Is the absolute frame really a nonsense?

Toulouse 4-6 November 2013

Marcel URBAN
from the FLOWER gang

content

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2- Some important steps in our knowledge of light

3- Which observations would be discriminating ?

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comparing Einstein relativity with Lorentz-Fitgerald theory

	Lorentz-Fitzgerald	**Einstein**
Postulates	1- Absolute frame 2- Rod contraction 3- Clock retardation	1- All inertial frames are equivalent 2- Speed of light invariant
Derived results	Lorentz transformations	Lorentz transformations Rod contraction Clock retardation

Up to now all experimental facts can be explained by both approaches.

This is because, independently of all interpretative aspects, the basic quantitative ingredients, namely Lorentz transformations, are the same in both theories.

comparing Einstein relativity with Lorentz-Fitgerald theory

Einstein postulates what Lorentz, Fitzgerald, Poincaré, Bell… are attempting to prove

In Einstein relativity the mechanism linking objects to space-time is not described

In Lorentz Fitgerald theory matter does really contract therefore quantum mechanics is essential in their relativity

Bell 1992

« Although Einstein's theory of special relativity would lead you to expect the FitzGerald contraction, you are not excused from seeing how the dynamics of the system also leads to the FitzGerald contraction. »

Bell, J.S. (1987), ***Speakable and unspeakable in quantum mechanics.*** **Cambridge,England: Cambridge University Press.**

Bell considered a single atom modelled by an electron circling a massive nucleus. The question he posed was:
what is the prediction in Maxwell's electrodynamics as to the effect on the electron orbit when the nucleus is set in motion in the plane of the orbit?
Using only Maxwell's field equations, the Lorentz force law and $p = \gamma\beta\, m_0 c$
He concluded that the orbit undergoes the familiar longitudinal ("Fitzgerald") contraction, and its period changes by the familiar ("Larmor") dilation.

comparing Einstein relativity with Lorentz-Fitgerald theory

	Lorentz-Fitzgerald	**Einstein**	**Experiment**
Speed of light does not depend upon the source (except in GR)	yes	yes	**verified**
There is an absolute frame	yes	no	not verified
c is the speed limit	no	yes	not verified
One way speed of light is c	Not necessarily	yes	not verified
inertial frames are symetrical	no	yes	not verified
Length contraction	Physical objects contract but not necessarily only longitudinally	yes	not verified
Clocks change their rate	yes	yes	**verified**
Mass increases	yes	yes	**verified**

Some important steps in our knowledge of light

- Ole Roemer (1676) c is determined through Io eclipses

- Bradley (1727) stellar aberration

- Michelson-Morley (1887) c does not depend on orbital motion of the Earth

- Kaufmann (1901-1906) m/Q increases with speed

- De Sitter (1913) light speed does not depend on its source movement

- Sagnac (1913) c does depend on rotation of the Earth on itself

- Ives and Stilwell (1938) time dilation
H. E. Ives, « An experimental study of the rate of a moving atomic clock », *Journal of the Optical Society of America*, vol. 28, no 7, 1938, p. 215 (He^+ and Li^+)

- Shapiro (1968) speed of light is not a constant
Physical Review Letters **20** (22): 1265–1269.

- Hafele and Keating (1972) time can contract and expand

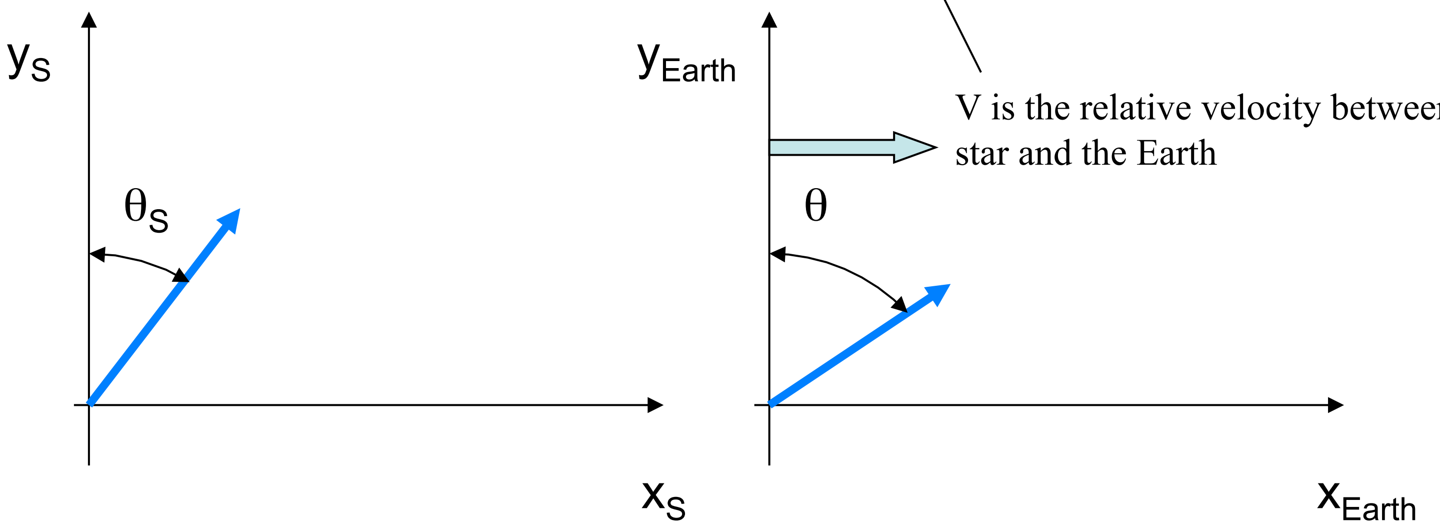
- Bailey et al. (1977) life time of muons

Bradley (1727) stellar aberration

stars describe small ellipses around their true position

From Lorentz transforms
$$\tan\theta = \frac{1}{\sqrt{1-\left[\frac{V}{c}\right]^2}}\,\frac{(\sin\theta_S - \frac{V}{c})}{\cos\theta_S}$$

V is the relative velocity between the star and the Earth



Frame where the star is at rest

Frame where the Earth is at rest

From experiment : V is the Earth velocity around the Sun

Willem De Sitter (1913)

"On the constancy of the velocity of light",
Proceedings of the Royal Netherlands Academy of Arts and Sciences **16** (1): 395–396

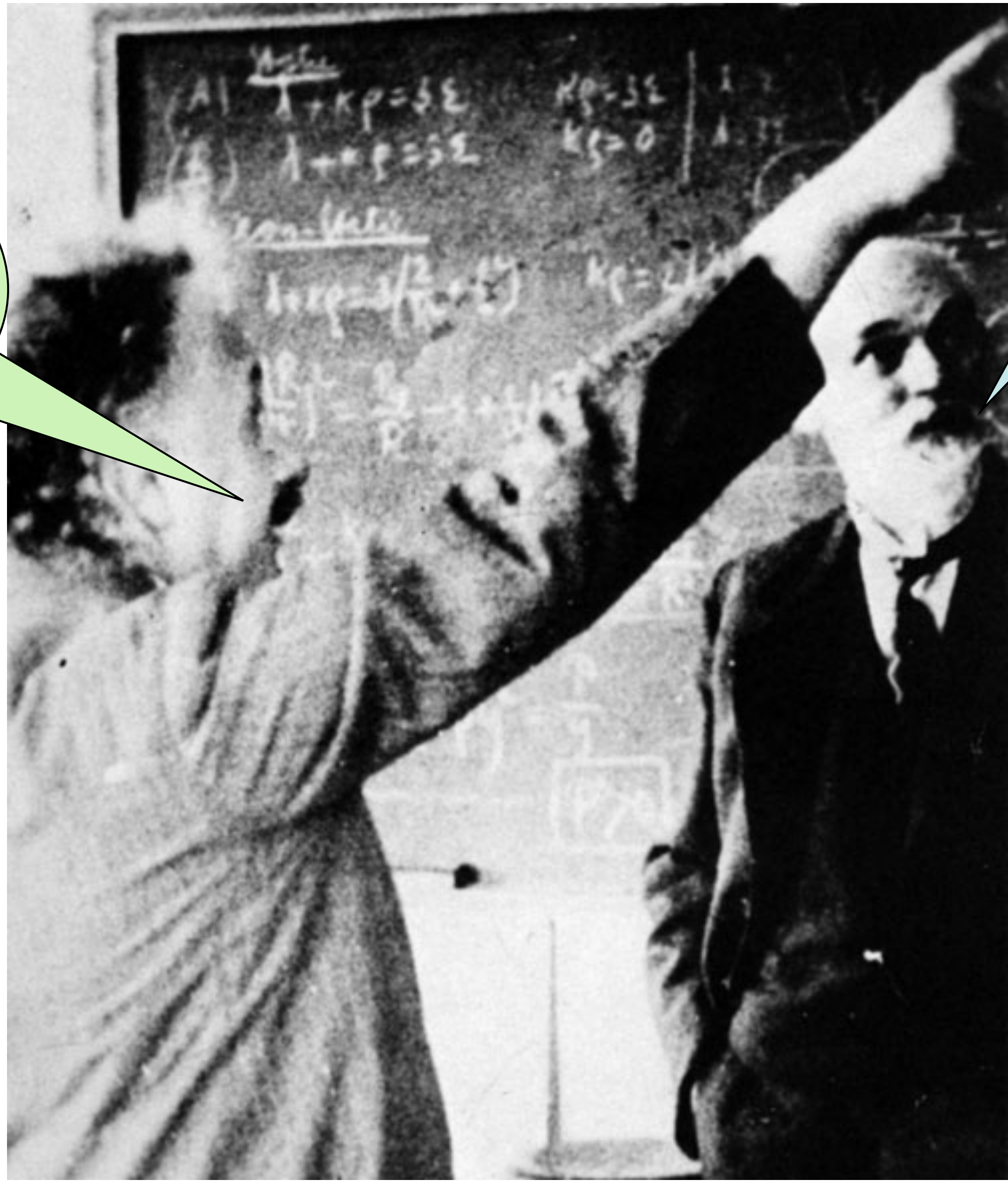
By studying binaries he observed two things:

1- Speed of light does not depend upon the source speed

This is clear for a wave in the Aether. Once launched it cruises in the Aether and does not depend upon the speed of its genitor. The stellar aberration is tough, though, on a wave description.

