the Free Fall is also observed in the motions of planets in order of 0.15%. By an assumed second invariant property of the four stable elementary particles e, p, P and E (negative charged proton), the $m^g$ of a body is proportional to its gravitational charge $g_m = g\, m^g = g\, N\,(m_P - m_e)$ on one hand. On the other hand, the inertial mass is $m^i = m^g - E_B/c^2$ with $E_B = m^g\ \Delta^{MD}\ c^2$. Newton's law $m^i\ a_m = -\mathbf{G}\, M^g\ m^g/r^2 = -g_M\ g_m/4\pi r^2$ with the gravitational constant $\mathbf{G} = g^2/4\pi$ corresponds solely to the static gravitational field, similar to Coulomb law of static electricity. Therefore, the Newtonian $G = \mathbf{G}\ M^g/\ M^i m^g/m^i \approx \mathbf{G}\ (1+\Delta^{MD}(M)+\Delta^{MD}(m))$ is composition dependent.

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The three fundamental assumptions in classical physics, the Universality of Free Fall (UFF), the equivalence of the inertial mass $m^i$ and the gravitational mass $m^g$ (WEP) as well as the universality of $G$ in Newton's equation of gravitational force

$m\,a = -\,G\,M\,m/r^2$ , (1)

are historically connected, but a controversy among these assumptions can be observed, see the internet pages of the Eöt-Wash group and O. V. Karagioz, Refs. **[1, 2]**, as well as Szász, *The Orbits of Planets Violate the UFF*, Ref. **[3]**. The three hypotheses are founded on Kepler's third law, on Galileo's observations of free fall and on Newton's law of gravitational force.

A motivation of the author to an experiment checking the UFF hypothesis in a range of pro mille, in a simultaneous free fall from 110 m fall height in vacuum with different materials, found mainly on the three "irregular" observations:

1) The observed values of G are widely scattered. For instance considering the measurements after 1995 only, the deviation of G is 0.7%.

→ *The quantity* $G = \boldsymbol{G}\, m^g / m^i$ *does not appear as a constant in measurements.*

2) A recalculation of Kepler's third law by Szász (2004) with all the nine planets has discovered a composition dependency up to 0.15%.

→ *The motions of planets are composition dependent and violate the UFF*.

3) The relative mass defects of isotopes $\Delta_A^{MD}$ offer a dependency from the mass number A up to 0.78%, Audi and Wapsta, Ref. **[11]**.

→ *In microgravity, there is a loss of* $m_A^i$ *and the change of* $\Delta_A^{MD}$ *depends on the number of nucleons*. The Newtonian would be $G = \boldsymbol{G}\, M^g / M^i\, m^g / m^i \approx \boldsymbol{G}\, (1 + \Delta^{MD}(M) + \Delta^{MD}(m))$

Prior to the description of the experiment performed never before, the theoretical background, which is extensively investigated by Szász (2002-2004), is shortly summarized. A distinction of the inertial mass $m^i_j$ and the gravitational mass $m^g_j$ for different materials, denoted with *j*, leads, according to

$$m^i_j a_j = -\boldsymbol{G} M^g m^g_j / r^2 , \qquad (2)$$

to different accelerations $a_j$ if

$$m^g_j / m^i_j \approx (1+\Delta^{MD}) > 1$$

is composition dependent.

On the surface of the earth, the acceleration of a test body is given by the equation

$$a_j = -\frac{1}{R_E^2} \boldsymbol{G} M^g_E \; m^g_j / m^i_j = -\gamma \; m^g_j / m^i_j , \qquad (3)$$

with the radius $R_E$ and the gravitational mass $M^g_E$ of the earth. The equivalence of Newton's law and Coulomb's law on one hand, and the three "irregular" observations on the other hand, forces us to hold onto the constancy of $\boldsymbol{G}$ in Eq. (3) and to *reject the hypothesis* $m^g = m^i$. Therefore, we assume that the value of the product $\gamma$ x$m^g_j / m^i_j$, thus the value of $m^g_j / m^i_j$ alone, depends on the chemical composition of a considered body. We want to distinguish between $\boldsymbol{G}$ and G, whereby the last quantity is defined with the WEP hypothesis.

In Euler's formulation of the equation of motion, Newton's law Eq. (1) with $m^g = m^i$ is the fundamental equation of the accepted theory of gravity; see Einstein's Equivalence Principle, Dicke, Ref. **[5]**, Will, Ref. **[4]** and Nobili, Ref. **[6]**.

But according to the "irregular" observations and Eq. (3), see Szász, Ref. **[7]**, the acceleration $a_j$ must be proportional to

$$m_j^g/m_j^i = (1-\Delta_j^{MD})^{-1} \approx 1+\Delta_j^{MD}. \quad (4)$$

Hereby $\Delta_j^{MD}$ is composition dependent in a range of

$1.4\text{x}10^{-8}$ (hydrogen) < $\Delta_j^{MD} < 7.8\text{x}10^{-3}$ (iron),

and **G** is smaller than G. Thus, $a_j$ is not the same for different elements as confirmed by this experimental report. A deviation of

$$\Delta a/a_i = (a_i - a_j)/a_i \approx \Delta_i^{MD} - \Delta_j^{MD} \quad (5)$$

from the zero value must be scientifically taken very seriously because the fundamental hypothesis of physics, $m_j^i = m_j^g$, would be invalid. The Universality of Free Fall, the oldest physical basic hypothesis of Philoponus and Galilei and taken over by Einstein, would not be valid. The invalidity of $m_j^i = m_j^g$ in nature would have enormous consequences for the structural thinking in physics.

