One-Way Speed of Light Measurements Without Clock Synchronisation

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The 1991 DeWitte double one-way 1st order in v/c experiment successfully measured the anisotropy of the speed of light using clocks at each end of the RF coaxial cables. However Spavieri et al., Physics Letters A (2012), dpl: 10.1016/j.physleta.2012.0010, have reported that (i) clock effects caused by clock transport should be included, and (ii) that this additional effect cancels the one-way light speed timing effect, implying that one-way light speed experiments "do not actually lead to the measurement of the one-way speed of light or determination of the absolute velocity of the preferred frame". Here we explain that the Spavieri et al. derivation makes an assumption that is not always valid: that the propagation is subject to the usual Fresnel drag effect, which is not the case for RF coaxial cables. As well DeWitte did take account of the clock transport effect. The Spavieri et al. paper has prompted this clarification of these issues.

1 Introduction

The enormously significant 1991 DeWitte double one-way 1st order in v/c experiment successfully measured the anisotropy of the speed of light using clocks at each end of the RF coaxial cables. The technique uses rotation of the light path to permit extraction of the speed of light anisotropy, despite the clocks not being synchronised. Data from this 1st order in v/c experiment agrees with the speed and direction of the anisotropy results from 2nd order in v/c Michelson gas-mode interferometer experiments by Michelson and Morley and by Miller, see data in [2], and with NASA spacecraft earth-flyby Doppler shift data [3], and also with more recent 1st order in v/c experiments using a new single clock technique. However Spavieri et al. [4] reported that (i) clock effects caused by clock transport should be included, and (ii) that this additional effect cancels the one-way light speed timing effect, implying that one-way light speed experiments “do not actually lead to the measurement of the one-way speed of light or determination of the absolute velocity of the preferred frame”. Here we explain that the Spavieri et al. derivation makes an assumption that is not always valid: that the propagation is subject to the usual Fresnel drag effect, which is not the case for RF coaxial cables. The Spavieri et al. paper has prompted this clarification of these issues.

2 First Order in v/c Speed of EMR Experiments

Fig.1 shows the arrangement for measuring the one-way speed of light, either in vacuum, a dielectric, or RF coaxial cable. It is usually argued that one-way speed of light measurements are not possible because the clocks C1 and C2 cannot be synchronised. However this is false, although an important previously neglected effect that needs to be included is the clock offset effect caused by transport when the apparatus is rotated [4], but most significantly the Fresnel drag effect is not present in RF coaxial cables. In Fig.1 the actual travel time tAB = tB - tA from A to B, as distinct from the clock indicated travel time TAB = T_B - T_A, is determined by

\[ V(v \cos(\theta))t_{AB} = L + v \cos(\theta)t_{AB} \]  

(1)

where the 2nd term comes from the end B moving an additional distance v cos(\theta)T_{AB} during time interval t_{AB}. With Fresnel drag \[ V(v) = \frac{c}{n} + v \left(1 - \frac{1}{2n^2}\right) \], when V and v are parallel, and where n is the dielectric refractive index. Then

\[ t_{AB} = \frac{L}{V(v \cos(\theta)) - v \cos(\theta)} = \frac{nL}{c} + \frac{v \cos(\theta)L}{c^2} + .. \]  

(2)

However if there is no Fresnel drag effect, V = c/n, as is the case in RF coaxial cables, then we obtain

\[ t_{AB} = \frac{L}{V(v \cos(\theta)) - v \cos(\theta)} = \frac{nL}{c} + \frac{v \cos(\theta)Ln^2}{c^2} + .. \]  

(3)

It would appear that the two terms in (2) or (3) can be separated by rotating the apparatus, giving the magnitude and direction of \[ v \]. However it is T_{AB} = T_B - T_A that is measured, and not t_{AB}, because of an unknown fixed clock offset \[ \tau \], as the clocks are not a priori synchronised, and as well an angle dependent clock transport offset \[ \Delta \tau \], at least until we can establish clock synchronisation, as explained below. Then the clock readings are \[ T_A = t_A \] and \[ T_B = t_B + \tau \], and \[ T_B = t_B' + \tau + \Delta \tau \], where \[ \Delta \tau \] is a clock offset that arises from slowing of clock C2 as it is transported during the rotation through angle \[ \Delta \theta \], see Fig.1.
3 Clock Transport Effect

