The Title of the Paper

I. Author1[1,*] and I. Author2[2]

[1] *Main (Pulkovo) Astronomical Observatory of the RAS, St. Petersburg, 196140 Russia*
[2] *Special Astrophysical Observatory, Russian Academy of Sciences, Nizhnii Arkhyz, 369167 Russia*

We study the nearest outskirts ($R < 3R_{200c}$) of 40 groups and clusters of galaxies of the local Universe ($0.02 < z < 0.045$ and 300 km s^{-1} $< \sigma <$ 950 km s^{-1}). Using the SDSS DR10 catalog data, we determined the stellar mass of galaxy clusters corresponding to K_s-luminosity (which we determined earlier based on the 2MASX catalog data) $(M_*/M_\odot) \propto (L_K/L_\odot)^{1.010\pm0.004}$ ($M_K < -21\overset{\mathrm{m}}{.}5$, $R < R_{200c}$). We also found the dependence of the galaxy cluster stellar mass on halo mass: $(M_*/M_\odot) \propto (M_{200c}/M_\odot)^{0.77\pm0.01}\ldots$

Keywords: stars: double or binary—stars: individual: ADS 48

1. INTRODUCTION

The multiple star system ADS 48, discovered by Otto Struve in 1876, has been repeatedly investigated by various authors (see, for example, Güntzel-Lingner 1955, Hopmann 1964), but their attention was mainly attracted by the inner pair AB. According to the identification in the Mason et al. (2016) catalog, the three stars—A, B and F—are physically connected (by common parallax and proper motions). For the inner AB pair, there has been a long series of observations since its discovery, and the F component has not been observed for almost a century.

2. FIRST SECTION

Here comes some math:

$$\rho = \sqrt{x^2 + y^2}\ , \qquad \theta = \arctan\frac{x}{y}$$

$$\mu = \sqrt{\mu_x'^2 + \mu_y'^2}\ , \qquad \psi = \arctan\frac{\mu_x'}{\mu_y'}.$$

Here

$$x = (\alpha_\mathrm{B} - \alpha_\mathrm{A})\cos\delta \times 3600,$$
$$y = (\delta_\mathrm{B} - \delta_\mathrm{A}) \times 3600,$$
$$\delta = (\delta_\mathrm{A} + \delta_\mathrm{B})/2,$$
$$\mu_x' = \mu_{x\mathrm{B}} - \mu_{x\mathrm{A}}, \qquad \mu_y' = \mu_{y\mathrm{B}} - \mu_{y\mathrm{A}}.$$

Table 1 shows AMPs calculated from observations of Gaia DR2, and long-term series of observations of the Pulkovo 26-inch refractor. For the AB pair, we compare only with the CCD observations of 2003–2012. For this pair, we found a systematic discrepancy in ρ, which is clearly visible in Fig. 1.

3. ANOTHER SECTION

The text of the Section.

4. THIRD SECTION

The motion of the outer pair is in the direction ρ, and we can definitely state that for all orbits of the family, the inclination of the orbit $i \approx 90°$, and the longitude of the ascending node $\Omega \approx \theta - 180°$. Therefore, you can calculate the angle between the planes of the outer and inner orbits. As a result, we get that the planes of the orbits are non-planar.

Equations:

$$v_1 = \sqrt{\frac{4\pi^2 {m_2}^2}{r(m_1 + m_2)}}.$$

Assuming $m_2 << m_1$, we get

$$m_2 = v_1 \times \sqrt{\frac{m_1}{4\pi^2} r},$$

$$\overrightarrow{v_1} = f \times (\overrightarrow{\mu_\mathrm{G}} - \overrightarrow{\mu_\mathrm{ph}})/p_t,$$

where $\overrightarrow{\mu_\mathrm{ph}} = (\mu_\mathrm{ph}\sin\psi_\mathrm{ph}, \mu_\mathrm{ph}\cos\psi_\mathrm{ph})$is the average orbital motion obtained from a long series