**Simultaneous Fall Experiment with Different Materials from 110 m Height**

For an experimental verification of the difference between the inertial and the gravitational mass, the author has used only solid chemical elements Li/Be/B/C/ Al/Fe/Pb and has performed a simultaneous fall experiment in the 110 m high vacuum tube at the drop tower of ZARM, University of Bremen. The weights of the test bodies were between ~2 g and ~7 g. The purities were better than 98.8% in all cases. The test bodies were freely placed at the middle of the safety glass cylinder. On the back plane of the experimental equipment, a cm scale was fixed with 0.0 cm at start, and with red marks for the fall distance prognoses according to Eq. (5). The relative movement of the test bodies was recorded with a standard CCD video camera. The camera was placed in front of the middle glass cylinder through a mirror arrangement in a distance (from the front of objective to the cm scale on the back ground) of ~ 60 cm directed to the height of 15 cm. The experimental equipment was fixed in the drop capsule falling freely in vacuum. The time resolution 0.04 s is to be calculated from 25 frames/s. From 256x256 pixels, the space resolution is in order of 1 mm for the quickest relative motion of Li. The time of fall was mirrored in by film exposure in 40 ms units. The time of fall with approximately free fall conditions and the relative fall distances in each time step can be read immediately from single pictures of film. The following sequence of four pictures shows the relative movement of the seven test bodies at fall times of 1.23 s, 2.43 s, 3.63 s and at 4.68 s, the end of the 110 m fall.

**Fig 1. - 4.** The relative movement of test bodies at four time points.

The overall uncertainty of 0.1 cm/1.1x$10^{5}$ cm ~ $10^{-5}$ was enough because the effect of UFF violation is awaited in a range of pro mille. Since the 430 kg drop capsule was mainly consisting of Al, the largest awaited acceleration difference in free fall conditions would be between Li and Al

$$\Delta a_{Al,Li}/a_{Al} \approx \Delta^{MD}_{Al} - \Delta^{MD}_{Li} \approx 0.29\%. \qquad (5`)$$

For 110 m free fall, the prognosis of fall distance difference for Li relative to the Al capsule is to be calculated as $\Delta s_{Al,Li} \approx$ 0.29% x 110 m $\approx$32 cm. In the fall experiment, an additional Al test body was also used as reference. The Fe test body, as a representative of all elements with acceleration larger than Al, has to be placed at the bottom of the experimental equipment during the fall. All the other test bodies Li/Be/B/C and also Pb, with values of $\Delta_j^{MD}$ smaller than $\Delta_{Al}^{MD}$, have to arise greater than 6 cm in an experiment with free fall conditions

A detailed evaluation of the experiment has been performed**.** Here a summary of the main results:

- The elements Be and B have not arisen from the ground because of the adhesion.
- The elements Li, C and Pb have shown UFF violation relative to Al. But the UFF violation was by a factor f = 6.7(4) smaller than expected from $\Delta_j^{MD}$.

  The fall condition was only approximately a free fall condition in the gravitational field of the earth. The test bodies were placed within a falling capsule.
- The UFF is violated in order of $\Delta a/a \approx$ 0.045(1)% with the used Li and Al. The acceleration deviation $\Delta a/a$ of C was 0.012(1) % and of Pb 0.011(1) %, compared to the Al capsule with a = 981 cm/s$^2$ .

The acceleration differences are calculated from the following table in time intervals from the beginning: for Li in 2.43 s, for C in 4.,23 s and for Pb in 3.63 s.

| time [s] | **Li** s [cm] | C s [cm] | Pb s [cm] | Li s/t [cm/s] | C s/t [cm/s] | Pb s/t [cm/s] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | | | |
| 0.35 | 0.55 | | 0.60 | 1.67 | | 1.82 |
| 0.63 | 1.10 | | 1.15 | 1.75 | | 1.83 |
| 0.95 | 1.70 | | 1.70 | 1.83 | | 1.83 |
| 1.23 | 2.30 | 0.10 | 2.30 | 1.87 | 0.08 | 1.87 |
| 1.55 | 3.00 | | 2.90 | 1.96 | | 1.90 |
| 1.83 | 3.80 | 0.20 | 3.50 | 2.08 | 0.11 | 1.91 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.15 | 4.50 | | 4.10 | 2.11 | | 1.92 |
| **2.43** | **5.20** | 0.40 | 4.70 | **2.14** | 0.16 | 1.93 |
| 2.75 | 5.60 | | 5.30 | 2.05 | | 1.94 |
| 3.03 | 6.00 | 0.60 | 5.90 | 1.98 | 0.20 | 1.95 |
| 3.35 | | | 6.60 | 0.00 | | 1.98 |
| **3.63** | 6.60 | 1.00 | **7.25** | 1.82 | 0.28 | **2.00** |
| 3.93 | | | 7.60 | 0.00 | | 1.93 |
| **4.23** | 7.20 | **1.40** | 8.20 | 1.70 | **0.33** | 1.94 |
| 4.55 | | | | | | |
| 4.63 | 7.50 | 1.60 | | 1.62 | 0.35 | |
| 4.68 | | | 9.00 | | | 1.94 |

In several independent reading procedures, sometimes a decision could not be done between values s in 1mm unit. Therefore, s values with 0.05 cm appear in the table. The read velocities increase up to times 2.43 s, 3.63 s and 4.23 s linear in the time within the uncertainties of the data. Within errors, the observed violation of UFF can be calculated according Eqs. (3) and (5). However, $\Delta a/a_i$ of (5) had to be corrected by the factor 1/f = 1/6.7. The observed values were smaller than the calculated.