The theories of emission (like Newton) are therefore in trouble except if there is a distance over which the photon does comply finally to the Aether rules. If this distance is small then it is fine. This is the case for FLOWER.

2- Stellar aberration is the same for both components of distant binary stars, even though the relative velocity of each with respect to the observer is quite different.


Dammit Willem… stellar aberration should depend on the relative speed between the star and the Earth!
Sorry, Albert, it does not!

No. 203. Vol. XXXIV. NOVEMBER, 1887.

Established by BENJAMIN SILLIMAN in 1818.

THE

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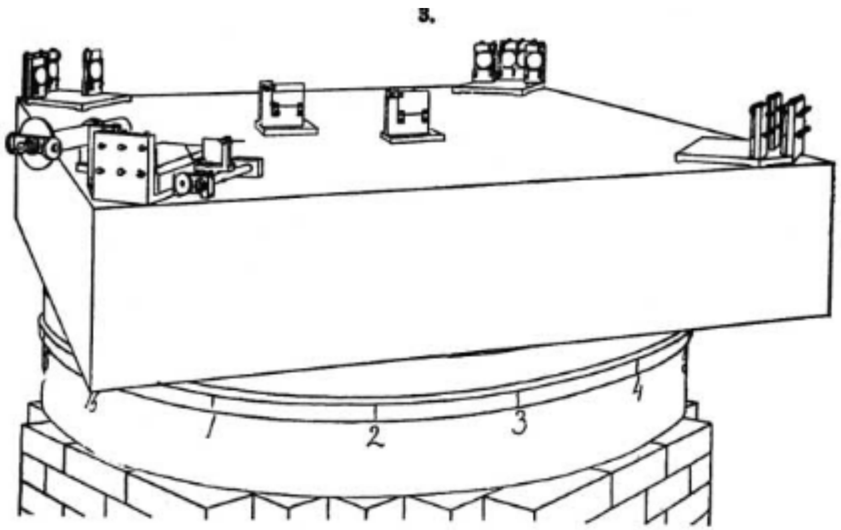
[THIRD SERIES.]

ART. XXXVI.—*On the Relative Motion of the Earth and the Luminiferous Ether;* by ALBERT A. MICHELSON and EDWARD W. MORLEY.*

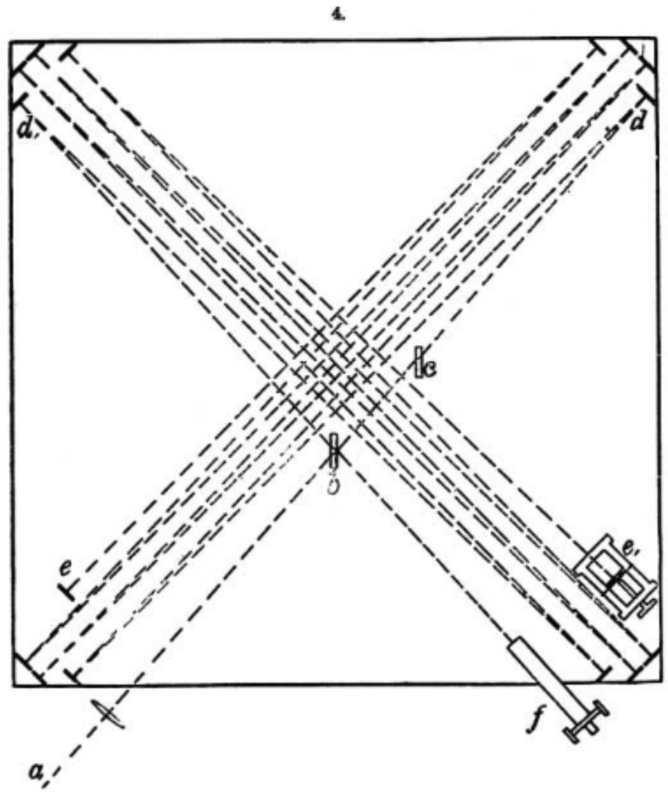
THE discovery of the aberration of light was soon followed by an explanation according to the emission theory. The effect was attributed to a simple composition of the velocity of light with the velocity of the earth in its orbit. The difficulties in this apparently sufficient explanation were overlooked until after an explanation on the undulatory theory of light was proposed. This new explanation was at first almost as simple as the former. But it failed to account for the fact proved by experiment that the aberration was unchanged when observations were made with a telescope filled with water. For if the tangent of the angle of aberration is the ratio of the velocity of the earth to the velocity of light, then, since the latter velocity in water is three-fourths its velocity in a vacuum, the aberration observed with a water telescope should be four-thirds of its true value.†

* This research was carried out with the aid of the Bache Fund.

† It may be noticed that most writers admit the sufficiency of the explanation according to the emission theory of light; while in fact the difficulty is even greater than according to the undulatory theory. For on the emission theory the velocity of light must be greater in the water telescope, and therefore the angle of aberration should be less; hence, in order to reduce it to its true value, we must make the absurd hypothesis that the motion of the water in the telescope carries the ray of light in the opposite direction!



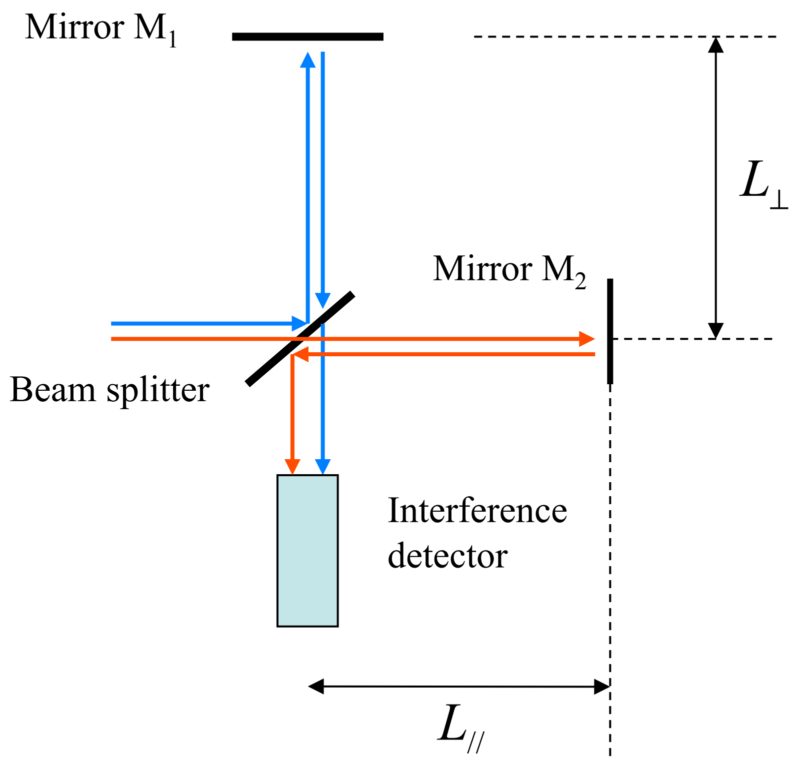
Stone floating on mercury



Total arm length = 11m

Michelson and Morley in absolute Galilean space

This experiment checks the synchronization of two perpendicular light clocks (blue and red)



$$L_\perp = L_{//} = 11m$$

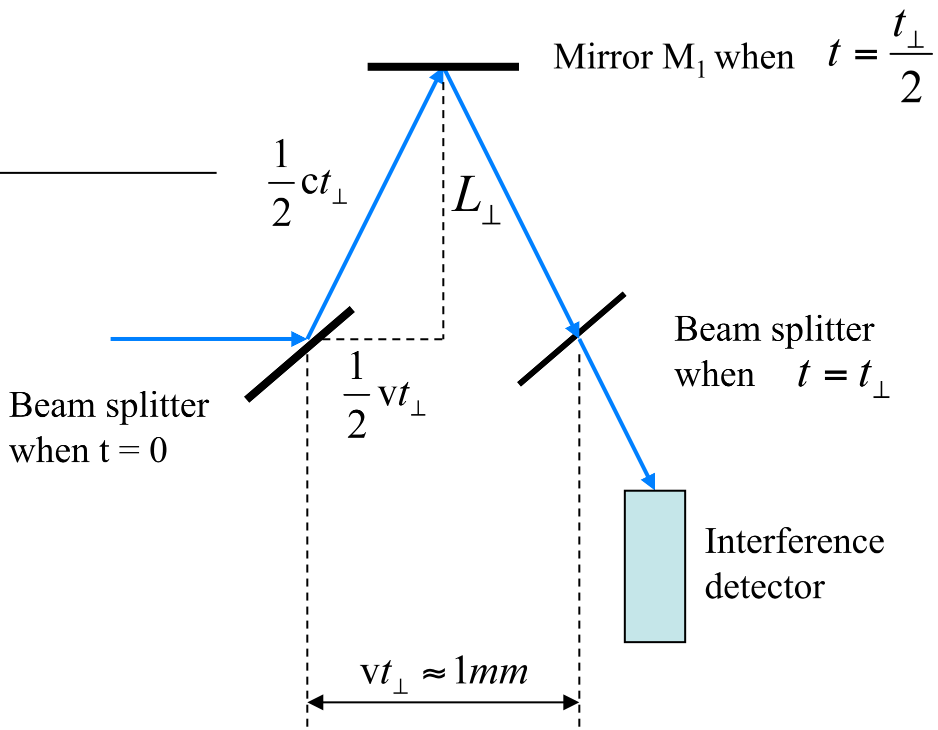
Entire apparatus has a velocity v with respect to the absolute frame.

