15.17: Aberration of Light

The direction of Earth's velocity on any particular date is called the *Apex of the Earth's Way*. In part (a) of Figure XV.23 I show Earth moving towards the apex at speed v, and light coming from a star at speed c from an angle χ from the apex.

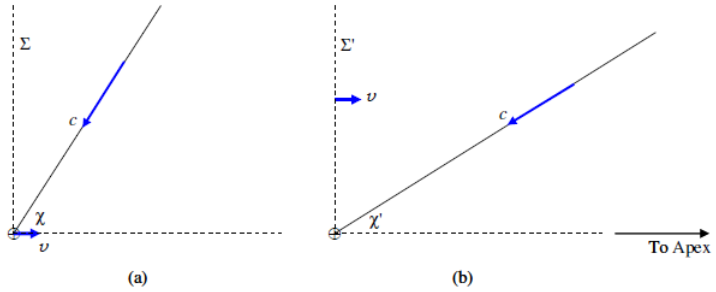

FIGURE XV.23

The x- and y- components of the velocity of light are respectively $-c\cos\chi$ and $-c\sin\chi$. Relative to Earth (part (b)), the x'- and y'- components are, by Equations 15.16.2 and 15.16.3 (or rather their inverses)

$$-\frac{c\cos\chi+v}{1+(\frac{v}{c})\cos\chi}$$

and

$$-\frac{c\sin\chi}{\gamma(1+(\frac{v}{c})\cos\chi)}.$$

You can verify that the orthogonal sum of these two components is c, as it should be according to our fundamental assumption that the speed of light is the same referred to all reference frames in uniform relative motion.

The apparent direction of the star is therefore given by

$$\sin\chi'=-\frac{\sin\chi}{\gamma(1+(\frac{v}{c})\cos\chi)} \tag{15.17.1}$$

It is left as an exercise to show that, for small $\frac{v}{c}$, this becomes

$$\chi-\chi'=\frac{v\sin\chi}{c}. \tag{15.17.2}$$

with v = 29.8 km s^{-1}, $\frac{v}{c}$ is about 20".5. More details about aberration of light, including the derivation of Equation 15.17.2, can be found in Celestial Mechanics, Section 11.3.