THE TRIPLE SYSTEM ZETA AQUARII[1]

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ABSTRACT

Zeta Aquarii is a bright and nearby (28 pc) triple star with a 26-year astrometric subsystem. Almost a half of the outer 540-year visual orbit has been covered in 238 years of its observations. Both inner and outer orbits are revised here taking into account recent direct resolution of the inner pair Aa,Ab. The inner orbit has a high eccentricity of 0.87 and is inclined to the outer orbit by 140±10°, suggesting that Kozai-Lidov cycles take place. The masses of the stars Aa, B, and Ab are 1.4, 1.4, and 0.6 solar. The age of the system is about 3 Gyr, and the two main components have just left the main sequence. Hypothetically, this system could have formed by a dynamical capture of the small star Ab in the twin binary Aa,B.

Subject headings:

1. INTRODUCTION

Dynamics of multiple stars contains information on their origin. From this perspective, triple systems where elements of both outer and inner orbits are known and reasonably accurate are particularly interesting, as relative orbit orientation, period ratio, and interaction between subsystems can be studied (e.g. Borkovits et al. 2016). However, such well-studied multiples are still rare, requiring a substantial observational effort. This work deals with one of those, ζ Aquarii. Papers bearing nearly the same title as the present one have been published by Franz (1958) and Heintz (1984).

The naked-eye ($V = 3.65$ mag) visual binary ζ Aquarii was measured in 1779 by W. Hershel, but an earlier observation is listed in the first double-star catalog by Mayer (1784), so we do not know the name of its real discoverer. Coordinates and basic identifiers of the components are given in Table 1. The proper motion is $(182.9, 50.4)$ mas yr^{-1}, the trigonometric parallax is 35.50 ± 1.26 mas (van Leeuwen 2007), the spectral type is F3III-IV. The two pairs are designated in the WDS (Mason et al. 2001) as STF 2909 AB and Ebe 1 Aa,Ab, although they have not been discovered by W. Struve and J. Ebersberger.

The WDS database contains about 1160 measures of the pair A,B made with different techniques and with a varying precision (Figure 1). The binary traveled only a short arc during the 19th century, but in the 20th century it became closer and moved faster. Photographic

TABLE 1
Basic data on ζ Aqr

Object	Identifiers
AB	ADS 15971, HIP 110960, 55 Aqr
AB	WDS J2228−0001, STF 2909 AB
A	22:28:49.91 −00:01:11.8 (J2000)
A	ζ_2 Aqr, HR 8559, HD 213052
B	ζ_1 Aqr, HR 8558, HD 213051

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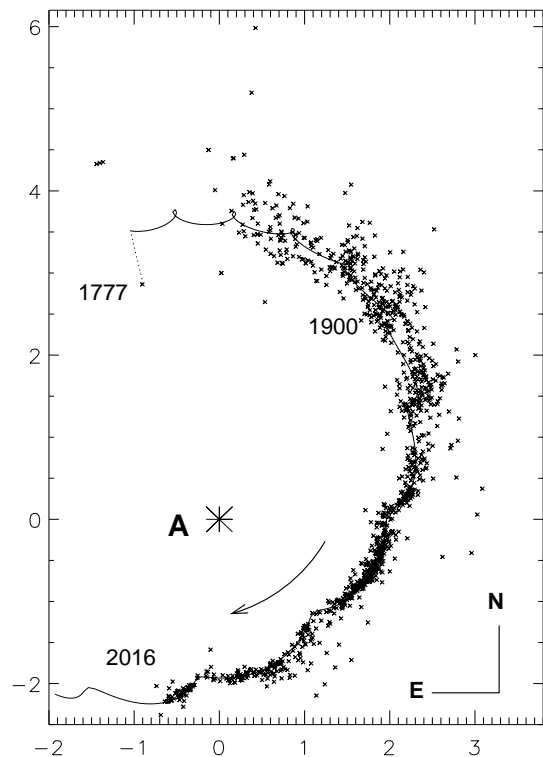[1] Based on observations obtained at the Southern Astrophysical Research (SOAR) telescope.

