On Aberration of Light and Reflection from Moving Mirrors

by

Florian Michael Schmitt

30th March 2018

Abstract

This paper is endorsing the possibility that electromagnetic waves might be reflected differently by moving mirrors in comparison to resting mirrors following a logic conclusion on Huygen's principle [1], thus the common law upon which the incident angel would equal the reflected angle would be not valid on such systems. A static ether concept [2] will be tested on the assumption that angles will be deflected in correlation of relative velocities of the transversal movement of the observation setup against the emerging center of one particular light wave front. Further on it will be demonstrated that reflection angles from any ray emerging from sources laying at the focal point of a parabolic mirror then will not be reflected parallel to the parable's axis but on a distinct differing angle that proves to be quite identical with the resultant angle of both velocity components of ray and mirror at any transversal movement of source and observer. Moreover it will be shown that this applies on multiple reflection between two parabolic mirrors with congruent focal point as in principle being used for laser arrays as well.

1. Introduction

All following examinations are based on the assumption that electromagnetic waves propagate as follows, and particularly as waves at all, whereby conclusions from the Special Relativity [3] will be excluded. Merely classic mechanic and dynamic principles will be applied:

- Individual light wave fronts move relatively to their emission point regarding velocity and direction, independently from the source's and observer's movement.
- Individual light wave fronts are not affected from each other and not tied together by a medium, contrarily to sound waves.
- The fixed reference system for each light wave front is only the emerging point of the said light wave front in space, not to be confused with the source's position or velocity.
- The classic Doppler- effect applies for any moving light source [4].
- The relative velocity between one wave front and the moving observer is varying accordingly to the observer's velocity against absolute space.
- The classic Doppler- effect applies for any moving observer [4].

2. Reflection from moving mirrors

A wave front is moving against a mirror that is tilted by 45 degrees and resting against the emerging point of the wave. The first edge of the front reaches the mirror prior to the adjacent edge and therefore will be reflected sooner. Considering the paths of four differing points on the wave front, those will be reflected displaced in time and thus we obtain the classic reflection angle according to Huygen's principle [1].

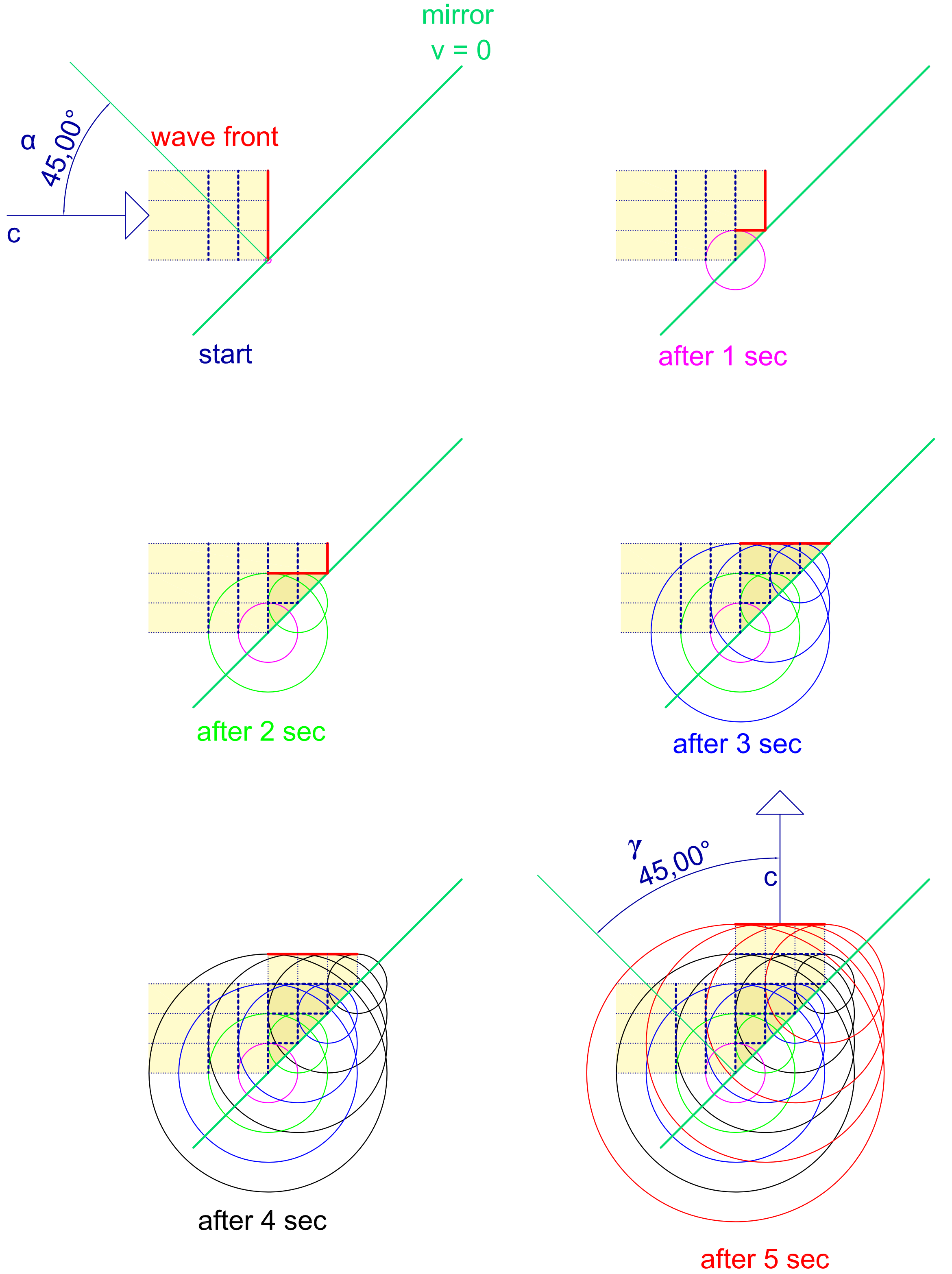

Fig. 1: Principle of classic reflection based on Huygen's principle

A merely logical derivation from this principle must be that if now the mirror is moving off the light wave front, the later edge of the wave front will be reflected with additional time compared to the prior edge because the mirror has again moved forward after the first edge has already met. Using a graphic representation with cad, it already becomes visible that the reflection angle of the wave front has varied, whereby no change of wave length occurs. The issue was in the past already worked out by Paul Marmet [5] and also by Aleksandar Gjurchinovski [6], but with either significantly different mathematic results.

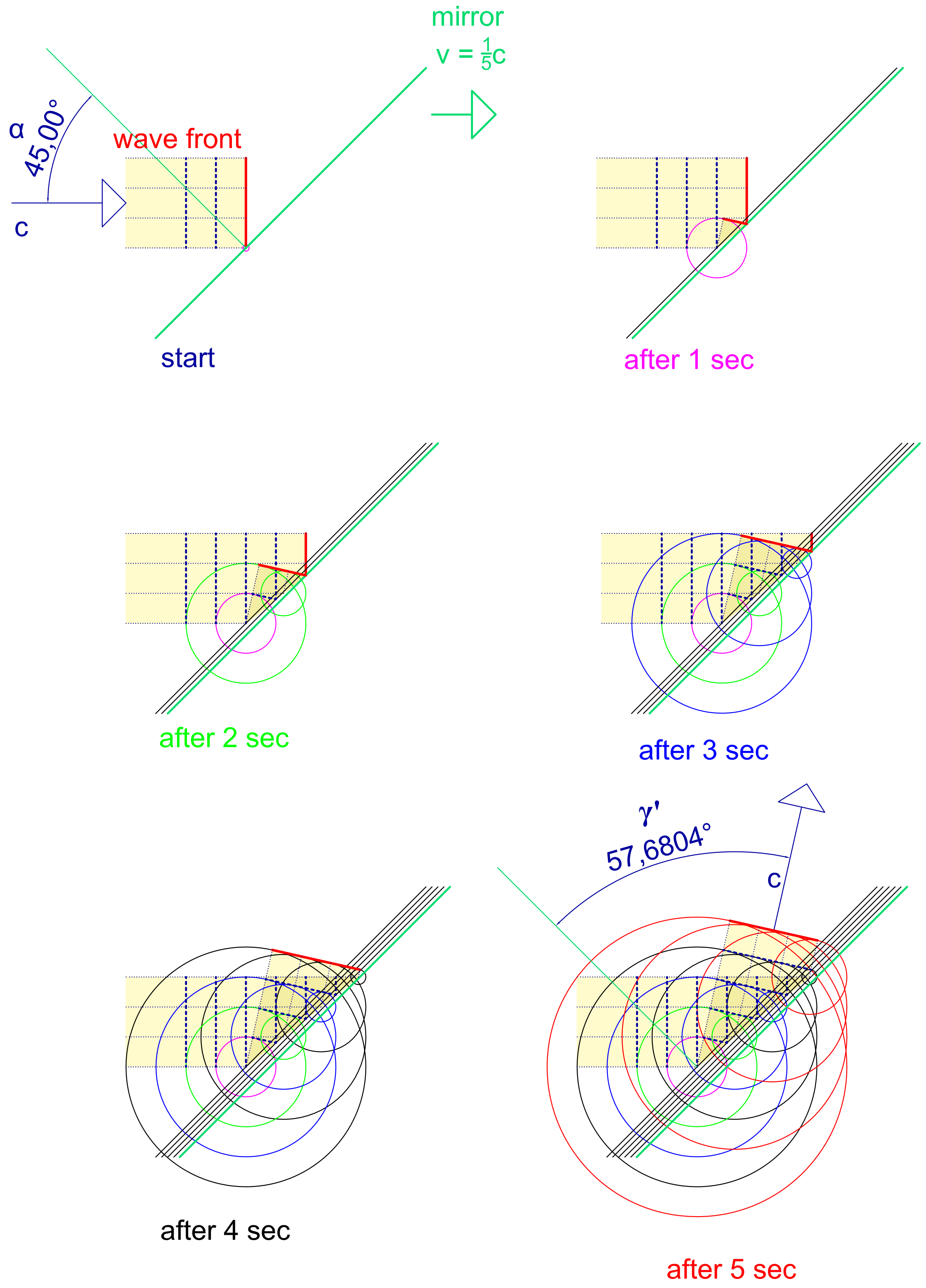

Fig. 2: Principle of reflection from moving mirror, based on logical derivation from Huygen's principle

