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The Determination of the Fringe Shift in the Fizeau Interferometer Experiment with Moving Water.

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This paper shows that the Fizeau experiment has a classical explanation, which does not verify special relativity, but in fact contradicts this theory.

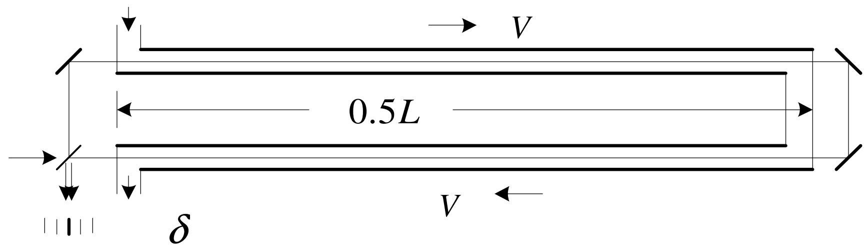

Fig.1

Instead of the real configuration of the experiment (Fig.1), it is convenient to consider an equivalent one, Fig.2, where interfering beams travel in two identical pipes with counter movement of the water and photons of frequency ν_0 entering the water with identical phases equal to zero.

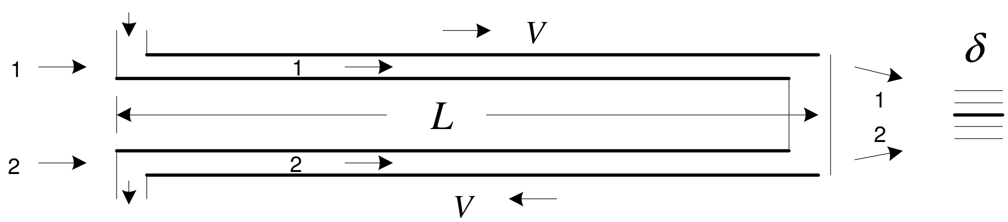

Fig.2

Let us suppose in accordance with the standard calculation, that **the beams** do not change frequency and **travel in moving water with frequency ν_0 and period T_0**.

When the water is at rest, the photons travel at speed $\frac{C}{n}$ relative to the interferometer and cover distance L in identical times, $t_0 = \frac{Ln}{C}$. They travel with wavelength $\frac{C}{n}T_0 = \frac{\lambda_0}{n}$ and up to the moment t_0, an identical number, $N_0 = \frac{t_0}{T_0} = \frac{Ln}{CT_0}$ of oscillations happen. In the arrangement of Fig.2, the photons enter the water at identical distances from the screen, cover the identical distances L and exit the water at identical distances from the screen and with identical phases, $\varphi_0 = 2\pi N_0 = 2\pi \frac{t_0}{T_0}$. The interference fringes are in the initial position, ($\delta = 0$).

When the water moves at speed V, full convection takes place and the photons travel relative to the interferometer at speeds $\frac{C}{n} + V$, $\frac{C}{n} - V$. The photons cover the distance L in the time intervals $t_1 = \frac{L}{\frac{C}{n} + V}$, $t_2 = \frac{L}{\frac{C}{n} - V}$ and $N_{10} = \frac{t_1}{T_0} = \frac{L}{\left(\frac{C}{n} + V\right)T_0}$, $N_{20} = \frac{t_2}{T_0} = \frac{L}{\left(\frac{C}{n} - V\right)T_0}$ oscillations occur during the time intervals t_1, t_2.

In the standard calculation, it is supposed that the beams travel in moving water with the same period T_0 and during that time, cover the distances $(\frac{C}{n} + V)T_0 = \frac{\lambda_0}{n} + VT_0$ in pipe 1 and $(\frac{C}{n} - V)T_0 = \frac{\lambda_0}{n} - VT_0$ in pipe 2. That is, the wavelengths are changed by $+VT_0$ or $-VT_0$ because of convection. It is supposed that "the frequency does not change but only wavelengths" and the convection of light only "stretches" or "contracts" the wavelengths as happens when sound enters a moving medium and travels in it with the same period of oscillations. But that means that light travels in water with wavelengths $\frac{\lambda_0}{n} + VT_0$, $\frac{\lambda_0}{n} - VT_0$ and the observers moving with the water see the frequencies $\frac{\left(\frac{\lambda_0}{n} + VT_0\right)n}{C}$, $\frac{\left(\frac{\lambda_0}{n} - VT_0\right)n}{C}$ which depend not only on speed V but also on the index of refraction n of the medium. That contradicts all observations and experiments.