Fig. 1.— All observations of the pair A,B available in the WDS database are plotted as crosses, together with the proposed orbit (line). The A-component is at the coordinate origin, the scale is in arcseconds. Slightly less than a half of the outer orbit is covered by measures taken from 1777 to 2016.

measurements available since 1900 are more precise than visual micrometer estimates. They revealed deviations from the pure Keplerian motion with a 25-year period, first discovered by Strand (1942). Since then, several authors have undertaken reanalysis of the orbital motions in this triple system (Table 2). Harrington (1968) pointed out that dynamical interaction between components causes measurable deviation from the purely Keplerian motion (see also recent work by Xu et al. 2015). Yet, Heintz (1984) argued that the variation of the osculating orbital elements is too slow to matter and fitted the data by two Keplerian orbits. As shown below, even this
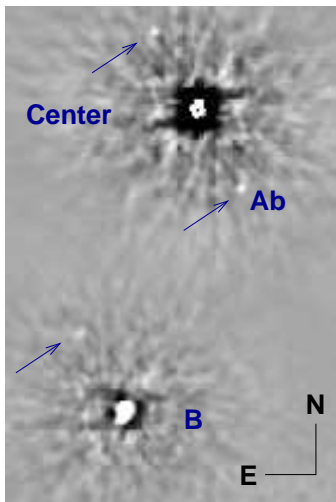
FIG. 2.— Fragment of the speckle auto-correlation function (ACF) recorded on 2015.74 at SOAR in the I band. The three weak peaks corresponding to the tertiary component Ab are indicated by arrows. The letters mark the positions of Ab and B relative to the ACF center.

TABLE 2
HISTORY OF ORBIT DETERMINATIONS OF ζ Aqr

Author	P_1 (yr)	a_1 ('')	e_1	P_2 (yr)	a_2 ('')	e_2
Strand (1942)	400	3.403	0.60	25	0.080	0
Franz (1958)	600	4.013	0.45	25.5	0.097	0.20
Harrington (1968)	856	5.055	0.50	25.5	0.072	0.26
Heintz (1984)	760	4.507	0.50	25.7	0.076	0.59
Scardia+ (2010)	487	3.380	0.43	25.8	0.062	0.13
This work	540	3.496	0.42	26.0	0.110	0.87

furnishes better spatial resolution and more accurate positions compared to the long-exposure imaging with partial AO correction (Figure 2).

The resolved measures of Aa,Ab do not match the latest astrometric orbit of Aa,Ab by Scardia et al. (2010). Arbitrary adjustment of the orbit was suggested by Tokovinin et al. (2014) to reach a better agreement. Since the work by Heintz (1984), the inner subsystem Aa,Ab has made one full revolution, so the next iteration on the orbits, now accounting for the resolved measures of Aa,Ab, can be made. This is the purpose of the present work.

first-order approximation of the observed motion was, so far, quite inaccurate; it is improved here to set the stage for a future dynamical analysis.

The motion of visual binaries is traditionally represented by an orbit of the secondary component B around the primary A. The "wave" in the motion was implicitly attributed to the "dark" (unseen) companion around B, until Heintz (1984) demonstrated that the perturbing body actually revolves around the component A. He categorically dismissed the detections of this dark companion to B by infrared interferometry (McCarthy et al. 1982) and the claimed resolution of Aa,Ab by optical speckle interferometry (Ebersberger & Weigelt 1979), as they did not match the orbit. Indeed, the large magnitude difference between Aa and Ab ($\Delta V \approx 6$ mag) and the modest dynamic range of early speckle instruments made such a resolution impossible. Despite the separation exceeding $0''.5$, the putative subsystem Aa,Ab has not been resolved in subsequent speckle observations until 2009. Note that McCarthy et al. (1982) calculated visibility from one-dimensional scans in the North-South direction that cannot distinguish which of the binary components is resolved. Their attribution of the tertiary to B was based entirely on the literature. At the time of their observation, 1981.94, the position of Aa,Ab was at ($168°.6$, $0''.23$) according to the new orbit, so it does not contradict their measured projected separation of $0''.17\pm0''.04$. However, the relative photometry in (McCarthy et al. 1982) disagrees with our estimates, throwing doubt on this claimed resolution.