The clock transport offset $\Delta \tau$ follows from the clock motion effect

$$\Delta \tau = dt \sqrt{1 - \frac{(v + u)^2}{c^2}} - dt \sqrt{1 - \frac{v^2}{c^2}} = -dt \frac{v \cdot u}{c^2} + \ldots,$$

when clock $C_2$ is transported at velocity $u$ over time interval $dt$, compared to $C_1$. Now $v \cdot u = vu \sin(\theta)$ and $dt = L\Delta \theta / u$. Then the change in $T_{AB}$ from this small rotation is, using (2) for the case of no Fresnel drag,

$$\Delta T_{AB} = \frac{v \sin(\theta) L n^2 \Delta \theta}{c^2} - \frac{v \sin(\theta) L \Delta \theta}{c^2} + \ldots$$

as the clock transport effect appears to make the clock-determined travel time shorter (2nd term). Integrating we get

$$T_B - T_A = \frac{nL}{c} + \frac{v \cos(\theta) L (n^2 - 1)}{c^2} + \tau,$$

where $\tau$ is now the constant offset time. The $v \cos(\theta)$ term may be separated by means of the angle dependence. Then the value of $\tau$ may be determined, and the clocks synchronised. However if the propagation medium is vacuum, liquid, or dielectrics such as glass and optical fibres, the Fresnel drag effect is present, and we then use (1), and not (2). Then in (6) we need make the replacement $n \rightarrow 1$, and then the 1st order in $v/c$ term vanishes, as reported by Spavieri et al. However, in principle, separated clocks may be synchronised by using RF coaxial cables.

4 DeWitte 1st Order in $v/c$ Detector

The DeWitte $L = 1.5$km 5MHz RF coaxial cable experiment, Brussels 1991, was a double 1st order in $v/c$ detector, using the scheme in Fig[1] but employing a 2nd RF coaxial cable for the opposite direction, giving clock difference $T_{DP} - T_{CD}$, to cancel temperature effects, and also used 3 Caesium atomic clocks at each end. The orientation was NS and rotation was achieved by that of the earth [1]. Then

$$T_{AB} - T_{CD} = \frac{2v \cos(\theta)L(n^2 - 1)}{c^2} + 2\tau$$

For a horizontal detector the dynamic range of $\cos(\theta)$ is $2\sin(\lambda) \cos(\delta)$, caused by the earth rotation, where $\lambda$ is the latitude of the detector location and $\delta$ is the declination of $v$. The value of $\tau$ may be determined and the clocks synchronised. Some of DeWitte’s data and results are in Figs. 2 and 3.

5 Dual RF Coaxial Cable Detector

The single clock Dual RF Coaxial Cable Detector exploits the absence of the Fresnel drag effect in RF coaxial cables [2]. Then from (3) the round trip travel time for one circuit is, see Fig[4]

$$t_{AB} + t_{CD} = \frac{(n_1 + n_2) L}{c} + \frac{v \cos(\theta) L (n_1^2 - n_2^2)}{c^2} + \ldots$$

where $n_1$ and $n_2$ are the effective refractive indices for the two different RF coaxial cables. There is no clock transport effect as the detector is rotated. Dual circuits reduce temperature effects. The travel time difference of the two circuits at the DSO is then

$$\Delta t = \frac{2v \cos(\theta) L (n_1^2 - n_2^2)}{c^2} + \ldots$$
Fig. 3: DeWitte collected data over 178 days and demonstrated that the zero crossing time, see Fig. 2, tracked sidereal time and not local solar time. The plot shows the negative of the drift in the crossing time vs local solar time, and has a slope, determined by the best-fit straight line, of -3.918 minutes per day, compared to the actual average value of -3.932 minutes per day. Again we see fluctuations from day to day.

Fig. 4: Because Fresnel drag is absent in RF coaxial cables this dual cable setup, using one clock (10MHz RF source and Digital Storage Oscilloscope DSO to measure and store timing difference between the two circuits, as in (9)), is capable of detecting the absolute motion of the detector wrt to space, revealing the earth sidereal rotation effect as well as wave/turbulence effects. Results from such an experiment are shown in Fig. 2. Andrews phase-stablised coaxial cables are used. More recent results are reported in [2].

A sample of data is shown in Fig. 2 and is in excellent agreement with the DeWitte data, the NASA flyby Doppler shift data, and the Michelson-Morley and Miller results.

6 Conclusions

The absence of the Fresnel drag in RF coaxial cables enables 1st order in \( v/c \) measurements of the anisotropy of the speed of light. DeWitte pioneered this using the multiple clock technique, and took account of the clock transport effect, while the new dual RF coaxial cable detector uses only one clock. This provides a very simple and robust technique. Experiments by Michelson and Morley 1887, Miller 1925/26, DeWitte 1991, Cahill 2006, 2009, 2012, and NASA earth-flyby Doppler shift data now all agree, giving the solar system a speed of \( \sim 486 \text{ km/s} \) in the direction RA=4.3\(^h\), Dec=-75.0\(^\circ\). These experiments have detected the fractal textured dynamical structure of space - the privileged local frame [2]. This report is from the Gravitational Wave Detector Project at Flinders University.

References

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