Upon the geometric consideration the change of reflection angle in dependence of mirror's velocity against the emerging point of wave can be obtained as follows:

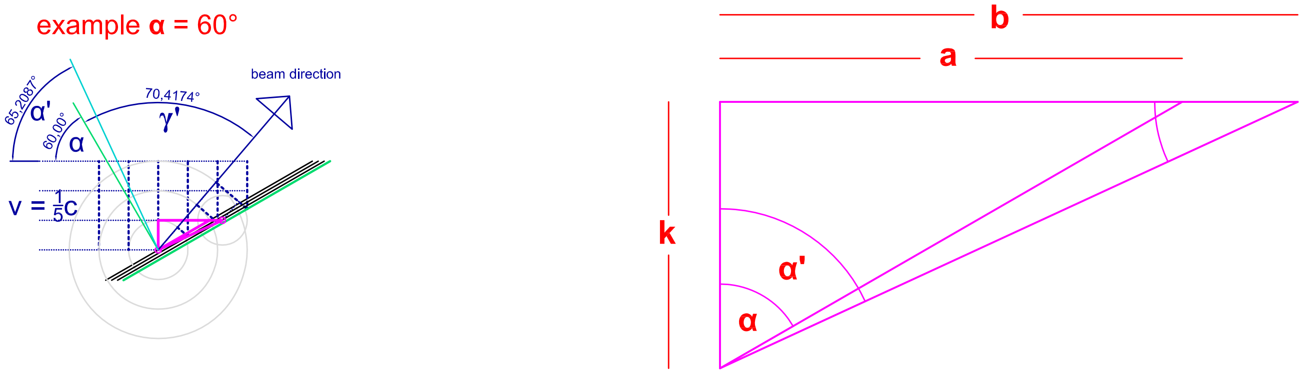

Fig. 3: Geometric situation at moving mirror and effective tilt angle

Due to the time shift of wave front points hitting the mirror we can assume a new, virtual or effective tilt angle of the mirror as shown in fig. 3 to calculate the reflection angle.

(1) $$\tan(\alpha) = \frac{a}{k} \Rightarrow k = \frac{a}{\tan(\alpha)}$$

(2) $$\tan(\alpha') = \frac{b}{k} \Rightarrow k = \frac{b}{\tan(\alpha')}$$

(3) $$b = \frac{a}{1-\frac{v}{c}}$$

(1) and (2) results:

$$\frac{a}{\tan(\alpha)} = \frac{b}{\tan(\alpha')} \Rightarrow a \cdot \tan(\alpha') = b \cdot \tan(\alpha) \Rightarrow a \cdot \tan(\alpha') = \frac{a}{1-\frac{v}{c}} \bullet \tan(\alpha)$$

$$\tan(\alpha') = \frac{a}{1-\frac{v}{c}} \bullet \tan(\alpha) \cdot \frac{1}{a} = \frac{\tan(\alpha)}{1-\frac{v}{c}}$$

$$\alpha' = \arctan\left(\frac{\tan(\alpha)}{1-\left(\frac{v}{c}\right)}\right)$$

α' is the new effective tilt angle of the mirror. Thus we obtain for the new reflected angle towards the perpendicular to the mirror:

$$\gamma' = 2 \cdot \alpha' - \alpha$$

$$\boxed{\gamma' = 2 \cdot \arctan\left(\frac{\tan(\alpha)}{1-\left(\frac{v}{c}\right)}\right) - \alpha}$$

The formula was double-checked by means of a cad image for several angles.

3. Refraction on a moving body

A similar principle applies for refraction of a wave front from a moving body with a different refraction coefficient. According to classic physics (Snellius's law) [7] the refraction can be inspected again by considering four points on the wave front.

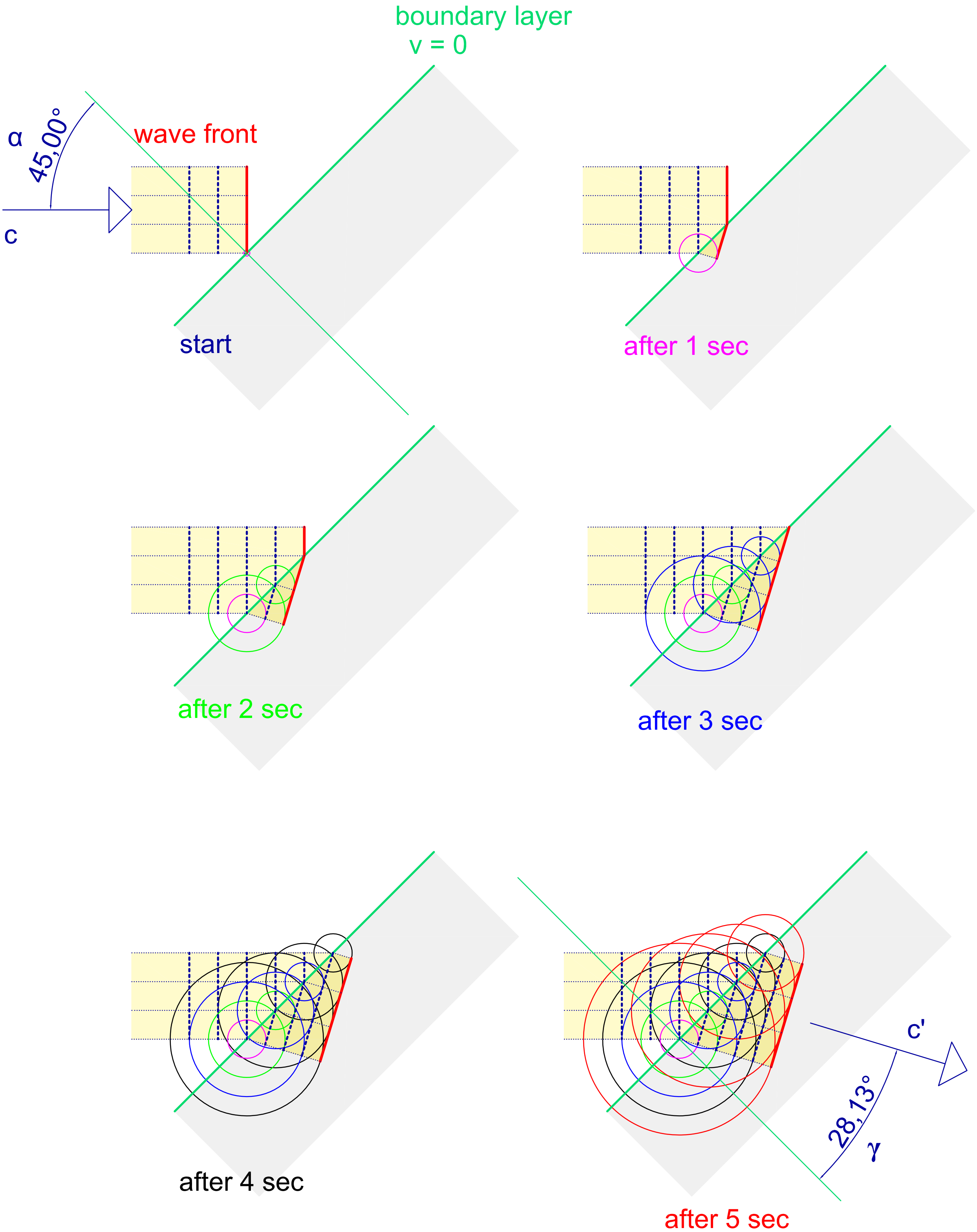

Fig. 4: Principle of classic refraction based upon Snellius's law

We can easily obtain Snellius's formula:

$\sin(\gamma) = \sin(\alpha) \cdot \frac{n_1}{n_2}$ whereby n_2 is the refraction coefficient of the refracting medium [7].