The first real detection of the third body in the ζ Aqr system has been made by adaptive optics in the I band at the Southern Astrophysical Research Telescope, SOAR (Tokovinin et al. 2010). The two stars A and B were observed separately, and the tertiary has been erroneously attributed to B. This has been corrected in the following observations, securely associating the low-mass tertiary with the main component A. Direct images of the subsystem Aa,Ab are given by Hartkopf et al. (2012). The tertiary Ab, 5.4 mag fainter than Aa in the I band, is just detectable by modern speckle interferometry, which

2. THE ORBITS

In my first attempt to update the orbits, I used an obvious but wrong strategy: fit the motion of A,B in the outer orbit and then represent the residuals from this motion by the inner astrometric orbit of Aa,Ab. The inner orbit is eccentric, therefore the star Aa, practically coincident with the photo-center A, spends most of the time near apastron and is displaced from the center of mass of Aa,Ab. The outer orbit must describe the motion of B around the center of mass, not around the photo-center (component A). When the outer orbit is computed from the positions of A,B, the average residuals are minimized, and the perturbation (deviations of A from the outer orbit) becomes centrally symmetric, leading to the false inner orbit with a small eccentricity. This explains why astrometric orbits tend to have small eccentricities in general. Whenever an astrometric binary is resolved, it often turns out that its true visual orbit has a larger eccentricity than the astrometric orbit. Heintz (1984) discussed this effect and insisted on fitting the two orbits simultaneously. Yet, Scardia et al. (2010) ignored his warning and derived the inner orbit of ζ Aqr with a small eccentricity after fitting and subtracting the outer orbit.

I include the resolved measures of Aa,Ab together with the positions of A,B in the data set and fit 15 free parameters: seven elements of A,B, seven elements of Aa,Ab, and F, the ratio of the true and astrometric semimajor axes in the inner orbit. If the subsystem belonged to the B, the parameter F would be negative (the reflex displacement of B is oposite to the vector Ba,Bb), but here it is positive. I modified the IDL code `orbit.pro`[2] to fit both orbits simultaneously.

The least-squares fitting implicitly assumes that the measurement errors are known and normally distributed. In this ideal case, the weights are inversely proportional to the squares of the measurement errors σ. It is well

known, however, that visual micrometer measures of binary stars are not normally distributed, showing both large occasional deviations and systematic errors (see Figure 1). There is no general rule allowing to describe these data by normally distributed random variables. Photographic measurements of binary stars can also have larger-than-usual errors caused by poor seeing, systematic errors proper to photography (interaction of closely spaced images in the emulsion), and subjective errors of persons who measured the plates. The CCD-based measurements should be better than the photography, although this is not the case for some low-quality CCD measures made by amateurs. In the speckle interferometry, the uncertainty of the pixel scale and detector orientation, difficult to quantify, is often a major contributor to the position errors of wide pairs such as ζ Aqr. Published errors of speckle measures do not always include the calibration errors.

The only viable approach to this problem is to censor the data by rejecting obvious outliers and to treat the errors of the remaining measurements as unknowns, estimating them from the orbital solution itself. The large number of measurements of ζ Aqr favors this strategy. I used averaged micrometer measures made prior to 1900, taking them from the paper by Heintz (1984), and assumed their errors of $0''.1$. All micrometer measures made after 1900 are ignored, as more accurate and objective photographic observations became available. I adopted the errors of photographic measures prior to 1940 as 50 mas, then as 30 mas, same as for the accepted CCD measures. The speckle measures are assumed to have errors of 3 to 9 mas. Obvious outliers were deleted. Then, in the process of fitting the orbits, those measures that deviated by more than 3σ in either coordinate were given an increased σ to bring their deviation to the 1σ level. After several rounds of manual error adjustment and automatic down-weighting of outliers, the resulting normalized goodness of fit χ^2/N (N being the number of degrees of freedom) became close to one in both coordinates. The 322 retained observations of A,B, their adopted errors, and residuals to the orbits are listed in Table 3. Given the large number of measures, it is not practical to cite references to all of them. A similar Table 4 gives the resolved measures of Aa,Ab, all coming from the speckle interferometry at SOAR. The latest measure in 2016.39 is still unpublished.

