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# The Fizeau Experiment Revisited

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**Abstract:**
A summary of the experiment is provided. A new theory based on full convection for light in water is proposed, which closely approximates the physical result. A major objection to full convection is eliminated in demonstrating that it accounts for stellar aberration.

**Summary:**
The Fizeau interferometer experiment[1] attempted a determination of the speed of light as it traversed a material body (water) in motion. Three possibilities were considered:

1. The aether is carried with the molecules of the body and shares in their motion. (Full convection.)
2. The aether is independent of the body and is not carried with it. (No convection.)
3. A portion of the aether is carried with the body. (Fresnell's partial convection.)

The second possibility was immediately rejected. The experiment resulted in a positive displacement, which was seen to be incompatible with a fixed aether. (This does not necessarily hold, since light propagating in both directions in a fixed aether would simply be the reverse of full convection and indistinguishable from it.)

It is quite evident in the description of the experiment that the speed of light was considered to be greater than currently accepted. The ratio of the speed of the water with that of light in water was considered By Dr. Fizeau to be 1/33 million, which would make it approximately 310,000 km/s in air. However, this would not affect the physical outcome of the experiment. The following are the experimental values:

$l = 1.4875m$ = length of water tube
$v = 7.059m/s$ = speed of water
$n = 1.333$ = refractive index of water
$c_1 = c/n$ = speed of light in water
$\lambda = 5.26 \times 10^{-7}m$ = wavelength of light source.

Note that the refractive index for light in air is neglected in the calculations since it does not appreciably affect the outcome. Second order values for the speed of water are also neglected for the same reason.

The formula for the shift in wavelength under full convection (two tubes at 1.4875m each) is,

$$4lvn^2 / \lambda c = .47327547 \qquad (1)$$

The average experimental value obtained by Dr. Fizeau was .23016 - less than half the value calculated for full convection.

According to Fresnel's partial convection formula, $(c_1+(1-1/n^2)v$, a fringe shift of *.20692486,* would be expected. This is approximately *10%* less than the average experimental value.

Dr. Fizeau also conducted a light experiment where air moving through a *1.495m* tube at 20m/s was used in place of water. It displayed no perceptible fringe shift. Fresnel's formula predicts a fringe shift of *.0002325* for this experiment. Since a fringe shift 100 times this value would not have been seen, Dr. Fizeau concluded (with reservations) that Fresnel's formula best explained both the water and air experiments.

**Alternate Theory**

A strong case for full convection was presented in an earlier paper[2] involving an analysis of the Hoek experiment, where a split beam of light traversed equal distances of fixed air and water in opposite directions. This produced a null result. The formula was given as

$$1 - 1/n^2 \equiv (n^2 - 1)/n^2 = .4372186 \qquad (2)$$

Since this is not a null result, Fresnel was led to his partial convection theory to explain it. However, a much simpler explanation is immediately evident if we recognize that the formula must include light **entering the water in opposite directions and exiting in the same way**. Entry reduces the wavelength by n and exit increases it by an equal factor.

$$((n^2 - 1)/n^2) - ((n^2 - 1)/n^2) = 0 \qquad (3)$$

Water in motion as in the Fizeau experiment, modifies the result. In the one instance, light speed is incremented by v as it enters the water, but decremented on exit. In the other instance, it is reversed. Since the paths of the light waves are equivalent, we have –

$$(n^2 - 1)/n^2) - \omega((n^2 - 1)/n^2 = .23029378 \qquad (4)$$

where $\omega = 4lvn^2 / \lambda c$. (full convection)

(Note that the second term in equation *(4)* is Fresnel's partial convection.)

Applying the formula to the experiment involving the convection of air, *where* $n = 1.0002926$ *S*TP and $\omega = .37945$ (using the same initial wavelength for light) would give an imperceptible shift in wavelength of $3.63 \times 10^{-4}$.

The above formula provides an excellent match for the experimental results and has the advantage of simplicity. Using equation *(4)* and substituting the refractive index for air provides *.23018077*, which agrees with the experimental result to *1* part in *10,000*

The null result of the Hoek experiment is convincing evidence of full convection. Even so, the range of values obtained by Dr. Fizeau in the 19 measurements leaves room for doubt. The doubt can be negated by removing the obstacle that decided against full convection at the outset - stellar aberration. This is completely resolved in the paper, http://wbabin.net/babin/precis.pdf

**End**

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**References:**

[1] All information is derived from the April 1860 translation of Fizeau's paper in the Philosophical Journal and Science Magazine. See http://wbabin.net/fizeau.pdf for a copy of the original provided by Robert and Declan Traill.

[2] Hoek, Fizeau and Einstein's Special Relativity, Walter Babin, http://wbabin.net/babin/fizeau.pdf