The situation changes analogically when the medium is moving:

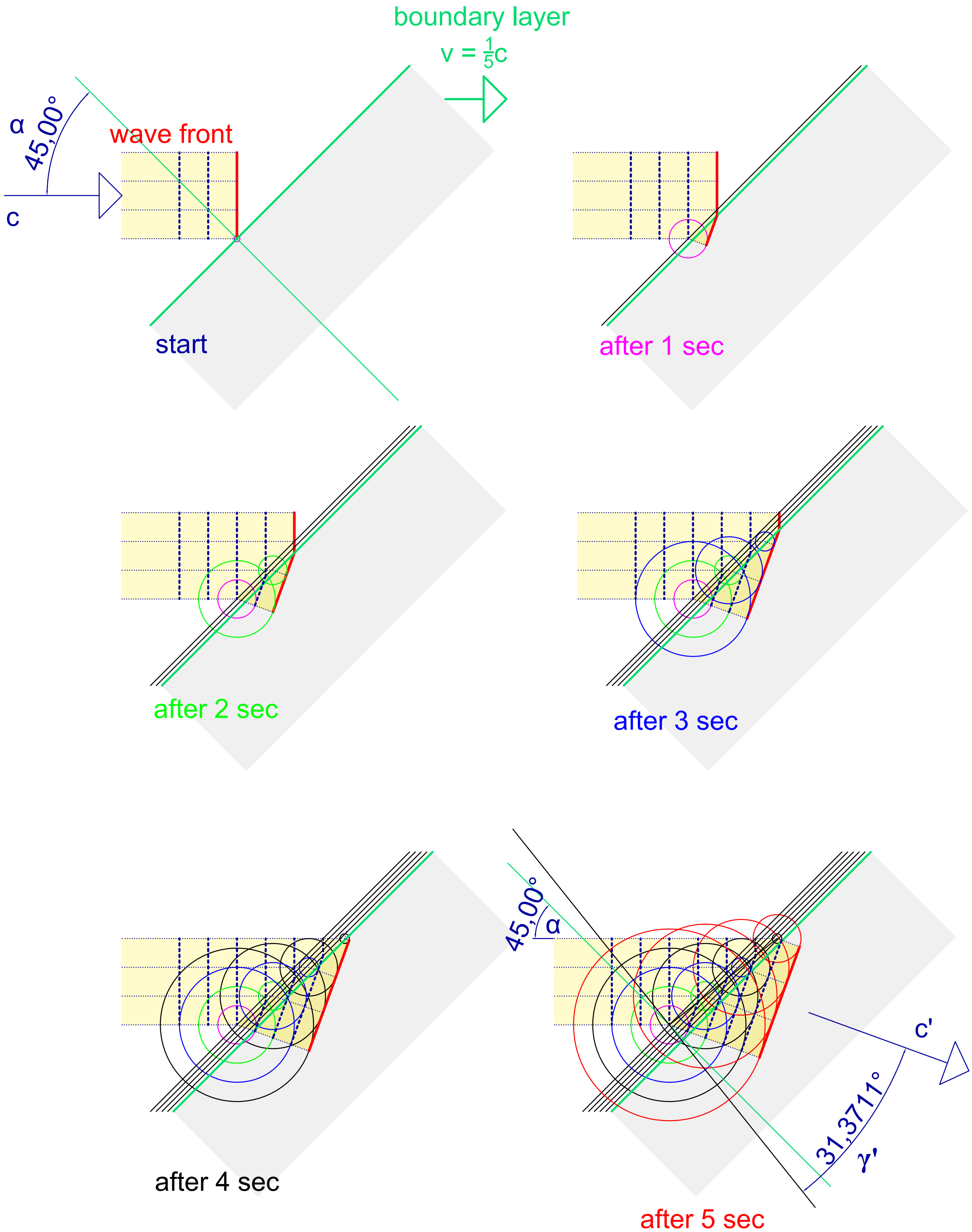

Fig. 5: Principle of refraction from a moving medium, based on logical derivation from Snellius's law

Again applying the angle α‘ of the effective perpendicular on the refracting surface in analogy to the reflection principle above we obtain:

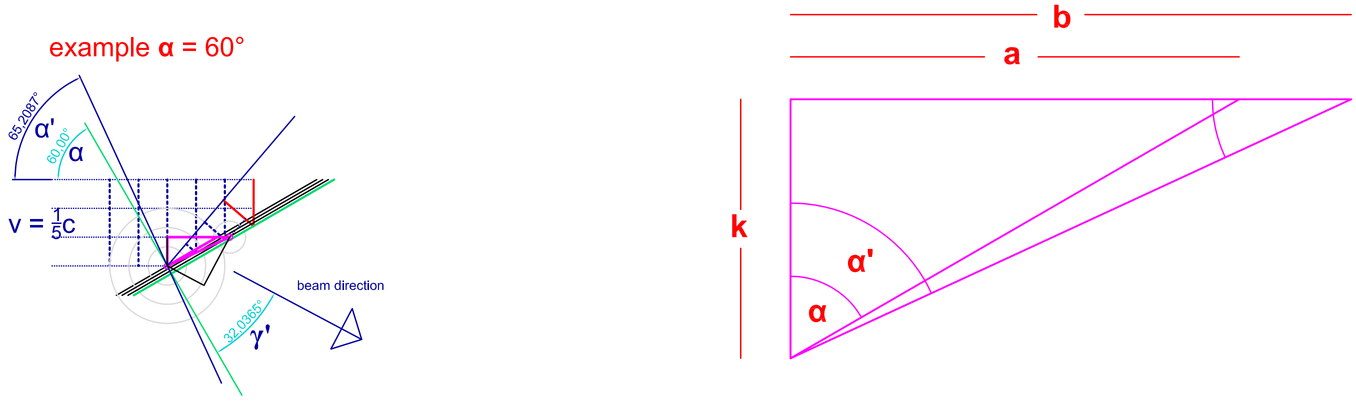

Fig. 6: Geometric situation on moving body and effective tilt angle

$$\sin(\gamma') = \sin(\alpha') \cdot \frac{n_1}{n_2} - \alpha' + \alpha$$

And α‘ inserted:

$$\sin(\gamma') = \sin\left(\arctan\left(\frac{\tan(\alpha)}{1-\frac{v}{c}}\right)\right) \cdot \frac{n_1}{n_2} - \arctan\left(\frac{\tan(\alpha)}{1-\frac{v}{c}}\right) + \alpha$$

Thus the new refraction angle to the actual perpendicular to the surface:

$$\boxed{\gamma' = \arcsin\left(\sin\left(\arctan\left(\frac{\tan(\alpha)}{1-\left(\frac{v}{c}\right)}\right)\right) \cdot \frac{n_1}{n_2}\right) - \arctan\left(\frac{\tan(\alpha)}{1-\left(\frac{v}{c}\right)}\right) + \alpha}$$

The formula was double-checked by means of a cad image for several angles.

4. Reflection from moving parabolic mirrors

We have established, that reflection angles vary upon the relation of c and v. Now we have to clear the interesting question, what this means for reflections on parabolic mirrors with a light source on its focal point. According to classic physics we would expect any beam to be reflected exactly parallel to the axis of the parable.

The following survey shows it is not:

First for better understanding an image with the setup of mirror and source (arbitrary dimensions):

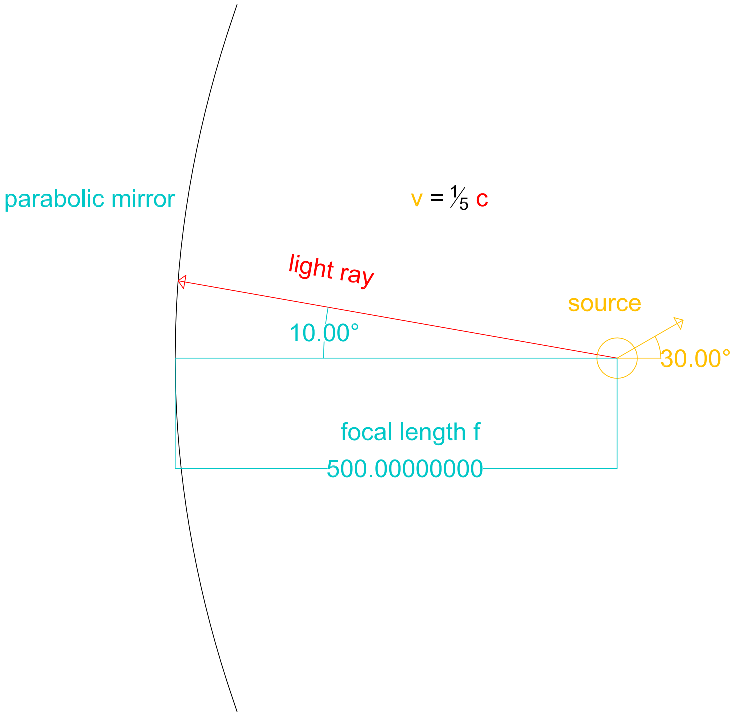

Fig. 7: Systematic layout of a lamp with parabolic mirror

Now we consider a light beam moving to the left under an angle α, whereby the whole setup is moving to the right under an angle β.