The supposition that the beams travel with frequency ν_0 and period T_0, **means** only that the beams travel in moving water with wavelength $\frac{C}{n}T_0 = \frac{\lambda_0}{n}$.

During the time t_1, the photons of beam 1 with wavelength $\frac{\lambda_0}{n}$ cover the distance $L_1 = \frac{C}{n}t_1 = L\frac{C}{n\left(\frac{C}{n} + V\right)}$ in water, which is less than L by $\frac{LV}{\left(\frac{C}{n} + V\right)} = Vt_1$.

$N_{10} = \frac{t_1}{T_0} = \frac{L_1}{\frac{\lambda_0}{n}} = \frac{LC}{\lambda_0\left(\frac{C}{n}+V\right)}$ oscillations occur during the time t_1 and the photons exit the water with phases $\varphi_{10} = 2\pi N_{10} = 2\pi\frac{L_1 n}{\lambda_0}$.

During time t_2, the photons of beam 2 with wavelength $\frac{\lambda_0}{n}$ cover the distance $L_2 = \frac{C}{n}t_2 = L\frac{C}{n\left(\frac{C}{n}-V\right)}$ in water, which is more than L by $\frac{LV}{\left(\frac{C}{n}-V\right)} = Vt_2$.

$N_{20} = \frac{t_2}{T_0} = \frac{L_2}{\frac{\lambda_0}{n}} = \frac{LC}{\lambda_0\left(\frac{C}{n}-V\right)}$ oscillations occur during time t_2 and the photons exit the water with phases $\varphi_{20} = 2\pi N_{20} = 2\pi\frac{L_2 n}{\lambda_0}$.

Thus, if beams 1 and 2 travel in water with the identical frequency ν_0 and under the condition that the refractive index n does not depend on the speed of the water, **the phases of the photons at moments t_1, t_2 are determined unequivocally by the distances L_1 and L_2 covered in the water.** It is true, that **conversely, the distances** covered in the water **are determined by the phases** with which the photons exit the water. However, we repeat once more, it is correct only in the case where the beams do not change their frequency and travel in the water with the identical frequency, ν_0.

The photons travel with wavelength $\frac{\lambda_0}{n}$. That is, they cover in time T_0 relative to the water, the distance $\frac{\lambda_0}{n}$. But because of convection, every oscillation shifts in time T_0 relative to the interferometer, by the distance VT_0 in the direction of the water's motion. During the time intervals t_1, t_2, the photons shift by the distances $N_{10}VT_0 = \frac{LV}{\left(\frac{C}{n}+V\right)} = Vt_1$, $N_{20}VT_0 = \frac{LV}{\left(\frac{C}{n}-V\right)} = Vt_2$ and therefore cover relative to the interferometer, the identical distances $L_1 + Vt_1 = L$, $L_2 + Vt_2 = L$. That is, the beams **covering different distances** in the water, **exit** from it **at identical distances from the screen** and therefore the fringe shift is determined simply by the time difference, and is $\delta_V = \frac{C\Delta t}{\lambda_0}$.

In reality, the photons in the Fizeau interferometer **travel in water, not with** ν_0 **but with the frequencies** $\nu_1 = \nu_0(1-\frac{V}{C})$ **,** $\nu_2 = \nu_0(1+\frac{V}{C})$**.**

$N_1 = \frac{t_1}{T_1} = \frac{L_1}{\lambda_1} = \frac{L(C-V)}{\lambda_0\left(\frac{C}{n}+V\right)} < N_{10}$ oscillations occur in the photons of beam 1 during time t_1 and they exit the water with the phase $\varphi_1 = 2\pi N_1 = 2\pi\frac{L_1}{\lambda_1}$ (Fig.3,a).

