Experimental Re-Examination of the Law of Conservation of Mass in Chemical Reactions

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Abstract — At the beginning of the century the law of conservation of mass in chemical reactions was checked experimentally by Landolt and various other experimenters. Even though in 8 of the 10 chemical reactions studied by Landolt the validity of conservation of mass was confirmed within the margin of experimental errors, in 2 reactions the pre vs. post comparison of the determined weights indicated mass differences that exceeded the experimental error by up to a factor of 6, indicating apparent violations of the law of conservation of mass. However by averaging between such results and subjective assessments Landolt discarded these deviations. We report on careful and systematic repetitions of one of Landolt's chemical experiments. Using modern sensitive and, in one case, automatic weighing techniques, the results obtained reveal time-dependent and long-range gravitational irregularities which are many orders of magnitude larger than expected relativistic mass effects, indicating an apparent violation of the law of conservation of mass in this special chemical reaction. Similar effects could be found in biological and purely physical systems, as well as synergistic effects between these systems. The observed spontaneous mass fluctuations suggest the existence of a form of cold, dark matter which is detected in the described systems.

Introduction

Laws of conservation, such as the law of conservation of energy, are among the most basic laws of modem science because they reflect basic symmetries of the laws of nature. The law of conservation of mass, a special case of the law of conservation of energy, is thought to be applicable to physical processes as well as to chemical or biochemical reactions. Although relativistic effects are in principle known in chemistry, relativistic mass changes as predicted by the special theory of relativity for exothermal or endothermal chemical reactions in thermodynamically closed systems are below the range of today's detectability: Even for an extremely strong exothermic or endothermic chemical reaction involving reaction enthalpies of $\Delta H = \pm 1000$ kJ/mol, undetectable relativistic mass changes, Δm, on the order of magnitude of $\Delta m = \pm \Delta H/c^2 = \pm 1.11 \times 10^{-11}$ kg/mol $= \pm 0.011$ mg/mol are to be expected. In the following, exothermic chemical reactions in thermodynamically closed systems will be studied in which relativistic mass losses due to loss of heat are on the order of 10^{-21} kg while the detectability of the mass of the weighed system with a total mass of 100 g is on the order of ± 2 microgram.

The most precise experimental tests of the law of conservation of mass comprise the studies of Landolt [1], [2], [3], and others [4], [5] at the beginning of this century. Landolt tested the law of conservation of mass in 10 different types of chemical reactions. In a set of 93 experiments carried out between 1890 and 1907 he used two similar H-shaped glass test samples with a total volume of 400 to 800 ml. In each experiment two samples were sealed gas-tight after filling two chemical reactants in each of the two branches of each of the H-shaped samples, respectively, without mixing. The two sealed samples represented thermodynamically closed systems. After placing the two samples with equal weight of about 500 g, respectively, on the two pans of a mechanical two-pan balance with an accuracy of 40.001 mg, Landolt monitored the weight difference between the two samples in each experiment for several days. From these pretests an experimental error of the monitored weight differences of ±0.02 mg resulted due to varying external atmospheric conditions, leading to slightly different buoyancies and amounts of absorbed water on the surface of the glass samples. After extensive artifact research, Landolt stated that any change of the weight difference between the two samples in the experiments larger than 40.03 mg could not be attributed to an experimental error.

After the pretest, the chemical reaction in one of the samples was initiated by slowly tilting the sample and, after thermal equilibrium was reached again, the monitoring of the weight differences was continued. After a few days, the second sample was usually also tilted to mix the reactants and the monitoring was again continued for several days. Then the mean pretest value of the weight was compared to the mean post value.

If for two experiments, using the same chemical reaction, no deviation of the weight differences between the pre vs. post comparisons was found larger than 40.03 mg, the experiment was not repeated. Most of the chemical reactions (8 out of 10), tested by Landolt, fell into this category. Assuming the equality and constancy of the earth's acceleration acting on both samples during an experiment, Landolt concluded that the constancy of mass for chemical reactions, in general, was verified.

However, for several chemical reactions, including the formation of metallic silver from an aqueous silver salt solution or reactions involving solid and dissolved forms of iodine, the majority of the repeatedly performed experiments did show mass differences in the pre-post comparison which were far larger than the 40.03 mg experimental error by up to a factor of 6. By averaging between such independently obtained results and by subjective assessments Landolt discarded these time-dependent deviations. Even though further possible corrections to these deviations in Landolt's silver experiments have been critically discussed in scientific literature [4] [5], no systematic and comprehensive studies were done to experimentally clarify this point.

About thirty years after Landolt, Hauschka, [6] reported deviations from the law of conservation of mass, including biochemical reactions. From 1934 until 1940 he carried out experiments twice per month on the mass of sprout-

ing seeds in a thermodynamically closed and equilibrated system in comparison to a similar system without seeds. Each experiment ran over a period of five to six days. A two-pan balance with a reproducibility of ±0.001 mg was used. Time-dependent maximum deviations in the range of a few milligrams were observed, excluding effects due to buoyancy differences between the test and control vessels, varying water adsorption on the external surfaces of the vessels or electrostatic influences.

In the 1950's Allais [7] and Saxl [8] reported time-dependent gravitational irregularities with different kinds of pendula, especially during lunar eclipses, indicating apparent mass changes within their systems.

In the following we report on systematic and comprehensive studies testing the law of conservation of mass in thermodynamically closed and thermally equilibrated systems with chemical and biochemical reactions in comparison with similar reference systems, as well as in purely physical test and reference systems. In addition synergistic effects between chemical/biochemical and purely physical systems have been studied.

First, after presenting the experimental method used, and describing comprehensive artifact research, we report on results obtained in repeating the above discussed chemical experiment of Landolt in which metallic silver is generated by slowly mixing two solutions, so that a maximum temperature increase of about 1 degree C could be observed.

Second, results are described, obtained with sprouting seeds in thermodynamically closed systems involving biochemical reactions.

Third, as a first conclusion, a working hypothesis is formulated for the repeatedly observed violations of the law of conservation of mass in thermodynamically closed systems including chemical and biochemical reactions.

Fourth, predictions from the working hypothesis are tested by checking the law of conservation of mass in purely physical systems, thus avoiding any chemical or biochemical reactions at all.

Fifth, results are presented about a synergistic increase of the observed mass deviation effects in chemical/biochemical reactions by combining the purely physical systems with the chemical and biochemical ones.

As a summary, the results obtained so far indicate significant time-dependent, long-range effects, leading to violations of the law of conservation of mass. Assuming the validity of the law of conservation of energy, the results are interpreted to reveal the existence of a heretofore unknown kind of non-bradyonic, cold dark matter with two different forms of interaction with normal matter.

Experimental Method and Pretests

For a systematic verification of Landolt's silver experiment, a measurement procedure and data evaluation were developed before repeating it which allowed (a) the elimination of systematic errors due to temperature changes during the weighing of the test and reference flasks due to the presence of the ex-

perimenter, and (b) the determination of statistical errors for each weighing test. This measuring procedure, during which the flasks were weighed in a special sequence, was itself tested, and comprehensive examination of possible artifacts which could interfere with the weighed masses was done to check the law of conservation of mass systematically and critically. In addition a modified measurement procedure during which the flasks were weighed in a random sequence was also used.

Measurement Procedure

Three sets of twelve 250 ml round bottom glass flasks each with standard joints and corresponding stoppers were used as thermodynamically closed systems. After filling with chemically inert or active components, each flask was sealed gas-tight with glass stoppers, using high vacuum grease and steel strings. Four flasks of each set served as controls, containing chemically inert materials, and eight flasks were used as experimental (test) flasks, respectively, in each set. The average volume of each sealed flask was 315.9 ml with a standard deviation of ±1.39 ml ($\pm0.44\%$). For the set with the largest mean volume difference between control and test flasks the difference was $+2.19$ ml ($+0.68\%$). The mean surface area for the flasks was 211.0 ± 0.9 cm^2 ($\pm0.43\%$).

In case of artifact experimentation, the four control and eight test flasks were filled before being sealed gas-tight with various chemically inert materials as described below.

In the case of a silver experiment, 20 ml of Tollen's solution' was poured into the eight experimental flasks, respectively, [9]. Within a separate small test tube, placed within each experimental flask, respectively, 5 ml of an aqueous solution of the reducing agent (2 molar aqueous glucose solution) was introduced. After sealing the flasks with glass stoppers, using high vacuum grease and a metallic spring to fix the stoppers, the glucose solution was mixed with the silver nitrate solution by slowly turning the flasks. Metallic silver immediately started to separate in solid form, silver plating the inner surface of the flasks. Due to the exothermic reaction the temperature in the flasks rose by about 1 C. Control flasks were filled with a corresponding amount of water or glass balls before sealing with glass stoppers. In the case of a silver experiment, the first weighing started sixty to ninety minutes after filling, sealing the flasks and initiating the chemical reaction. By then the flasks were again in thermal equilibrium with the surroundings. Independent experiments confirmed that this period of time was sufficient to thermally equilibrate the test flasks (see below).

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1. 30 ml of an aqueous sodium hydroxide solution (10% by weight) was added to 60 ml of an aqueous silver nitrate solution (10% by weight) and 90 ml of aqueous ammonium hydroxide solution (3% by weight) was gradually added to this mixture while stirring

The weighing procedure started by weighing the four control flasks in a special sequence after calibration of the balance. Then the eight test flasks were weighed in a special sequence, and then again the four control flasks in the same sequence as before. Every measurement took nearly the same time; the total measurement procedure lasted about 20 minutes. By this measurement procedure, as mentioned, systematic errors due to temperature changes during the weighing sessions caused by the presence of the experimenter could be eliminated. This procedure was repeated one or two times per day over a period of five to six days in each experiment. The flasks were stored dust free, placed on cork rings in glass beakers within a box in the dark, and grouped together as control or experiment with distances between the groups of 0.5 to 3 m. The air-conditioned environment showed maximum temperature variations of ±2 C. As described below, this measuring procedure was itself tested.

Unless otherwise stated, weighings were done with an electronic scale, type Mettler AE 163 with a weighing range of 163 g and an accuracy of ±0.1 mg (experimentally determined standard deviation σ .= −0.04 mg, $n = 20$). The linearity of the scale was tested and found to be accurate to 0.1 mg over the entire range.

Handling of the samples was done with 30 cm long steel tweezers. During each weighing procedure each flask was exposed to light for about six minutes. The light conditions were kept constant for each subsequent measuring procedure. The weighing sequence of the flasks was also kept constant. Before and after every measurement procedure temperature, pressure, and relative humidity of the air were monitored and noted.

Data Evaluation and Statistical Analysis

During a measurement procedure a linear temperature increase in the room of about 0.5 to 0.9 C could not be avoided due the presence of the experimenter (see below for quantitative details). This caused a systematic change in the air buoyancy of the weighed flasks which could be eliminated by applying the following data evaluation.

It was shown in an independent test (see below) that this temperature change could be described by a linear function. Therefore the weights of the test and control flasks were corrected in the following way before statistical analysis of the data: A linear interpolation of the weights of the four control flasks which had been weighed before and after the test flasks as pre-and post-controls in each measurement procedure was done as shown in Figure 1. This linear function allowed the determination of the systematic deviation of the weight of each individual test flask in the 20 minute run due to the temperature increase during this time. By subtracting the thus determined individual deviation from the measured weight of each test flask, the weight of each test flask corrected for the systematic temperature drift could be determined.