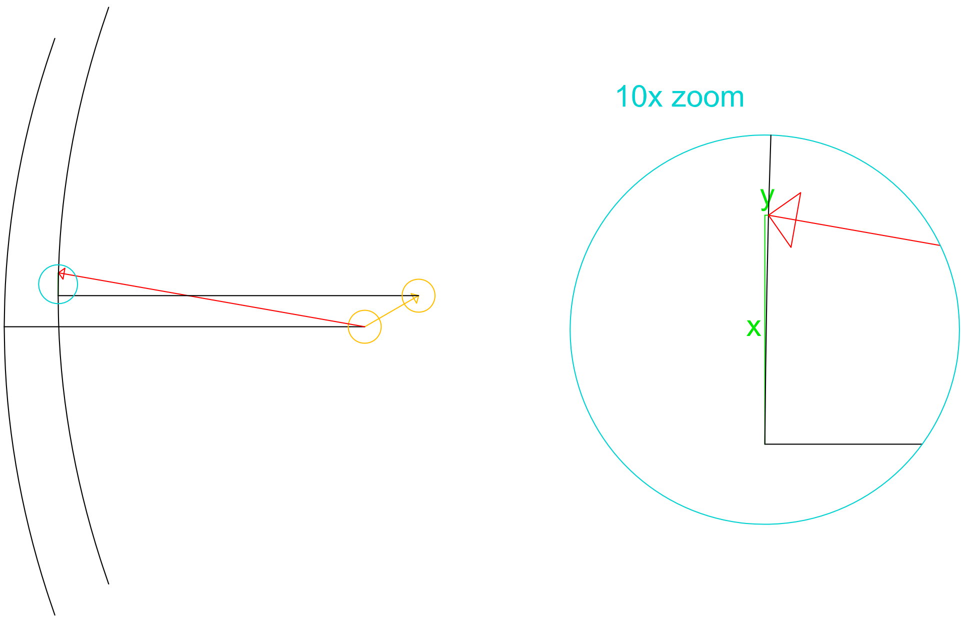

Fig. 8: Principle of the beam propagation and movement of the mirror

The determination of the meeting point now causes some trouble, since the mirror is roaming and additionally "bending" towards the beam.

The problem can be solved if we define functions for the respective movements. l is the distance the light beam is travelling, s the distance of the transversally moving setup, α the angle of the beam to the parable's axis, β the angle of the transverse movement of the setup to the parable's axis. f is the distance between focal point and vertex of the parable.

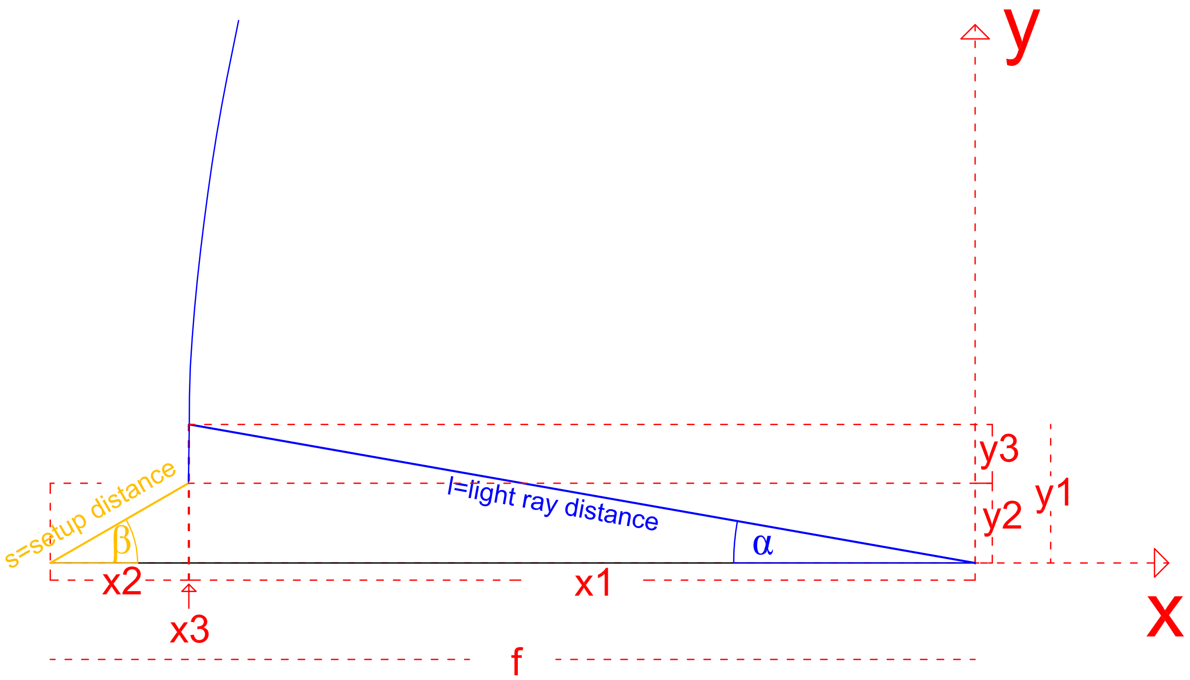

Fig. 9: Definition of the geometric conditions using functions

(1) is the function for the light beam propagation

(2) is the function for the transversal movement of the mirror

(3) is the function for the parable's curve

(1) $y_1 = x_1 \cdot \tan(\alpha)$ and hence $\boxed{x_1 = l \cdot \cos(\alpha)}$ and $\boxed{y_1 = l \cdot \sin(\alpha)}$

(2) $y_2 = x_2 \cdot \tan(\beta)$ and hence $x_2 = s \cdot \cos(\beta) = \boxed{l \cdot \frac{v}{c} \cdot \cos(\beta)}$ and $y_2 = s \cdot \sin(\beta) = \boxed{l \cdot \frac{v}{c} \cdot \sin(\beta)}$

(3) $y_3 = \sqrt{x_3 \cdot 4 \cdot f}$ $\quad x_3 = \frac{y_3^2}{4 \cdot f}$

From the mutual dependence of the functions we can derive the following equation, targeting the determination of l:

$$x_1 = f - x_2 - x_3$$

$$x_1 = f - l \cdot \frac{v}{c} \cdot \cos(\beta) - \frac{y_3^2}{4 \cdot f} \text{ und: } y_3 = y_1 - y_2 = l \cdot \sin(\alpha) - l \cdot \frac{v}{c} \cdot \sin(\beta)$$

thus:

(4) $$x_1 = f - l \cdot \frac{v}{c} \cdot \cos(\beta) - \frac{\left(l \cdot \sin(\alpha) - l \cdot \frac{v}{c} \cdot \sin(\beta)\right)^2}{4 \cdot f}$$

(1) and (4) will now be equated and resolved:

$$l\cdot\cos(\alpha)=f-l\cdot\frac{v}{c}\cdot\cos(\beta)-\frac{\left(l\cdot\sin(\alpha)-l\cdot\frac{v}{c}\cdot\sin(\beta)\right)^2}{4\cdot f}$$

$$-4\cdot f\cdot\left(l\cdot\cos(\alpha)-f+l\cdot\frac{v}{c}\cdot\cos(\beta)\right)=\left(l\cdot\sin(\alpha)\right)^2-2\cdot l\cdot\sin(\alpha)\cdot l\cdot\frac{v}{c}\cdot\sin(\beta)+\left(l\cdot\frac{v}{c}\cdot\sin(\beta)\right)^2$$

$$-l\cdot 4\cdot f\cdot\cos(\alpha)+4\cdot f^2-l\cdot 4\cdot f\cdot\frac{v}{c}\cdot\cos(\beta)-l^2\cdot\sin(\alpha)^2+l^2\cdot 2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)-l^2\cdot\frac{v^2}{c^2}\cdot\sin(\beta)^2=0$$

$$l^2\cdot\left(-\sin(\alpha)^2+2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)-\frac{v^2}{c^2}\cdot\sin(\beta)^2\right)+l\cdot\left(-4\cdot f\cdot\cos(\alpha)-4\cdot f\cdot\frac{v}{c}\cdot\cos(\beta)\right)+4\cdot f^2=0$$

And after resolving the quadratic equation:

$$l=\frac{-\left(-4\cdot f\cdot\cos(\alpha)-4\cdot f\cdot\frac{v}{c}\cdot\cos(\beta)\right)-\sqrt{\left(-4\cdot f\cdot\cos(\alpha)-4\cdot f\cdot\frac{v}{c}\cdot\cos(\beta)\right)^2-4\cdot\left(-\sin(\alpha)^2+2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)-\frac{v^2}{c^2}\cdot\sin(\beta)^2\right)\cdot 4\cdot f^2}}{2\cdot\left(-\sin(\alpha)^2+2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)-\frac{v^2}{c^2}\cdot\sin(\beta)^2\right)}$$

$$l=\frac{4\cdot f\cdot\left(\cos(\alpha)+\frac{v}{c}\cdot\cos(\beta)\right)-\sqrt{16\cdot f^2\left(\cos(\alpha)+\frac{v}{c}\cdot\cos(\beta)\right)^2+16\cdot f^2\cdot\left(\sin(\alpha)^2-2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)+\frac{v^2}{c^2}\cdot\sin(\beta)^2\right)}}{-2\cdot\left(\sin(\alpha)^2-2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)+\frac{v^2}{c^2}\cdot\sin(\beta)^2\right)}$$

$$l=\frac{4\cdot f\cdot\left(\cos(\alpha)+\frac{v}{c}\cdot\cos(\beta)\right)-4\cdot f\cdot\sqrt{\left(\cos(\alpha)+\frac{v}{c}\cdot\cos(\beta)\right)^2+\left(\sin(\alpha)-\frac{v}{c}\cdot\sin(\beta)\right)^2}}{-2\cdot\left(\sin(\alpha)^2-2\cdot\sin(\alpha)\cdot\frac{v}{c}\cdot\sin(\beta)+\frac{v^2}{c^2}\cdot\sin(\beta)^2\right)}$$

$$\boxed{l=-2\cdot f\cdot\frac{\left(\cos(\alpha)+\frac{v}{c}\cdot\cos(\beta)\right)-\sqrt{\left(\cos(\alpha)+\frac{v}{c}\cdot\cos(\beta)\right)^2+\left(\sin(\alpha)-\frac{v}{c}\cdot\sin(\beta)\right)^2}}{\left(\sin(\alpha)-\frac{v}{c}\cdot\sin(\beta)\right)^2}}$$

