the general science journal

Algol confirms the independence of the velocity of light from its source

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Abstract: Based on astronomers' observations of binary stars, the hypothesis that the velocity of light is independent of the velocity of its source was accepted and the hypothesis that the velocity of light depends on the velocity of its source, known as Ritz ballistic hypothesis, was rejected. In this paper, the times in which the light from a binary star B on its orbit travels to an observer are calculated for both hypotheses. The result is applied to Algol, one of the examples of binary star systems that W. de Sitter pointed out to reject the Ritz ballistic theory. This study confirms astronomers' conclusion that the velocity of light is independent of the velocity of its source.

1 Introduction

When the plane of the circular orbit of a star is perpendicular to the observer's line of sight, the circular orbit is observed as a circle without irregularities for both hypotheses.

When the observation of a binary star is in the plane of the orbit, as illustrated in figure 1, the circular orbit is observed as a line. In this case, the magnitude of the irregularities are at maximum for the hypothesis that the velocity of light depends on the velocity of its source. These binary stars are eclipsing binary stars.

Ritz ballistic theory [1] was rejected by the remarks stated by W. de Sitter [2, 3]. The orbit of the β Persei Aa2, a component of Algol binary system [4, 5], has a circular orbit and the binary star system is considered here as a total eclipsing stars; the inclination angle $i = 98.70°$ is approximated with 90°.

The calculations of the irregularities are based on the paper "Irregularities in observing binary stars if the velocity of light depends on the velocity of its source" by Filip Dambi [6]. The derivation of the irregularities for the particular case of the eclipsing binary star is presented here as well, in section 2.

2 Observation of a binary star B within the plane of its orbit

2.1 Derivation of the time in which the light travels from binary star B to observer if the velocity of light depends on the velocity of its source

Figure 1 illustrates the observation of a binary star B located at point E on its circular orbit. The radius R at point E makes an angle a with the axis of the coordinate $O_s x$.

The speed of light from a source at rest is the constant c. A ray of light from point E travels in the direction EG with the speed c. The velocity v of the binary star B at point E drags the velocity c in the direction GO. The vector sum of the velocities c and v makes the ray of light travel along the distance EO with the speed c_{sa}, in the time t_{sa} calculated below.

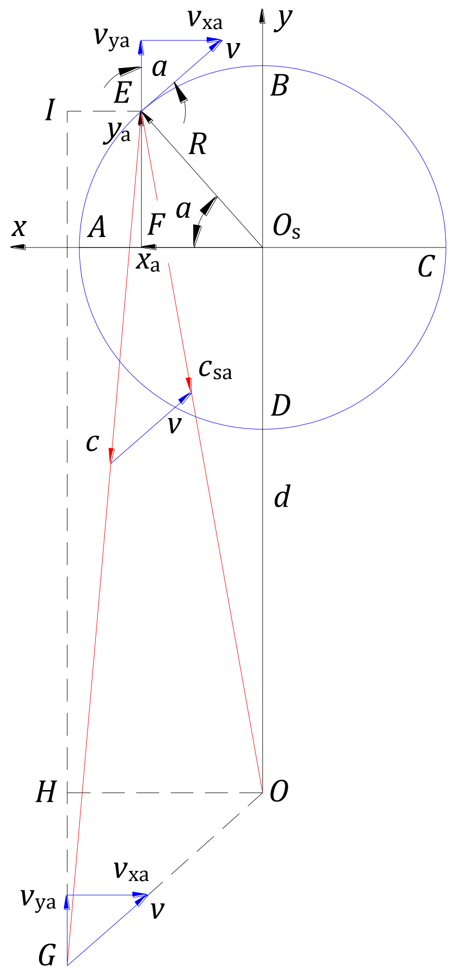

Figure 1. Binary star B on its orbit at a radians from the initial position.

From figure 1, $x_a = R\cos a$, $y_a = R\sin a$, $v_{xa} = v\sin a$, and $v_{ya} = v\cos a$.

$$EG^2 = IG^2 + IE^2 = (O_sO + EF + GH)^2 + (OH - O_sF)^2 \quad \Rightarrow$$

$$c^2t_{sa}^2 = \left(d + y_a + v_{ya}t_{sa}\right)^2 + (v_{xa}t_{sa} - x_a)^2$$
$$= (d + R\sin a + vt_{sa}\cos a)^2 + (vt_{sa}\sin a - R\cos a)^2 \quad \Rightarrow$$
$$c^2t_{sa}^2 = d^2 + R^2\sin^2 a + v^2t_{sa}^2\cos^2 a + 2dR\sin a + 2dvt_{sa}\cos a + 2Rvt_{sa}\sin a\cos a$$
$$+ v^2t_{sa}^2\sin^2 a - 2Rvt_{sa}\sin a\cos a + R^2\cos^2 a \quad \Rightarrow$$

