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Hoek Experiment

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Martinus Hoek carried out an interference experiment using an interferometer with one arm containing water [1]. The surprising result was that contrary to the Fizeau experiment, no effect was found.

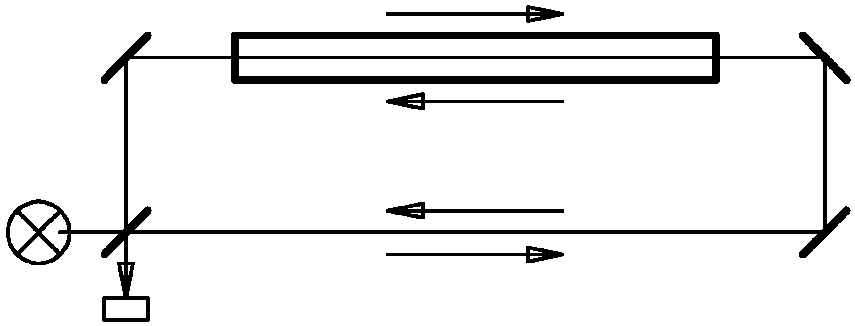

Figure 1: *Schematic representation of the Hoek interferometer.*

With Fizeau formula for moving medium, for east west orientation of the Hoek interferometer the following difference of the light running times results:

$$\Delta T = \frac{L}{c-v} + \frac{L}{c/n - v(1-1/n^2) + v} - \frac{L}{c+v} - \frac{L}{c/n + v(1-1/n^2) - v},$$

$$\Delta T \approx \frac{2Lv^3}{c^4}\left(1-\frac{1}{n^2}\right),$$

whereby L is the length of the interferometer arm. From this time difference one receives the formula for the shift of the interference fringes as an effect of third order:

$$\Delta N = \Delta T \frac{c}{\lambda} \approx \frac{2Lv^3}{c^3\lambda}\left(1-\frac{1}{n^2}\right).$$

Consequence: Hoek experiment is not suitable for the determination of the relative velocity between earth surface and the ether.

In his historical paper Hoek used another notations: Speed of apparatus ε, speed of light in water λ, speed of light in the air $n\lambda$ and speed of light in moving water $\lambda \pm \varphi$. After finding negative result and solving the equation:

$$\Delta T = 0 = \frac{L}{n\lambda - \varepsilon} + \frac{L}{\lambda - \varphi + v} - \frac{L}{n\lambda + \varepsilon} - \frac{L}{\lambda + \varphi - \varepsilon}$$

he completely confirmed so-called Fresnel's coefficient of entrainment:

$$\varphi = v\left(1 - \frac{1}{n^2}\right).$$

According to Hoek experiment the speed of light in moving water is not constant relative to comoving observer:

$$c' = \frac{c}{n} \mp \frac{v}{n^2} \ .$$

Using this result one can calculate the difference in light propagation time in two directions in comoving medium:

$$\Delta t = \frac{L}{\frac{c}{n} - \frac{v}{n^2}} - \frac{L}{\frac{c}{n} + \frac{v}{n^2}} \approx \frac{2Lv}{c^2},$$

which is surprisingly independent of the index of refraction. This nonrelativistic property of comoving medium is verified by different fibre optics Sagnac interferometers.

References

1. M. Hoek, Archives Neerlandaises des Sciences Exactes et Naturelles **3**, 180, (1868).