Following determination of l all other dimensions can now be determined:

$$\boxed{s=l\cdot\frac{v}{c}}$$

$$\boxed{y_{\text{Parabel}}=l\cdot\left(\sin(\alpha)-\frac{v}{c}\cdot\sin(\beta)\right)}$$

$$\boxed{x_{Parabel} = \frac{l^2 \cdot \left(\sin(\alpha) - \frac{v}{c} \cdot \sin(\beta)\right)^2}{4 \cdot f}}$$

Using the dimension of l and its angle und assuming values for c and v we can now determine the reflection angle on the moving parabolic mirror. The perpendicular to the tangent on the parable's curve at the meeting time now is essential for determination of the meeting point.

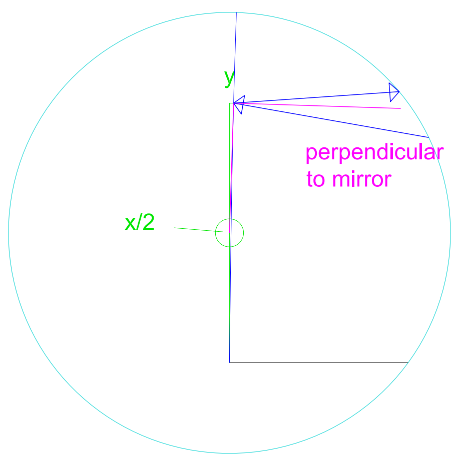

Fig. 10: Zoomed situation on parable's tangent

The tangent can be created by drawing a line from half of the x- dimension to the meeting point of parable and beam. In the following $x_{Parabel}$ and $y_{Parabel}$ is meant by x and y. We obtain the angle between tangent and perpendicular:

$$\tan(\text{perpendicular}\sphericalangle\text{tangent}) = \frac{x}{y/2} = 2 \cdot \frac{x}{y}$$

$$\text{perpendicular}\sphericalangle\text{tangent} = \arctan\left(2 \cdot \frac{x}{y}\right)$$

And resultant the angle between perpendicular on the tangent and the beam:

$\text{perpendicular}\sphericalangle\text{beam} = \alpha - \arctan\left(2 \cdot \frac{x}{y}\right)$ whereby α again is the angle of the beam to the parable's axis.

the above formula for reflection on moving mirrors

$$\gamma' = 2 \cdot \arctan\left(\frac{\tan(\text{perpendicular}\sphericalangle\text{beam})}{1 - \left(\frac{v'}{c}\right)}\right) - \text{perpendicular}\sphericalangle\text{beam}$$

now must be completed with the appropriate values for c and v. For v we have to find the respective velocity component v' of the tilted mirror directional to c. This is:

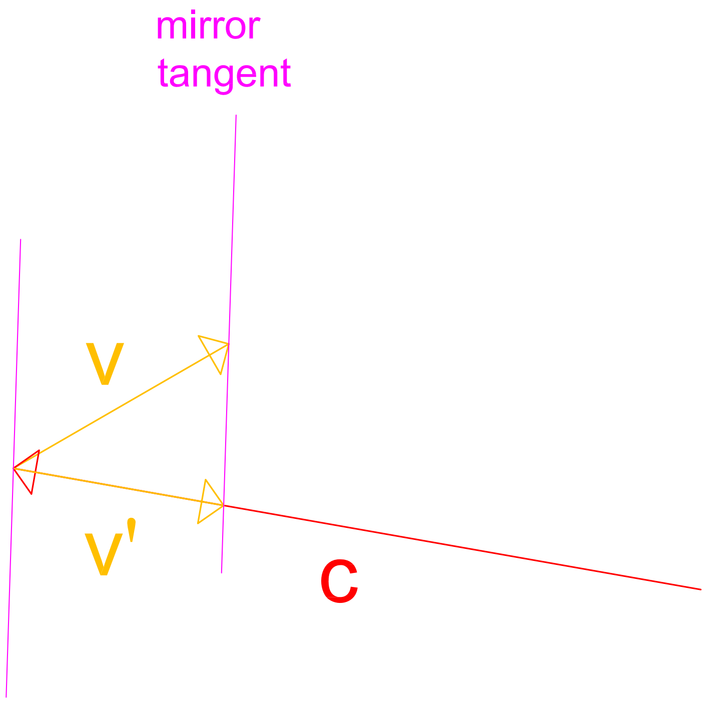

Fig. 11: Geometry of mirror movement directional to beam

$$v' = v \cdot \frac{\sin(90° - \beta - \text{perpendicular}\sphericalangle\text{tangent})}{\sin(90° - \alpha + \text{perpendicular}\sphericalangle\text{tangent})}$$

Thus the angle between reflected beam and perpendicular to the mirror is:

$$\boxed{\gamma' = 2 \cdot \arctan\left(\frac{\tan\left(\alpha - \arctan\left(2 \cdot \frac{x}{y}\right)\right)}{1 + \left(\frac{v}{c} \cdot \frac{\sin\left(90° - \beta - \arctan\left(2 \cdot \frac{x}{y}\right)\right)}{\sin\left(90° - \alpha + \arctan\left(2 \cdot \frac{x}{y}\right)\right)}\right)}\right) - \alpha + \arctan\left(2 \cdot \frac{x}{y}\right)}$$

The accuracy of the above approach was double-checked with cad. In particular the calculated relations of v and c must be correctly readable from the drawing.

Further on the above formula was now used for an excel- routine. Realistic values were set for c = 300.000 km/s and v = 350 km/s. The focal length is irrelevant since the whole geometry is then just zooming appropriately. The movement angle of the setup to the parable's axis was chosen with 30 degrees. Now the reflection angles for varying angles of the starting ray towards parable's axis were calculated. According to classic physics all angles would be expected to be equal and zero. Here is the output.

Starting ray angle to parable's axis degree	reflected ray angle to parable's axis degree	Deviation to average degree	Deviation to average µrad
0°	0,033355093022000	-0,000012863110222	-0,224503625424836
10°	0,033349902302000	-0,000018053830222	-0,315098779973943
20°	0,033348129868000	-0,000019826264222	-0,346033589048231
30°	0,033349831918000	-0,000018124214222	-0,316327212514724
45°	0,033358258536000	-0,000009697596222	-0,169254983606830
60°	0,033371869592000	0,000003913459778	0,068302758266498
70°	0,033382422981000	0,000014466848778	0,252494143560169
80°	0,033393087636000	0,000025131503778	0,438627486899431
90°	0,033403009335000	0,000035053202778	0,611793801841256
Average	0,033367956132222	0,000000000000000	0,000000000000000

According to the calculation the reflection angle is different from 0°. But also it becomes obvious that all angles diverge by less than 1 µrad!

Of even more interest is to calculate the reflection angles now with varying angles of transverse mirror movement:

The starting angle of the beam is now for convenience set to zero degrees, being of no much relevance as we have seen from the above table.

transversal mirror movement angle degree	reflected ray angle to parable's axis degree
0°	0,000000000000000
10°	0,011580898419696
20°	0,022812313440984
30°	0,033355093033177
45°	0,047188690356774
60°	0,057822006159651
70°	0,062763663542204
80°	0,065802812190023
90°	0,066845000284998

5. Terrestrial aberration

Without applying the special relativity, the fact of absence of terrestrial aberration is hard to explain with common ether theories. This is the major topic of this paper, offering a new approach on the issue.

First, neglecting the experimental facts, we should reflect now, how aberration would look like in classic physics if it would exist.