$(c^2 - v^2)t_{sa}^2 - 2dvt_{sa}\cos a - (d^2 + 2dR\sin a + R^2) = 0$, with the convenient solution

$$t_{sa} = \frac{\sqrt{d^2v^2\cos^2 a + (d^2 + 2dR\sin a + R^2)(c^2 - v^2)} + dv\cos a}{c^2 - v^2}.$$

The length of the arc from A to E is $L = aR$. The time in which the star travels from A to E is $t_{ra} = L/v = aR/v$. Time $t_a = t_{ra} + t_{sa}$.

2.2 Derivation of the time in which the light travels from binary star B to observer if the velocity of light is independent of the velocity of its source

If the velocity of light is independent of the velocity of its source, the light from point E travels to point O the same distance EO as in section 2.1, but with the speed c instead of c_{sa}, in time t'_{sa}:

$$t'_{sa} = \frac{OE}{c} = \frac{\sqrt{(OO_s + EF)^2 + O_sF^2}}{c} = \frac{\sqrt{(d + R\sin a)^2 + (R\cos a)^2}}{c} \quad \Rightarrow$$

$$t'_{sa} = \frac{\sqrt{d^2 + 2dR\sin a + R^2}}{c}.$$

The time in which the star travels from A to E is $t_{ra} = L/v = aR/v$, and time $t'_a = t_{ra} + t'_{sa}$.

3 Algol or β Persei Aa1Aa2 binary system

The data of the Earth used in the calculations for times t_a and t'_a are presented below.

- The time of one year on the Earth in seconds is $T_\mathrm{E} = 365\,d \times 24\,h \times 60\,m \times 60\,s = 3.153600\mathrm{E}+07\,s$.
- The speed of light from a source at rest is $c = 3.00\mathrm{E}+08\,m/s$. One light year in meters is $ly = c \times T_\mathrm{E} = 9.460800E + 15\,m$.

The data of the β Persei Aa2 binary star [4] used in the calculations for times t_a and t'_a are as follows: the distance $d = 90 \pm 3\,ly$, the period $P = 2.867328\,d$, the semi-major axis, noted here with f instead of a, is $f = 0.00215"$, the eccentricity $e = 0$, and the inclination $i = 98.70°$ that is approximated with 90°.

All quantities are converted in meters, seconds, and radians, respectively, and then used in the calculations.

- The distance is considered $d = 90\,ly \times 1\,ly\,m = 8.514720\mathrm{E}+17\,m$.
- The period is $P = 2.867328\,d$, $P = 2.867328\,d/365\,d = 0.007856\,yr$, and in seconds $P = 0.007856\,yr \times T_\mathrm{E} = 2.477371\mathrm{E}+05\,s$.
- The semi-major axis $f = 0.00215"$, $f = 0.00215"/3600" = 5.972222\mathrm{E}-07°$, $f = 5.972222\mathrm{E}-07° \times \pi\,rad/180° = 1.042349\mathrm{E}-08\,rad$.
- The eccentricity is $e = 0$. Thus, the orbit of the β Persei Aa2 is a circular orbit.
- The semi-minor axis is $b = f\sqrt{1-e^2} = f = 1.042349\mathrm{E}-08\,rad$.
- The orbit is considered having the radius $R = d\sin f \cong df = 8.875313\mathrm{E}+09\,m$.
- The orbit length is $L = 2\pi R = 5.576524\mathrm{E}+10\,m$.
- The circular orbit speed is $v = L/P = 2.250984\mathrm{E}+05\,m/s$.

The observer, located at the distance $d = 90\,ly$, sees the light from the β Persei Aa2 star for different angles a with the corresponding times t_a and t'_a, for the two hypotheses.

The time t'_a predicts no irregularities; the star is observed at one location at any time. The time t_a predicts irregularities; the star is observed at multiple locations at any time.