* example@list.ru

Table 1. Two column table

pair	AB	AB	AB–F	AB–F	AB–F
Instrument / Parameters	26″, CCD individual	GAIA	26″, photo individual	26″, photo smoothed	GAIA
$T_1 - T_2$	2003–2012	–	1968–1995	1971–1992	–
T_0	2008.6	2015.5	1981.5	1981.5	2015.5
n	48	–	115	30	–
ρ, arcsec.	6.0534	6.00768*	327.3322	327.3339	327.1754
	±0.0012	±0.00008	±0.0023	±0.0010	±0.0002
θ_{2000}, degr.	185.3604	188.2084	254.2942	254.2943	254.25739
	±0.0059	±0.0010	±0.0017	±0.0005	±0.00001
μ, mas/year	43.1	44.94	4.3	3.9	5.4
	±0.3	±0.18	±0.5	±0.2	±0.1
ψ_{2000}, degr.	283.09	288.06	86.4	73.2	37.8
	±0.7	±0.16	±19.6	±7.4	±1.1
$\dot{\rho}$, mas/year	−6.4	−7.7	−4.2	−3.9	−4.4
	±0.5	±0.1	±0.4	±0.2	±0.1
$\dot{\theta}$, degr./year	0.4034	0.4202	−0.0002	−0.0000	−0.00056
	±0.0024	±0.0017	±0.0003	±0.0001	±0.00001

Here n is the number of individual or smoothed observations,

*—the value ρ is given adjusted for Gaia–CCD= $+0''.03$.

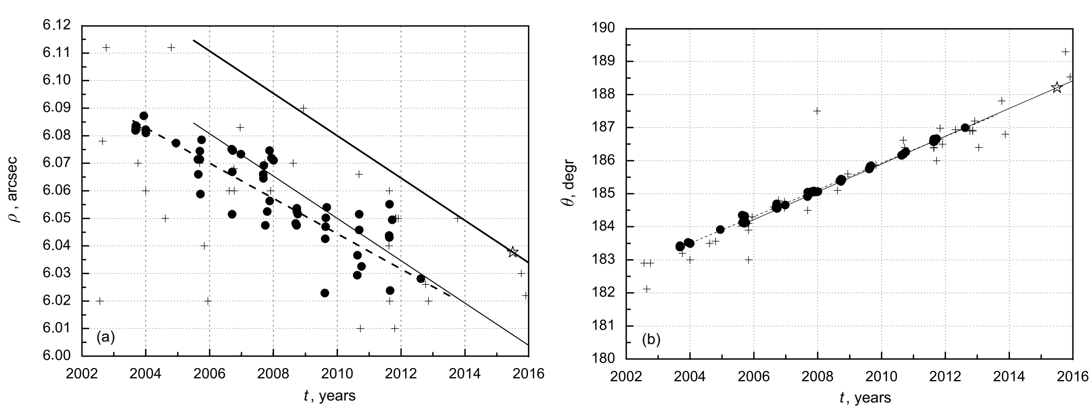

Figure 1. Two column figure.

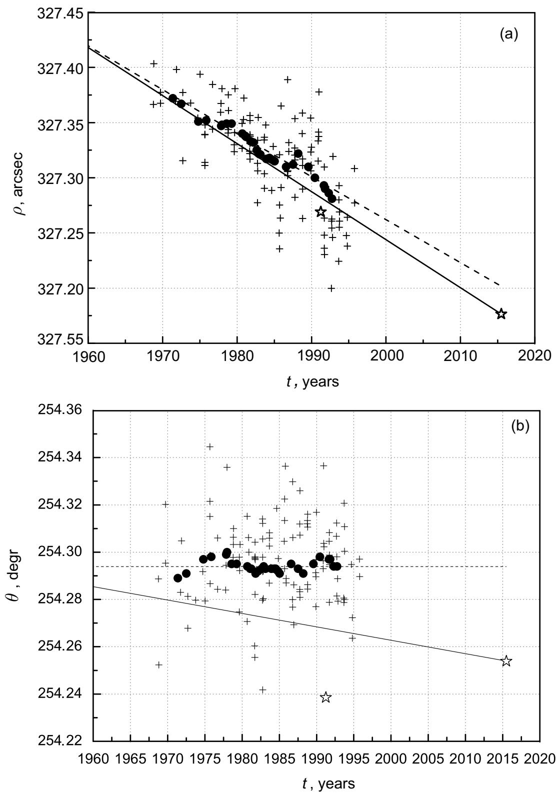

Figure 2. One column figure.