In the following, I denote the orbital elements of the outer and inner pairs by the indices 1 and 2, respectively, and use common notation (P – period, T_0 – epoch of periastron, e – eccentricity, a – semimajor axis, Ω – position angle of the node, ω – argument of periastron, i – orbital inclination). The orbital elements found by fitting 15 parameters are listed in Table 5. For the inner orbit, the astrometric semimajor axis a_2 is given; it should be multiplied by F to get the true axis. The weighted rms residuals to the measures of A,B are 15 mas in both coordinates. The resolved measures of Aa,Ab have rms residuals of 10 mas. They are less accurate than most speckle data from SOAR because of the large magnitude difference between Aa and Ab. The periods P_1 and P_2 are similar to their values found in the previous studies, but the inner eccentricity $e_2 = 0.87$ found here is substantially larger (see Table 2).

Although the overall character of the orbital motion is well defined, the range of inner orbits compatible with the data is quite large, more than suggested by the formal errors of the elements. Additional consideration helps to select the most plausible inner orbit. Owing to the faintness of Ab, it is safe to assume that the photo-center of the composite component A is located at the primary Aa, so the measurements of A,B and Aa,B are equivalent. In such case, the mass ratio in the inner pair $q_2 = \mathcal{M}_{Ab}/\mathcal{M}_{Aa} = 1/(F-1)$. The mass sum of the inner pair is proportional to $(a_2F)^3P_2^{-2}$, the mass sum of the outer pair is proportional to $a_1^3P_1^{-2}$. As the stars Aa and B have very similar brightness, we expect equal masses $\mathcal{M}_{Aa} \approx \mathcal{M}_B$. So, the ratio of the mass sums in the inner and outer orbits should be close to $(1+q_2)/(2+q_2)$. This leads to

$$\frac{(a_2F)^3P_2^{-2}}{a_1^3P_1^{-2}} \approx \frac{1+q_2}{2+q_2}. \qquad (1)$$

Both periods and the outer semimajor axis a_1 are rather well defined, hence the inner semimajor axis should be $Fa_2 \approx 0''.39$ according to this equation. The unconstrained least-squares fit produces an inner orbit with $e_2 = 0.96$ and $a_2 = 0''.22$, too large to match the expected inner mass sum. Convergence of astrometric orbits derived from noisy data to nearly parabolic solutions has been studied by Lucy (2014), and here we have a similar situation. As the line of apsides of Aa,Ab is almost perpendicular to the line of nodes ($\omega_2 \sim 110°$), increasing the inclination i_2, the eccentricity e_2, and the semimajor axis a_2 simultaneously has little effect on the apparent orbital ellipse. The measures alone do not constrain well enough the semimajor axis of the inner orbit and allow solutions with unrealistically large a_2.

The final orbits (Figure 3) were obtained by fixing a_2 to the value given by (1) and fitting all other elements plus F. Then the new value of a_2 was computed and the constrained fit was repeated, until the iterations converged to $a_2 = 0''.110$. There is no doubt that the inner orbit has a high eccentricity; for example, a fixed $e_2 = 0.8$ leads to substantially larger residuals.

Visual measures in the 19th century seem to deviate systematically from the orbit of A,B. This could be caused by an over-estimation of the angular separation. However, such residuals might also result from dynamical interaction between the orbits, according to Harrington (1968).