Table 1. Times t_a and t'_a for different angles a if the velocity of light depends on and is independent of the velocity of its source.

a [º]	0	30	45	60	90	120	135	150	180
ta=90yr+d	24.67	21.60	17.80	12.81	0.73	-11.36	-16.34	-20.13	-23.20
$t'a$=90yr+d	0.00	0.24	0.36	0.48	0.72	0.96	1.08	1.19	1.43

a [º]	210	225	240	270	300	315	330	360
ta=90yr+d	-19.66	-15.62	-10.40	2.16	14.72	19.95	23.99	27.53
$t'a$=90yr+d	1.67	1.79	1.91	2.15	2.39	2.51	2.63	2.87

Figure 2 illustrates times t_a for one period P if the light depend on the velocity of its source. For one period P, the star is seen at two closed places almost all the time.

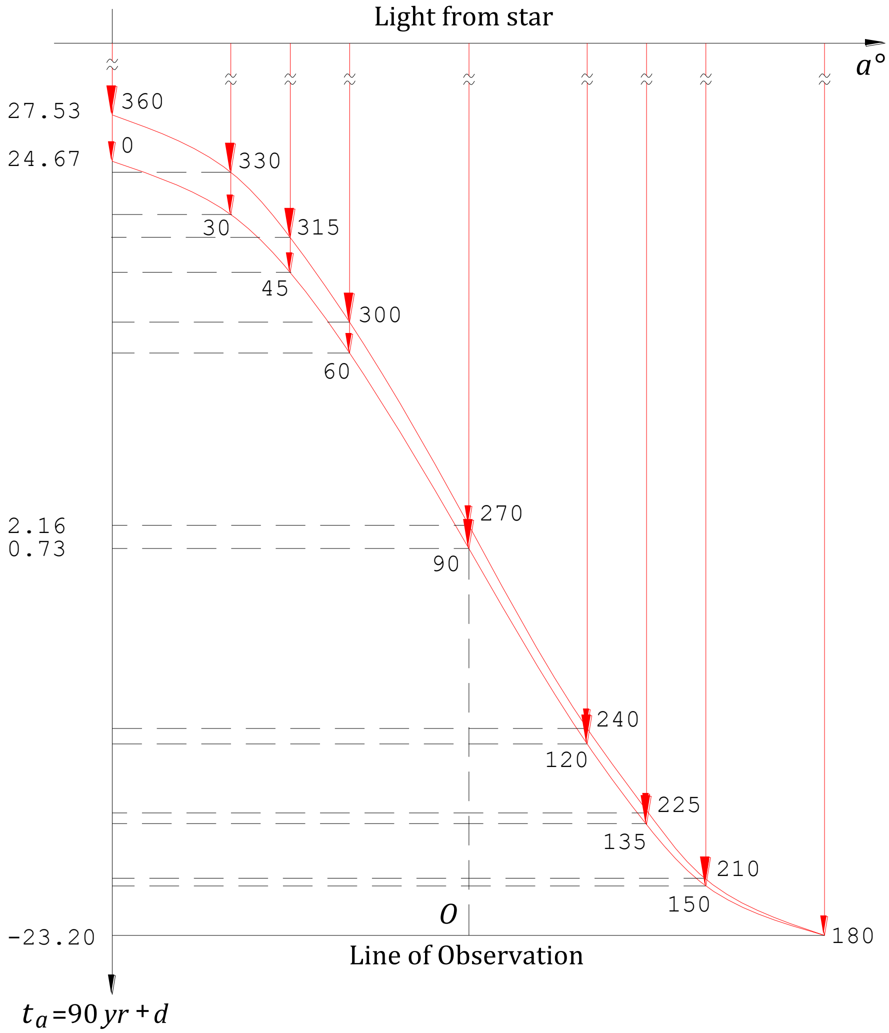

Figure 2. Times t_a for one period P if the light depends on the velocity of its source.

Reference [5] shows the orbit closed to a line of the β Persei Aa2 binary star in a square on the diagonal direction of top-left to bottom-right. With the approximation that the binary star system is total eclipsing stars ($i = 90°$), if the observer turns 45° correctly, then the orbit as a line is seen as illustrated in figure 1; both eyes of the observer are in the orbit plane.

The observation of the star takes place at the point of observation O, but for clarity this point is spread out to the line of observation; otherwise the direction of light from different points on the orbit perpendicular to the line of observation has to be directed to point O.

For drawing simplicity, because the distance $d = 8.514720\text{E} + 17\ m \gg 2R = 1.775063\text{E} + 10\ m$, the light from the circular orbit is shown from the horizontal axis $O_s x$, and the line of observation is approximated at angle $a = 180°$ instead of angle $a = 0°$.