The initial velocities of the test bodies where Li: $v_0$ = 1.62(1), C: $v_0$ = 0.0(1) and Pb: $v_0$ = 1.80(3) all in cm/s. They are caused by the starting procedure of the fall capsule in the drop tower.

The appearance of the factor f is in all probability caused by the falling capsule which pulls the test bodies with itself. Fall experiments from 110m height, entirely in vacuum and without the drop capsule, must be performed in order to eliminate or to reduce the factor f. But such an experiment is inaccessible at the moment in the drop tower of ZARM. Therefore, the next measurement is planned with the same experimental device and with Be, B, two times Li and three times C.

All the results are obtained with a simple method: The evaluation of the equation

$$s = v\,t + a/2\,t^2 , \qquad (6)$$

at so many different points $(s_1, t_1)$ and $(s_2, t_2)$ as possible, lead to different values of the two parameters $v$ and $a$ and the accelerations $a$ were composition dependent.

Jörg Friedrich, University Mainz, has performed a $\chi^2$ fit with the Ansatz (6) and he has obtained slightly different values for $v$ and $a$. His values are, if in the case of C all available values are taken with a fixed value $v = 0$:

| | Li | C | Pb |
|---|---|---|---|
| $v$ [cm/s] | 1.63(4) | 0.0 | 1.81(2) |
| $a$ [cm/s$^2$] | 0.434(5) | 0.150(3) | 0.102(8) |
| $\Delta a/a$ [%] | 0.0442(5) | 0.0150(3) | 0.0104(8) |

Although I prefer to use my data; nevertheless, Friedrich's fit is more accurate. The UFF is clearly violated in both evaluations and for all the three test bodies.

This experimental result shows a composition dependent deviation of the fall of test bodies with different composition.

The found $\Delta a/a > 0.045\%$ supports a hypothesis that mass defects of isotopes play a role for the UFF violation. Furthermore, the four stable particles have a second type of charges, the elementary gravitational charges which are Maxwell charges, and they cause the gravitational field, Szász *What generates the gravitation?*, Ref. **[13]**. The gravitational mass of a body is proportional to the sum of the assumed elementary gravitational charges of stable particles within the body, which can never change. Then, the gravitational mass of an electric neutral atom with the mass number A is, expressed with the mass of proton and electron

$$m_A^g = A\,(m_P - m_e), \quad (7)$$

and the binding energy of the atomic nucleus with mass number A is

$$E_B = \Delta_j^{MD}\, A\,(m_P - m_e)\, c^2 . \quad (8)$$

With the binding energy $E_B$, the inertial mass is

$$m^i = m^g - E_B / c^2 . \quad (9)$$

Only the inertial mass changes at the binding of the nucleons in a nucleus.

**Consequences:** The obtained experimental result is compatible with the three "irregular" observations of gravity, all in the range of pro mille. But the result is in discrepancy with the generalizations derived from the experiments of Niebauer et al., Ref. **[8]**, Kuroda et al., Ref. **[9]** and Su et al., Ref. **[10]**. These generalizations set the UFF confirmation in the range of $\sim 10^{-12}$. The perception "mass" is an inaccurate understood term in physics and requires a general revision. If the assumption is accepted that the gravitational mass can be derived from the gravitational charges as the second type of elementary charges of the four elementary particles, the deficiency of the other measurements of the Weak Equivalence Principle is understandable. The non vanishing influence of the electric charges has been neglected in all other WEP testing experiments. This influence can simply be understood if for instance one considers the distance between two hydrogen atoms behind the gravity as dominant. The distance has to be in the range of earth-moon distance. The movements of $\sim 10^{26}$ particles with two kinds of elementary charges (e- and g-charges) within vicinal bodies and with a relation of force strengths $F^e/F^g \sim 10^{42}$ require some additional estimation for body distances of $\sim 10^3$ cm even if the considered vicinal bodies are electric neutral. The assumption about the existence of pure gravitational forces between bodies in laboratory distances is not allowed without further analysis.

The assumed elementary gravitational charges $g_j = \pm gm_j^g$ cause, together with the elementary electric charges, a covariant fundamental field, the Unified Field (UF) consisting of the electromagnetic field and the covariant gravitational field. In order to avoid the fundamental inconsistency of the accepted physical description, that nature does not have two different Riemann's metrics in the space-time continuum; one for Einstein's geometrized gravity and the other for electromagnetism. The propagation of the Unified Field is independent on the state of the motion of its sources and has the value c in all frames. The relative distance between two events, between two sources, is given uniquely by the invariant quantity $ds^2 = (d\mathbf{x})^2 - (cdt)^2$ in a finite space-time domain. The velocity of gravity with $c^g = c$ is supported by the recent measurement of S. Kopeikin and E. Fomalont, Ref. **[12]**. The manifestly covariant UF has four kinds of sources e, p, P and E, each having two kinds of invariant e-charges and g-charges. The UF theory is able to give a new description of nature being completely different from the accepted one, see an attempt by Szász, Refs. **[13, 14]**. Based on these new general principles, new variation principles for open, non-conservative physical systems in finite space-time domains are able to explain the microscopic processes, especially the existence of bound stationary states and of unstable particles, without the usage of the accepted quantum mechanics and the connected field quantization. The consequence is that the sources of the UF are quantized, not the UF itself.

