Distance.nb

Farest Distance Ever Measured

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Last Calculation: 10. 1.2003 Norbert Südland
Last Correction: 9.10.2006 Norbert Südland

■ 1.1. Question

■ 1.1.1. Motivation

Jeremiah let write down (Jeremiah 31,37):

37. Thus saith the LORD; If heaven above can be measured,
and the foundations of the earth searched out beneath,
I will also cast off all the seed of Israel
for all that they have done, saith the LORD.

In this text two factual statements, actually having nothing to do to each other, are coupled, namely the existence of Israel and the measurability of outer space.

This Bible cite has been the contentional reason for discrepancies and disputations between physics and theology. The question for the farest measured distance has played a role to both of these research groups.

■ 1.1.2. Definition of Measurement

The solution of this problem consists in measurement. This problem is purely physical. The philosophic discussion starts where near to the limit of measurability is disputed about evaluation of the experiment.

A measurement within the meaning of the Holy Bible roots back to the following maxim (Deuteronomy 19,15):

15. One witness shall not rise up against a man for any iniquity,
or for any sin, in any sin that he sinneth:
at the mouth of two witnesses, or at the mouth of three witnesses,
shall the matter be established.

There is no way to vote democratically about natural laws, but in spite of this at least two *witnesses of measurement* are necessary to speak of *measurement*. This leads to the following definition:

A successful measurement is characterized by
an unequivocal deviation tolerance.

The deviation tolerance results from the declarations of several witnesses of measurement.

■ 1.1.3. Determination of the Deviation Tolerance

Carl Friedrich Gauß (1777-1855) established *deviation calculus* and *equalization calculus*, which based on a mathematical over-determined problem yields a justifiable compromise to lead from formally contradictuous *individual measurements* to *assured literal worths and their specific tolerance*.

The skill of *deviation* and *equalization calculus* is learned best on a concrete problem of measurement, more than sometimes at a practical course or at least on the job, when a *checking measurement* results surprisingly.

■ 1.2. Measurement of Distance in the Outer Space

■ 1.2.1. How Not To Do

Measuring of distances in the outer space cannot be done by using a proper yard-stick.

■ 1.2.2. How to Do Perhaps

Land surveying is done by determination of angulars being seen to bearing rutes, where with respect to the curvature of the earth sensible compromises are to be found to do carthography.

When distance to a space body is measured, its angular deviation to the fixed stars is determined. This works with planets quite well and quite accurately, where already occur problems to do a checking measurement:

⌚ How to evaluate, if the beam of light is not rectilinear, but curved?

According to the information being present to me, there is a free dropping even of light, namely a deviation by a gravitational field of a star or of the earth.

The supposition of rectilinear spreading of light historically lead to the deduction of Kepler's laws (being approximative?) and thus again to the deduction of Newton's gravitation law. At the end there is the proof of a free dropping of light within the gravitational field of the earth.

For *"exact"* philosophers the practicability of distance measurement already is *"impossible"* because of this as soon as a bearing rute is used to measure distance.

The deviations of the planets compared with the fixed stars are so large and regularly, that Kepler's laws being another representation of the zycloides of Ptolemaius are not totally wrong. Thus there is at first a need to look for an independent *checking measurement* to confirm the results at least according to the order.

■ 1.2.3. How to Do Actually

■ 1.2.3.1. Determination of Light Velocity

The independent checking measurement is the runtime of light from the earth to a planet and back again. For the first time in 1676, Olaf Römer (see [BS1993], **III Optics**, section 2.1.1, pages 190-191) determined an influence of light velocity to the observation of planets, and based on the assumption of Kepler's laws he yielded a light velocity of $\mathbf{214000\,km}/s$. In 1728, Bradley (see [BS1993], **III Optics**, section 2.1.2, pages 191-192) confirmed the influence of light velocity to a minimale deviation of the "fixed stars" up to $\mathbf{41.2\,\frac{''}{annum}}$ in connection to the running of the earth around the sun. From this at least by today's methods of measurement can be determined light velocity to be at $\mathbf{298000\,km}/s$.

The experiments to determine light velocity in the end resulted in 1967 the best value of $\mathbf{(299792.5 \pm 15)\,km}/s$ (see [BS1993], **III Optics**, section 2.1.5, pages 195-197), while in 1972 via runtime measurement to a mirror placed on the moon resulted a light velocity of $\mathbf{(299792458 \pm 18)}\,m/s$ (see [BS1993], **III Optics**, section 2.1.5, page 196) - distance could not be measured simultaneous by this! Also in 1972 (by Barger, Hall and others), light velocity has been determined in a laboratory to be $\mathbf{(299792458 \pm 1, 2)}\,m/s$ (see [BS1993], **III Optics**, section 2.1.5, page 196).

■ 1.2.3.2. Combination of two Methods of Measurement

By combination of sight angulars and runtime of light with mirrors, distance measurement is mathematically over-determined, because a checking measurement is respected. Within the limits of equalization calculus the result is gotten out, that uses the best combination of both methods.

The largest distance being measured by this kind of work, is the distance to the planet Pluto. It has been calculated based on Kepler's laws from angular deviations and has been confirmed by both of the Voyager probes via a runtime difference duration of the instruction signals of **12 hours**.

■ 1.2.4. Result

The farest distance measured so far in the outer space has got **6 light hours**, being a distance of

$$\mathbf{result} = c\,t\ /.\ \left\{c \to 299792458\,\frac{\text{"m"}}{\text{"s"}},\ t \to 6\,\text{"h"}\right\}\ /.\ \{\text{"h"} \to 3600\,\text{"s"}\}$$

6475517092800 m

namely corresponding to **6 Tm**. All farer distance values are theoretical extrapolations and need a checking measurement yet, to be important. The choice of evaluation theory is free as long as no measured value is against it.

It turns out that the light hour to be a measurement of far distances is quite helpful. Its value is

$$\mathbf{lighthour} = c\,t\ /.\ \left\{c \to 299792458\,\frac{\text{"m"}}{\text{"s"}},\ t \to 3600\,\text{"s"}\right\}$$

1079252848800 m

By this result even a literally understood **7 day** creation (Genesis 1) is valid, where in the morning of the fourth creation day also planet Pluto would have given his light to the earth if not the sun had been in between - this kind of accuracy is given to reconstruct the moving of stars by calculation!

If the limits of theology and physics respectively are noticed then both of them complete in a great manner (see Psalm 111,2):

2. The works of the LORD [are] great, sought out of all them that have pleasure therein.

■ 1.3. Protocol

The *Mathematica* version has been:

{$Version, $ReleaseNumber, $LicenseID}

{Microsoft Windows 3.0 (October 6, 1996), 0, L4526−3546}

The calculation time was (in seconds):

TimeUsed[]

0.39

Literature

The Bible, Authorized King James Version, Oxford University Press, (e.g. 1994)

[BS1993]
Bergmann L., Schaefer C. *Lehrbuch der Experimentalphysik* **Volume 3 Optics**, de Gruyter Berlin, 9th edition, (1993)