The thus-corrected set of experimental weights of the test flasks of each measurement procedure (index i) was then used in data evaluation for determi-
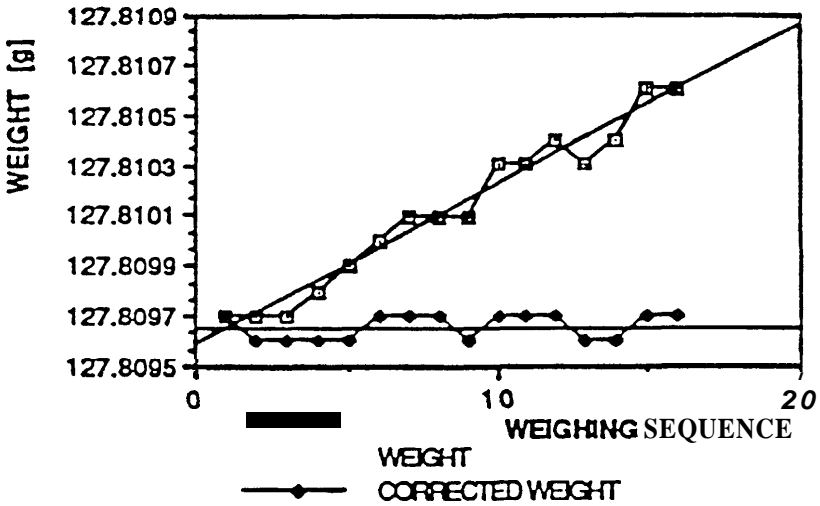
Fig. 1.   Linearity check of the mass of an empty, sealed 250 ml round bottom glass flask. The flask
was weighed 16 times in sequence, simulating a measuring procedure of a real experi-
ment.

nation of the average measuring effect Am, of each measuring procedure (mass
changes Δm_i , assuming the constancy of the earth's acceleration during the
measurement procedure). The Δm_i values were calculated according to (1), re-
spectively, and are given with their standard errors and the standard error of
the base line in the following figures, where $i = 0$ indicates the masses of the
test (m_t) and control (m,) flasks of the first weighing.

$$\Delta m_i = (m_{ti}\text{-}m_{t0})\text{-}(m_{ci}\text{-}m_{c0}) \tag{1}$$

For statistical analysis of an experiment the sets of $(m_{ti}\text{-}m_{t0})$ values and $(m_{ci}\text{-}$
m,) values were used for a computer analysis of variance for repeated mea-
surements (ANOVA [11]) to determine the significance of the mass differ-
ences between the control (zero-line) and test (measuring effect) values. The
degrees of freedom of the statistical test (BMDP P2V, 1988 release, cf. Winer
[10] and BMDP User's Manual [11]) were corrected after Huynh-Feldt [12].
The resulting p-values for a whole experiment are given below. In case of a sta-
tistically significant (p 10.05) deviation between the test and control flasks,
i.e., significant deviations of the measuring effect Δm_i from the zero-line, a
significant violation of the conservation law of mass is indicated.

Test of the Measurement Procedure and Test of the Data Evaluation

To test the linear change of the flasks during the measurement procedure and
data evaluation due to the unavoidable temperature increase of about 0.5 to
0.9 C caused by the presence of the experimenter during a measurement proce-

dure a sealed and empty 250 ml round bottom glass flask was weighed 16 times in sequence over a period of about 20 minutes. In Figure 1 the 16 original weighing results of a typical experiment are plotted over time. They show a continuous increase in weight due to a systematic temperature increase. In addition, the linearly corrected values are shown, leading to a horizontal line. (The values in Figure 1 are rounded, but in the complete data evaluation used for statistical analysis the un-rounded values were used.)

The weight difference between the first and last weighing in this experiment ($m_1 = 127.8097$ g, $m_{16} = 127.8106$ g) was $+ 0.9 \pm 0.14$ mg. (The error was estimated, using as error the individual weight readings ± 0.1 mg and applying error propagation for the difference). From the noted atmospheric data before and after the experiment (T, $= 23$ C, P, $= 1021.2$ mbar, h, $= 28\%$, and $T_2 = 23.8$ C, $P_2 = 1021.3$ mbar, $h_2 = 28\%$) the calculated difference from the changing buoyancy is 1.01 ± 0.14 mg which is in agreement with the experimentally found value of 0.9 ± 0.14 mg. This confirms that minor linear changes in weight of test and control samples during a measurement procedure are caused by linearly changing room temperature due to the presence of the experimenter and can quantitatively be understood from known effects and thus eliminated by the data evaluation method, given above.

As a further check of the statistical evaluation method, the above statistical analysis was applied to the corrected data of Figure 1 using the corrected weighings No. 1 to 4 and 13 to 16 as four controls (pre-and post-controls) and weighings No. 5 to 12 as eight experimental flasks. The resulting "pseudo measuring effect" was in all tests less than 0.05 mg, i.e. a factor of 2 below the accuracy of the balance (± 0.1 mg). This established the expected conservation of mass of the weighed flask.

In a series of additional experiments the three sets of twelve 250 ml flasks were used in further pretests, respectively, before using them in the following experiments. For several days up to one month, the weight of four arbitrarily chosen flasks serving as controls was compared in the morning and evening to eight flasks simulating the test flasks. All flasks were empty and sealed gastight. They were handled following the measuring procedure, and the results were evaluated and statistically analyzed as described above.

A typical result is given in Figure 2. Consistent with the law of conservation of mass, no significant measuring effect could be detected in these tests. The maximum mean weight difference between test and control flasks observed in these experiments was 0.1 ± 0.05 mg. Thus a value of ± 0.1 mg, the accuracy of the balance, can be seen as the residual error of the measuring effect of the experiments described below.

Similar results were obtained when all flasks were partially filled with water or glass balls.

Artifact Investigation

To evaluate the influence of known parameters which could interfere with the mass determination and the measuring effect Δm_i in the experiments de-
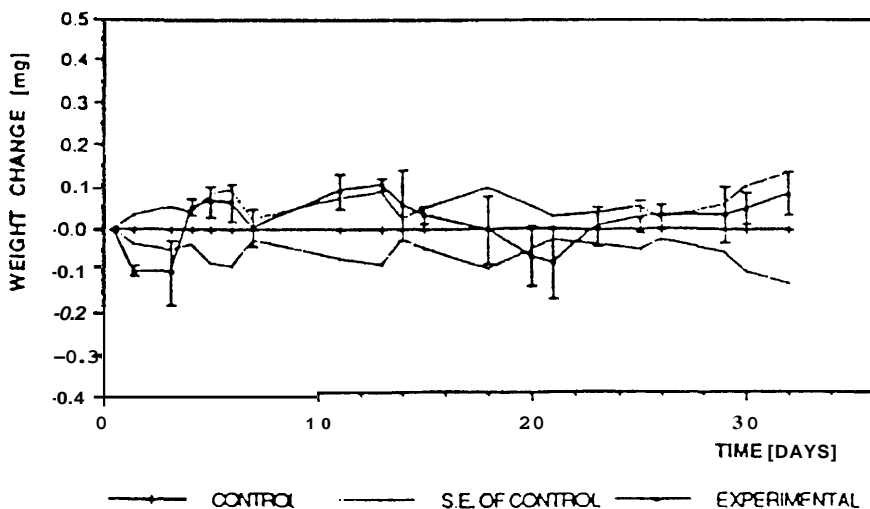
Fig. 2. Example for a test of the measurement procedure with 12 empty and sealed 250 ml round
bottom glass flasks grouped randomly into 4 control and 8 test samples and evaluated ac-
cording to the data evaluation and statistical analysis as described in the text. There is no
significant deviation between test and control flasks detectable ($p > 0.53$), as expected
from the law of conservation of mass. As in all other figures the vertical bars indicate
standard errors, except in Figures 5 and 6 where 95% confidence margins are given.

scribed below, various further pretests were performed to check for possible
artifacts. In the experiments described below, maximum disturbances which
could be expected during the application of the above described measurement
procedure have been experimentally simulated to test their influence on the
measuring effect Δm_i as defined above. Compared to the studies of Landolt,
[1], [2], and [3], and Manley [5], as well as other researchers, [4], this artifact
investigation and the applied measurement procedure as well as the data eval-
uation for correction of systematic temperature increase during the measuring
session due to the presence of the experimenter and statistical analysis of the
corrected data is very comprehensive. The results described below demon-
strate that known influences, parameter fluctuations and effects cannot be used
to explain the measuring effects Δm_i described below.

*Maximum Atmospheric Influences of Temperature, Pressure, and Humidity in
View of Individual Flasks*

Changing atmospheric conditions can influence air buoyancy or water ad-
sorption on the external surface of the glass flasks. To check the maximum ef-
fects due to such atmospheric variations, the weight of one sealed glass flask
was determined each morning and evening over a period of one month. Maxi-
mum weight differences of up to 12 mg were observed. For the set of glass
flasks with the largest mean volume difference between control and test flasks

of 0.68%, the maximum change of 12 mg in absolute weight of a flask due to changing atmospheric conditions can create a maximum buoyancy difference of 0.08 mg. If the same maximum weight change of 12 mg is used to estimate the maximum influence of water adsorption on the difference between test and control flasks (0.43%), a value smaller than 0.06 mg follows. Due to these results and the results described above, no further correction of the obtained weight differences between test and control flasks in view of air buoyancy or water vapor adsorption on the samples was therefore done.

Temperature Differences

The temperature increase within a 250 ml flask due to the exothermic production of metallic silver was measured to be +0.9 C. Equilibrium to room temperature was reached after 30 minutes. This indicates that the time period of 60 to 90 minutes used in the above described preparation method of the test flasks was sufficient for their thermal equilibrium, so that weight differences due to thermal imbalances were below ±0.1 mg.

The expected behavior of the as yet unused flasks in view of measuring effects, as shown in Figure 2, demonstrates that minor temperature fluctuations in the room where the experiments were done cannot be the cause for possible significant mass deviations between test and control flasks.

Differences of Atmospheric Conditions Between the Balance Casing and the Surroundings

It could be shown that between the inside of the casing of the balance and the surroundings a temperature difference of two to three degrees existed. Thus, when the flasks were introduced into the casing of the balance for weighing, it could be expected that uncontrolled air convection might be generated leading to dynamical convection effects on the weight. In a special test the pan of the balance was connected via a stainless steel wire and a hole in the bench to a pan in a box below in which the temperature was identical to the surroundings. In this case a test with chemically non-active materials in the control and test flasks showed no significant measuring effect, similar to the tests where the flasks were weighed inside the casing of the balance.

Pressure Changes Inside the Flasks

In the eight test flasks of an experiment an internal absolute pressure of 3 bar was created by mixing a solution of sulfuric acid with an appropriate amount of sodium carbonate after sealing the flasks gas-tight. The pressure in the sealed control flasks was 1 bar, as usual. Even after a period of 30 days, no significant weight differences between the test and control flasks were found.

This indicates that minor changes in pressure inside the test flasks during an experiment on the order of $P_2 - P_1 = P_1(T_2/T_1 - I) = 0.003$ bar (with $P_1 = 1$ bar, $T_2 = 294$ K, $T_1 = 293$ K, and $T_2 - T_1 = 1$ C as the maximum temperature increase in-

side the test flasks due to the exothermic chemical reaction) could not affect the weighing results. In addition this result proves that the sealing of the flasks really created thermodynamically closed systems.

Electric and Magnetic Fields

It cannot be excluded that changing electric and magnetic fields in the neighborhood of the stored test and control samples can in principle influence the weight of the flasks, i.e., by influencing the external surface in view of water adsorption. In case of a test of constancy of mass of sprouting seeds such fields can in principle be created by the biochemical processes of the sprouting material.

To check the possible effect of electric and magnetic fields on the measuring effect, 1.2 Volt batteries were connected with an electric circuit containing magnetic coils, capacitors and resistors (in sequence and in parallel) and placed into four 250 ml sealed flasks. Over a period of 30 days the batteries gradually discharged creating changing magnetic and electric fields in the flasks. During this period the weight of these test flasks was compared to four control flasks filled partially with water. No significant mass differences could be observed.

Light Absorption in the Flasks

To check the influence of light adsorption in the test flasks, eight flasks were filled with black paper and the weight was monitored over a period of 30 days in reference to four control flasks. This test was done under the same light conditions as all others. No mass changes could be found.

Conclusions from Artifact Investigation

In summary, these pretests, done to study possible artifacts which could interfere with the mass of the flasks, demonstrate, as already mentioned, that according to the above described measuring procedure used in the experiments, a stable base line with no measuring effect could be verified in agreement with the law of conservation of mass. In total 65 experiments were done which all showed no significant deviations between test and control flasks. Maximum weight deviations of ± 0.1 mg between the control and test flasks of the three sets of glass flasks, which were used in the same combination as control and test flasks in the following experiments, could be detected due to the known effects and influences described in this section.