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**Technical Detail of the Drop Experiment**

The experiment has been performed at the drop tower of ZARM at the University of Bremen in a vacuum tube of 110 m height. The 431 kg capsule was mainly consisting of Al. The experimental device holding the seven test bodies was made by IKS GmbH, Ingelheim. Technicians of ZARM have installed the experimental device in the drop capsule, the clock which measured the time of fall and the video camera in the front of the device which registered the relative movements of the test bodies through a mirror arrangement. The digital numbers of the clock mirrored on the film.

Safety conditions:

Because of safety conditions, each test body was contained in a closed plexus glass cylinder, (outer diameter = 5 cm, wall thickness = 0.3 cm and length = 45 cm). The test bodies were freely placed in the middle of the cylinder. On the back plane of the experimental equipment, a measuring device was placed with 0.0 cm at start, and with the red marks of the prognoses from the mass defects of isotopes. The distance from the measuring device on the back plane to the middle of the glass cylinder, where the test bodies move, was approximately 4 cm. The experimental equipment was fixed in the drop capsule; the capsule was falling freely in vacuum (ca. 1 Pascal). Inside the capsule pressure was normal.

Test bodies:

The weights of the test bodies were between ~2 g and ~7 g. The purities were better than 98.8% in all cases. Only the Li body had a notable larger contribution of other element ${}^{23}_{11}\mathrm{Na}$ ~1%. The test bodies were in disk form, the lithium body only approximately. Li and graphite was cold cut from a rod. The boron disk was hot pressed. The others bodies were melted in protected atmosphere in order to bring them in a suitable form. The most frequent isotopes of the elements are ${}^{7}_{3}\mathrm{Li}$

of 92.5%, ${}^{9}_{4}Be$ of 100%, ${}^{11}_{5}B$ of 80.1%, ${}^{12}_{6}C$ of 98.89%, ${}^{27}_{13}Al$ of 100%, ${}^{56}_{26}Fe$ of 91.754% and ${}^{208}_{82}Pb$ of 52.4%, according to Nuclear Physics Tables. The properties of the test bodies are shown in the following Table:

| **Test Body** | **Purity [%]** | **Weight [g]** | **Diameter [cm]** | **Height [cm]** | **Deliverer, Product No.** | **Melted in Disk Form by** |
|---|---|---|---|---|---|---|
| Li | 98.84 | 5.4 | ~2.80 | ~2.2 | Merck PN.: 5660, University of Mainz, | (cold cut from rod) |
| Be | 99.4 | 4.9 | 3.0 | 0.38 | BrushWellman Inc., PN:1270/0000199208/S-65 | BrushWellman |
| B | 99.9 | 1.8 | 2.0 | 0.30 | Goodfellow, Bad Nauheim. PN.: 12345 | (hot pressed) Goodfellow |
| C, Graphite | 99.0 | 5.9 | 1.65 | 1.35 | ChemPur, PN.: 901670 University of Mainz, | (cold cut from a rod) |
| Al | 99.999 | 6.3 | 2.15 | 0.62 | Hahn-Meitner Institut, Berlin | University of Miskolc |
| Fe | 99.9 | 6.2 | 1.7 | 0.28 | KFKI, Budapest, electrolyte iron in $H_2$ atmosphere | KFKI, in electron ray |
| Pb | 99.9 | 7.6 | 2.1 | 0.13 | KFKI, Budapest | University of Frankfurt |

CCD video camera:

The relative movement of the test bodies was recorded with a standard CCD video camera. The time resolution is to be calculated from 25 frames/s and from 256x256 pixels corresponding to a space resolution of ~ 0.1 cm for the fastest motion of Li. The time of fall was mirrored by the film exposure in 0.04 s unit. The film camera was placed in front of the middle glass cylinder in a distance (from the front of objective to the measuring device on the plane back ground) of ca. 38.0 cm + 26.5 cm and in a height of 15 cm (optical distance). The relative fall distances and the time of fall could be read immediately from single film pictures.

The date of the experiment

21. June 2004, at 14:45.

The geographic coordinates and orientation of the devices:

The geological coordinates of the drop tower are: the degree of altitude = 53° 06' 43'' and the degree of latitude = -8° 41' 32''. The height of the tower at the starting point is 2,783 m + 119 m about NN Amsterdam.

Orientation of the device:

No data available.

The literature value of acceleration in Bremen:

The acceleration of the empty capsule was set to the value g = 981321.970 mgal (Borgfeld: 53.1355169 degree of altitude, 8.94669302 degree of latitude).

Further technical information on the drop tower Bremen are available in the User Manual of ZARM, Version 10. July 2003.