One cannot help noting that the outer and inner pairs move in the opposite directions, retrograde and prograde, hence their orbital angular momenta cannot be aligned. There are no radial velocity (RV) data of adequate precision to establish the correct orbital nodes. Examination of the disparate published RVs indicates that RV(A) was less than RV(B) in the first half of the 20th century, meaning that the node $\omega_1 = 269°$ corresponds to the component A. The amplitude of the RV difference between A and B is about $4\,\mathrm{km\,s^{-1}}$, presently it is $+3$ km s^{-1} according to the new orbit. However, the orbit of Aa,Ab is seen almost face-on, so the RVs of A might be of little help for defining the inner node. Fortunately, the two possible angles between the orbital angular momentum vectors computed without knowledge of the true nodes are close to each other: $\Phi_1 = 146°.5 \pm 9°.9$ and $\Phi_2 = 136°.9 \pm 10°.0$. The period ratio is 20.8 ± 0.6.

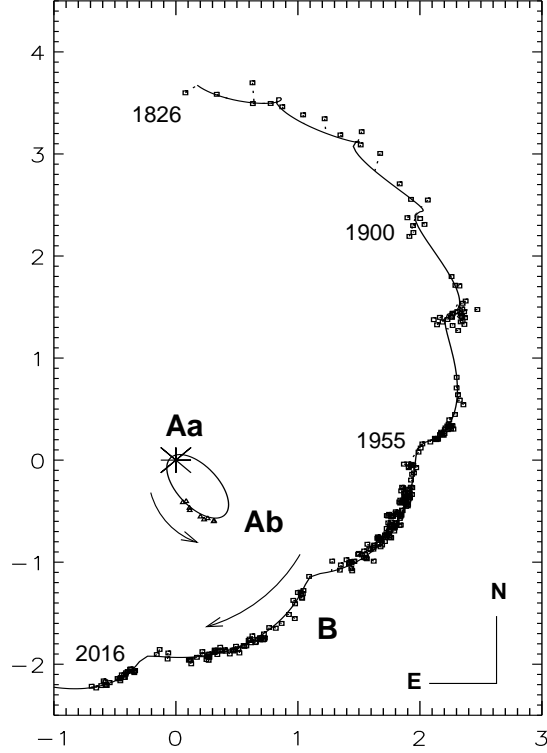Relative orientation of the orbits and the high inner

Fig. 3.— Orbits of A,B and Aa,Ab. The component Aa is at the coordinate origin. The curves show motions of B and Ab around Aa on the same scale (in arcseconds); squares and triangles depict observations of A,B and Aa,Ab, respectively.

TABLE 4
Observations and residuals of Aa,Ab

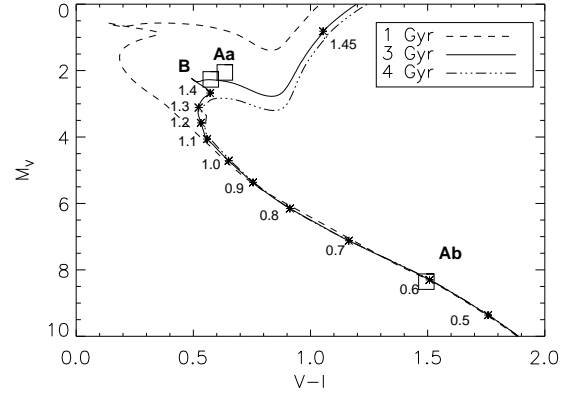| T (yr)	θ (°)	ρ ('')	σ ('')	O−C$_\theta$ (°)	O−C$_\rho$ ('')
2009.7552	192.0	0.4057	0.009	4.9	0.0015
2009.7552	187.9	0.4115	0.009	0.8	0.0073
2010.8914	193.4	0.4760	0.009	0.5	−0.0031
2010.9681	193.2	0.4976	0.009	0.0	0.0140
2012.9229	200.2	0.5835	0.009	0.2	0.0042
2013.7364	201.8	0.6211	0.009	−0.4	0.0113
2014.7631	204.7	0.6218	0.009	−0.1	−0.0198
2015.7379	207.5	0.6700	0.009	0.4	0.0046
2016.3901	208.0	0.6665	0.009	−0.5	−0.0116

Fig. 4.— Components of ζ Aqr on the $(M_V, V - I_C)$ color-magnitude diagram and Dartmouth isochrones for solar metallicity. Asterisks and small numbers show masses on the 3-Gyr isochrone.