We do not know what v is, neither in absolute value nor in direction, but it was assumed that the absolute frame was fixed wrt the Sun and thus v=30km/s (the velocity of the Earth around the Sun).

Michelson and Morley in absolute Galilean space

The blue ray seen from the Sun

Pythagoras



The clock time in the rest frame is

$$\tau_\perp = \frac{2L_\perp}{c}$$

Therefore we get, in absolute Galilean space, the time dilation of light clocks

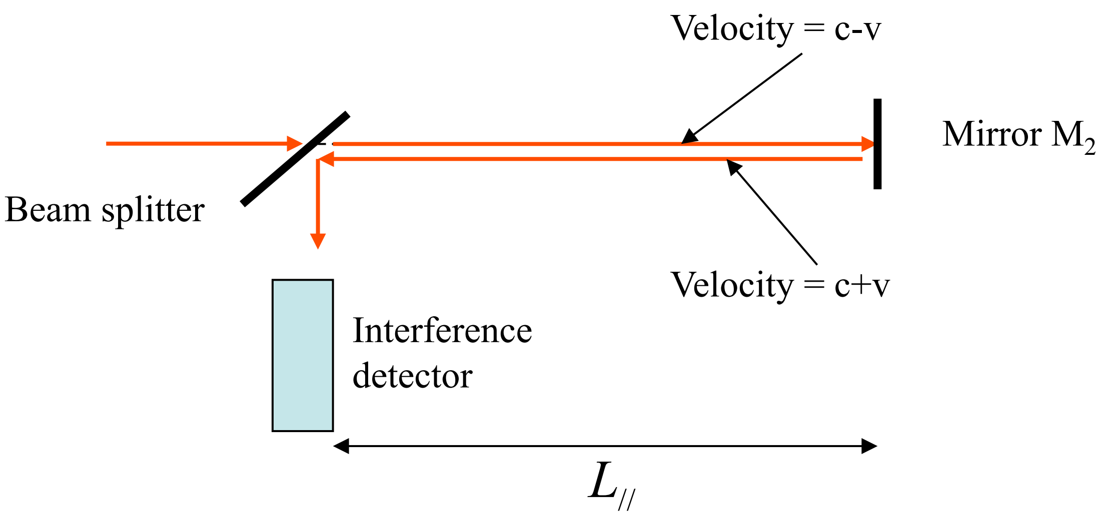
$$t_\perp = \gamma \tau_\perp$$

$$L_\perp^2 + \left(\frac{1}{2}\mathrm{v} t_\perp\right)^2 = \left(\frac{1}{2} c t_\perp\right)^2 \quad \Rightarrow \quad t_\perp = \frac{2L_\perp}{c} \frac{1}{\sqrt{1-\beta^2}}$$

Michelson and Morley in absolute Galilean space

The red ray seen from the laboratory

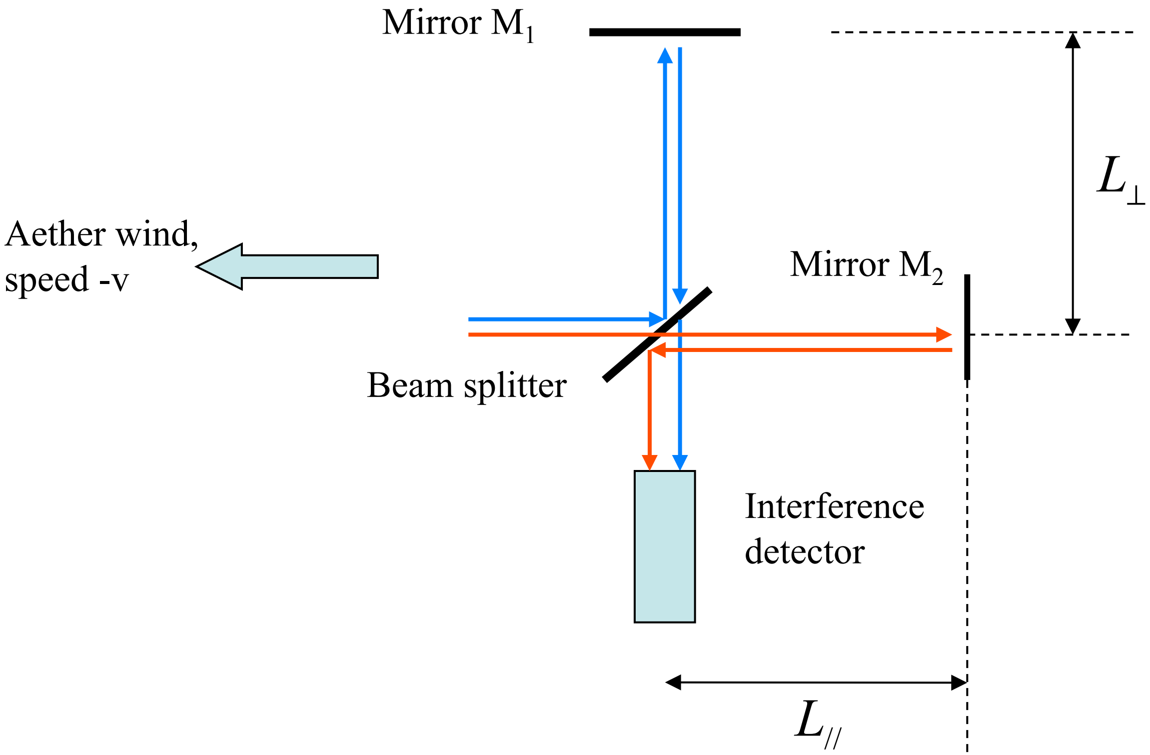
The result is the same if we run the calculations in the frame from the sun. It is done in the back up



$$t_{//} = \frac{L_{//}}{c+\mathrm{v}} + \frac{L_{//}}{c-\mathrm{v}} = \frac{2L_{//}}{c}\frac{1}{1-\beta^2}$$

Michelson-Morley in Einstein relativity

In the apparatus system



Speed of Aether is –v. Ligth propagates in the Aether at c. The law of speed addition is:

$$c_{\text{in interferometer}} = \frac{c+v}{1+\dfrac{cv}{c^2}} = c$$

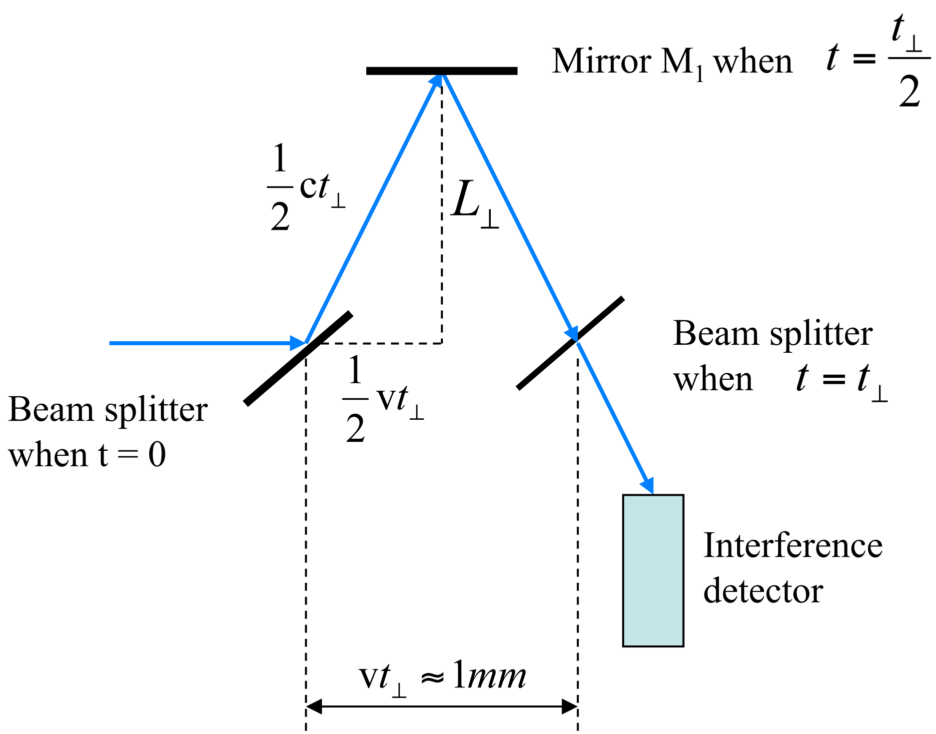
No surprise of course!

Then since the speed is c and the distances are equal the propagation times in both arms are equal.

Very simple indeed!