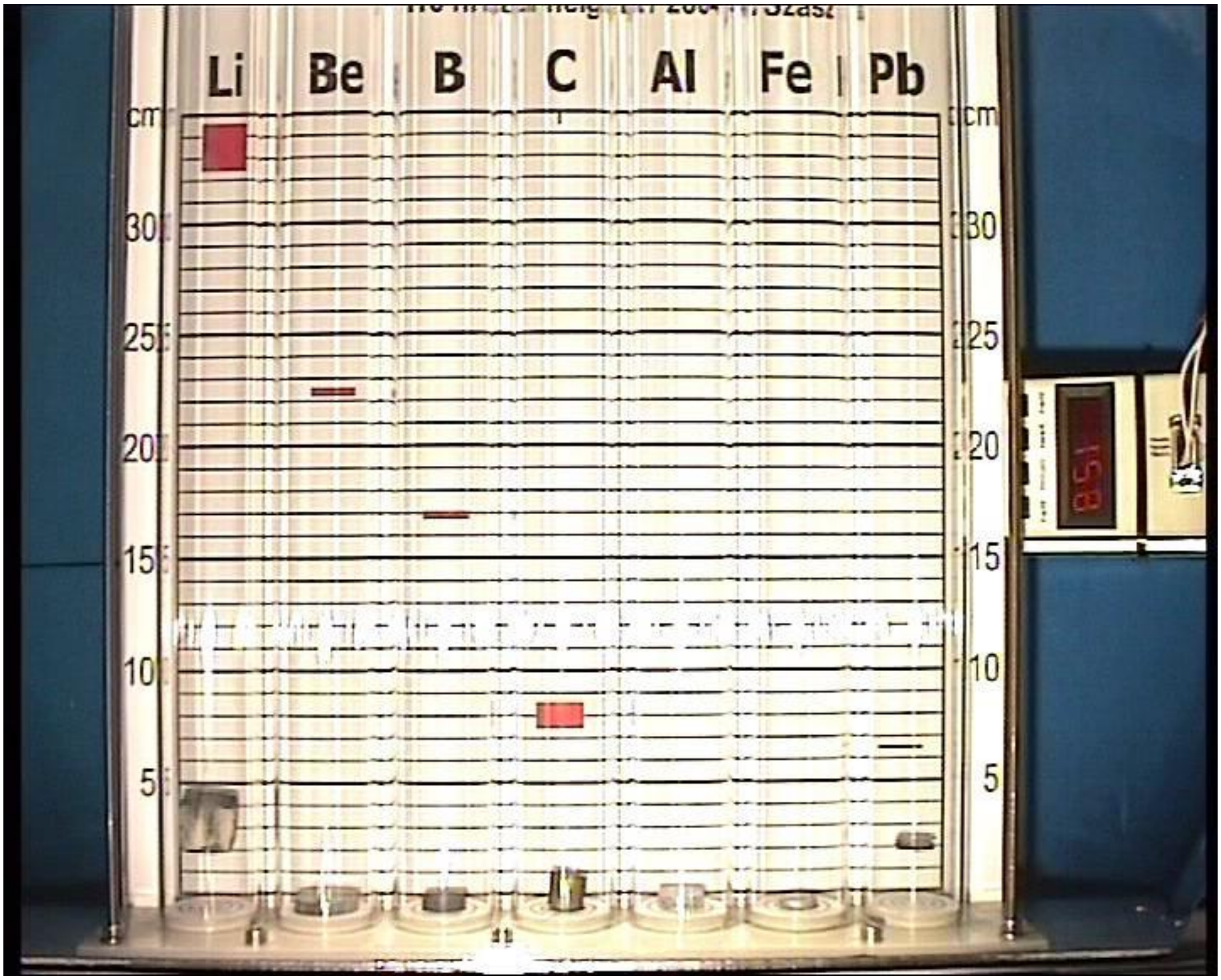
GLP protocol:

At the end of measurement a GLP protocol has been written and signed by R. Forke, a member of DLR, by Klaus Hüttemann, Jörg Friedrich, István Szász, Inge Jakobi Szász, Julian Szász, Michael Schön and by myself. ZARM did not sign the protocol. One example of the GLP protocol and a copy of the CD with the registered movements of the test bodies were given to DLR for archiving. In the GLP protocol the missed 200 frame/s video camera is fixed. Instead of the high resolution camera, only a 25 frame/s camera was installed by ZARM.

## References

**[1]** Internet page of the Eöt-Wash Group, Seattle, *The Controversy over Newton's Gravitational Constant*, http://www.npl.washington.edu/eotwash/gconst.html.