Repetition of Landolt's Silver Experiments

In a series of 12 experiments, using the above described measurement procedure, the weight of 8 sealed test flasks which contained an internal film of metallic silver generated in the sealed flasks prior to the first weighing, see above, was compared to 4 water containing control flasks over a period of five
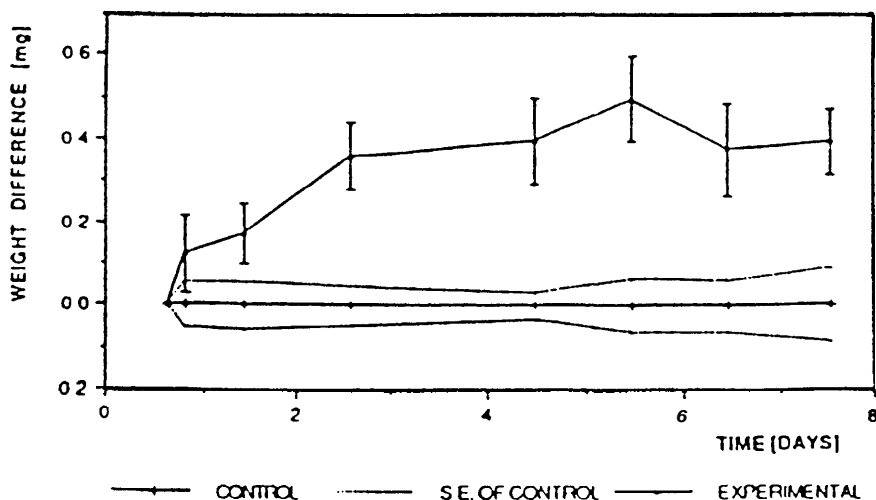
Fig. **3.** Repetition of Landolt's silver experiment. Control flasks contained 25 ml of water respec-
tively. Each test flask contained 20 ml of Tollen's solution and 5 ml of 2 molar glucose so-
lution, mixed after sealing the flasks, to produce metallic silver. The experiment was start-
ed at April 15, 1987 in U.S.A. A significant ($p < 0.002$) positive deviation between test
and control flasks was found.

to six days. The above measurement procedure was done every morning and
evening, in some cases only once per day.

In summary, 7 of the 12 experiments showed significant measuring effects,
i.e., significant weight and, by assuming constancy of gravitational force dur-
ing an experiment, thus mass deviations between the test and control flasks,
while in 5 experiments no measuring effect was found with results similar to
Figure 2. A typical result with a highly significant measuring effect ($p \, 10.002$)
is shown in Figure 3. In this case positive deviations of the mass of the test
flasks in the range of +0.2 to +0.4 mg with standard deviations on the order of
±0.1 mg were found.

In other experiments with significant measuring effects also negative devia-
tions in the range of -0.3±0.1 mg could be observed. Sometimes the deviations
followed a monotonic curve as in Figure 3, sometimes the deviation of the test
samples showed minima or maxima after 2 or 3 days. In one case the sign of
the deviation changed more or less linearly during the test from -0.4±0.1 mg
after one day to +0.4±0.1 mg after 5 days, and the overall measuring effect
showed a significant ($p \, 10.037$) deviation.

The observation of positive as well as negative deviations of the test flasks
from the base line are consistent with the results of Landolt, [1], [2], and [3].

Repetition of "Sprouting Seed Experiments"

In total, a series of 22 experiments with sprouting seed material (mung
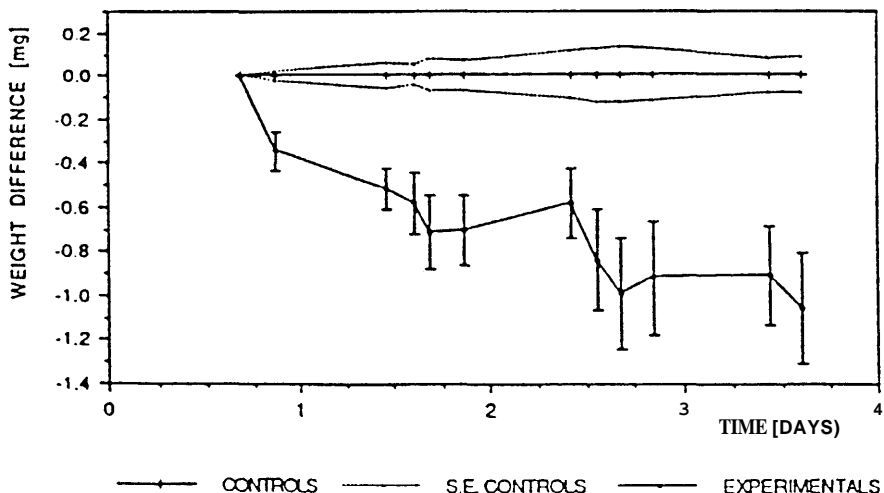beans) were performed applying the above described measurement procedure.

Fig. 4.   Repetition of Hauschka's experiment with sprouting seeds. The 8 test flasks contained 4 g
of mung beans and 8 ml of water, each, while the 4 controls were filled with 12 ml of
water, respectively. The experiment was started at April 30, 1985 in U.S.A. A measuring
effect with highly significant ($p < 0.0002$) negative deviation from the zero-line was
found.

Fourteen of these experiments showed significant measuring effects, indicat-
ing mass deviations between test and control flasks, while in 8 tests no devia-
tions could be found, similar to the results of Figure 2. A typical result with a
highly significant measuring effect ($p < 0.0002$) is shown in Figure 4. In this
case the 8 test flasks contained 4 g of mung beans and 8 ml of water, while the
four control flasks were filled with 12 ml of water, respectively.

As in the above described silver experiments the deviations in case of sig-
nificant measuring effects in these biological experiments were again positive
or negative with maximum values of $+2\pm0.75$ mg and $-6k\ 0.6$ mg. The corre-
sponding standard deviations of the control flasks were as usual about ±0.1
mg. The results are consistent with Hauschka's observations, cf. [6].

First Conclusions and the Formulation of a Working Hypothesis

The results described so far indicate that time-dependent positive or nega-
tive deviations from the law of conservation of mass can be found in thermo-
dynamically closed systems in which chemical or biochemical reactions occur.
The fact that the results were not unidirectional in nature agrees, as mentioned,
with the observations of Landolt and Hauschka (cf. [1], [2], [3], and [6]) and
was not a presumption of the experiments presented here.

In addition, the significant measuring effects described above, including
chemical and biochemical reactions in thermodynamically closed systems as

compared to chemically non-active materials in similar systems, follow a pattern which indicates that both sets of effects may have the same basic origin.

As a common feature of the chemical and biochemical experiments leading to the violation of the law of conservation of mass, newly created phase boundaries during the test may play a key role. In case of the silver experiments this is due to the formation of metallic silver from a homogeneous solution, while in the biochemical experiments the membranes of the newly generated cells in the sprouting seeds can be regarded as such phase boundaries.

As a preliminary working hypothesis it can be concluded that the measuring effects may be connected to the formation of microscopic and/or macroscopic new phase boundaries. To test this hypothesis the following experiments with purely physical systems, excluding chemical or biochemical reactions at all, have been done.

Weight Constancy of Purely Physical Systems (Rolls)

To scrutinize the constancy of mass for purely physical systems with newly created phase boundaries and without chemical reactions, two macroscopic physical samples with different shapes which had been newly assembled prior to the experiment from two sets of identical materials were used. Thus, in principle, two systems with newly created phase boundaries were obtained which could be used to test the above hypothesis. As described in the next section, the test sample was rolled up and had a capacitor-like structure while the control sample, which was constructed from similar materials of similar size, had a folded structure.

In total 21 tests with purely physical systems were performed from which 9 showed significant weight and thus mass deviations between test and control samples.

Detailed Description of the Preparation of the Purely Physical Samples

Both, the test and control sample consisted of two strips of polyethylene and two strips of aluminum foil, respectively. The dimensions of the polyethylene and aluminum strips before rolling up were approximately 140 x 18 x 0.005 cm and 130 x 14.7 x 0.005 cm.

To produce the capacitor-like test sample ("roll"), two polyethylene and aluminum foil strips were placed onto each other alternatingly and were rolled up. After rolling up, this sample measured approximately 18 cm in length. The outer of the four alternating layers was a polyethylene foil. For mechanical stabilization, the four foils had a tube-shaped core measuring 18 cm in length and 3 cm in diameter which had previously been made of PVC foil (0.5 mm thick) and which was secured by adhesive tape. After completion the entire device was put on a small iron wire frame forming the final test sample of mass m_{ti}. The outer surface area of this test sample was about 36.8 cm^2. The aluminum foil had practically no direct contact to the air.

The control sample, also measuring 18 cm in length, had also been made immediately prior to the experiment. It consisted of similar polyethylene, aluminum, and PVC foils as used for the test sample. Its shape, however, was different, as mentioned. The two superimposed polyethylene strips were each folded five times in the middle, respectively. The two aluminum foils were submitted to the same procedure. Together with the PVC foil which had been folded three times, the two stacks of polyethylene and aluminum foil, superimposed lengthwise, supported by the PVC stack, with the aluminum stack in the middle, were held together by a wire frame and represented the control sample of mass m_c The outer surface area of the control sample was about twice the outer surface area of the test sample. The surface area of the aluminum foil contacting the air was about 7 cm^2.

Artifact Research and Experimental Method for Tests with Purely Physical Systems

Immediately following sample assemblage, measurements with a sensitive Coulomb meter on both test and control samples were taken and no electrostatic charges could be detected. Both samples were stored after their assemblage for approximately 45 minutes in order to eliminate possible differences in temperature, and were then initially weighed four times, respectively. These measurements resulted in average values of $m_{,}$ and m_{c0} for test and control samples. The measurements were then continued for five or six consecutive days, with the samples being weighed morning and evening, four times during each session. Between sessions the samples were stored in a dust-free environment. From these measurements the averages m_{ti} and m_{ci} for test and control samples in each measurement session were obtained, i being the session number. In addition, for each session, at the beginning and the end, measurements were made on temperature, atmospheric pressure, and relative atmospheric moisture.

Balance, Experimental Method and Data Evaluation for Tests with Purely Physical Systems

Unless otherwise specified, the samples were weighed on mechanical scales, Sauter Typ 414, with a maximum charge of 200 g, a precision of ± 0.1 mg, and a standard deviation of $\sigma = 0.05$ mg ($n = 10$). As in all other experiments described in this section, the balance was calibrated before each session and reset before each individual measurement. All samples were handled with steel tweezers and leather gloves in order to eliminate localized atmospheric influences on test and control samples. The balance was placed so as to avoid shocks and vibrations or strong changes in atmospheric conditions.

For the determination of a measuring effect Δm_i of each weighing section, equation (1) was used, as above. In the case of constancy of mass for both test and control samples, the measuring effect Δm_i should be zero for all measuring series.
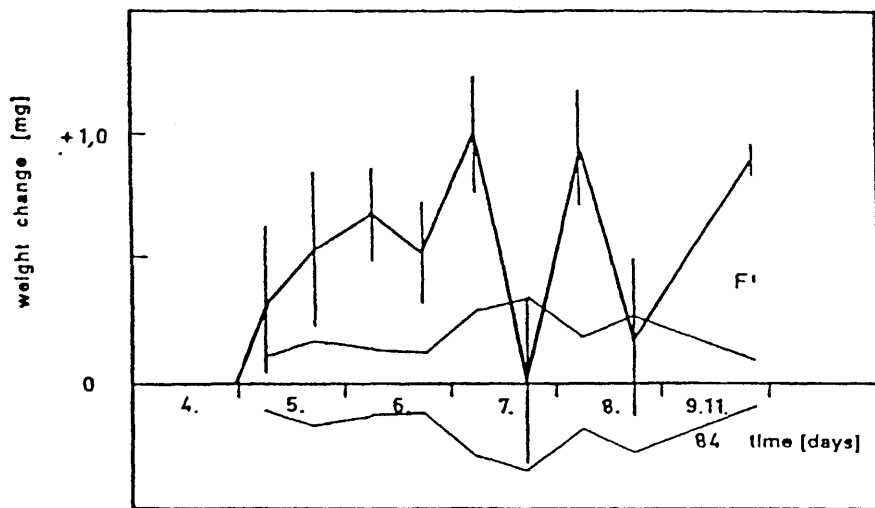
Fig. 5. Investigation of mass constancy of a purely physical test sample (roll) compared to a fold-
ed control sample. The experiment was started at November 4, 1984 in Germany. A sig-
nificant positive deviation from the zero-line was found for the measuring sessions 3, 4,
5, 7, and 9 in statistical t-tests. F indicates that the test sample was dropped from a height
of about 20 cm on the table before weighing. All experiments done in Germany have been
performed by K. Volkamer, the tests done in U.S.A. by C. Streicher.