Michelson-Morley in Einstein relativity

In the sun system

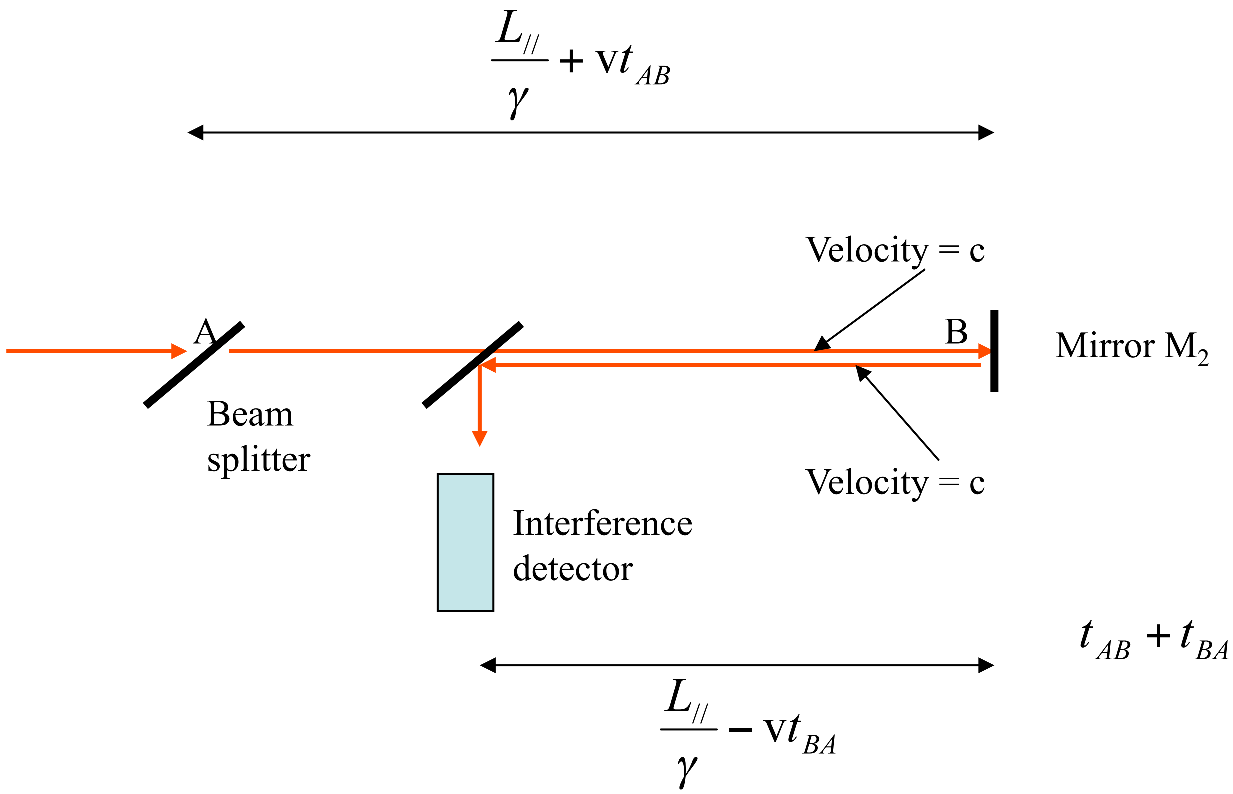


$L_\perp$ is unchanged thus the calculations are the same as in the Galilean case and produce the same time:

$$t_\perp = \frac{2L_\perp}{c} \frac{1}{\sqrt{1-\beta^2}}$$

Michelson-Morley in Einstein relativity

In the sun system



$$t_{AB} = \frac{1}{c}\left[\frac{L_{//}}{\gamma} + \mathrm{v}t_{AB}\right]$$

$$t_{AB} = \frac{L_{//}}{\gamma(c-\mathrm{v})}$$

$$t_{BA} = \frac{L_{//}}{\gamma(c+\mathrm{v})}$$

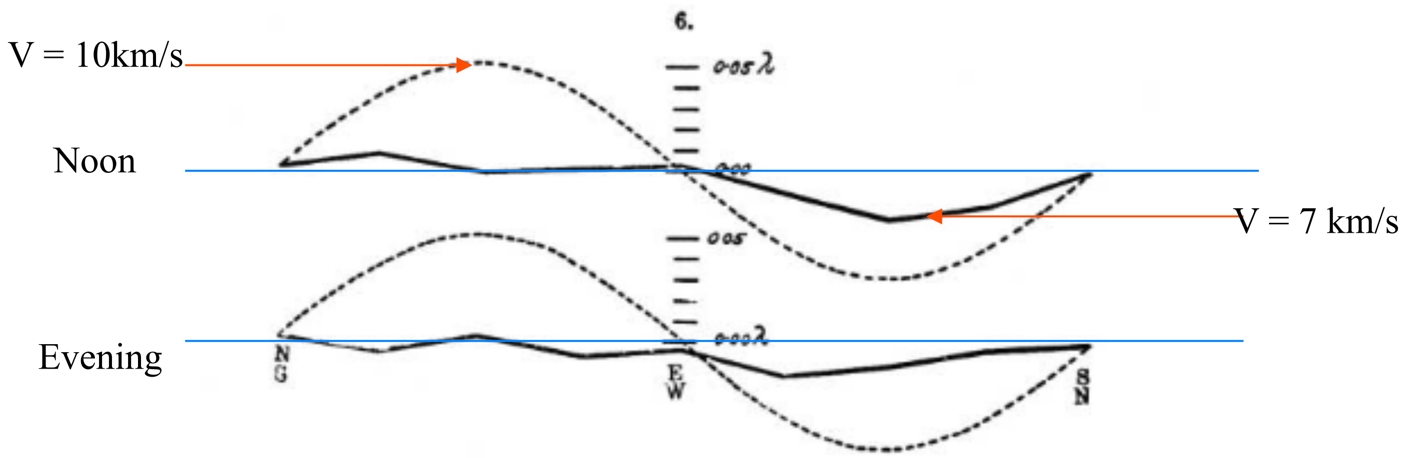
$$t_{AB} + t_{BA} = \frac{L_{//}}{\gamma}\left(\frac{1}{c-\mathrm{v}} + \frac{1}{c+\mathrm{v}}\right) = \frac{2L_{//}}{c}\gamma$$

The galilean result was $\frac{2L_{//}}{c}\gamma^2$

The experimental results

July 8, 9, 11 and 12 (1887)

16 observations at noon and in the evening by turning slowly the apparatus.



The relative velocity between the Earth and the Aether is less than 7 km/s

Most people assume it is zero

The difference in the number of wavelength in each arm does not change when turning the interferometer => equality of the transit times?

$$t_{//} = \frac{2L_{//}}{c} \frac{1}{1-\beta^2} \qquad t_{\perp} = \frac{2L_{\perp}}{c} \frac{1}{\sqrt{1-\beta^2}}$$

$$t_{\perp} = t_{//} \Longrightarrow \boxed{\frac{L_{\perp}}{L_{//}} = \gamma}$$

1- Lorentz postulated any one of a certain family of possible deformation effects for rigid bodies in motion, including purely transverse expansion. Strict longitudinal contraction is not required.

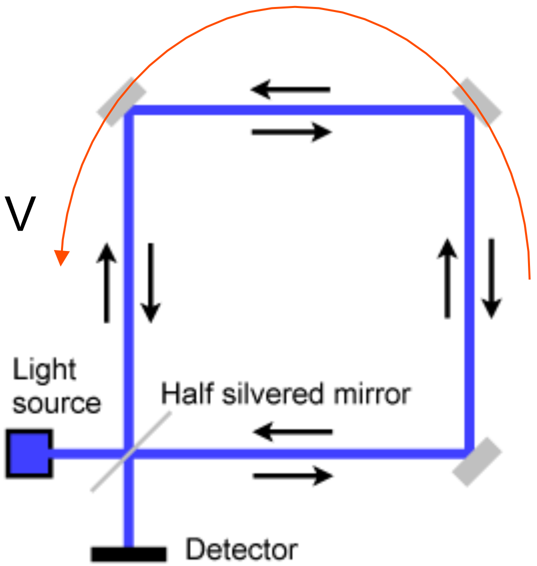
2- Einstein relativity picks up the solution where the longitudinal lengths appear contracted

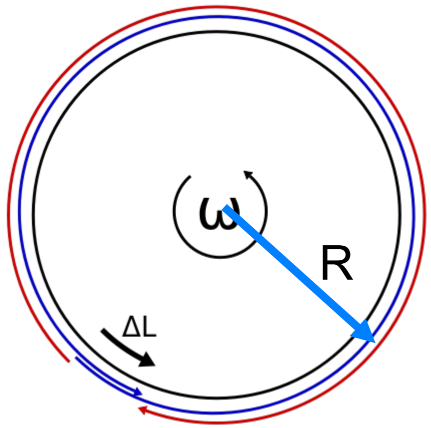
3- Because of the addition of velocities in Einstein relativity, the null result of the M-M experiment does not rule out any Aether

4- Another possibility is $\beta = 0$

Sagnac, Georges (1913)

"L'éther lumineux démontré par l'effet du vent relatif d'éther dans un interféromètre en rotation uniforme", *Comptes Rendus* **157**: 708–710





$$t_1 = \frac{2\pi R}{c - V} \qquad t_2 = \frac{2\pi R}{c + V} \qquad \Delta t = t_1 - t_2 = \frac{4\pi R V}{c^2 - V^2} = \frac{4\pi R}{c}\beta\gamma^2$$

First order in v/c

Sagnac, Georges

Einstein's publications never mention it.
A first discussion by **Langevin** came 8 years later (1921).
Langevin wrote a second article in 1937 in which two (!) relativistic treatments were presented.

Abhay Ashtekar and Anne Magnon
Enrico Fermi Institute, University of Chicago, J. Math. Phys. **16**, 341 (1975)
A description of the Sagnac experiment is obtained within the context of general relativity. In this context the effect provides an operational definition of rotation. An expression for the magnitude of the phase shift is derived under fairly general conditions. The general definition of rotation provided by this experiment is shown to reduce, in certain particular cases, to the usual definitions available.

Hum!

Hafele and Keating

"Around-the-World Atomic Clocks: Observed Relativistic Time Gains". Science **177** (4044): 168–170.

From M&M, standing still on the Earth surface is standing in an inertial frame.

We send one clock to the east and one to the west with the same absolute velocity with respect to the clock staying at home.

What will be the time differences between the three clocks, knowing that the time dilation depends only on the square of the relative velocity?

Well… I expect that the flying clocks will be late with respect to the « stay at home » clock by the same amount!

Let us see what happened

of the two moved clocks one increased in time and the other decreased!!!

Time difference (in ns)	Eastward	Westward
Observed:	**- 59 ± 10**	**+ 273** ± 21

$$\frac{\Delta t}{t_0} \approx \frac{gh}{c^2} - \frac{V_{Earth}}{c}\frac{V}{c} - \frac{1}{2}\left[\frac{V}{c}\right]^2$$

where $V_{Earth} = \Omega R \cos\theta = 400 m/s$ (at the equator)

gravitation

Sagnac effect depends upon the sign of V

Velocity time dilation

	Eastward	Westward
Gravitational	144 +/- 14	179 +/- 18
Kinematic	-184 +/- 18	96 +/- 10
Net effect	**- 40** +/- 23	**+275** +/- 21

We must acknowledge that in the Hafele and Keating experiment, one twin definitely experiences a speeding up of his clock, and the other a slowing down, and from their motions alone, they can determine their velocities with respect to the non-rotating, geocentric frame of the earth.