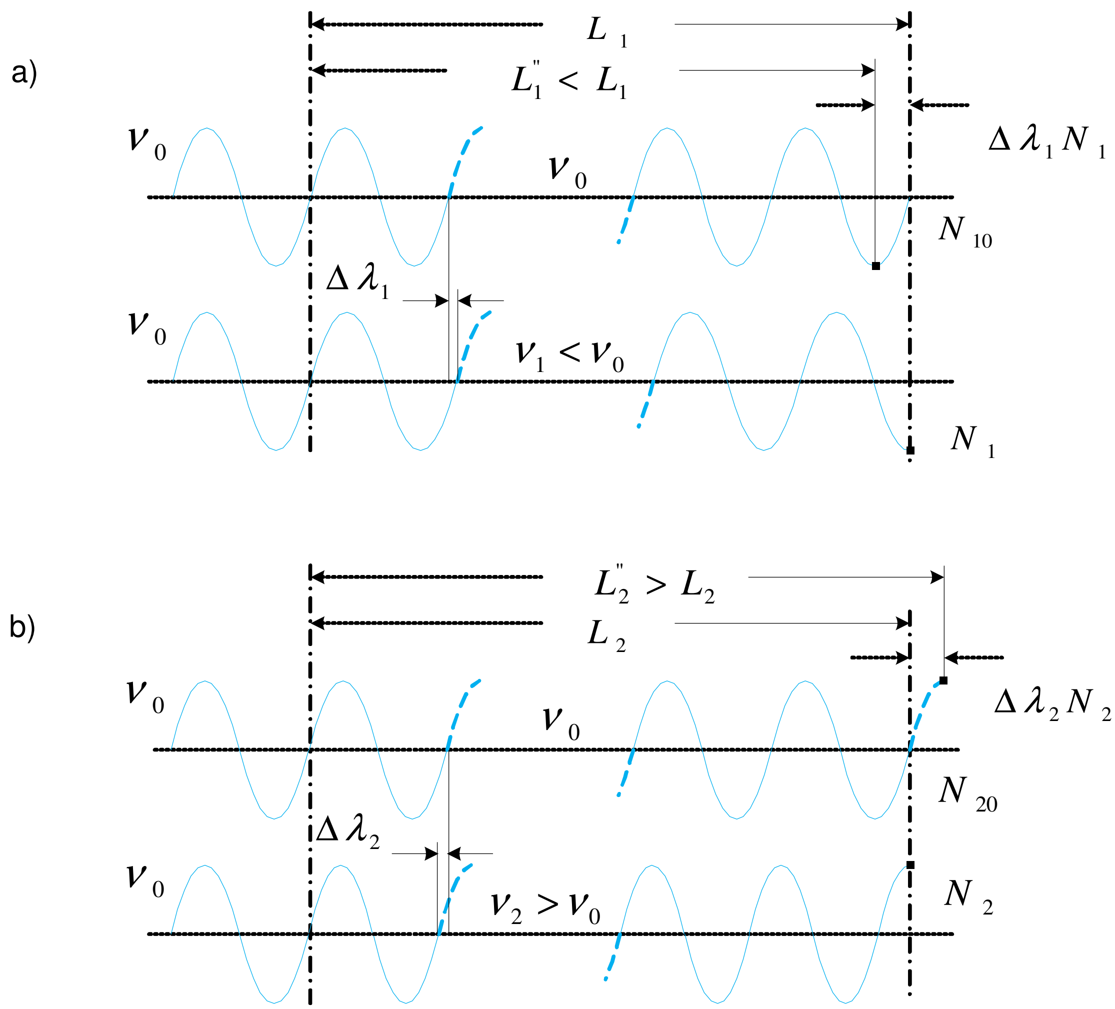

Fig.3

$N_2 = \frac{t_2}{T_2} = \frac{L_2}{\lambda_2} = \frac{L(C+V)}{\lambda_0\left(\frac{C}{n} - V\right)} > N_{20}$ oscillations occur in the photons of beam 2 during time t_2 and they exit the water with the phase $\varphi_2 = 2\pi N_2 = 2\pi \frac{L_2}{\lambda_2}$ (Fig.3,b).