of photographic observations; $\overrightarrow{\mu_{\mathrm{G}}}$ is the instantaneous orbital motion determined by Gaia observation; $p_t = 87$ mas is the parallax; f is the coefficient of transition from the relative velocity of the orbital motion to the velocity relative to the center of mass of the hierarchical triple system, which is motionless. If component F has a satellite, then

$$f_{\mathrm{F}} = M_{\mathrm{A+B}}/M_{\mathrm{A+B+F}}.$$

If the center of mass of the AB system oscillates, then

$$f_{\mathrm{C}} = M_{\mathrm{F}}/M_{\mathrm{A+B+F}},$$
$$f_{\mathrm{A}} = f_{\mathrm{C}}\,(M_{\mathrm{A+B}}/M_{\mathrm{A}}),$$
$$f_{\mathrm{B}} = f_{\mathrm{C}}\,(M_{\mathrm{A+B}}/M_{\mathrm{B}}).$$

If we use the values of μ_{ph} according to the smoothed series, then

$$m_{2,\mathrm{F}}/\sqrt{r} = 0.0030 \pm 0.0006\ M_{\odot},$$
$$m_{2,\mathrm{A}}/\sqrt{r} = m_{2,\mathrm{B}}/\sqrt{r} = 0.0027 \pm 0.0006\ M_{\odot};$$

Table 2. One column table.

Parameters	Orbits			
	1	2	3	4
a_{ph}, mas	15.0	14.3	8.2	4.0
P, year	11.0	11.04	9.52	10.97
e	0.2	0.24	0.53	0.3
i, degr.	97.0	96.3	179.98	44
ω, degr.	235.0	258.6	79.8	56.2
Ω, degr.	147.2	143.2	12.0	217.1
T, year	1980.0	1980.56	1988.15	1982.8
$V_{r\gamma}$, m c^{-1}	–	–	−0.7	–
p_t, mas	87.0	87.0	87.0	86.9
M_1, $M_{\odot}$	0.5	0.5	0.5	0.65
a_1, a.u.	0.17	0.16	0.094	0.046
M_2, $M_{\odot}$	0.023	0.022	0.013	0.007
a_2, a.u.	3.82	3.82	3.50	4.28
σ_x, mas	2.2	2.0	3.6	5.1
σ_y, mas	12.3	12.0	13.5	5.4
σ_{V_r}, mas/year	–	–	0.078	–

if we use the values of μ_{ph} according to individual observations, then

$$m_{2,\mathrm{F}}/\sqrt{r} = 0.0039 \pm 0.0017\ M_{\odot},$$
$$m_{2,\mathrm{A}}/\sqrt{r} = m_{2,\mathrm{B}}/\sqrt{r} = 0.0035 \pm 0.0015\ M_{\odot}.$$

The system of equations is solved:

$$x(t) = x_0 + \dot{x}(t - t_0) + BX_{\varphi} + GY_{\varphi}, \quad (1)$$

$$y(t) = y_0 + \dot{y}(t - t_0) + AX_{\varphi} + FY_{\varphi}, \quad (2)$$

where $x = \rho \sin\theta$, $y = \rho\cos\theta$; phase $\varphi = (t - t_0)/P$; $X_{\varphi} = \cos(E_{\varphi}) - e$, $Y_{\varphi} = \sqrt{1-e^2}\sin(E_{\varphi})$are orbital coordinates corresponding to dynamic orbital elements P, T and e; x_0 and y_0 are coordinates of the center of mass at the moment t_0; A, B, F and G are the Thiele-Innes elements, from which we obtain the geometric elements of the orbit (a, i, ω, Ω). In Table 2, this orbit is represented by number 2.

5. CONCLUSION

This paper demonstrates the possibility...

ACKNOWLEDGMENTS

The authors are grateful...

FUNDING

This work was supported by the...

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

U. Güntzel-Lingner, Astronomische Nachrichten **282** (4), 183 (1955).

J. Hopmann, Annalen der K.K. Sternwarte Wien **26**, 1 (1964).

B. D. Mason, G. L. Wycoff, W. I. Hartkopf, et al., VizieR Online Data Catalog B/wds (2016).