**[2]** O. V. Karagioz, V. P. Izmailov, *The Newtonian Gravitational Constant Data Base*, Moscow, http://zeus.wdcb.ru/wdcb/sep/GravConst/tab2_en.html, last update 06/15/2001.
**[3]** Gy. I. Szász, *The Orbits of Planets Violate the UFF*, (2004).
**[4]** C. Will, *Theory and experiment in gravitational physics*, Revised Edition (Cambridge University Press, Cambridge, 1993).
**[5]** R. H. Dicke, *The theoretical significance of experimental relativity*, (Gordon and Breach, NY-London-Paris, 1968).
**[6]** A. M. Nobili, *Precise gravitation measurements on earth and space, Test of Equivalence Principle*, Int. School of Phys. "Enrico Fermi", Course CXVI, IOSS Press, 509 (2001).
**[7]** Gy. I. Szász, *The Non-Equivalency of the Inertial and Gravitational Mass within a Theory of Gravitational Charges*, (2002).
**[8]** T. M. Niebauer, M. P. McHugh, J. E. Faller, Phys. Rev. Lett. **59**, 609 (1987).
**[9]** K. Kuroda, N. Mio, Phys. Rev. Lett. **62**, 1941 (1989).
**[10]** Y. Su; B. R. Hechel, E. C. Adelberger, J. H. Gundlach, M. Harris, G. L. Smith, H. E. Swanson, Phys. Rev. **D 50**, 3614 (1994).
**[11]** G. Audi, A. H. Wapsta, Nucl. Phys**. A595,** 409 (1995).
**[12]** S. Kopeikin, E. Fomalont, arXiv: gr-qc/0212121v1, (2003), presented at the Meeting of the AAS, Seattle (January/08/2003), gr-qc/0310059 and S. Kopeikin, CQG, **21**, 3251 (2004).
**[13]** Gy. I. Szász, *Mi okozza a gravitációt?* (*What Causes the Gravitation?*) (2004).
**[14]** Gy. I. Szász, *Gravitaciós töltések az Egyesített Mező Elméletben* (*Gravitational Charges in the Unified Field Theory*) (2004).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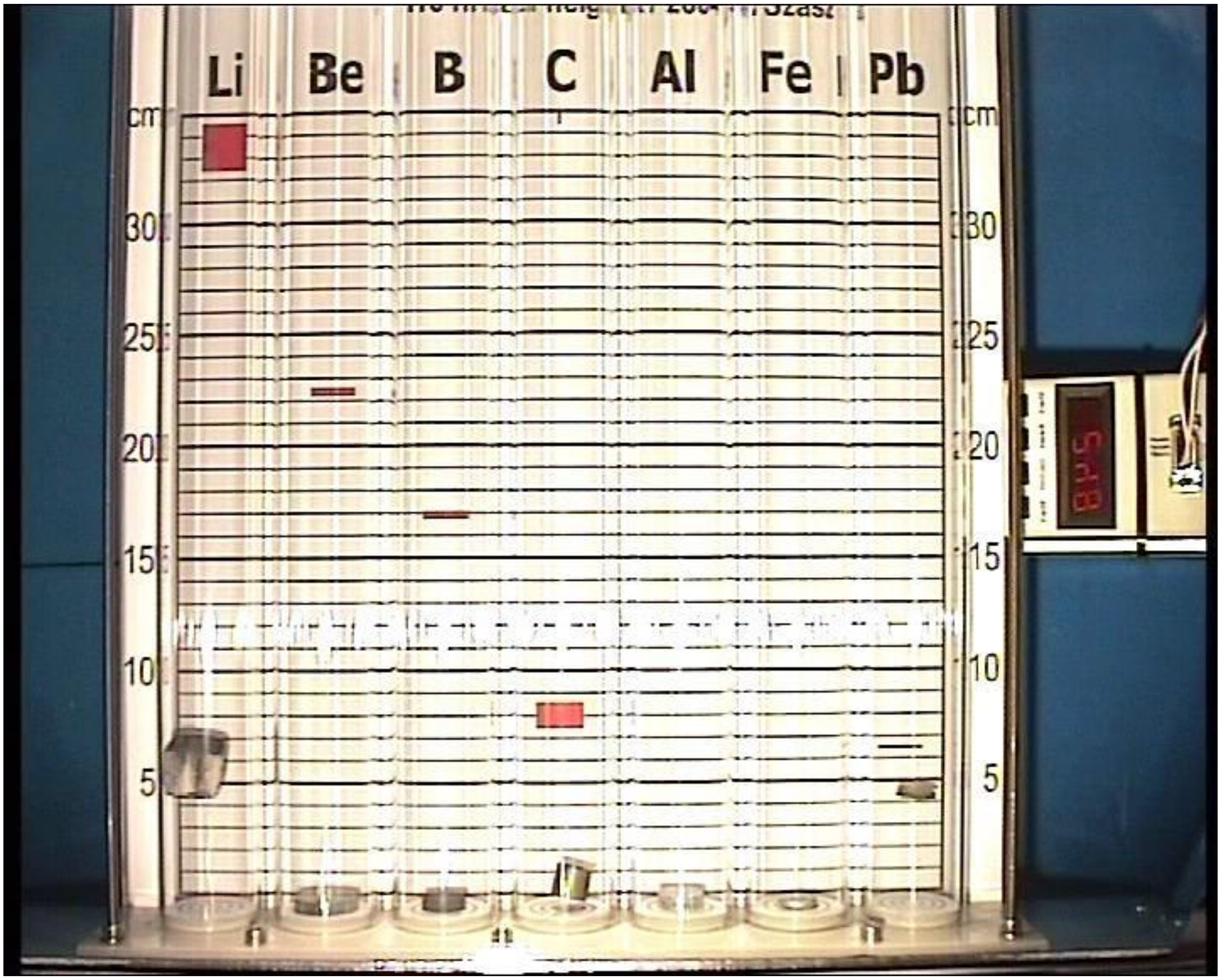
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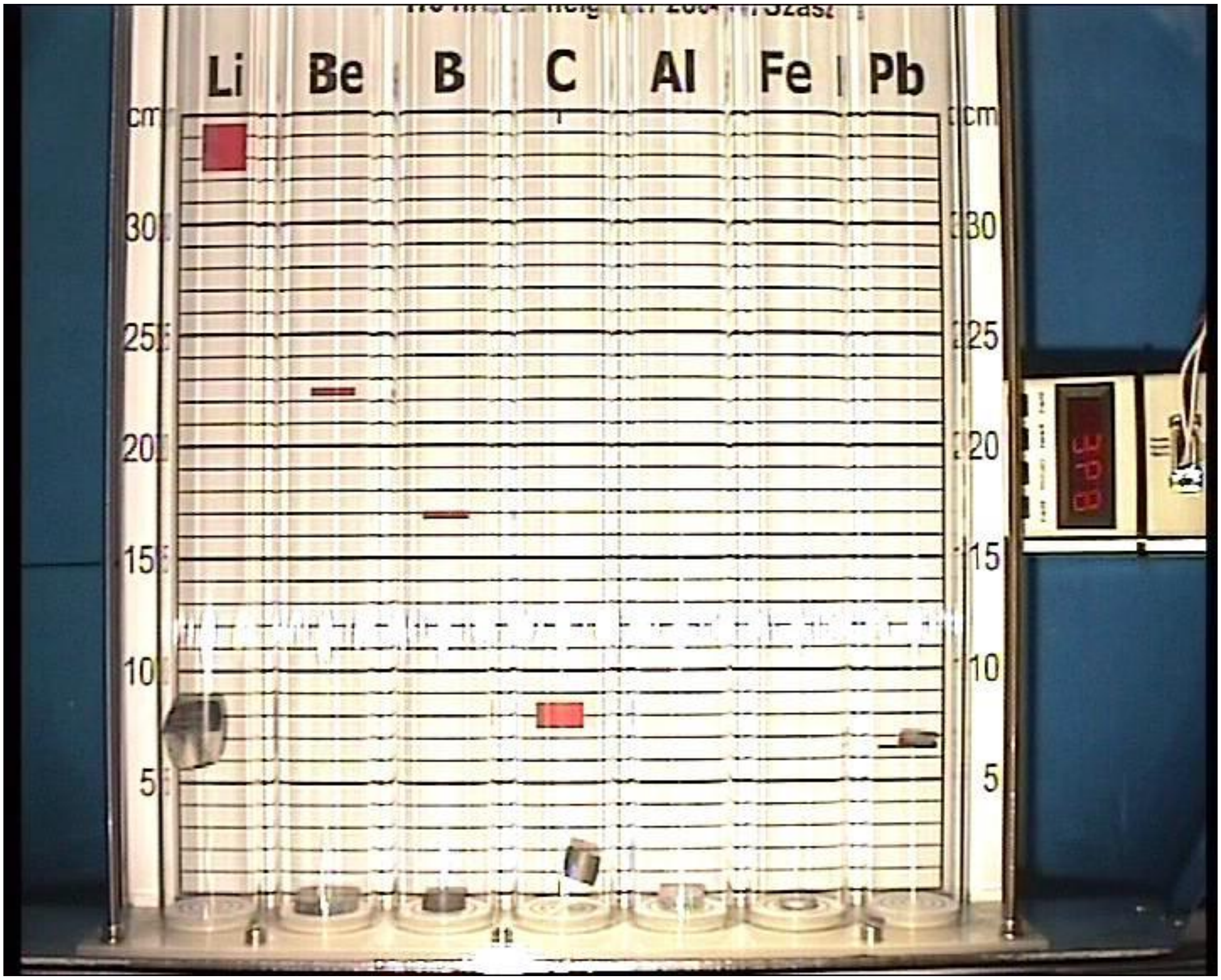