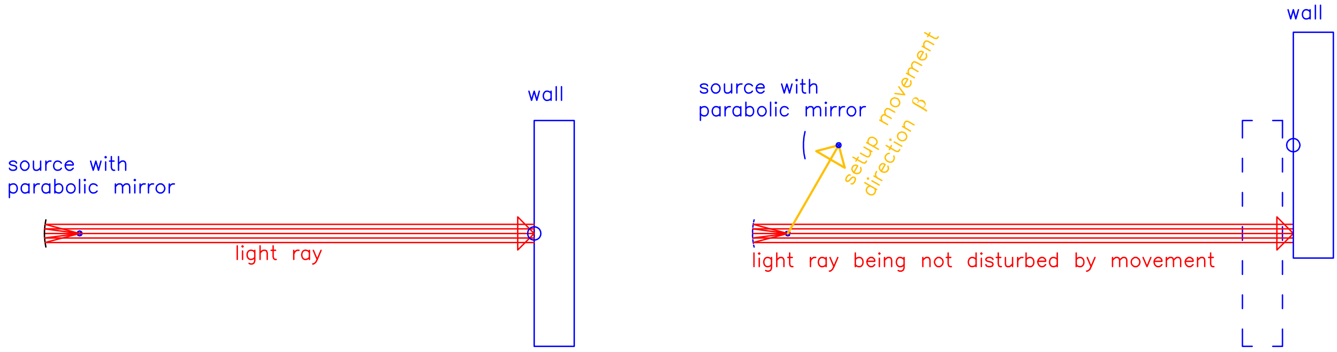

Fig.12: Theoretical principle of terrestrial aberration in classic physics

We imagine a light ray consisting of only one wave front section that would be projected against a wall from a parabolic mirror lamp. While the ray is proceeding, the wall together with the lamp would be shifting along the rotating direction of earth. We assume that the ray is not disturbed during this process regarding its velocity and direction, in respect to the emerging point and absolute space. That means, when the wave front section arrives at the wall, the wall has shifted transversely so the ray would hit on a differing point. Dependent on the direction of transversal movement, the meeting point would roam well distinguishable to one and the other side. Therefore aberration should be visible under such circumstances.

Now we imagine, the ray would be arbitrarily going along another inclined path, so that it would meet at the same point as if the wall would not have shifted relatively, in other words, would compensate this theoretic aberration angle:

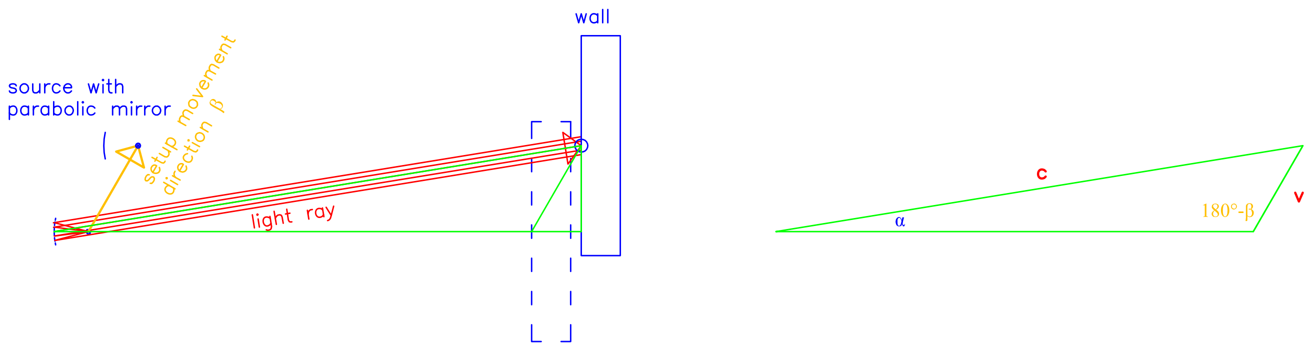

Fig. 13: Geometry of a theoretic ray compensating aberration

No we have to identify its necessary angle to do so.

According to the sine rule:

$$\frac{\sin(\alpha)}{\sin(\beta)} = \frac{v}{c}$$

$$\sin(\alpha) = \frac{v}{c} \cdot \sin(\beta)$$

With the same settings as before for c and v the excel- routine gives the following comparison:

transversal setup movement angle degree	Reflected angle from parabolic mirror lamp degree	Aberration compensating angle degree	deviation in µrad
0°	0,000000000000000	0,000000000000000	-0,000000000000000
10°	0,011580898419696	0,011607525729929	-0,464734234513533
20°	0,022812313440984	0,022862363114547	-0,873531593220237
30°	0,033355093033177	0,033422539944790	-1,177170677946250
45°	0,047188690356774	0,047266611959508	-1,359988526152570
60°	0,057822006159651	0,057889543868554	-1,178755389612020
70°	0,062763663542204	0,062813837328296	-0,875697765486524
80°	0,065802812190023	0,065829563675850	-0,466901507486992
90°	0,066845000284998	0,066845091262535	-0,001587857555416

Thus the ostensible non- existence of terrestrial aberration explains itself easily although it might exist. Even the best laser arrays probably have divergence angles of approx. 100 µrad and the above determined deviation lays almost two orders of magnitude below. For this reason terrestrial aberration is simply not detectable by means of any state of the art technique.

To what extend the performed calculations might be infected by rounding failure due to the excessive use of trigonometric methods is also questionable, perhaps the angles could even be equal. A mathematical proof would have to be conducted.

It can be summarized that the deflection on moving parabolic mirrors **makes any angle fit to compensate terrestrial aberration in any transversal movement direction**.

6. Reflection between two parabolic mirrors inside a laser array

Now it should be undeceived in what behavior the emission angle would arise from a laser array, using some simplifications.

Commonly rays are being reflected back and forth for a ten thousand times between two mirrors with identical focal points before they can escape from the one half translucent of the mirrors. We want to determine now the angle that the ray would have when leaving the instrument.

In analogy to the formerly conducted principle we determine the path of the wave front section having been reflected from the first mirror to meet the second mirror and produce the formula for calculation.

2nd ray:

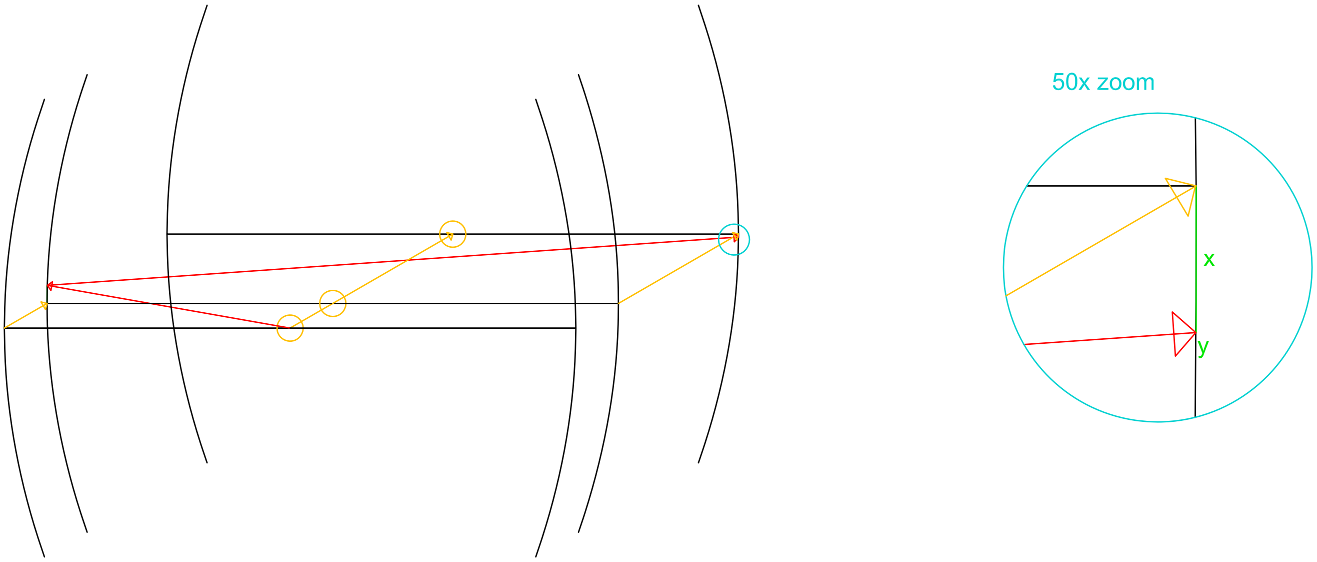

Fig. 14: Geomety of the 2nd ray inside an array with two parabolic mirrors, v = 1/5 c

Similarly to the above we can identify three functions for the movements:

