Direction of the Light Deviation Vector during Satellite Laser Ranging

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Projections onto the telescope’s field of view of
1) Measured apparent deviation $\mathbf{AB}$,
2) Vector opposite to velocity aberration $(-\mathbf{AC})=\mathbf{CA}$,
3) True anomalous deviation $\mathbf{CB}$. Absolute values are in arcseconds, directions are in degrees relatively to the abscissa axis in the field of view. Arrows indicate the start of the pass.

$\mathbf{CB} = \mathbf{AB} + (-\mathbf{AC})$

[Ignatenko et al., Poznań, 2008]
Light Deviation Vector Reconstruction (3D) and Determination of Its Direction in the Near-Earth Space

1) Combination of a three-dimensional vector of anomalous light deviation from its different projections onto the telescope’s field of view in different instants of time during a satellite pass.

2) Elimination of the Earth orbital motion to obtain “pure” light deviation vector in the near-Earth space.
Crucial points’ $O$, $O'$, $S$ topocentric coordinates determination for 3D light deviation vector reconstruction

$OO' = R$ – range station–satellite,
$O'S = r$ – anomalous deviation of light in the telescope’s focal plane $P$,
$A$ – azimuth, $H$ – elevation, $\psi$ – rotation angle of the $O'S$ vector in the telescope’s field of view

$O (0,0,0)$; $O' (R \cos H \sin A, R \cos H \cos A, R \sin H)$;
$S (R \cos H \sin A + r (\cos A \sin \psi - \sin A \sin H \cos \psi), R \cos H \cos A - r (\sin A \sin \psi + \cos A \sin H \cos \psi), R \sin H + r \cos H \cos \psi)$
Planes’ $P_1$ and $P_2$ equations

$$\begin{cases} A_1 x + B_1 y + C_1 z + D_1 = 0 \\ A_2 x + B_2 y + C_2 z + D_2 = 0 \end{cases}$$

and their intersection line

$$\frac{x - x_1}{x - x_2} = \frac{y - y_1}{y - y_2} = \frac{z - z_1}{z - z_2}$$

$T_1$ and $T_2$ – telescope’s focal planes at two instants of time,

$P_1$ and $P_2$ – additional planes perpendicular to $T_1$ and $T_2$ for

3D light deviation vector $\Phi$ reconstruction
Reconstructed directions of the anomalous light deviation 3D-vector for LAGEOS passes during 2007 and 2008 are shown in the equatorial RA/Dec coordinate system. Each point corresponds to one pass.
Earth velocity direction for June 10

\[ \varphi = \frac{2v_\oplus}{c} \approx 41'' \]

Value of the Earth velocity vector in arcseconds

\[ \cos AB = \sin \delta_1 \sin \delta_2 + \cos \delta_1 \cos \delta_2 \cos (\alpha_2 - \alpha_1) \]

Arc AB corresponds to an angle between vectors of the anomalous light deviation and of the Earth orbital velocity; \( \alpha \) and \( \delta \) denote their right ascension and declination.
Directions of the purified anomalous light deviation 3D-vector in the near-Earth space (influence of the Earth orbital motion is excluded) are shown in the equatorial RA/Dec coordinate system for LAGEOS passes during 2007 and 2008. Points are located on the ellipse with center coordinates $\alpha = 284^\circ$ and $\delta = 67^\circ$. 
Conclusion

According to obtained results it is concluded that the luminiferous medium moves in the near-Earth space with velocity slightly different by absolute value and direction from the Earth orbital velocity. Observed deviation of light from preset direction is a result of composition of the satellite relative-to-observer velocity, the Earth orbital velocity, and velocity of the luminiferous medium.