Results and Statistical Tests Regarding the Measuring *Effects* with Purely Physical Systems

The results from an experiment with significant time-dependent deviations
of Δm_i from zero are given in Figure 5. For the measuring effects in Figure 5
(and in Figure 6), a 95% confidence margin of mean value Δm_i, as well as the
base line per session was specified. This was calculated by taking into account
the original measuring values and an error propagation using the correspond-
ing standard deviations of m_{ti}, m_{ti}, m_{c0}, and m_{ci}.

For the results in Figure 5 statistical t-tests, cf. [13], for various measuring
sessions (i = 5, Am, = 0.97±0.4 mg, p < 0.0032; i = 7, Am, = 0.9 ± 0.33 mg, $p <$
0.0034; i = 9, Am, = 0.88±0.18 mg, p < 0.0016) show deviations with maxi-
mum measuring effects from zero-line indicating violations of the law of con-
servation of mass even in this purely physical system where new phase bound-
aries had been created prior to the experiment. (See below, in connection with
the experimental results given in Figure 7, for a more sophisticated evaluation
procedure, in view of changing atmospheric conditions per measuring session
and further corrections of the original measuring values and the measuring ef-
fects in regard to linearity errors of the balance, air buoyancy and static as well
as dynamical water absorption processes on the surface of the test and refer-
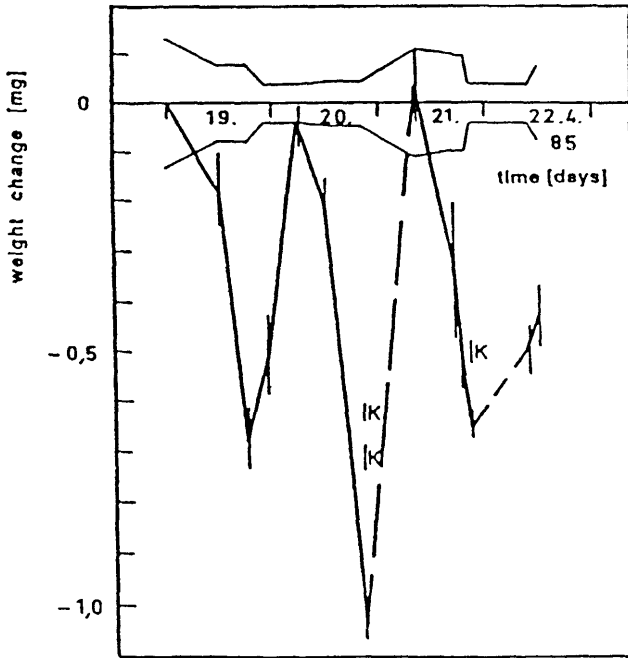ence samples).

Fig. 6. A repetition of the experiment shown in Fig. 5, comparing newly assembled rolled and
folded samples. The test was started at April 19, 1985 in Germany and showed significant
negative deviations from the zero-line. The dotted line indicates that the measuring effect
Am at first spontaneously jumped to lower values after knocking (K) the test and reference
samples and then, without any further disturbance, ran on to the next value.

Figure 6 shows the results from another similar experiment. Due to higher
precision of the scale (a mechanical Sartorius scale was used, with a maximum
load of 100 g and a reproducibility of ±0.01 mg), the 95% confidence margins
are smaller. Here the measuring effects Δm_i show negative deviations up to-
1.020.2 mg. When this experiment was continued for another three weeks, the
measuring effects finally fluctuated in an irregular manner above and below
the zero-line. In this continued period no significant deviation was found for
the whole set of measuring effects ($p > 0.23$).

Furthermore, in the context of experimental results shown in Figures 5 and
6, the following observations were made: when accidentally a sample dropped
from the tweezer onto the clean working table from a height of 10-15 cm, con-
secutive measurements showed minute spontaneous changes in weight as com-
pared to the general curve of results. In order to verify whether this was a re-
producible effect, the rolled test sample of the last session in Figure 5 was
intentionally dropped onto the completely clean and dry working table from a
height of approximately 20 cm. Repeated consecutive weighing showed a sig-
nificantly lower mean value *Am* than for the folded control sample, marked F
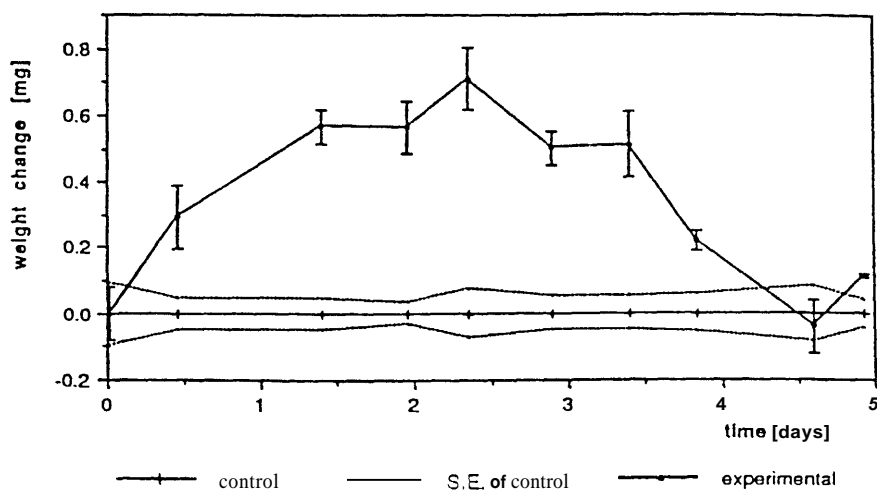
Fig. 7. A further repetition of the experiment shown in Fig. 5, comparing rolled and folded sam-
ples yielding highly significant ($p < 0.00005$) deviations of mass between test and control
samples. The test was started at June 14, 1987 in Germany. **All** measuring effects, Am,, are
threefold corrected with respect to linearity errors of the balance, air buoyancy and
minutely varying adsorption of water on the surface of both the rolled test and the folded
reference sample, after determination of model parameters for corresponding BET water
vapor isotherms.

in Figure 5. In the next experiment, shown in Figure 6, after obtaining the sec-
ond and third minimum values, both test and control sample were tapped
shortly with a dry and clean metal rod. While the rolled test sample showed no
noticeable change in weight, the weight of the folded control sample de-
creased, resulting in an increase of weight marked K in Figure 6. This was then
repeated after the first minimum value. The result again was an increase of the
mean value Am, whereas there was no change for the test sample.

Similar results in another experiment with significant deviations of Am,
from the zero-line, which are not discussed here, lead to the conclusion that
these observations may not be attributed to dust deposits on test and control
samples, which had been removed by the mechanical shock, since all samples
had been stored in a dust-free environment, but were based on actual experi-
mental effects.

*Quantitative, Critical Evaluation of an Experiment with a Purely Physical
System*

Yet another repetition of the same experiment is shown in Figure 7. In this
case, the diurnal rhythm, expressed clearly in Figures 5 and 6, is faint. In this
case the atmospheric conditions during the experiment varied, as also for the
other tests, only within small margins: T = 19.95±0.55 C, $P = 760\pm5$ Torr, and
$h = 61.6\pm2.9$ %. In this case, a very critical assessment of the original weighing

readings m for the test and control samples of each weighing session was done
to eliminate minor linearity errors L of the balance, varying buoyancy fluctua-
tions K, and systematic changes in water adsorption W on the surface of the
samples.

*Determination of Corrected, Absolute Mass Values of the Samples of a Purely
Physical System*

The following equation (2) was used to calculate for the test and control
samples of each measuring session the threefold corrected final, absolute mass
values m_a from the original readings m:

$$m_a = m + L + K - W \tag{2}$$

The L-values were determined experimentally by stepwise addition of cali-
brated weights to the balance. The buoyancy values K were determined from
the original atmospheric data readings prior and after each weighing session
according to the following equation (3), cf. [14]:

$$K = (m + L)\,\rho_a(1/\rho_x - 1/\rho_b)/(1 - \rho_a/\rho_x) \tag{3}$$

Here ρ_x is the density of the samples (test sample: $\rho_x = 1.4768$ g/cm^3, con-
trol sample $\rho_x = 1.4640$ g/cm^3, p, = 7.95 g/cm^3 is the density of the built-in
weights in the balance and ρ_a describes the density of the air as a function of
atmospheric pressure P in Torr, temperature T in C, and relative atmospheric
moisture F in percent cf. [14]:

$$\rho_a = 10^{-3}(0.464554P - F(0.002052T - 0.0205812))/(273.15 + T) \tag{4}$$

In order to calculate the mass W of the adsorbed waterskin on the samples
of each weighing session, for both test and control samples the parameters c
and W_m (molecular water layer) with respect to the individual BET isotherms,
[15], were determined from the original set of experimental data according to
(5).

$$W = cW_m z/[(1-z)(c-1)z] \tag{5}$$

With z = F/100 it followed for the parameters c and W_m in *(5)*for the test and
control samples, respectively that for the test sample, c = 3.07, $W_m = 7.0624$
mg; linear regression coefficient between calculated and observed data: $r =$
0.9639 with 95% confidence margins of 0.850 and 0.992; and for the control
sample: c = 3.52, $W_m = 7.6499$ mg; linear regression coefficient between cal-
culated and observed data: $r = 0.9925$ with 95% confidence margins of 0.967
and 0.998.

*Results Based on the Obtained Corrected, Absolute Mass Values of a Purely
Physical System*

With the equations (3), (4), and (5) as well as the experimentally deter-
mined parameters given above, threefold corrected measuring effects Δm_i from

absolute mass values m_a of test and control samples could be determined from (2) and (I). These threefold corrected final measuring effects are given with their standard deviations in Figure 7.

In statistical t-tests comparing threefold corrected measuring effects Δm_i, listed in Figure 7, with zero-line, significant differences for sessions $i = 2$ and 4 ($p < 0.01$) are found. The overall test using analysis of variance for repeated measurements yielded a highly significant ($p < 0.00005$) deviation of the measuring effects from the zero-line.

One could argue that the threefold corrected measuring effects are very sensitive to uncertainties of the reference values leading to displacements of all Δm_i values per experiment parallel to the zero-line. Even though this argument is ruled out by the highly significant overall test result ($p < 0.00005$) using the analysis of variance for the whole set of data, to check this argument further, a statistical test for linearity of the assumed linear correlation function Am, = Am,, where Am, is the mean value of the observed measuring effects, was done [16]. As a result of this test, the Null hypothesis had to be refused at the p < 0.0001 level. On the other hand, a quadratic correlation of the Δm_i-values led to a coefficient of the quadratic term which was significantly ($p < 0.0001$) different from zero in a statistical test [17], even though in both tests the errors of the zero-line were added to the errors of the measuring effects by error propagation.

Influences of Dynamical Diffusion of Water on the Results of a Purely Physical System

Eventually it became obvious that varying dynamic diffusion effects of water vapor on test and control samples could equally not be used in interpreting the results, i.e., a check for a linear correlation between the threefold corrected Δm_i measuring effects and the corresponding relative moisture values resulted in a correlation coefficient $r = 0.568$ which was not different from zero on a 95% significance level ($-0.15 < r < 0.89$, $p = 0.05$, $n = 9$).

Conclusions from the Quantitative Evaluations of a Test with a Purely Physical System

In summary, zero hypothesis, i.e., the observed differences in mass between test and control samples, after correction of linearity error of the balance and buoyancy bias, are attributable only to varying static or dynamical water adsorption of test and control samples, is therefore to be refuted. This leads to the consequence that even a purely physical system consisting of differently shaped and newly created phase borders can show time-dependent violations of the law of conservation of mass.