Figure 3 illustrates multiple previous periods P to the one of figure 2. The period P is the difference of times $t_{a=360} - t_{a=0} = 90\ yr + 27.53\ d - 90\ yr - 24.67\ d = 2.867328\ d$. The light from the star on its orbit for one period is observed in the time $t_{a=360} - t_{a=180} = 90\ yr + 27.53\ d - 90\ yr + 23.20\ d = 50{,}73\ d$. Thus, the observer sees the light at the points along the observation line coming from $(50{,}73\ d/2.867328\ d) \cong 18$ periods P, at the same time.

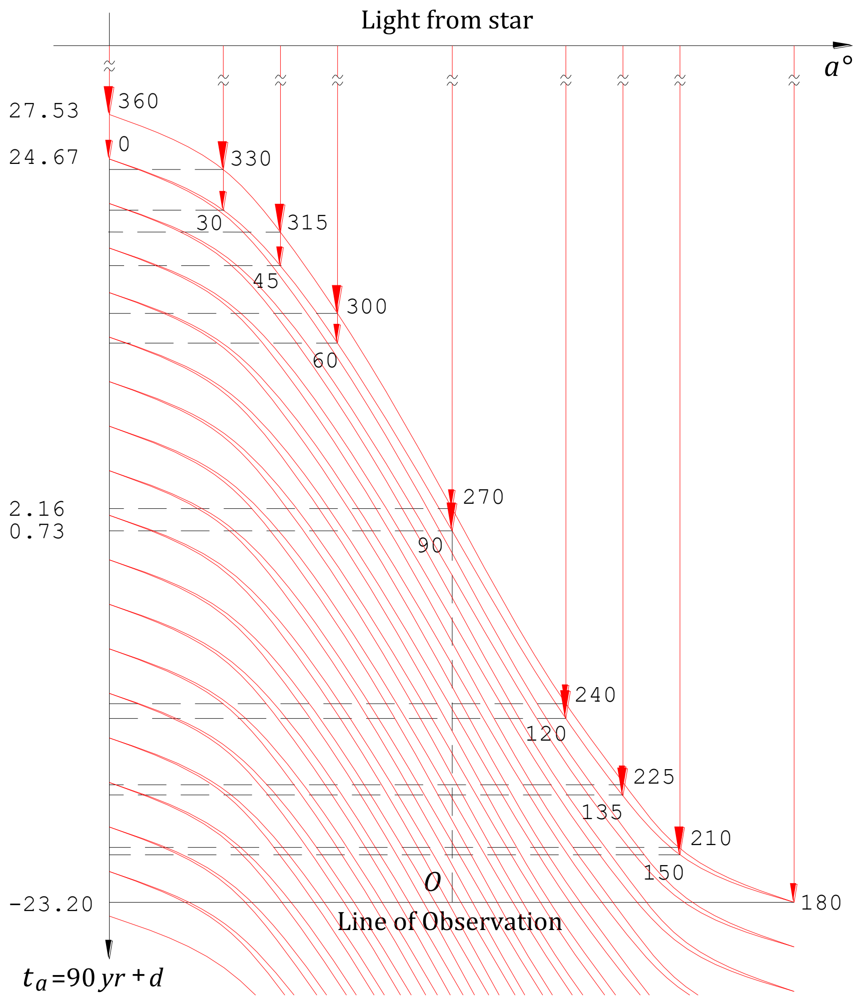

Figure 3. Times t_a observed from 18 periods P if the light depend on the velocity of its source.

Figure 3 predicts the binary star to be seen in about thirty four places distributed almost equally between the two half of the observation line, at any time. Taking into account the short period $P = 2.867328\ d$ and the large diameter of stars, the line of observation would be lighted all along its length. Thus, the ballistic hypothesis cannot be accepted according to the result of this study as well.

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[1] W. Ritz, "Recherches critiques sur l'Électrodynamique générale". *Annales de Chimie et de Physique*. **13**: 145–275. 1908. Bibcode:1908AChPh..13..145R.

[2] W. de Sitter, "A proof of the constancy of the velocity of light". Proceedings of the Royal Netherlands Academy of Arts and Sciences. 15 (II): 1297-1298. 1913. (Communicated in the meeting of February 22, 1913).

[3] W. de Sitter, "On the constancy of the velocity of light". Proceedings of the Royal Netherlands Academy of Arts and Sciences. 16 (I): 395–396. 1913.

[4] https://en.wikipedia.org/wiki/Algol

[5] https://www.constellation-guide.com/algol/

[6] F. Dambi, "Irregularities in observing binary stars if the velocity of light depends on the velocity of its source". General Science Journal. 2019. https://www.gsjournal.net/Science-Journals/Research%20Papers-Astronomy/Download/7836