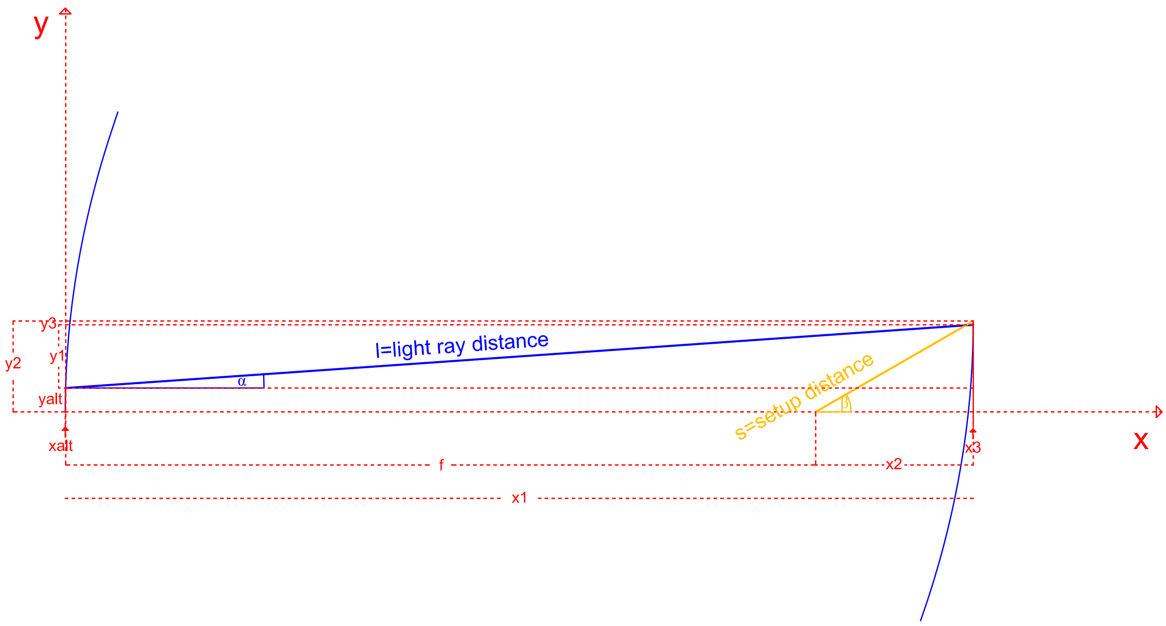

Fig. 15: Definition geometric relationships with functions

(1) is the function for the ray

(2) is the function for the transversal movement of the mirror

(3) is the function for the parable's curve

(1) $y_1 = x_1 \cdot \tan(\alpha)$ and resulting $\boxed{x_1 = l \cdot \cos(\alpha)}$ and $\boxed{y_1 = l \cdot \sin(\alpha)}$

(2) $y_2 = y_2 \cdot \tan(\beta)$ and resulting $x_2 = s \cdot \cos(\beta) = \boxed{l \cdot \frac{v}{c} \cdot \cos(\beta)}$ and $y_2 = s \cdot \sin(\beta) = \boxed{l \cdot \frac{v}{c} \cdot \sin(\beta)}$

(3) $y_3 = \sqrt{x_3 \cdot 4 \cdot f}$ $\qquad x_3 = \frac{y_3^2}{4 \cdot f}$

From the mutual dependence of the functions we can derive the following equation, targeting the determination of l:

$$x_1 = 2 \cdot f + x_2 - x_3 - x_{alt}$$

$x_1 = 2 \cdot f + l \cdot \frac{v}{c} \cdot \cos(\beta) - \frac{y_3^2}{4 \cdot f} - \frac{y_{alt}^2}{4 \cdot f}$ und:

$$y_3 = y_1 - y_2 + y_{alt} = l \cdot \sin(\alpha) - l \cdot \frac{v}{c} \cdot \sin(\beta) + y_{alt}$$

Therefore:

(4) $$x_1 = 2 \cdot f + l \cdot \frac{v}{c} \cdot \cos(\beta) - \frac{\left(l \cdot \sin(\alpha) - l \cdot \frac{v}{c} \cdot \sin(\beta) + y_{alt}\right)^2 + y_{alt}^2}{4 \cdot f}$$

(1) and (4) now be equated and resolved:

$$l \cdot \cos(\alpha) = 2 \cdot f + l \cdot \frac{v}{c} \cdot \cos(\beta) - \frac{\left(l \cdot \sin(\alpha) - l \cdot \frac{v}{c} \cdot \sin(\beta) + y_{alt}\right)^2 + y_{alt}^2}{4 \cdot f}$$

$$-4 \cdot f \cdot \left(l \cdot \cos(\alpha) - 2 \cdot f - l \cdot \frac{v}{c} \cdot \cos(\beta)\right) = \left(l \cdot \sin(\alpha) - l \cdot \frac{v}{c} \cdot \sin(\beta) + y_{alt}\right)^2 + y_{alt}^2$$

$$-4 \cdot f \cdot \left(l \cdot \cos(\alpha) - 2 \cdot f - l \cdot \frac{v}{c} \cdot \cos(\beta)\right) = \left(l \cdot \frac{v}{c} \cdot \sin(\beta)\right)^2 + \left(l \cdot \sin(\alpha)\right)^2 + y_{alt}^2 - 2 \cdot l^2 \cdot \frac{v}{c} \cdot \sin(\beta) \cdot \sin(\alpha) - 2 \cdot l \cdot \frac{v}{c} \cdot \sin(\beta) \cdot y_{alt} + 2 \cdot l \cdot \sin(\alpha) \cdot y_{alt} + y_{alt}^2$$

$$l \cdot \cos(\alpha) \cdot 4 \cdot f - 8 \cdot f^2 - l \cdot 4 \cdot f \cdot \frac{v}{c} \cdot \cos(\beta) + \left(l \cdot \frac{v}{c} \cdot \sin(\beta)\right)^2 + \left(l \cdot \sin(\alpha)\right)^2 + y_{alt}^2 - l^2 \cdot 2 \cdot \frac{v}{c} \cdot \sin(\beta) \cdot \sin(\alpha) - 2 \cdot l \cdot \frac{v}{c} \cdot \sin(\beta) \cdot y_{alt} + 2 \cdot l \cdot \sin(\alpha) \cdot y_{alt} + y_{alt}^2 = 0$$

$$l^2 \left(\frac{v^2}{c^2} \cdot \sin(\beta)^2 + \sin(\alpha)^2 - 2 \cdot \frac{v}{c} \cdot \sin(\beta) \cdot \sin(\alpha)\right) + l\left(\cos(\alpha) \cdot 4 \cdot f - 4 \cdot f \cdot \frac{v}{c} \cdot \cos(\beta) - 2 \cdot \frac{v}{c} \cdot \sin(\beta) \cdot y_{alt} + 2 \cdot \sin(\alpha) \cdot y_{alt}\right) - 8 \cdot f^2 + 2 \cdot y_{alt}^2 = 0$$

$$l^2 \left(\frac{v}{c} \cdot \sin(\beta) - \sin(\alpha)\right)^2 + l\left(4 \cdot f \cdot \left(\cos(\alpha) - \frac{v}{c} \cdot \cos(\beta)\right) + 2 \cdot y_{alt} \cdot \left(\sin(\alpha) - \frac{v}{c} \cdot \sin(\beta)\right)\right) - 8 \cdot f^2 + 2 \cdot y_{alt}^2 = 0$$

And after resolving the quadratic equation:

$$\boxed{l=\frac{-\left(4\cdot f\cdot\left(\cos(\alpha)-\cos(\beta)\cdot\frac{v}{c}\right)+2\cdot y_{alt}\cdot\left(\sin(\alpha)-\sin(\beta)\cdot\frac{v}{c}\right)\right)-\sqrt{\left(4\cdot f\cdot\left(\cos(\alpha)-\cos(\beta)\cdot\frac{v}{c}\right)+2\cdot y_{alt}\cdot\left(\sin(\alpha)-\sin(\beta)\cdot\frac{v}{c}\right)\right)^2-4\cdot\left(2\cdot y_{alt}^2-8\cdot f^2\right)\cdot\left(\sin(\beta)\cdot\frac{v}{c}-\sin(\alpha)\right)^2}}{2\cdot\left(\sin(\beta)\cdot\frac{v}{c}-\sin(\alpha)\right)^2}}$$

$$\boxed{y_{Parabel}=l\cdot\sin(\alpha)-l\cdot\frac{v}{c}\cdot\sin(\beta)+y_{alt}}$$

On the basis of the determined values we now find the reflection angle form the moving mirror, this time with modified operation signs due to the opposite direction of ray movement.

$$\boxed{\gamma'=2\cdot\arctan\left(\frac{\tan\left(\alpha-\arctan\left(2\cdot\frac{x}{y}\right)\right)}{1-\left(\frac{v}{c}\cdot\frac{\sin\left(90^\circ-\beta+\arctan\left(2\cdot\frac{x}{y}\right)\right)}{\sin\left(90^\circ+\alpha-\arctan\left(2\cdot\frac{x}{y}\right)\right)}\right)}\right)-\alpha+\arctan\left(2\cdot\frac{x}{y}\right)}$$

3rd ray

In analogy to the above, again with modified operation signs, the relevant difference is here:

$$x_1=2\cdot f-x_2-x_3-x_{alt}$$

After this modification for l:

$$\boxed{l=\frac{-\left(4\cdot f\cdot\left(\cos(\alpha)+\cos(\beta)\cdot\frac{v}{c}\right)+2\cdot y_{alt}\cdot\left(\sin(\alpha)-\sin(\beta)\cdot\frac{v}{c}\right)\right)-\sqrt{\left(4\cdot f\cdot\left(\cos(\alpha)+\cos(\beta)\cdot\frac{v}{c}\right)+2\cdot y_{alt}\cdot\left(\sin(\alpha)-\sin(\beta)\cdot\frac{v}{c}\right)\right)^2-4\cdot\left(2\cdot y_{alt}^2-8\cdot f^2\right)\cdot\left(\sin(\beta)\cdot\frac{v}{c}-\sin(\alpha)\right)^2}}{2\cdot\left(\sin(\beta)\cdot\frac{v}{c}-\sin(\alpha)\right)^2}}$$

Reflection angle to be calculated according to the former ray.