Synergistic Enhancement Between Silver Experiments and Rolls

The experiments described above are in agreement with the hypothesis formulated earlier that newly created phase boundaries in microscopic and
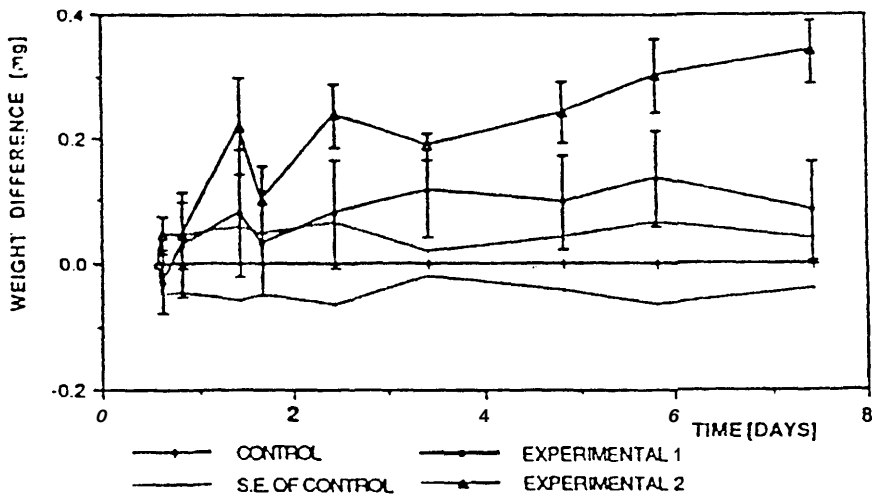
Fig. 8. Silver experiment with 4 tlasks (internally silver plated) in rolls and 4 flasks (internally silver plated) without rolls compared to 4 control flasks containing 25 g of glass balls, respectively (modified silver standard experiment). The test was started at October 27, 1987 in U.S.A. Deviations of silver in rolls compared to controls were highly significant ($p <$ 0.0001), while the 4 other test flasks (silver without rolls) showed a slight increase in mass compared to the controls without reaching a significance level ($p = 0.0854$).

macroscopic systems, with or without the involvement of chemical or biochemical reactions, can be the cause for time-dependent violations of the law of conservation of mass.

For further experimental test of causal correlations between the observed effects in chemical/biochemical and purely physical systems, the experimental methods were combined to look for synergistic effects between mass deviations in silver experiments and the capacitor-like samples (rolls) as described above.

Experimental Method, Balance, and Data Evaluation of "Silver Standard Experiments"

The experimental method described above, using the measurement procedure involving sets of twelve glass flasks was therefore modified in the following way (resulting in what is referred to in the following as the "silver standard experiment"): The silver experiments were done while four or eight of the test flasks were stored in capacitor-like rolls. To achieve this, aluminum and polyethylene sheets were wound around the glass beakers in which the test samples were stored, forming the rolls. The size of the sheets was approximately 150 x 12 x 0.05 cm. The diameter of these rolls was about 9.3 cm. (Of course, the test flasks were always weighed *without* these rolls and had no direct mechanical contact with them during the storage periods. The rolls around the glass beakers were not renewed in each experiment.)

Results of "Silver Standard Experiments" with and without Enhancement by Rolls

The results of a modified silver standard experiment are shown in Figure 8. In this case the 4 control flasks contained 25 g of glass balls, respectively. The 8 test flasks contained 20 ml of Tollen's solution and 5 ml of 2 molar glucose. Four of these test flasks were stored in glass beakers, around which the rolls were wound while the other 4 test flasks were stored in glass beakers without such rolls. As can be seen from Figure 8, the flasks stored within the rolls showed a significant increase in weight ($p \leq 0.0001$) when compared to the controls. The test flasks without rolls showed a slight increase compared to the controls without reaching a significance level ($p = 0.0854$).

This experiment was repeated five times. For each of the experiments the test flasks stored within rolls showed a weight change in the same positive or negative direction but of larger amount than those test flasks which had not been stored in rolls. In pooling the results of all these experiments the overall synergistically enhanced measuring effect between the two test groups, i.e., influence of the rolls on the measuring effect was highly significant ($p 50.01$).

The silver standard experiments where at least four test flasks with silver were stored within rolls and were compared to controls and/or other test flasks stored with or without rolls, was repeated in total 79 times, 72 times under atmospheric conditions, 3 times in a box with controlled external conditions, and 4 times parallel to another experiment done in blind from another experimenter. These 79 tests yielded the following results: From 72 experiments done under atmospheric conditions, 58 tests showed significant positive or negative deviations of the silvered test flasks from the zero-line.

Results from Tests in a Box Using the "Silver Standard Experiment"

Three further tests of the set of 79 experiments, all 3 yielding significant violations of the law of conservation of mass, were done in a box under constant temperature and humidity conditions. Under these circumstances the weight of the controls changed only due to pressure dependent buoyancy variations and could quantitatively be calculated from the initial weighing and the pressure readings of each measuring session, while this was not possible for the test samples.

Results from "Blind Experiments" with the "Silver Standard Experiment"

Another 4 of the set of 79 experiments were performed in such a way that a first experimenter weighed the pre-prepared 12 flasks which were wrapped in aluminum foil so that their contents could not be seen while a second experimenter, who had arranged also the first test set, did an experiment with a second set of 12 flasks in parallel but at a different place. Thus, the first experiment was done in blind. The distance between the two sites differed from 15 m to about 1000 m, and finally about 400 km. All 4 sets of two experiments, run
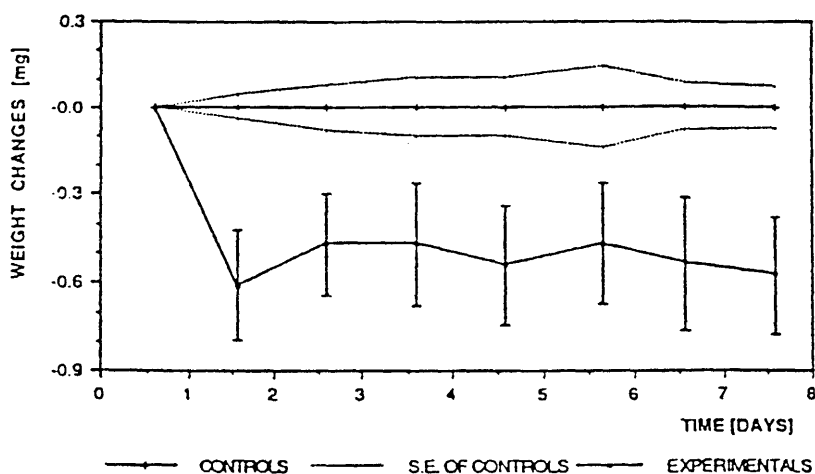
Fig. 9a. Silver standard experiment (8 internally silver plated test flasks stored in rolls, versus 4 controls containing similar amounts of water and being stored without rolls, respectively) done by a third person in a blind experiment. All flasks were wrapped into aluminum foil. The experiment started at October 16, 1987 in U.S.A. A significant ($p < 0.0285$) negative deviation of the measuring effect from the zero-line was found.
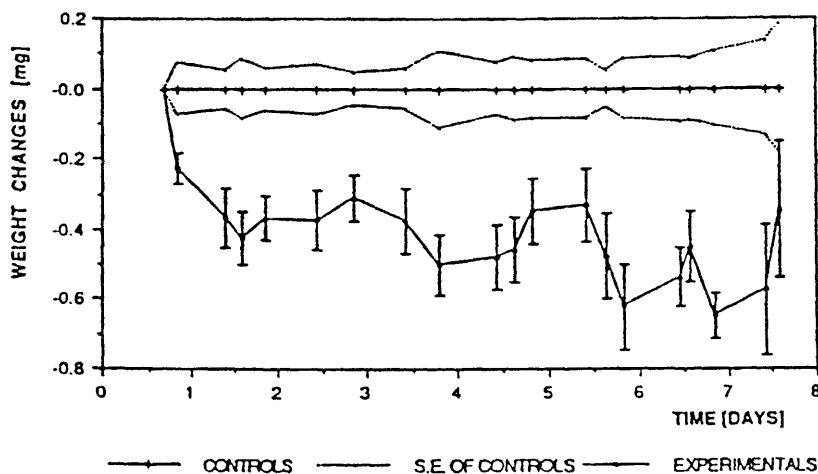

Fig. 9b. Parallel silver standard experiment to the test of Fig. 9a with identical set-up and separated by about 15 m. The experiment was started at October 16, 1987 in U.S.A. The measuring effects runs more or less parallel to that in Fig. 9a and show a highly significant (p < 0.0038) deviation from the zero-line. The p-value is lower compared to the p-value of Fig. 9a due to a higher number of readings.
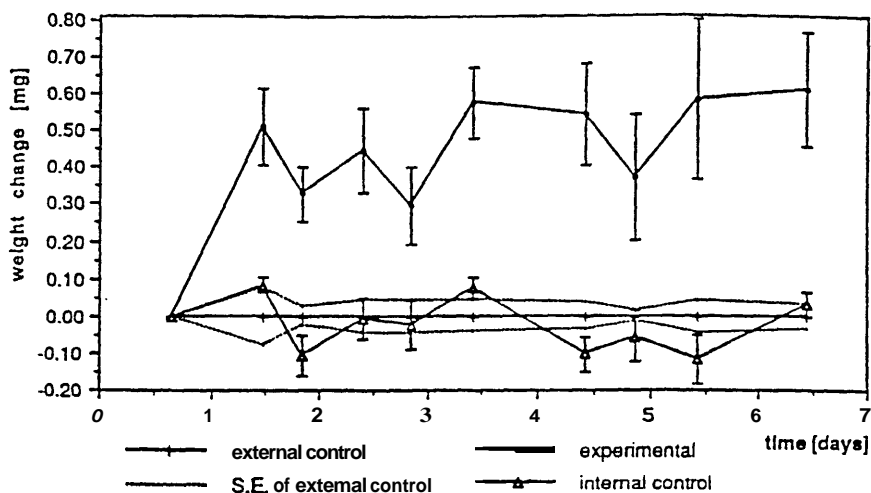
Fig. 10. Results of a modified silver standard experiment in which 4 controls, containing 25 ml of water, each, were compared against 4 test flasks, containing also 25 ml of water, each, and being not stored in rolls (as the controls), and 4 silver plated test flasks, being stored in rolls. The experiment started at February 18, 1991 in U.S.A. The sequence of weighing of the 8 test flasks was chosen randomly and was not known to the experimenter who weighed the flasks. No mass deviation effects ($p > 0.12$) could be found between the external water controls and the internal, water containing test flasks, while there was a highly significant ($p < 0.0005$) mass deviation between the pooled water containing flasks and the silvered test flasks, as well as between the silvered flasks and the internal ($p < 0.0046$) and external ($p < 0.0048$) water samples.

in parallel, showed significant deviations from the law of conservation of mass. A typical result is shown in Figures 9a and 9b. In all cases the curves in the two experiments run more or less parallel to each other with similar positive or negative deviations from the zero-line.

Results of a "Silver Standard Experiment" with a Randomly Selected Weighing Sequence

In another type of modified silver standard experiment, done in blind, the 12 flasks were also wrapped with aluminum foil. The 4 control flasks contained 25 ml of water. Four of the 8 test flasks also contained 25 ml of water and were not stored in rolls, while 4 other test flasks contained the silver producing chemicals (20 ml of Tollen's and 5 ml of glucose solution) and were stored within rolls as usual. The three sets of flasks were stored in groups with a distance of about 2 m between the groups. The weighing sequence of the water and silver containing test flasks was chosen randomly and the experimenter who handled the flasks during the weighing procedure did not know this sequence. A second person who had chosen the random sequence of the 8 test flasks in the beginning of the experiment handed the flasks to the experimenter with a tweezer
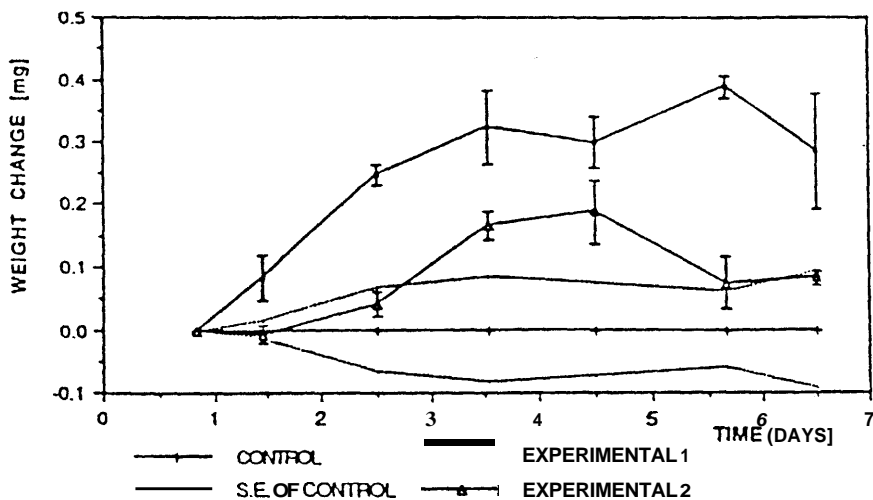
Fig. 11. Modified silver standard experiment with 4 flasks, stored in rolls, and 4 flasks with 25 ml of water, stored also in rolls, respectively, versus 4 control flasks containing 25g of glass balls, being not stored in rolls. The experiment started at February 21, 1988 in U.S.A. The mass difference between the two test groups (silver and water), both stored in rolls, is significant ($p < 0.0059$), while both the silver group ($p < 0.0033$) and also the water group ($p < 0.045$) showed significant deviations from the control group.

during the experimental sessions in the same randomly chosen sequence. The result obtained (see Figure 10) showed highly significant positive deviations for the weight of the silvered flasks compared to the pooled water containing test and control samples ($p < 0.0005$), as well as significant deviations between the silvered flasks and the internal ($p < 0.0046$) and external ($p < 0.0048$) water samples, while no significant ($p > 0.12$) deviation could be detected between the external controls and the internal water containing test flasks. This experiment was repeated once with similar results. By this test the argument that the experimenter who usually prepared and handled all the flasks during an experiment could influence the result by any bias was eliminated.