Bailey et al.

Nature, 268, 301 (1977)

Muon (3 GeV) storage ring at CERN

1- Life time goes from 2.2 μs to 64 μs.

This goes like $\gamma\tau$ although the frame is a ring like in Sagnac and not an inertial frame

2- Time dilation does not depend upon acceleration (10^{15}g)

$\Rightarrow$ quid of equivalence principle?

3- Is the situation reciprocal ? Do high-speed muons would really see laboratory muons live longer? No test was then possible.

which observations would be discriminating ?

1- one way speed of light

2- speed limit

3- are inertial frames symetrical ?

4- privileged frame

one way speed of light

The Rod Contraction-Clock Retardation Ether Theory and the Special Theory of Relativity
Herman Erlichson: Am. J. Phys. 41, 1068 (1973)

The difficulty in measuring the one way speed of light is that it requires synchronized clocks at the start and finish. This is Einstein convention implying that the one way speed is c.

So far no experimental proposal would avoid that problem and it may be that none is possible.

Remark:

for someone standing up on the Sagnac rotating platform, the speed of light is different between left and rigth directions! But… this frame is not inertial!

speed limit

1- superluminal effects have been studied in connection with quantum-tunnelling experiments. (R Y Chiao and A M Steinberg 1997 *Progress in Optics* **XXXVII** 347, G. Nimtz and A. A. Stahlhofen with prisms and 9 GHz)

2- The collapsus of wave functions is asking for superluminal speeds

3- If the expansion is accelerating most galaxies will cross a cosmological horizon. No light they emit will ever reach us. This is so because their peculiar velocity towards us is smaller than the expansion velocity away from us.

4- The speed of gravitons is superluminal because the escape speed from a black hole is c.

FLOWER predicts that gravitons should have speeds way larger than c because they interact much less than photons with the vacuum.

What is the speed of gravity anyway?

Laplace (1825) $v_{gravity} > 10^8\, c$
T. Van Flandern : Physics Letters A 250:1-11 (1998) $v_{gravity} > 2\ 10^{10}\, c$
See backup

An interesting question is

what mechanism produces a speed limit?

are inertial frames symetrical ?

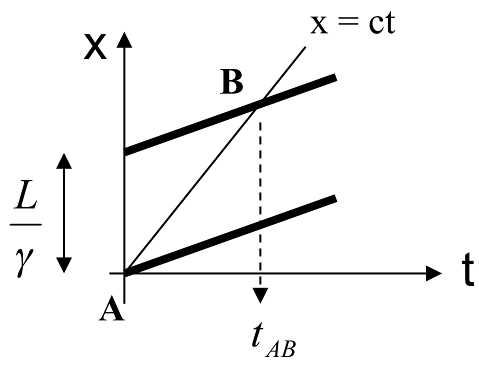
1- F. Selleri in Apeiron , **11**, 246 (2004)
An unpleasant aspect of this symetry is the fact that energy, for instance, is given a different value by each observer and since they are all valid, one is forced to conclude that a real value of energy does not exist!

2- the experiment of Hafele and Keating seems to indicate that the symetry is not obvious

3- From F. Couchot.
Let us say you have 100, 3 GeV, Muons entering a storage ring at CERN in 1977 and, at the same time, 100 muons sent to rest in the middle of that ring. **After one complete turn** (roughly 128 μs) there are, from the point of view of a physicist at rest in the lab, 13 muons alive and turning and **no more muons in the middle**. However these 13 turning muons are expecting **13 muons at rest in the middle** of their circle.

privileged frame

The transit time fluctuations of a burst of photons is predicted in FLOWER due to the finite average number of stops over a distance L.



Let δ be the average distance between stops in the privileged frame.

From the privileged frame the path to cross is:

$$L_{AB} = \frac{L}{\gamma} + Vt_{AB}$$

t is the time for a photon to go from A to B. The speed of the photon being c in the privileged frame, we get t_{AB} from

$$ct_{AB} = \frac{L}{\gamma} + Vt_{AB} \Rightarrow t_{AB} = \frac{L}{\gamma(c-V)} \Rightarrow L_{AB} = \frac{L}{\gamma}\frac{c}{c-V}$$

The number of stops is an invariant $$N(V) = \frac{L_{AB}}{\delta} = \frac{L}{\delta}\frac{c}{c-V} = \frac{N(V=0)}{1-\beta}$$

The relative fluctuation of the crossing time is $$\boxed{\frac{\sigma_t}{t} = \frac{1}{\sqrt{N(V)}} = \frac{\sigma_{t_0}}{t_0}\sqrt{1-\beta}}$$

The relative fluctuation of the crossing times gives the absolute speed with respect to the absolute frame (but no indication of direction).

This relative fluctuation is the largest when standing still in the absolute frame.


Sagnac has made
me melancholy...
Einstein with his therapist
LIFE

Questions to the audience

=> Life time of muons depends on their speed and **presumably** depends on the force of the gravitation they stand in.

According to the equivalence principle this gravitation produces the same effects as an acceleration.

An acceleration is a speed which varies so it should not produce a constant shift in time.

Furthermore the muons, in the CERN experiment, did not care about a 10^{15}g acceleration.

⇒When moving on the Earth from the poles to the equator the centrifugal acceleration varies a lot however the clocks depend on the differences in height with respect to the center of the Earth.

1- Do you think that gravitational acceleration and centrifugal acceleration are not equivalent at all ?

2- Mass grows with speed so do you think that mass changes with acceleration or gravitation ?

Conclusion

An absolute frame is not necessarily nonsense!

In case it does exist:

where is it ?

what is its constitution ?

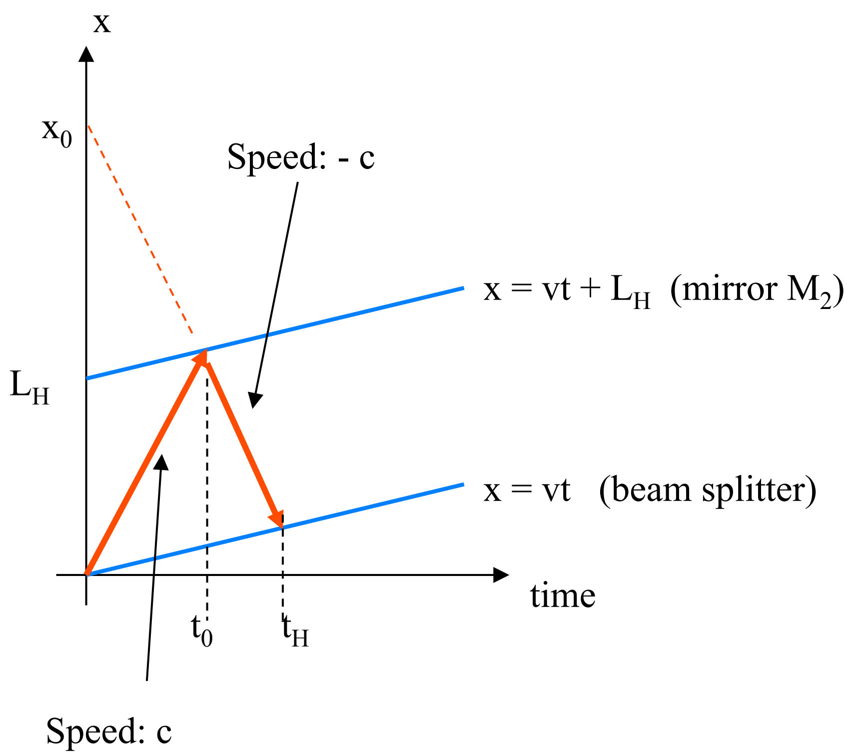
Can its properties vary (varying c) ?

Is it unique or could we have several contiguous or of the Matriochka types?

New experiments are needed

Back up

t_H from the Sun (supposed to be the absolute frame)



$$x_0 - ct_0 = L_H + vt_0$$

$$\Rightarrow \quad x_0 = L_H + (v + c)t_0$$

$$x_0 - ct_0 = ct_0$$

$$t_0 = \frac{L_H}{c - v}$$

$$x_0 = \frac{2c}{c - v} L_H$$

$$x_0 - ct_H = vt_H$$

$$2L_H \frac{c}{c - v} = (c + v)t_H$$

$$t_H = 2L_H \frac{c}{c^2 - v^2}$$

$$\boxed{t_H = \frac{2L_H}{c} \frac{1}{1 - \beta^2}}$$

Number of wavelength

When we are in the Sun frame we see the mirrors moving. The photons will therefore change their wavelength upon reflection.

The relative change is big since it is 2β with an angular factor when the incidence is not 0°.

I suppose that the changes cancel in the round trip.

In the frame of the mirrors they are not moving but the speed of the photons is c+v and c-v and this , I imagine, will change their λ by a Doppler effect.