TABLE 3
Observations and residuals of A,B (Fragment)

T (yr)	θ (°)	ρ ('')	σ ('')	O−C$_\theta$ (°)	O−C$_\rho$ ('')
1826.4000	358.8	3.6000	0.100	1.5	−0.0793
1832.6000	354.7	3.6000	0.100	1.5	0.0295
1838.8900	350.4	3.7500	0.100	0.8	0.1918
. . .	. . .	. . .	. . .	. . .	. . .
2014.7631	164.5	2.2928	0.009	0.0	−0.0020
2015.7379	163.7	2.3261	0.003	0.1	0.0094
2016.3901	162.7	2.3212	0.003	−0.2	−0.0091

eccentricity are strongly suggestive of the Kozai-Lidov cycles in this triple system. If the inner orbit were originally almost perpendicular to the outer orbit, it would evolve towards high eccentricity and relative inclination of 39° or 141°. In a system of three point masses the inclination and inner eccentricity oscillate with a period on the order of $P_1^2/P_2 \sim 12\,\mathrm{kyr}$, but real stars can tidally interact at periastron, locking the inner orbit in the high-e state, with subsequent circularization (Kiseleva et al. 1998). However, the distance between Aa and Ab at periastron is about 1.4 A.U., too large for tidal interaction.

3. PHYSICAL PARAMETERS OF THE STARS

The *Hipparcos* parallax of 35.5±1.3 mas (distance modulus 2.25 mag) relates orbital elements to masses. The mass sum of AB is 3.3±0.3 $\mathcal{M}_\odot$ and the mass sum of A is 2.0±0.2 $\mathcal{M}_\odot$. As noted above, the inner mass sum is not tightly constrained, for this reason the near-equality of the masses of Aa and B was imposed in the orbit fit. The masses of Aa, B, and Ab deduced from the orbits

and the mass ratio q_2 are 1.4, 1.4 and 0.6 $\mathcal{M}_\odot$, with an uncertainty of 10%.

Available combined and differential photometry is collected in Table 6. The component A is brighter and redder than B, as the magnitude difference between A and B increases with wavelength: $\Delta B = 0.14$ mag, $\Delta V = 0.21$ mag (Fabricius & Makarov 2000), $\Delta I = 0.27$ mag (Hartkopf et al. 2012), $\Delta K = 0.33$ mag (Carbillet et al. 1996). Six measurements of the magnitude difference between Aa and Ab in the I band made at SOAR average at 5.44 mag with the rms scatter of 0.13 mag. Considering that the absolute I_C magnitude of Ab $M_I = 6.9$ mag matches a main-sequence star of 0.6 $\mathcal{M}_\odot$, its magnitudes in V and K_s are estimated from the isochrone, not measured directly (numbers in brackets). Individual magnitudes of the components are computed from the combined and differential photometry.

Figure 4 places the components of ζ Aqr on the $(M_V, V - I_C)$ color-magnitude diagram. The most massive stars Aa and B are located above the main sequence and match the 3-Gyr Dartmouth isochrone for solar metallicity (Dotter et al. 2008). The corresponding masses are 1.42 $\mathcal{M}_\odot$, in excellent agreement with the orbit. This means that this system is unlikely to contain additional close (spectroscopic) stellar companions to any of the stars. The near-equality of the masses of A and B, adopted above as a hypothesis, is supported by the isochrones because at this evolutionary stage the dependence of color on mass is strong. The age of this system is close to 3 Gyr.