The fact that significant measuring effects could also be observed in these blind-experiments while all the 12 flasks of the experiments were wrapped into aluminum foil, respectively, excludes the possibility that different light reflective properties of the test flasks (silver plated) and control flasks (normal glass flasks partially filled with water) could be the cause for the significant measuring effects.

Results of Further Variations of "Silver Standard Experiments"

To test the enhancing ability of the rolls further, another test variation with the silver standard experiment was done. Four controls contained 25 g of glass balls, 4 test flasks 20 ml of Tollen's solution and 5 ml of 2 molar glucose solution while in the rest of the 4 test flasks only 25 ml of water were filled in. The
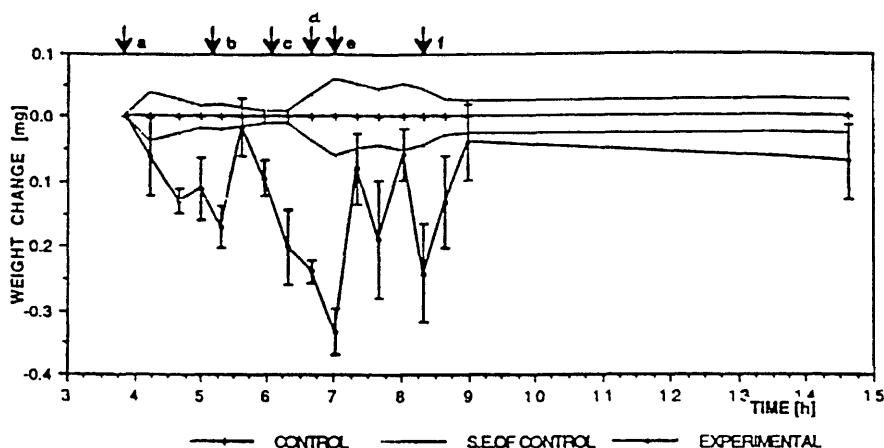
Fig. 12. Section of the silver standard experiment (test flasks internally silver plated, controls with
glass balls) from August 27, 1988 including the partial moon eclipse of August 27, 1988,
visible at the site of the experiment in U.S.A. The experiment was started at August 25,
1988 and ended at September 3, 1988. Before and after the moon eclipse no significant
mass deviations between test and control flasks were found. During the eclipse, however,
a time-dependent and highly significant ($p < 0.00005$) negative deviation was observed.
(a) Moon enters penumbra 3:52 UT; (b) Moon enters umbra 5:08 UT; (c) Middle of the
eclipse 6:04 UT; (d) Moon set 6:36 UT (e) Moon leaves umbra 7:20 UT; (f) Moon leaves
penumbra 8:18 UT.

test flasks with silver and those with water were both stored in beakers carrying
rolls, while the controls with glass balls were stored in beakers without rolls.

The result of this experiment is given in Figure 11. The weight differences of
the two experimental test groups, silver and water, were significantly (p <
0.0059) different from each other. But not only the silver group showed a sig-
nificant ($p < 0.0033$) deviation from the control group; also the test flasks with
water, stored in rolls, differed significantly ($p < 0.045$) from the controls.

When the amount of silver separated in the test flasks was varied, the mea-
suring effect also changed, but not exactly in a linear manner.

Results of a "Silver Standard Experiment" During a Lunar Eclipse

Furthermore, a silver standard experiment was done during a partial lunar
eclipse on August 27, 1988 which was visible from the experimental site in the
U.S.A. The experiment showed a stable baseline without any deviations be-
tween the control and test groups before and after the eclipse. During the
eclipse, highly significant deviations ($p < 0.00005$) could be observed. The re-
sults are shown in Figure 12. These results indicate that long range factors
seem to be involved in the observed time-dependent violations of the law of
conservation of mass. Furthermore they indicate that the findings reported
here, and the gravitational irregularities observed from Allais, [7], and Saxl,
[8], may have a common cause.

Conclusions from "Silver Standard Experiments"

From these results it is obvious that the rolls, as mentioned above, synergistically enhanced the measuring effects. On the other hand, as mentioned above, these findings indirectly revealed that the purely physical rolls can for themselves be used to demonstrate time-dependent violations of the law of conservation of mass.

In addition, the experiments described in this section give further support to the conclusion that the measured mass deviations in the silver experiments where chemical reactions are involved and in the purely physical systems, such as the described rolls, can also be attributed to the same common cause.

Synergistic Enhancement Between Biological Experiments and Rolls

The following experiments lead to the conclusion that the measured mass deviations in physical and in biological systems can also be attributed to a common determining influence.

Experimental Method, Balances and Data Evaluation of Enhanced Biological Experiments

In two experiments, done in parallel, starting in October 1984 in Germany, the conservation of mass of sprouting cress seeds in 4 test samples was determined by comparison with that of 4 similar control samples, respectively. In these experiments the above mentioned Sauter balance was used.

In the first set-up each of the 4 test samples consisted of a gas-tight glass tube (length 10.4 cm, diameter 3.2 cm) which contained about 0.5 g of cress seeds, deposited on a moist filter paper, and was inserted into a newly assembled capacitor-like structure (roll) as described above. All 4 control samples had an identical set-up, but did not contain any cress seeds inside the tubes.

In the second set-up, use was made of 4 gas-tight glass tubes, containing cress seeds deposited on a moist filter paper, and 4 corresponding control samples without seeds, as in the other set-up. The glass tubes in this second test were, however, not stored in rolls.

All samples in these two experiments were weighed twice per session. The means of both test and control samples were then evaluated according to equation (1).

Results and Conclusions of Enhanced Biological Experiments

A statistical evaluation of the data lead to the following results: The measuring effects Δm_i of experiment without rolls showed a significantly negative deviation from the zero-line ($p < 0.001$). In the experiment including rolls the negative deviation of the measuring effect Δm_i from the zero line was much more significant ($p < 0.000001$). In addition there was a significant difference between the measuring effects of the experiment with and without rolls ($p < 0.00001$).

These results show that there exists also a synergistic enhancement of the biological system by the purely physical rolls. It can be expected that in the experiment with rolls, differences in weight between the roll-supported 4 tests and 4 control samples would average out due to their identical set-up and that a comparison of both experiments should equally show no difference if such a synergistic enhancement would not exist.

Repetition of Landolt's Silver Experiment with a Comparator

In the following a test of the law of conservation of mass in chemical reactions using Landolt's silver experiment is described in which as balance a so-called comparator type C 1000 from Sartorius AG was used. This instrument can automatically and continuously weigh in sequence the weights of a set of four samples which in the beginning of an experiment are mounted in the instrument. This weighing technology with a weighing reproducibility of ±2 microgram presents the latest state of the art technology. Details of the experimental method are given in the next section.

Experimental Method of the Comparator Test

As thermodynamically closed systems four gas-tight sealed glass flasks were used, see below. Two flasks contained chemically inert materials and served as references. Two other flasks were used as test samples. In the test samples two solutions were stored separately, respectively, from which metallic silver could be generated after mixing.

In a baseline pretest, under thermally equilibrated conditions during which the chemical reactions were not yet started, the weight differences of all four flasks were automatically monitored over a period of about two days. Then the four flasks were mounted on a frame and tilted slowly, so that the two chemical components in the test flasks were mixed and metallic silver was generated within a few minutes. Then the weighing procedure was continued and the weight differences obtained after starting the chemical reaction and after reaching thermal equilibrium again, were compared to the baseline pretest.

Detailed Description of the Experimental Method of the Comparator Test

As balance, an electronic comparator from Sartorius AG, type C 1000, was used with a reproducibility of ±0.002 mg and a total load which could be varied stepwise from 100, to 200, 500 or 1000 g. The four samples (with a maximum diameter of 5.1 cm and a total height of 11.1 cm) could be mounted simultaneously in an experiment in the measuring house of the comparator. They were placed at symmetrical positions (N, P_1, P_2, and P_3; N and P_2 being opposite to each other), at the four corners of a square (4x5.6 cm) on a circular, metallic platform with 13.4 cm diameter. At its center this platform was connected by means of a vertical metal shaft to a mechanical device which was mounted on top of the measuring housing.

During the experiment this device lifted and stepwise displaced the four samples by 90, 180 or 270 degrees relative to the starting position (N), and placed them in a regular sequence (N, P,, N; N, P_2, N; N, P,, N) on the weighing pin. Such a weighing cycle took 40 min, including the printing of the obtained data. After printing the mass differences (P_1-N), (P_2-N), and (P_3-N) (taking the weight average of the beginning and end values of N, respectively), the next cycle started automatically. In this manner an experiment could be run over several weeks without opening the measuring housing or touching the samples. The whole comparator was, in addition, mounted for stabilizing the temperature in the measuring housing in an external insulating box made out of wood. During an experiment the internal temperature in the measuring housing was indicated electronically outside the external box. Controls showed that it remained constant within ±0.3 K during an experiment.

As thermodynamically closed systems 4 spherical 50 ml glass flasks were used, with flat bottom and ground joint neck, sealed gas-tight with glass stoppers with ground joint cone, using high-vacuum grease and steel springs. The flasks had identical external shape and deviated in volume less than ±0.5%, weighing after filling, as described below, 100.025±0.04 g.

Each of the four flasks contained 25 ml of Raschig-rings (small pieces of glass pipes, 5 x 5 mm, to increase the internal surface area) and an inserted glass pipe, standing in an upright position, which was closed at the bottom and in which 3 ml of a liquid could be filled in.

Two of the flasks served as test-flasks as mentioned. They each were prepared in the following way for the generation of metallic silver from two homogeneous solutions which were stored inside the flasks (first without mixing): 3 ml of an aqueous 2 molar glucose solution was given into the inserted pipe (which was standing in an upright position) while the other part of each flask contained 14 ml of Tollen's solution (prepared by mixing 20 ml of an aqueous 10% by weight silver nitrate solution, 10 ml of an aqueous 10% by weight sodium hydroxide solution and 17 ml of an aqueous 5% by weight ammonium hydroxide solution). In order to further increase the internal surface of the test flasks, a finely ground chemically inert crystalline material (0.2 g) was filled in each flask.

Two flasks contained similar amounts of distilled water and served as references, as mentioned. In addition these reference flasks each contained two sealed small glass pipes filled with crystalline forms of silver nitrate and glucose, respectively, so that similar chemical components were stored in all four flasks. Only in the test flasks, however, could the chemical reaction take place by mixing the chemical components. All four flasks were cleaned carefully with acetone on the outside surface to remove any traces of organic materials (except the ring of high-vacuum grease at the glass stoppers) and were handled afterwards with cotton gloves, and, after filling and sealing gas-tight, with 30 cm long steel tweezers.