Hafele and Keating Equation (2)

$$T - T_o = \{\ gh/c^2 - (2R\Omega v \cos(\theta) + V^2/2C^2)\}\ {}^*T_o$$

translates to:

$$T - T_o = \left[\ \frac{gh}{c^2} - \frac{R\Omega v \cos(\theta)}{C^2} - \frac{V^2}{2C^2}\ \right] {}^*T_o$$

height term

Sagnac term

tangential velocity term (velocity time dilation)

Sagnac Term:

$$\frac{R\Omega v \cos(\theta)}{C^2} {}^*T_o = \frac{2\,\Omega\, A_E}{C^2}$$

Ω = angular velocity with respect to absolute space

A_E = Earth area swept out by radius R over time T

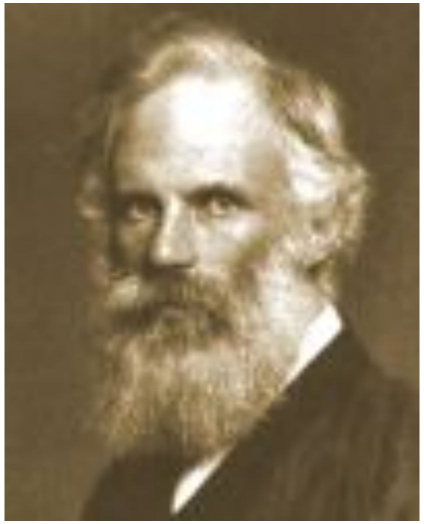
R = earth radius

v = clock velocity

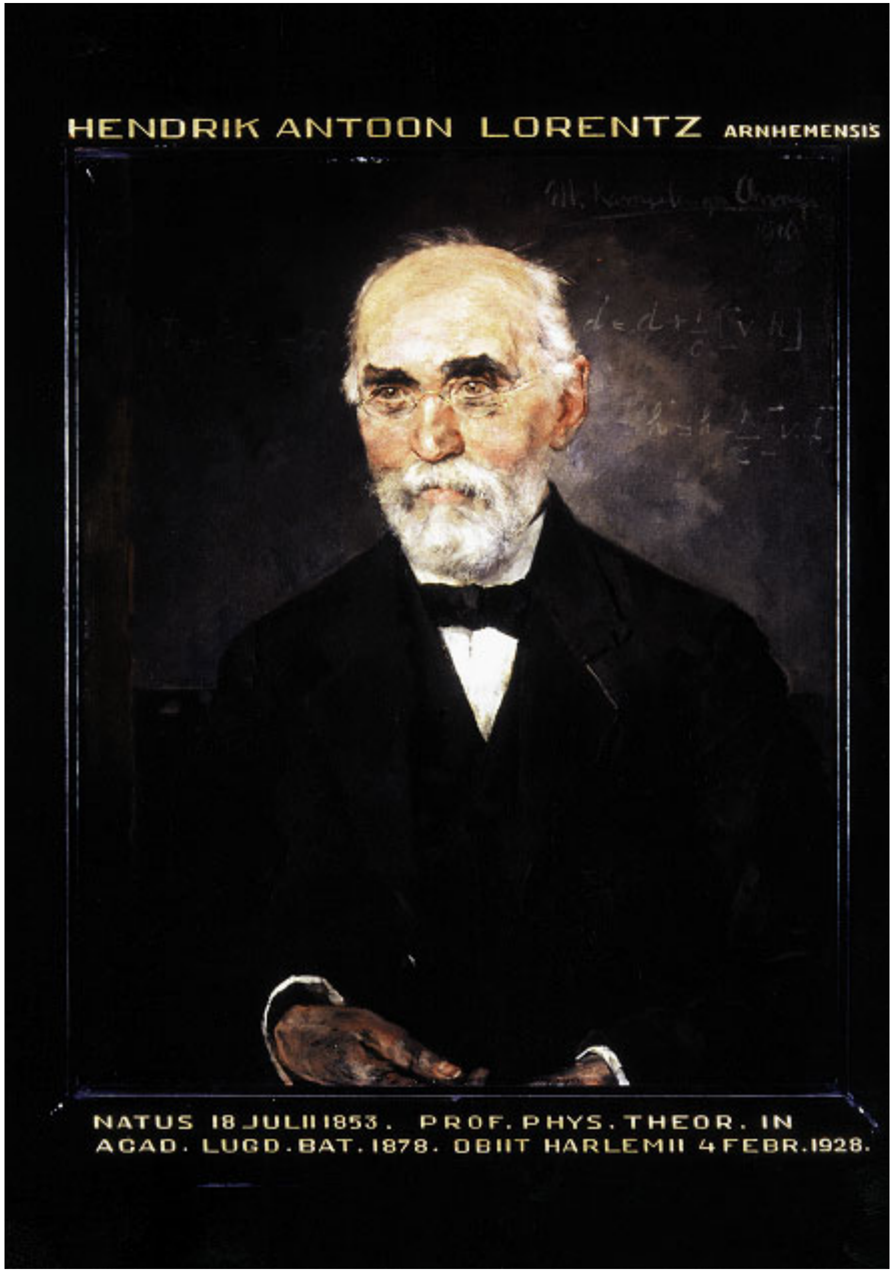
θ = angle from equator

Ole Roemer

James
Bradley



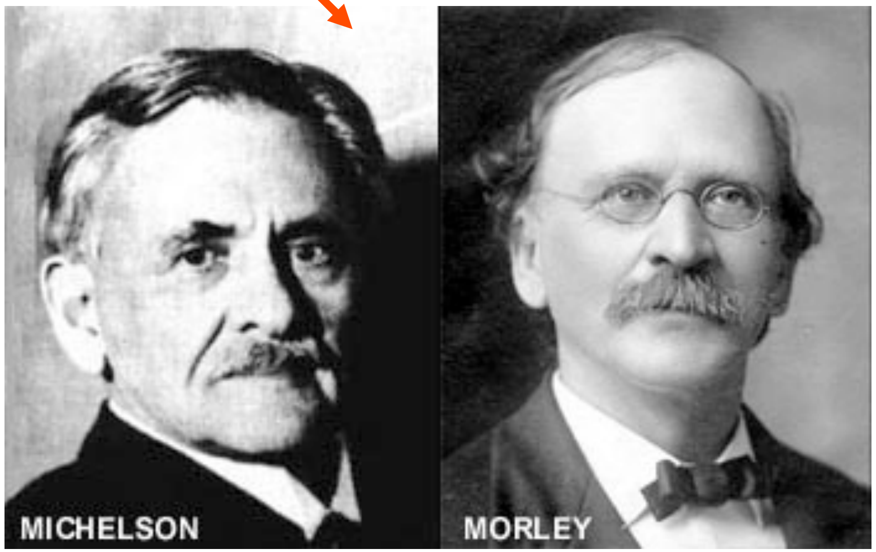
Fitzgerald

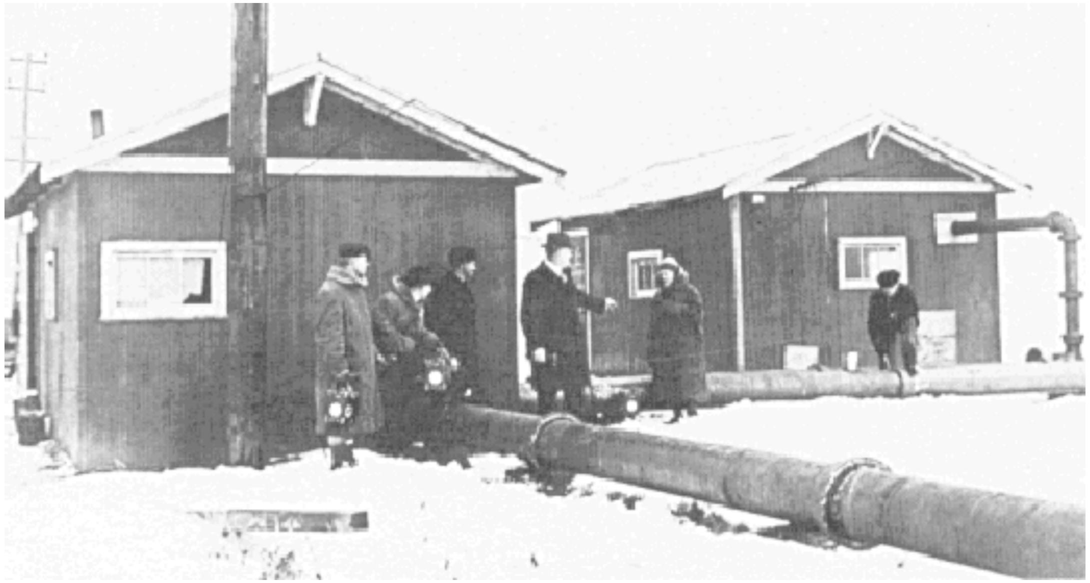

HENDRIK ANTOON LORENTZ ARNHEMENSIS
NATUS 18 JULII 1853. PROF. PHYS. THEOR. IN
ACAD. LUGD. BAT. 1878. OBIIT HARLEMII 4 FEBR. 1928.

A.A. Michelson
1852 - 1931

E.W. Morley
1838 - 1923

Time
expansion





Michelson-Gale Experiment (1925)
A. Michelson, H. Gale, "The Effect of the Earth's Rotation on the Velocity of Light,"

The Astrophysical Journal, April 1925, vol. LXI, number 3

Herbert Eugene Ives. Photo publiée
ou prise en 1913.

Modifications des atomes lors d'un mouvement

Ce qui compte pour la force de Coulomb c'est le flux des photons éphémères. Combien l'électron reçoit de photons par seconde et quelles impulsions ont-ils ?