Because of the frequency change, the photons exit the water with changed phases

$$\varphi_1 = 2\pi \frac{L_1}{\lambda_1} = 2\pi \frac{L(C-V)}{\lambda_0\left(\frac{C}{n} + V\right)} < \varphi_{10}, \qquad \varphi_2 = 2\pi \frac{L_2}{\lambda_2} = 2\pi \frac{L(C+V)}{\lambda_0\left(\frac{C}{n} - V\right)} > \varphi_{20}$$

but not with $\varphi_{10} = 2\pi \frac{L_1 n}{\lambda_0} = 2\pi \frac{LC}{\lambda_0\left(\frac{C}{n} + V\right)}$, $\varphi_{20} = 2\pi \frac{L_2 n}{\lambda_0} = \frac{LC}{\lambda_0\left(\frac{C}{n} - V\right)}$.

The distances L_1, L_2 correspond to the phases φ_{10}, φ_{20}. Because of convection, the photons additionally shift by the distances Vt_1, Vt_2 and therefore exit the water at identical distance from the screen. The fringe shift is $\delta_V = \frac{C\Delta t}{\lambda_0}$.

The distance L_1'' which is less by $\Delta L_1''$ than L, corresponds to the phase φ_1 and the distance L_2'' which is more by $\Delta L_2''$ than L, corresponds to the phase φ_2. That is, because of the change of frequencies, the phase deviations change as if the points, where the photons exit the water, change by $\Delta L_1''$ backward in beam 1 and by $\Delta L_2''$ ahead in beam 2. Conditioned by convection, the shifts Vt_1 , Vt_2 do not change and the fringe shift in the interferometer decreases from $\delta_V = \frac{C\Delta t}{\lambda_0}$ to $\delta = \delta_V - \frac{\Delta L_1'' + \Delta L_2''}{\lambda_0}$.

The wavelengths in the water are $\lambda_1 = \frac{C}{n} T_1 = \frac{\lambda_0}{n} + \frac{\lambda_0 V}{n(C-V)} = \frac{\lambda_0}{n} + \Delta\lambda_1$ and $\lambda_2 = \frac{C}{n} T_2 = \frac{\lambda_0}{n} - \frac{\lambda_0 V}{n(C+V)} = \frac{\lambda_0}{n} - \Delta\lambda_2$. That is, because of the change of frequencies from ν_0 to ν_1, ν_2, every oscillation additionally shifts relative to the interferometer by $\Delta\lambda_1 = \lambda_1 - \frac{\lambda_0}{n} = \frac{\lambda_0}{n} \frac{V}{(C-V)}$ in beam 1 and by $\Delta\lambda_2 = \frac{\lambda_0}{n} - \lambda_2 = \frac{\lambda_0}{n} \frac{V}{(C+V)}$ in beam 2.

The shifts $\Delta L_1'' = \Delta\lambda_1 N_1 = \frac{LV}{n\left(\frac{C}{n} + V\right)}$, $\Delta L_2'' = \Delta\lambda_2 N_2 = \frac{LV}{n\left(\frac{C}{n} - V\right)}$ are accumulated in distances L_1, L_2 and $\Delta L_1'' + \Delta L_2'' = \frac{LV}{n} \frac{\frac{C}{n} + V + \frac{C}{n} - V}{\left(\frac{C}{n} + V\right)\left(\frac{C}{n} - V\right)} = \frac{2LVC}{n^2\left(\frac{C}{n} + V\right)\left(\frac{C}{n} - V\right)}$.

The fringe shift is equal to

$$\delta = \delta_V - \frac{\Delta L_1'' + \Delta L_2''}{\lambda_0} = \frac{2LVC}{\lambda_0\left(\frac{C}{n}+V\right)\left(\frac{C}{n}-V\right)} - \frac{2LVC}{n^2\lambda_0\left(\frac{C}{n}+V\right)\left(\frac{C}{n}-V\right)} = \delta_V\left(1-\frac{1}{n^2}\right).$$

Thus, the estimated fringe shift in the interferometer with moving water is really determined by the expression $\delta = \delta_V\left(1-\frac{1}{n^2}\right)$, which is the value verified by all experiments. It does not shift according to expression $\delta_V = \frac{2LVC}{\lambda_0\left(\frac{C}{n}+V\right)\left(\frac{C}{n}-V\right)}$ as Fizeau mistakenly supposed and special relativity alleges.

The Fizeau experiment contradicts special relativity and cannot be considered proof of it.