After placing the two reference flasks (positions N and P_2) and the two test flasks (positions P, and P_3) in an upright standing position in the measuring
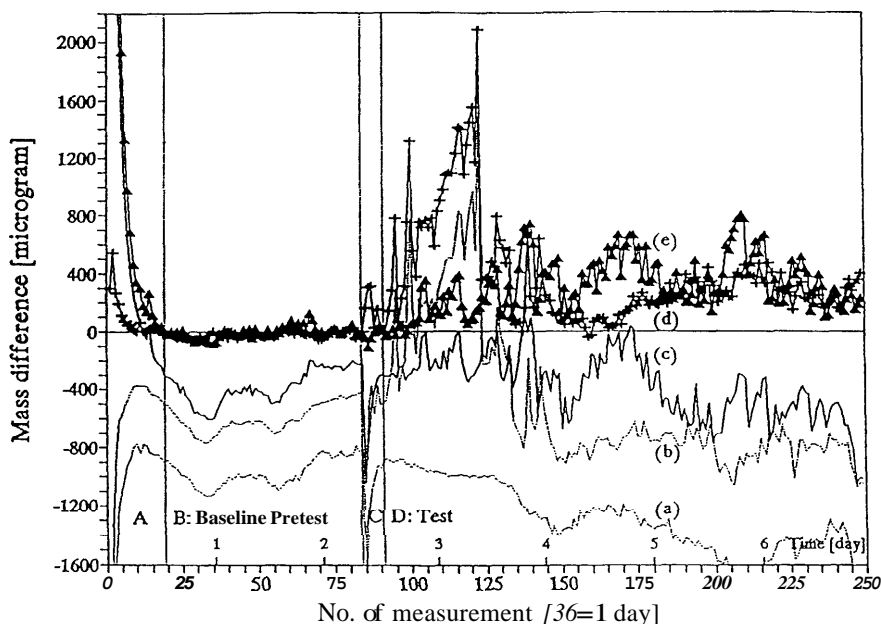
Exp. No. 12, **Start** Nov. 17, 91, 3:08 am

Fig. 13. Summary of results from an experiment done with a comparator in Germany to check the law of conservation of mass in chemical reactions using a comparator. "No. of measurement" runs parallel to the time axis. Periods A and C were needed to reach thermal equilibrium after mounting the four samples in the comparator. Period B depicts the baseline pretests before starting the chemical reaction which took place after measurement No. 84. Period D and curves (d) and (e) illustrate the actual tests.

house of the comparator (without mixing the two different chemical solutions in the test flasks), as described above, and closing the measuring housing as well as the external box, the comparator was put into operation. The start-up simultaneously put the mechanical device into operation which continued automatically to lift and turn the four mounted flasks, placing them in the above given sequence on the weighing pin during the whole experiment.

Experimental Run, Evaluation and Presentation of the Obtained Data of the Comparator Test

Typical results of such an experiment (experiment No. 12, started at Nov. 12, 1991) are shown in Figure 13. In total, 250 measuring cycles are given in this figure representing a total experimentation period of 6 days, 22 h and about 40 min (36 measuring cycles, 40 min each, could be run during one day).

Periods A and C in Figure 13 indicate numbers of measurement cycles, i.e. times which were required to reach thermal equilibrium after mounting the samples in the comparator. Period B depicts the baseline pretest. Period D

shows the actual test results after starting the chemical reaction and after reaching thermal equilibrium again. The actual test was started at the end of the baseline pretest, after measurement No. 84, by mounting and fixing all four samples outside of the comparator on a dry and clean frame, so that they could be tilted slowly. Thus the chemical reaction in the two test samples was started by mixing the internally stored two solutions. This operation, during which the four samples where handled with tweezers, as mentioned, without touching or opening them, took about 5 min while the reduction of the dissolved silver ions by glucose was completed within a few minutes, thus perfectly silver-plating the total inner surface of the test flasks. Then the samples were again mounted on the comparator and after a total of about 10 min of interruption the automatic weighing was continued.

Independent control tests showed that due to the exothermic formation of metallic silver the temperature rose in the test flasks by about 0.2 C which was much less than the thermal disturbance caused by taking the samples out of the comparator.

In Figure 13, a survey of all results obtained in this test is given. Figure 13, curve (a), shows the mass differences per measuring cycle, according to (6) in microgram:

$$N(t) = (P2(i)-N(i))-(P2(19)-N(19))-900 \tag{6}$$

$N(t)$ gives the mass differences between the two reference flasks in positions $P2(i)$ and $N(i)$ minus the same mass difference of measuring cycle 19, $P2(19)$ and $N(19)$ (index i gives the No. of the measuring cycle) for the whole test. Curve (a) in Figure 13 is displaced by -900 microgram parallel to the time axis to avoid superposition with the other curves. From a comparison of all other curves it can be seen, that from measuring cycle No. 1 through 18 (indicated in Figure 13 as period A) the whole system reached thermal equilibrium, corresponding to 12 h, see below. Curve (a) in Figure 13 illustrates how the mass difference between the two reference samples shifted due to minute fluctuations of the external atmospheric conditions.

Figure 13, curve (b), indicates the mass differences per measuring cycle, according to (7) in microgram:

$$T1(t) = (P3(i)-N(i))-(P3(19)-N(19))-500 \tag{7}$$

Tl (t) gives the mass differences between the test flask at position $P3(i)$ and the reference sample $N(i)$ at position N, minus the same mass difference of measuring cycle 19, $P3(19)$ and $N(19)$, for the whole test. The curve is displaced by -500 microgram parallel to the time axis and shows that these mass differences run more or less parallel, especially during the baseline pretest, to curve (a).

Figure 13, curve (c), similarly gives the mass differences per measuring cycle, according to (8) in microgram:

$$T2(t) = (PI(i)-N(i))-(P1(19)-N(19))-300 \tag{8}$$

$T2(t)$ shows the mass differences between the test flask at position $P1(i)$ and the reference sample $N(i)$ at position N, minus the same mass difference of measuring cycle 19, $P1(19)$ and $N(19)$, for the whole test. The curve is displaced by -300 microgram parallel to the time axis, and runs during the baseline pretest again parallel to curves (a) and (b).

Discussion of the Measuring *Effects* of the Comparator Test

Figure 13, curve (d), depicts, as a first test for the constancy of mass ("measuring effect" $ME1$), the mass differences per measuring cycle, according to (9) in microgram:

$$ME1(i) = ((P3(i)-N(i))-(P3(19)-N(19)))-((P2(i)-N(i))-(P2(19)-N(19)))\ (9)$$

$ME1(i)$ depicts the difference of Tl(t) from (7) minus $N(t)$ from (6) (except the values -900 and -500 microgram, added in (6) and (7)). By this mathematical evaluation the various fluctuations of the mass differences due to minute external changes in atmospheric conditions are eliminated. Thus, the final values of the measuring effect (+ signs in Figure 13) are scattering during the pretest around the baseline, as one has to expect for thermodynamically closed systems in which the conservation of mass holds.

Figure 13, curve (e), depicts as a second test for the constancy of mass ("measuring effect" ME2) the mass differences per measuring cycle according to (10) in microgram:

$$ME2(i) = ((P1(i)-N(i))-(P1(0)-N(0)))-((P2(i)-N(i))-(P2(0)-N(0)))\ (10)$$

$ME2(i)$ shows the difference of $T2(t)$ from (8) minus $N(t)$ from (6) (except the added values -900 and -300 microgram, added in (6) and (8)). Again, by this mathematical evaluation the various fluctuations of the mass differences due to minute external changes in atmospheric conditions are eliminated, and the values (full triangles in Figure 13) are scattering during the pretest around the baseline, as is to be expected for systems in which the conservation of mass is valid.

Conclusions from the Comparator Test and Comparison with Landolt's Results

The straight and horizontal line obtained during the baseline pretest at a mean value of -23.106 microgram, as depicted during period B indicates the following:

(1) After 12 h, starting from measurement No. 19 through 84, the whole system had reached thermal equilibrium and the varying external atmospheric conditions subsequently influenced the four flasks in the same way.

(2) The quality of the comparator is characterized by the standard deviation $\sigma = \pm 20.650$ microgram, $n = 66$, and the 95% confidence margin of $\sigma t/n^{1/2} = \pm 5$ microgram, which is larger than the above given value of reproducibility of ± 2 microgram due to minute differences in the ab-

solute volumes between the used flasks, leading to small differences in buoyancy (t = 2, student factor).

(3) The law of conservation of mass is (within the margins of the used experimentation method) perfectly confirmed during the baseline pretest.

After starting the chemical reaction between measurement No. 84 and 85, temperature equilibrium was again reached after another 5.3 h (measuring cycles No. 85 through 92, indicated as periods C in Figure 13). This can be seen from a comparison of the curves (a) and (c) in Figure 13 which both reached horizontal plateau values after measurement No. 92, after strong negative peaks due to thermal effects in period C. Thus the actual tests on conservation of mass proceeded from measuring cycle No. 92 through 250 over a period of 4 days and about 9 h, cf. periods D in Figure 13.

Because it is physically reasonable to assume that during the whole test the earth's acceleration remained constant and acted identical on the individual flasks in the respective weighing processes (which is confirmed in period B of the baseline pre-test), the observed weight differences in periods D of Figure 13 finally indicate mass differences. This means, that as a result of the tests, it can be stated, even without sophisticated statistical evaluation, from curves (d) and (e) in Figure 13, in comparison with the baseline pretest (period B) in both figures, that highly significant deviations from the law of conservation of mass could be observed.

It is of special importance that maximum measuring effects occurred from measurement Nos. 92 through 125 in period D, as indicated in curves (d) and (e) of Figurc 13, during which the mass differences between the two reference flasks (curve (a) in Figure 13) showed only very small fluctuations due to changing external atmospheric conditions, as compared to the baseline pretest of period B.

Landolt, cf. [1], [2], and [3], reported maximum deviations after some weeks of about 100 microgram which is in principle in good agreement with the values at the end of curves (d) and (e) in Figure 13.

Similar results indicating highly significant violations of the law of conservation of mass in the above described chemical reaction can be seen from the second test (curve (e), full triangles in Figure 13), even though the deviations are not so dramatic as shown in curve (d) of Figure 13.

As mentioned above, during silver-plating the temperature rose in the test flasks, due to the exothermic chemical reaction, by about $AT = + 0.2$ C. According to the special theory of relativity, this corresponded (with a sample mass of m = 0.1 kg and an estimated maximal heat capacity of a filled glass flask of $C_p = 4.3 \times 10^{-3}$ $J/(kgK)$ which is the value of water that is larger than that of Pyrex glass by a factor of 5.363) to a mass loss (Am) of the flasks into the surroundings in the following thermal equilibration process of less than $Am = mC_p\Delta T/c^2 = -9.4 \times 10^{-22}$ kg. This mass cannot be detected with present day weighing systems and cannot explain the mass deviations in the tests, cf. periods D of curves (d) and (e) in Figure 13. The above reported measuring effect is

thus larger than mass corrections from special theory of relativity by a factor of $(2079.5+23.106)/9.4 \times 10^{-13} = 2 \times 10^{15}$.

These results reflect at present the most significant experimental arguments that deviations from the law of conservation of mass occur in the chemical reaction first studied by Landolt, cf. [1], [2], and [3], and support the conclusion of sections 3 through 8.

Final Remarks

Landolt's research into the constancy of mass in chemical reactions, especially the reaction in which metallic silver is generated, started in October 1890, cf. [1] page 15. After 16 years of research on this topic, Landolt concluded in 1906, cf. [2] page 606, that the maximum experimental error in his tests was ±0.030 mg and he confirmed, as already stated in 1906, in his final report in 1910 (cf. [18] page 93) that there is a "complete certainty" that any deviation between the masses of his tested systems (before and after a chemical reaction) which exceeded this error would indicate a deviation of the law of conservation of mass. Landolt reported in 1906 (cf. [2] page 606) that he had used chemically inert materials in his samples to verify this statement. With this experimental experience which he had gained in 1906, after 16 years of research, as mentioned, Landolt reported maximum mass deviations between pre and post tests in which metallic silver was generated of -0.199 mg, cf. [2], see results in the table on page 608 as well as the comment on page 609, where he confirms the maximum error of this result of up to ±0.030 mg. Two years later, in 1908 (cf. [3] page 598) he reported that the determination of the maximum experimental error, using chemically inert materials, would have been omitted in the experiments of the 1906 report, and he used this (inconsistent) argument to state in view of the silver experiments which by far exceeded the experimental maximum error of ±0.030 mg (cf. [3] page 598): "I believe, therefore, to have to omit these observations as not certain." This evaluation therefore is not free from a subjective assessment of Landolt. Manley, cf. [5] page 260, who had repeated Landolt's silver experiments came to the conclusion: "The increase in the average variation here shown, though in itself small, is, we believe, definite, and we think that it is quite possible that as a result of the chemical reaction some at present unknown minute disturbing factor has been introduced; further research may bring this to light."