Le module de la vitesse des photons éphémères dans le vide absolu est une constante et vaut c mais sa direction est affectée par le mouvement de la source. Nous devrions avoir une augmentation du flux à l'avant du noyau et une diminution derrière. En quelque sorte le mouvement du noyau couche les vecteurs.
En ce qui concerne l'intervalle en temps entre les arrivées des photons je dirais qu'il n'y a pas de changement mais c'est à voir !
Par les transformations de Lorentz on va avoir

$$p_z = \gamma(p^* \cos\theta^* + \beta \frac{E^*}{c}) = \gamma p^* (\cos\theta^* + \beta)$$

$$E = \gamma(E^* + \beta c p^* \cos\theta^*) = \gamma c p^* (1 + \beta \cos\theta^*)$$

Et nous obtenons le cosθ en fonction du cosθ* qui, lui, est distribué uniforme.

$$\cos\theta = \frac{p_z c}{E} = \frac{\cos\theta^* + \beta}{1 + \beta \cos\theta^*}$$

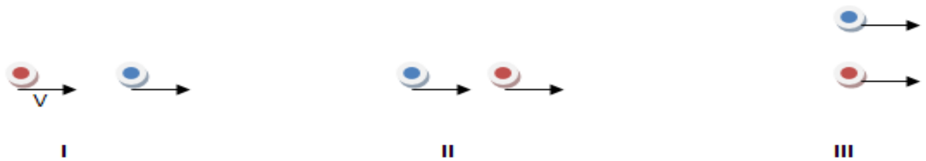
L'élément d'angle solide est

$$d\Omega = 2\pi\ d(\cos\theta) = 2\pi \left[\frac{1}{1 + \beta\cos\theta^*} - \frac{\cos\theta^* + \beta}{(1 + \beta\cos\theta^*)^2} \beta \right]$$

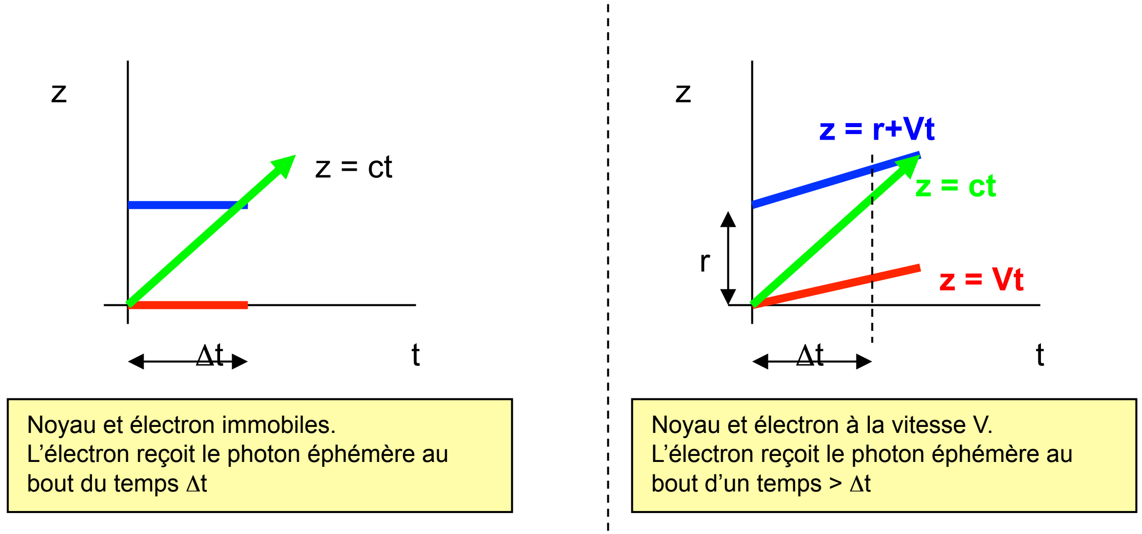
$$d\Omega = 2\pi\ d(\cos\theta) = 2\pi \frac{1 + \beta\cos\theta^* - \beta\cos\theta^* - \beta^2}{(1 + \beta\cos\theta^*)^2} d(\cos\theta^*)$$

$$d\Omega = \frac{1}{\gamma^2} \frac{1}{(1 + \beta\cos\theta^*)^2} d\Omega^*$$

L'angle solide dans le repère absolu est donc bien contracté par rapport au repère où le noyau est au repos. Les photons éphémères émis dans $d\Omega^*$ se retrouvent dans un angle solide plus petit. A part le terme $1/\gamma^2$ qui est commun on observe qu'à l'avant ($\theta^*=0$) le flux est plus important qu'à l'arrière ($\theta^*=\pi$).
Considérons trois cas où le système noyau-électron se déplace à la vitesse constante V.



Sur le premier nous voyons que lorsque le noyau émet un photon, celui-ci, pour atteindre l'électron, doit parcourir un chemin plus long puisque pendant le temps du trajet l'électron s'est déporté vers la droite.



Le photon doit vivre plus longtemps et son impulsion est donc plus faible. Ce fait est contrebalancé, en partie, par l'augmentation du flux à l'avant. Dans le cas II c'est le contraire, l'électron va au devant du photon éphémère. Le cas III n'est pas très simple et je verrai plus tard mais en première approximation il n'y a pas de changement par rapport au repos.

La force de Coulomb est : $F = \alpha \frac{\hbar c}{r^2}$

r est la distance entre les deux charges unité. Dans FLOWER nous disons que ceci peut s'écrire :

$$F = \alpha \frac{\hbar c}{r^2} = \frac{dp}{dt} \qquad dp = p = \frac{\hbar}{2r} \qquad dt = \frac{r}{2\alpha\, c} = \frac{T}{4\pi}$$

T est la période de révolution de l'électron autour du noyau au repos.

L'augmentation de la distance à parcourir à l'avant est donnée par

$$\frac{r*}{r} = \frac{c}{c-V} = \frac{1}{1-\beta}$$

En définitive la force, à l'avant, est multipliée par

$$\frac{F}{F*})_{avant} = (\frac{r}{r*})^2 \frac{d\Omega *}{d\Omega} = (1-\beta)^2 \gamma^2 (1+\beta\cos\theta *)^2$$

$$\frac{F}{F*})_{avant} = \gamma^2 (1-\beta)^2 (1+\beta)^2 = \frac{(1-\beta^2)^2}{1-\beta^2} = \frac{1}{\gamma^2}$$

A l'arrière nous avons la même chose !

$$\frac{F}{F*})_{arriere} = (\frac{r}{r*})^2 \frac{d\Omega *}{d\Omega} = (1+\beta)^2 \gamma^2 (1-\beta)^2 = \frac{1}{\gamma^2}$$

Ainsi la force est diminuée par γ^2 aussi bien à l'avant qu'à l'arrière !
Pour avoir la même force, l'électron doit se rapprocher du noyau d'un facteur γ car la force va comme l'inverse du carré des distances
=> **contraction des longueurs de γ!**

Temps de parcours de l'orbite

La distance au noyau a été divisée par γ pour avoir la même force de Coulomb. La force centrifuge doit rester la même donc

$$\frac{mu^2}{r})_{repos} = \frac{m_V u_V^2}{r_V})_V = \frac{m_V u_V^2}{r/\gamma})_V$$

On admet que la masse de l'électron est multipliée par γ (**on ne sait toujours pas expliquer ce phénomène**) et donc :

$$\frac{mu^2}{r})_{repos} = \gamma^2 \frac{mu_V^2}{r}$$

Ceci implique :

$$u_V^2 = \frac{u^2}{\gamma^2}$$

Pour une orbite parallèle au vecteur V, la vitesse est donc γ fois plus petite ce qui entraine un temps de révolution de l'électron autour du noyau plus que γ fois plus grand.
Il y a des orbites qui sont perpendiculaires à V et elles ne changent sans doute pas beaucoup.

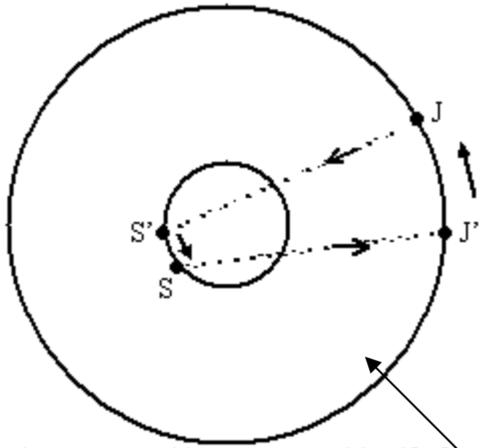


Figure 1. Orbits are unstable if forces propagate with finite speed.

Speed of gravity

Why don't we see the equivalent of the Poynting Robertson effect?

Why do photons from the Sun travel in directions that are not parallel to the direction of Earth's gravitational acceleration toward the Sun?

How can black holes have gravity when nothing can get out because escape speed is greater than the speed of light?

Because of the finite speed of light, a portion of that radial force acts in a transverse direction, like a drag, slowing the orbital speed of the dust particles and causing them to eventually spiral into the Sun. This phenomenon is known as the Poynting-Robertson effect.

From the absence of such an effect, Laplace set a lower limit to the speed of propagation of classical gravity of about 10^8 *c*, where *c* is the speed of light. (Laplace, 1825, pp. 642-645 of translation)