Now we have run through the whole cycle, follow-up rays to be determined in analogy. The image shows as this would look like:

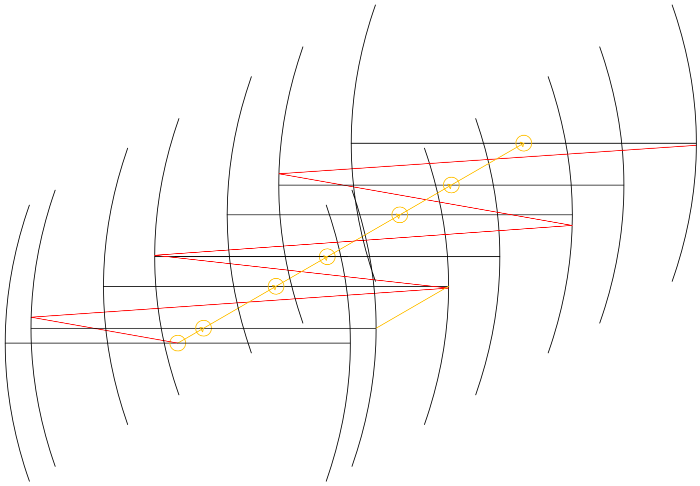

Fig. 16: multiple ray sequence, v = 1/5 c

On basis of above formula another excel- routine reveals the deviation after 10.000 reflections.

We can see that the ray now performs an increasing divergence from the first ray.

transversal setup movement angle degree	Reflected angle from parabolic mirror degree 1st ray	Reflected angle from parabolic mirror degree 10.000th ray	Divergence of rays in µrad
0°	0,000000000000000	0,000000000000000	0,000000000000000
10°	0,011580898419696	0,011729368557654	-2,591292748256260
20°	0,022812313440984	0,023050775846591	-4,161954120065270
30°	0,033355093033177	0,033582638557864	-3,971418603977660
45°	0,047188690356774	0,047188689080904	0,000022268131600
60°	0,057822006159651	0,057427868292055	6,879003496334780
70°	0,062763663542204	0,062108446861657	11,435688389528900
80°	0,065802812190023	0,064960527944279	14,700633325914100
90°	0,066845000284998	0,065934815523929	15,885720882128500

A further result is another divergence of two following rays:

transversal setup movement angle degree	Reflected angle from parabolic mirror degree 10.001st ray	Reflected angle from parabolic mirror degree 10.003rd ray	Divergence of rays in µrad
0°	0,000000000000000	0,000000000000000	0,000000000000000
10°	0,011729309206553	0,011432428229051	5,181550543944580
20°	0,023050680474458	0,022573851002817	8,322244250688590
30°	0,033582547565273	0,033127547520961	7,941248869971810
45°	0,047188689077823	0,047188691633885	-0,000044611695743
60°	0,057428025888063	0,058216144009675	-13,755256116761000
70°	0,062108708835951	0,063418880216460	-22,866804355283500
80°	0,064960864716920	0,066645096415956	-29,395388514639900
90°	0,065935179438785	0,067755185028176	-31,765089939572100

But there is a much smaller divergence between two rays leaving out one:

transversal setup movement angle degree	Reflected angle from parabolic mirror degree 10.001st ray	Reflected angle from parabolic mirror degree 10.005th ray	Divergence of rays in µrad
0°	0,000000000000000	0,000000000000000	0,000000000000000
10°	0,011729309206553	0,011729368557654	-0,001035872132266
20°	0,023050680474458	0,023050775846591	-0,001664557736470
30°	0,033582547565273	0,033582638557864	-0,001588120310114
45°	0,047188689077823	0,047188689080904	-0,000000053760891
60°	0,057428025888063	0,057427868292055	0,002750569231121
70°	0,062108708835951	0,062108446861657	0,004572313978761
80°	0,064960864716920	0,064960527944279	0,005877791412633
90°	0,065935179438785	0,065934815523929	0,006351512425397

Summarizing it can be stated that the beam has split in two diverging rays well below resolution of any laser array, whereby the mean of both is again extremely close to the aberration angle as before:

transversal setup movement angle degree	Reflected angle from parabolic mirror degree 10.001st ray	Reflected angle from parabolic mirror degree 10.003rd ray	Average degree	Aberration compensation angle degree	deviation in µrad
0°	0,000000000000	0,000000000000	0,000000000000	0,000000000000	0,000000000000
10°	0,011729309207	0,011432428229	0,011580868718	0,011607525730	-0,465252630362
20°	0,023050680474	0,022573851003	0,022812265739	0,022862363115	-0,874364156236
30°	0,033582547565	0,033127547521	0,033355047543	0,033422539945	-1,177964629265
45°	0,047188689078	0,047188691634	0,047188690356	0,047266611960	-1,359988542197
60°	0,057428025888	0,058216144010	0,057822084949	0,057889543869	-1,177380258335
70°	0,062108708836	0,063418880216	0,062763794526	0,062813837328	-0,873411663395
80°	0,064960864717	0,066645096416	0,065802980566	0,065829563676	-0,463962784669
90°	0,065935179439	0,067755185028	0,066845182233	0,066845091263	0,001587742528

These results can be estimated as equal to the deviation of a standard parabolic mirror lamp as shown above.

7. Conclusion and prospectives

For no apparent reason the assumption, that reflection laws will not apply identically to moving mirrors and reflection angels could be subject to relative velocities of light and mirror, is neglected by the literature almost throughout. At the same time this assumption is simple and obvious, having thoroughly contemplated on the native reason for reflection as such.

The approach used in this paper is offering a simple and obvious solution to the understanding of terrestrial aberration and shows that even in a static ether environment terrestrial aberration would be hard to detect.

Florian Michael Schmitt

Berlin 2018

References and Acknowledgments (in order of appearance):

[1] Huygens, Christiaan, Treatise on Light, Bde. %1 von %2Rendered into English by Silvanus P. Thompson, http://www.gutenberg.org/files/14725/14725-h/14725-h.htm#Page_23, University of Chicago Press, 1690.

[2] Fresnel, Augustin, Lettre d'Augustin Fresnel à François Arago sur l'influence du mouvement terrestre dans quelques phénomènes d'optique, Bde. %1 von %2Oeuvres complètes d'Augustin Fresnel / publiées par MM. Henri de Senarmont, http://visualiseur.bnf.fr/CadresFenetre?O=NUMM-91937&I=633&M=tdm, Gallica, 1818.

[3] Einstein, Albert, Zur Elektrodynamik bewegter Körper, Annalen der Physik und Chemie. 17, 1905, S. 891–921, 1905.

[4] Doppler, Chrisitan, Über das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels, Böhmische Gesellschaft der Wissenschaften, 1842.

[5] Marmet, Paul, The Overlooked Phenomena in the Michelson-Morley Experiment, http://www.newtonphysics.on.ca/michelson/index.html, 2004.

[6] Gjurchinovski, Aleksandar, Reflection from a moving mirror - a simple derivation using the photon model of light, Bd. http://arxiv.org/abs/1207.0998, Cornell University Library, 2012.

[7] Snellius, Willebrord, De Refractione, Bd. Handschriften van de Remonstrantsche Kerk 683 [Bc 1], University Library University of Amsterdam, 1625.

[8] Airy, George Bidell, On a Supposed Alteration in the Amount of Astronomical Aberration of Light, Produced by the Passage of the Light through a Considerable Thickness of Refracting Medium,

Bde. %1 von %2Proceedings of the Royal Society of London, Volume 20, January 1, 1871 20 35-39; doi:10.1098/rspl.1871.0011, The Royal Society, 1871.

[9] Bradley, James, A Letter from the Reverend Mr. James Bradley Savilian Professor of Astronomy at Oxford, and F.R.S. to Dr. Edmond Halley Astronom. Reg. &c. Giving an Account of a New Discovered Motion of the Fix'd Stars, Bde. %1 von %2Philosophical Transactions 35, 1727-1728, doi:10.1098/rstl.1727.0064, The Royal Society, 1727.

[10] Feist, Norbert, Talk presented at the Spring Conference of the German Physical Society (DPG) on 28 March 2001 in Bonn, http://arxiv.org/abs/physics/0104059, Cornell University Library, 2001.

[11] Michelson, A. A., Morley, E.W, On the Relative Motion of the Earth and the Luminiferous Ether, Bde. %1 von %21887, 34 (203): 333–345 1881, American Journal of Science, 1887.

[12] Miller, Dayton C., The Ether-Drift Experiments and the Determination of the Absolute Motion of the Earth, Bde. %1 von %2Vol. 133 p. 162, February 3rd 1934, Nature, 1934.

[13] Newton, Sir Isaac, Hypothesis explaining the properties of light, Bde. %1 von %2published in Thomas Birch, The History of the Royal Society for improving of natural knowledge from its first rise, vol. 3 (London: 1757), pp. 247-305, The Royal Society, 1675.

[14] Stokes, George, mathematical and physical papers, Vol.1, Cambridge University Press, 1880.