Recently, intensive studies on the so-called fifth force have been done. A careful examination of the fifth force experiments in the last few years, however, has led to the conclusion that no such stationary, short-range effects exist, cf. [19]. Compared to the fifth force research, which focused on the verification of a time-independent, short-range correction of Newton's law of gravity, the experiments described here verify the existence of time-dependent and long-range gravitational irregularities. An analysis of the sign and magnitude of the measuring effects in the above experiments indicated periodic variations at various scales, similar to other experiments described in scientific literature, cf. [20], [21], and [22]. Similar to the experimental effects reported in

[22], the observed gravitational anomalies reported here indicate that they are caused by cold dark matter, cf. [23], [24] and [25], which is detected by the described systems. Further studies should be done to clarify this point, as well as other observed anomalies which are reported in scientific literature. A detailed discussion of such anomalies, cf. [26], could give further support to the reported results but would exceed the scope of this report which shall remain focused on the presentation of the experimental findings.

From a theoretical point of view, an understanding of the observed gravitational anomalies is missing so far, although new kinds of matter as predicted from GUT and unified field theories, as well as other considerations, cf. [27], regarding observable forms of so far unknown forms of matter may be used to explain the described observations.

Acknowledgment

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Response to Volkamer *et al.*

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This paper claims to have established the existence of an anomalous variation in mass that results when reacting chemicals, biological entities, or even static physical systems are placed in sealed vessels whose weights are monitored on sensitive analytical balances. Furthermore, the authors then claim that the mass variations reveal the existence of dark matter. The paper presents an interesting dilemma for the reader. Was the work done carefully enough to support the purported anomalous variations in mass? Have all possible sources of bias been adequately investigated? Does the existence of dark matter follow logically from the experimental results? Denis Rousseau at Bell Labs has refined the concept of *pathological science* (scientific error from self-delusion and associated sloppiness) that was developed by the late Nobel Laureate, Irving Langmuir (Rousseau, 1993). Rousseau sees three major characteristics of such science:

(a) The claimed effect is at the limit of detectability or has very low statistical significance.
(b) The effect's discoverers are ready and willing to disregard prevailing theories and ignore criticism from experts.
(c) The discoverers do not conduct the critical experiments needed to determine whether the effect is real.

The characterization of honest but flawed scientific work as *pathological science* is inappropriate, but it should be recognized that Rousseau's three characteristics are pertinent to examining a controversial scientific study. In that respect, the claimed anomalous mass variations reported in this paper occur near the limit of detectability of the analytical balance. While the authors make an attempt to consider prevailing theories, there is considerable doubt in our minds that the critical experiments were performed, or performed adequately.

In the Introduction, the authors survey previous work, primarily by Landolt (1893,1906,1908) and Manley (1913). They state that Landolt rejected apparent violations of the law of conservation of mass in the silver-generating experiment by averaging between such results and subjective assessments. Manley, in his paper on the apparent change in weight during chemical reaction, repeated Landolt's silver experiments, but is quoted totally out-of-context by the authors in the Final Remarks section, when he discusses an "unknown

minute disturbing factor" causing an increase in the average measurement variation. They do not report Manley's final statement in his paper, "we are led to conclude that this present research has tended but to confirm the truth of an almost universally accepted belief, that a given total mass is an unchanging and unchangeable quantity." When investigating the effect of reaction-induced changes in vessel internal pressure, Manley built an apparatus in which the change in the flask volume could be measured by liquid displacement. He determined significant weighing anomalies caused by temperature inhomogeneities and pressure variations, and his paper is a model of careful scientific work. The "unknown minute disturbing factor" that Manley describes is on the order of 0.004 mg, several orders of magnitude smaller than the anomalies measured in the Volkamer manuscript. Manley reports that the apparent increase in total mass in his experiments was 0.001 mg, which is 6 times smaller than the average variations of the experiments. Contrast this careful work to that of the current paper, where it is reported in a short paragraph that eight flasks were filled with sulfuric acid and sodium carbonate to create an internal pressure of 3 bar, and that no weight differences from a control were observed after 30 days. This is not to say that they should have seen an effect. Based on Manley's work, they should not have, because the effect is almost an order of magnitude lower than the readability of their balance. But this manner of investigating and reporting possible experimental sources of error is typical of the paper. A more fundamental weakness in their work is the sensitivity of the balance. They are using balances whose sensitivity is one to two orders of magnitude poorer than that used in the experiments almost a century ago. These balances would be unable to resolve most of the effects reported by Manley and Landolt. The effects reported in this paper are much larger than those reported by the previous researchers.

There are several other critical weaknesses in the Volkamer paper. The use of electronic balances, rather than the classical two pan mechanical balances used by Landolt and Manley, make the measurements more sensitive to exotic sources of error such as electromagnetic interference and static charge. The AE163 balance reported by Volkamer to have an "accuracy" of 0.1 mg and a standard deviation of 0.04 mg is reported by the manufacturer to have a readability and a reproducibility (standard deviation) of 0.1 mg. The U.S. Pharmacopoeia requirements for accurate weighing establish a criteria for accuracy that is 3 times the standard deviation of the balance, or 0.3 mg for this balance. Therefore, many of the anomalous results observed by Volkamer are close to the limits of the balance measurement capabilities. The glass flasks should have been coated inside and out with an electrically-conductive material such as tin oxide before beginning the experiment. Large glass flasks are very difficult to weigh because of conductivity effects. In the plant experiment, the moisture content inside the flask will change as the plant grows, changing the conductivity and inducing apparent mass anomalies. Ideally, the inner and outer surfaces of the flasks should have been electrically connected and the flask and balance pan grounded via fine wire. Again, a comparison of experi-

mental technique between the present authors and that of Manley is striking. Perhaps most importantly, a consistency of effect is not seen. Both mass gains and losses are reported, but not for all samples. This has all the trappings of an uncontrolled measurement bias.

Finally, assuming the constancy of kinetic and potential energy equations throughout the universe and the validity of the Doppler effect and Hubble's constant, it is fairly easy to show that the universe may have from 90% to 99% dark matter of some kind, if the universe is closed (less if not). The maximum amount works out to about 10^{-26} kg/m^3, or -10 amu/m^3. Because the experimenters found discrepancies $\sim 10^{-11}$ kg/m^3 that they attribute to dark matter, they are claiming to have produced (or attracted?), in their small containers, about 10^{15} times the density needed throughout the universe. That would be 10^{16} particles/m^3 if each had a mass of 1 amu. Now because no one knows what dark matter is (but it clearly includes at least some understood stuff like asteroids and planets that we just can't see), we suppose they can make this claim, but then they should be willing to take their experiment to one of the dark matter detector experiments that have been established to find just one particle unequivocally! It is even less likely, if that's possible, that their process merely attracted dark matter from somewhere else because it is generally conjectured that non-baryonic (non asteroids and such) dark matter is affected only by the gravitational force or else it could be made to radiate and be seen. In any case, they simply do not have sufficient basis to prefer their Conclusion C over Conclusion A.

In conclusion, since the weighing anomalies observed were not consistent within experiments, and since their results did not agree with the more careful work of Manley, insufficient evidence exists to establish the weighing anomalies as anything more than uncontrolled experimental bias, most likely caused by buildup of static charge.

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ERRATUM

Figures 1 and 2 of the paper, "Bayesian Analysis of Random Event Generator Data," which appeared in the *Journal of Scientific Exploration,* 4, 153-169, were drawn incorrectly. Corrected versions are shown in Figures 1 and 2 of this note. The effect of the change is to marginally strengthen the conclusions of the paper.

In addition to correcting the figures, the following changes should be made in the body of the paper:

1) On p. 161, second paragraph, change "0.55" to "0.534" in both places. Change "0.5025 to "0.5017" and "0.4%" to "0.34%."
2) On p. 163, first paragraph, change "0.59" to "0.566" and change "0.505" to "0.5034."

I am indebted to Topher Cooper for discovering this error. I apologize to any who may have been inconvenienced by it.

William H. Jefferys
Department of Astronomy
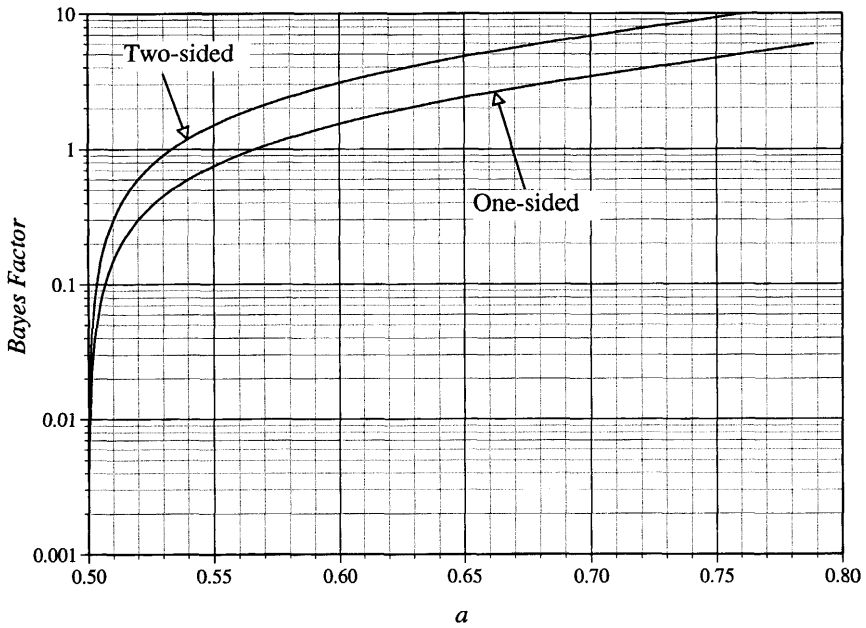*University of Texas at Austin*
Austin, TX 78712

Erratum

Fig. 1. The Bayes factor as a function of *a*. Top *curve:* Two-sided alternative. *Bottom curve:* One-sided alternative.
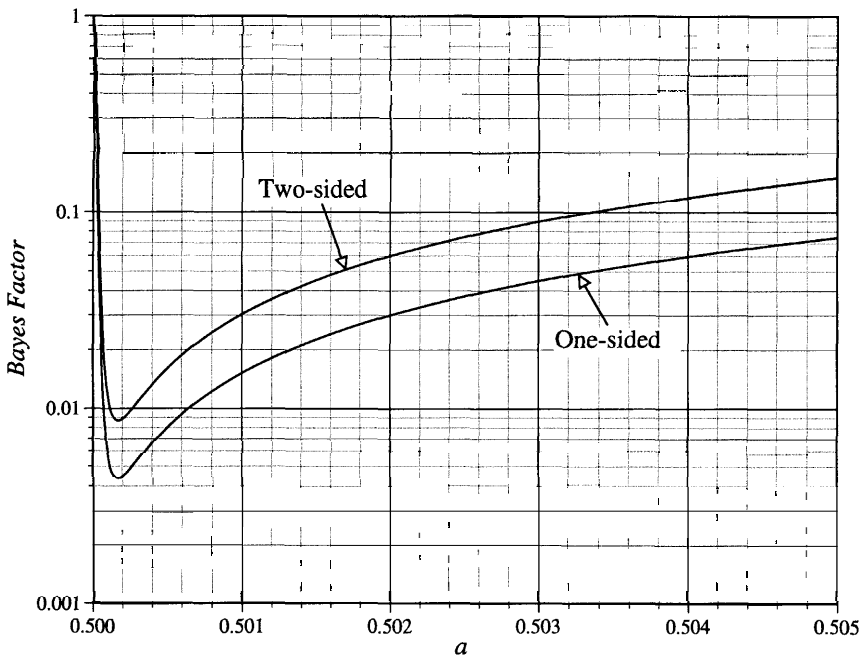

Fig. 2. Blowup of the region of Figure 1 near *a* = 0.5.