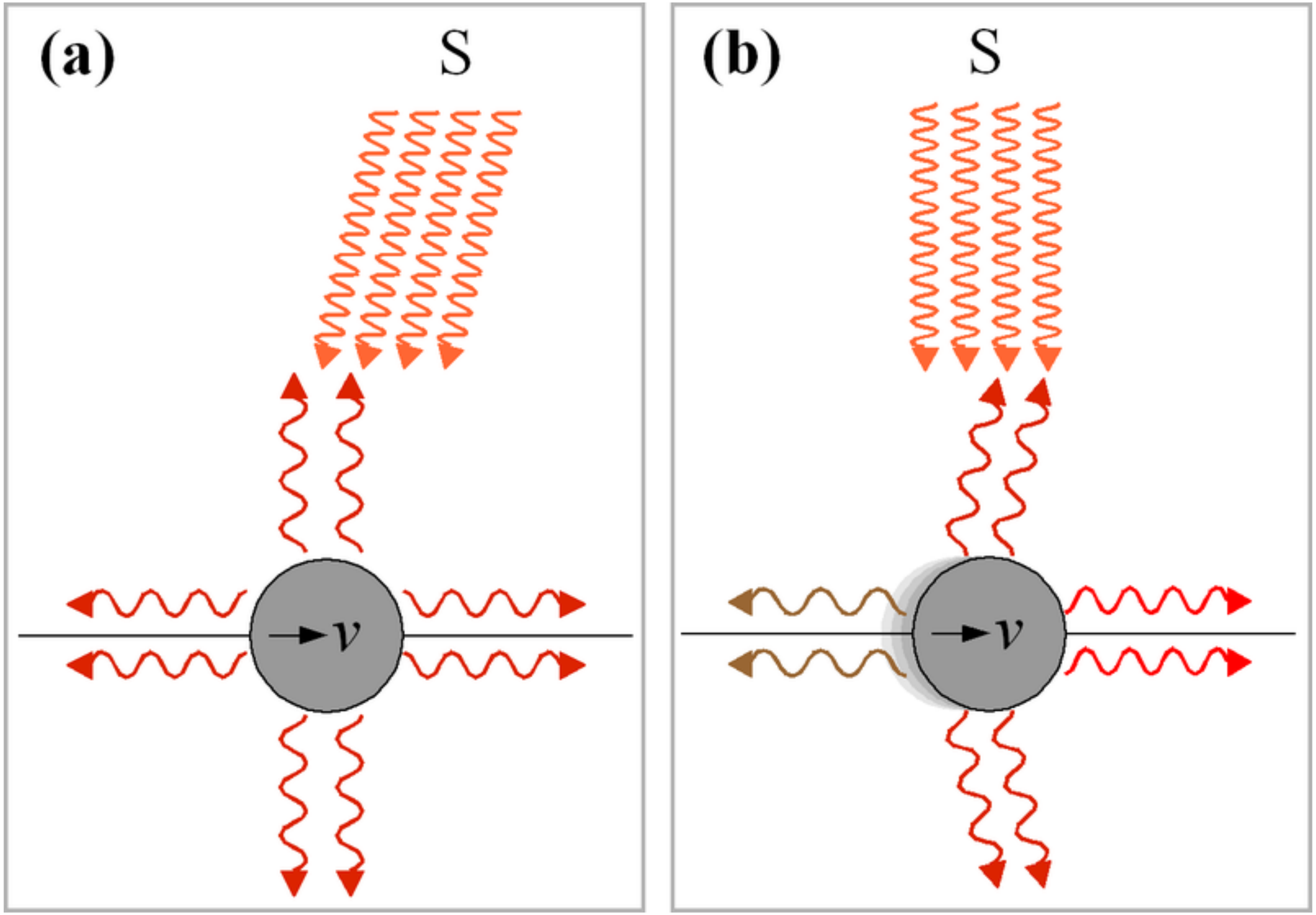
Speed of gravity

Such measurements of Earth's acceleration through space are now easy to make using precise timing data from stable pulsars in various directions on the sky. Any movement of the Earth in any direction is immediately reflected in a decreased delay in the time of arrival of pulses toward that direction, and an increased delay toward the opposite direction. In principle, Earth's orbit could be determined from pulsar timings alone. In practice, the orbit determined from planetary radar ranging data is checked with pulsar timing data and found consistent with it to very high precision.

How then does the direction of Earth's acceleration compare with the direction of the visible Sun? By direct calculation from geometric ephemerides fitted to such observations, such as those published by the U.S. Naval Observatory or the Development Ephemerides of the Jet Propulsion Laboratory, **the Earth accelerates toward a point 20 arc seconds in front of the visible Sun, where the Sun will appear to be in 8.3 minutes.** In other words, the acceleration now is toward the true, instantaneous direction of the Sun now, and is not parallel to the direction of the arriving solar photons now. This is additional evidence that forces from electromagnetic radiation pressure and from gravity do not have the same propagation speed.

The **Poynting–Robertson effect**, also known as **Poynting–Robertson drag**, named after John Henry Poynting and Howard Percy Robertson, is a process by which solar radiation causes a dust grain in the Solar System to spiral slowly into the Sun. The drag is essentially a component of radiation pressure tangential to the grain's motion. Poynting gave a description of the effect in 1903 based on the "luminiferous aether" theory, which was superseded by the theories of relativity in 1905–1915. In 1937 Robertson described the effect in terms of general relativity.

The effect can be understood in two ways, depending on the reference frame chosen.
Radiation from the Sun (S) and thermal radiation from a particle seen (a) from an observer moving with the particle and (b) from an observer at rest with respect to the Sun.
From the perspective of the grain of dust circling the Sun (panel (a) of the figure), the Sun's radiation appears to be coming from a slightly forward direction (aberration of light). Therefore the absorption of this radiation leads to a force with a component against the direction of movement. (The angle of aberration is extremely small since the radiation is moving at the speed of light while the dust grain is moving many orders of magnitude slower than that.)
From the perspective of the Solar System as a whole (panel (b) of the figure), the dust grain absorbs sunlight entirely in a radial direction, thus the grain's angular momentum is not affected by it. But the *re-emission* of photons, which is isotropic in the frame of the grain (a), is no longer isotropic in the frame of the Solar System (b). This anisotropic emission causes the photons to carry away angular momentum from the dust grain.
The Poynting–Robertson drag can be understood as an effective force opposite the direction of the dust grain's orbital motion, leading to a drop in the grain's angular momentum. It should be mentioned that while the dust grain thus spirals slowly into the Sun, its orbital speed increases continuously.


(a)
S
v
(b)
S
v

Principe d'équivalence et dilatation des temps

Dans le cas de vitesses faibles devant c la fréquence des horloges varie et nous avons:

$1-\dfrac{V^2}{2c^2}$ par la relativité d'Einstein et $1-G\dfrac{M}{rc^2}$ par la relativité générale.

L'accélération due à la gravité de la Terre est : $a=G\dfrac{M}{r^2}$

et ainsi la variation de fréquence due à la gravité peut s'écrire: $1-\dfrac{ar}{c^2}$

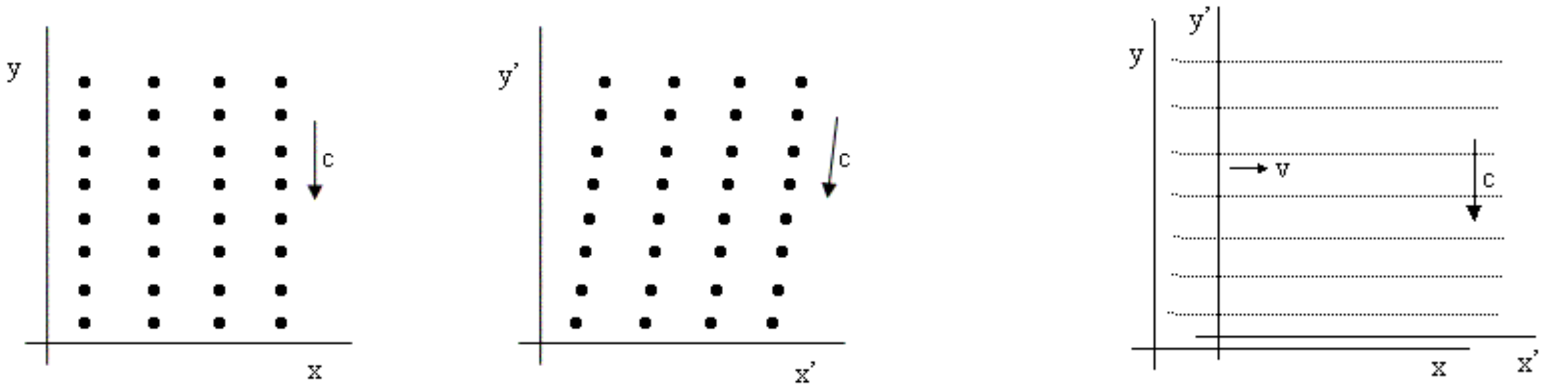
Comment faire entrer le principe d'équivalence dans cet effet?
Une accélération c'est clair mais quelle distance r prendre ? En plus on peut avoir ar >> c^2 !
Comparaison Terre, Soleil Galaxie pour les potentiels :
Terre, M = 6 10^{24}kg, r = 6.4$10^6$m,
Soleil, M = 2 10^{30} kg, r = 1.5 10^{11}m
Galaxie, M = 10^{11} Soleils, r = 0.7 10^{21}m
Le potentiel de gravitation du Soleil à la surface de la Terre est 14 fois plus grand que celui de la Terre. La galaxie produit un potentiel 20 fois plus grand que celui du Soleil et donc 300 fois celui de la Terre sur elle-même !!!
La vitesse V correspondant à cette accélération est: $V=\sqrt{2ar}$

A la surface de la Terre nous avons a = 10ms^{-2}, r = 6.4 10^6m et donc V = 11km/s la vitesse de libération. Ainsi les effets pour le GPS vont être comparables.

Bradley (1727) stellar aberration

apparent position of a star that is roughly θ above the ecliptic ought to describe a small circle (or ellipse) around its true position, and the “radius” of this path should be $\sin(\theta)(v/c)$ where v is the Earth’s orbital speed and c is the speed of light.

so the magnitude of the aberration for γ Draconis is $(v/c)\sin(75\ \text{deg}) = (9.59)10^{-5}$ radians = 19.8 seconds of arc.



Illustrating the difficulty of explaining the aberration within the wave description of light

Applying a model of time dilation to the earth is considerably more complicated. Einstein in his 1905 article argued that an observer on the equator would experience more time dilation due to their rotation at v2/2c2, as compared to an observer at the pole. This has been now shown not to be true; - the rate of clocks at sea level (or more precisely, on earth's geoid surface) all count at the same rate all over the globe. The reason for this is that the two competing time dilation effects, gravitational time dilation and velocity time dilation, cancel out. The conventional argument goes that earth is an oblate sphere due to the equator bulging out from the centrifugal force. Since the pole is closer to the center than the equator, the pole is at a larger negative gravitational potential -GM/r, and thus experiences a larger time dilation gh/c2 than the equator. However, since the equator observer is rotating at the tangential velocity v, they experience a counter-acting velocity time dilation v2/2c2, which is sometimes referred to as the centripetal term. The height effect at the pole is almost twice as large as the velocity effect at the equator; the argument is then that the distribution of mass in the earth due to its oblateness creates additional gravitational forces that serve to balance this out. This last term is the gravitational quadrupole term. When all three terms are added together, the time dilation on the geoid is the same rate everywhere on the globe.

The fact that the centrifugal force at the equator does not counter-act the time dilation effect of gravity demonstrates that gravitational acceleration and centrifugal acceleration are not equivalent at all. The former subtracts from the latter to lower the gravitational acceleration, but when it comes to the calculation of time dilation, it is treated as a centripetal force instead, under which the two component effects add to increase the time dilation. This is why what is referred to as "centripetal acceleration" component of time dilation is inappropriately named - it should be called the velocity time dilation effect, since acceleration, in and of itself, has no effect on time dilation beyond its velocity effect.