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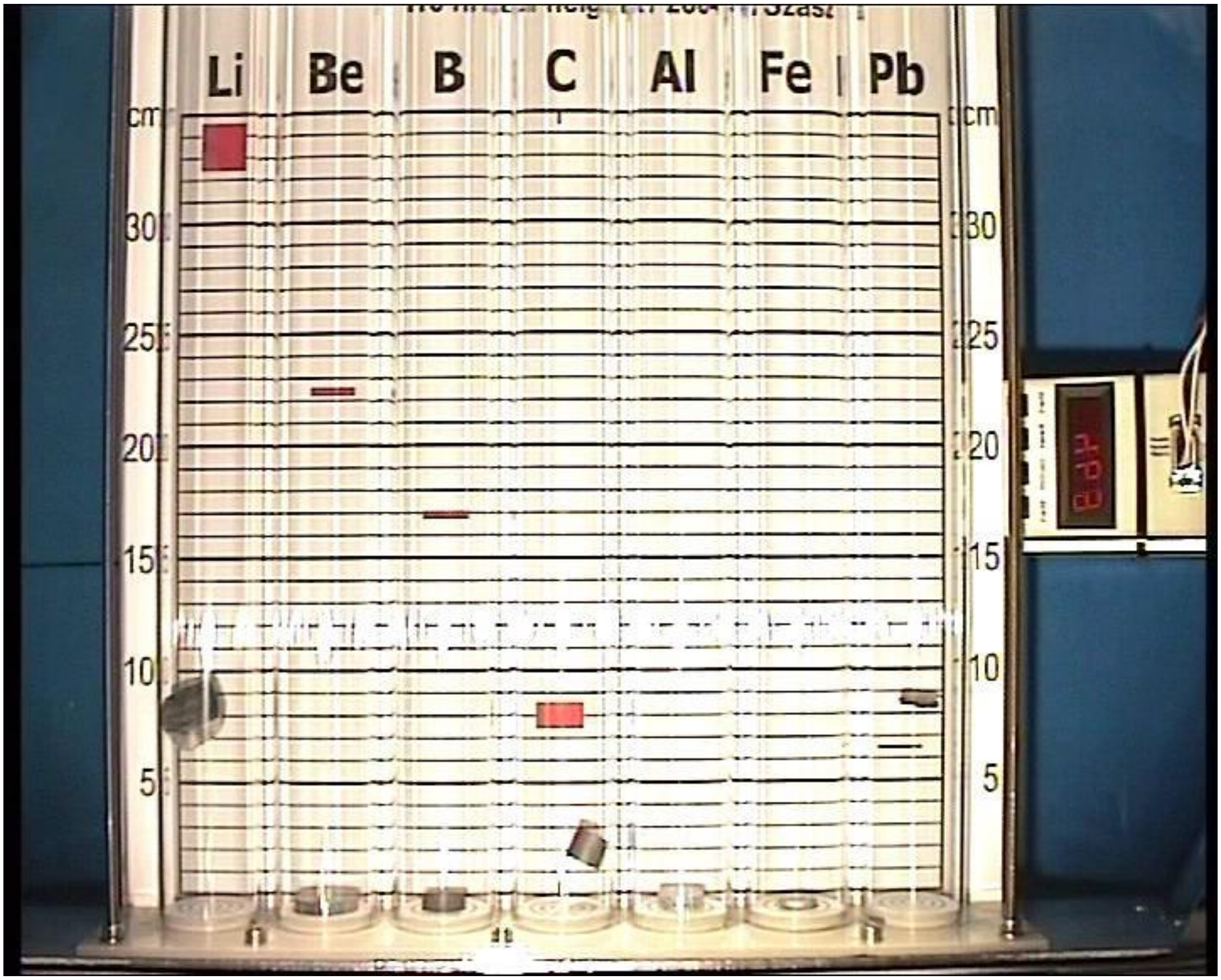
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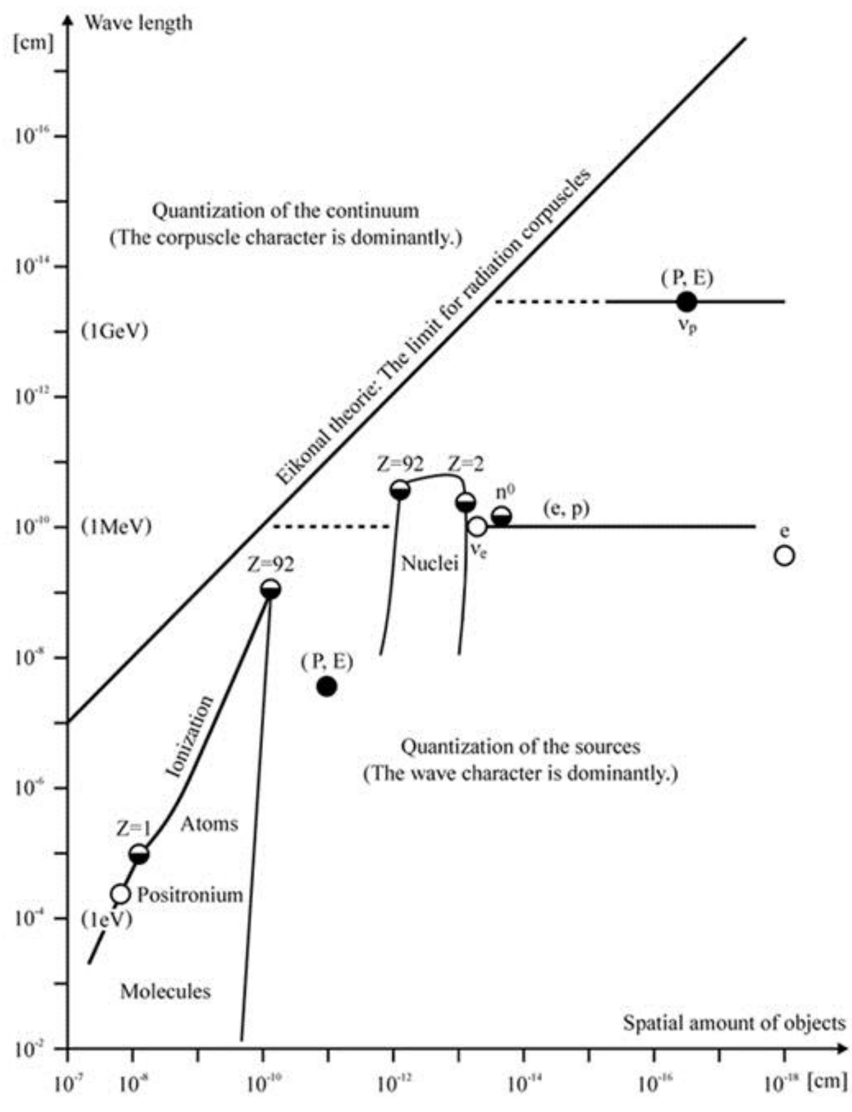

Wave length
[cm]
$10^{-16}$
$10^{-14}$
$10^{-12}$
$10^{-10}$
$10^{-8}$
$10^{-6}$
$10^{-4}$
$10^{-2}$
(1GeV)
(1MeV)
(1eV)
Quantization of the continuum
(The corpuscle character is dominantly.)
Eikonal theorie: The limit for radiation corpuscles
(P, E)
$\nu_p$
Z=92
Z=2
$n^0$
(e, p)
$\nu_e$
e
Nuclei
Z=92
(P, E)
Ionization
Quantization of the sources
(The wave character is dominantly.)
Z=1
Atoms
Positronium
Molecules
Spatial amount of objects
$10^{-7}$
$10^{-8}$
$10^{-10}$
$10^{-12}$
$10^{-14}$
$10^{-16}$
$10^{-18}$ [cm]