The stars Aa and B have a fast axial rotation (about

TABLE 5
ORBITAL ELEMENTS

System	P (yr)	T_0 (yr)	e	a ($''$)	Ω (°)	ω (°)	i (°)	F
A,B	540 ± 15	1981.50 ± 0.58	0.419 ± 0.011	3.496 ± 0.046	131.3 ± 0.8	269.3 ± 1.7	142.0 ± 0.4	...
Aa,Ab	25.95 ± 0.048	2006.52 ± 0.13	0.872 ± 0.006	0.110 fixed	293.7 ± 74	100.9 ± 73	11.8 ± 6.7	3.50 ± 0.09

TABLE 6
PHOTOMETRY

Comp.	V	I_C	K_s
A+B	3.65	3.04	2.72
B−A	0.21	0.27	0.33
Ab−Aa	(6.3)	5.44	(4.0)
Aa	4.30	3.67	3.21
B	4.51	3.94	3.93
Ab	(10.60)	9.11	(7.3)

$50\,\mathrm{km\,s^{-1}}$), not uncommon for their spectral type and evolutionary status as subgiants. Fast rotation is related to the high chromoshheric activity and X-ray luminosity (Schroeder et al. 2009). Liebre et al. (1999) measured a high lithium abundance in the photosphere of these stars. Most spectroscopic studies treat the object as a single star, given that the light of two closely spaced and nearly equal components Aa and B is usually mixed in the slit. When the spectra of both components were taken separately, the unusual slit illumination possiblly caused discordant RVs and false claims of RV variability. Nordström et al. (2004) found a constant RV of $25.90\,\mathrm{km\,s^{-1}}$ over a 3.8-yr time span in the combined light of both components. Using this RV and the *Hipparcos* astrometry, the Galactic velocity is $(U, V, W) = (-16.0, +15.9, -28.3)\,\mathrm{km\,s^{-1}}$ (U is directed away from the Galactic center). The spatial motion does not match any known kinematic group, supporting the view that this multiple system is not very young.

4. DISCUSSION

Comparable separations in the inner and outer orbits of ζ Aqr raise concern of its dynamical stability. There are no exact formulations for a criterion of dynamical stability of triple systems, while the existing approximate criteria do not differ substantially between themselves. One of the popular criteria by Mardling & Aarseth (2001) for coplanar orbits can be written as

$$(P_1/P_2)^{2/3} \geq 2.8(1 + q_1)^{1/15}$$
$$\times (1 + e_1)^{0.4}(1 - e_1)^{1.2} \qquad (2)$$

in present notation. This translates to $P_1/P_2 > 16.2$ for $q_1 = 0.70$ and $e_1 = 0.42$. According to this criterion, ζ Aqr with $P_1/P_2 = 20.8$ is within the stability boundary. On the other hand, the "empirical stability criterion" by Tokovinin (2004), $P_1(1 - e_1)^3/P_2 > 5$, calls for $P_1/P_2 > 25.5$, placing this triple system in the instability zone. Given the age of this system, we know that it is in fact stable. In any case, the dynamical interaction between inner and outer orbits should be strong, and the description of the motion by two Keplerian orbits can certainly be improved by taking it into account.

The stability criteria can be checked against multiple systems with known outer and inner orbits. A selection
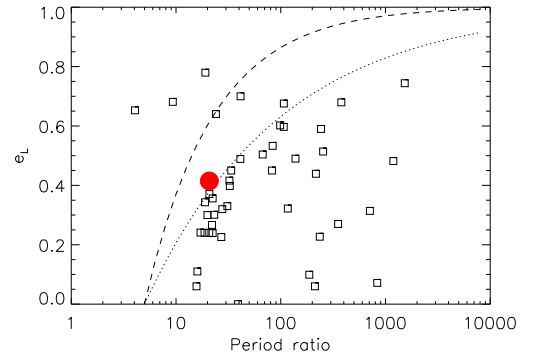

FIG. 5.— Outer eccentricity e_L vs. period ratio P_1/P_2 in triple stars with outer and inner orbits listed in the Sixth Orbit Catalog (squares), with the position of ζ Aqr marked by the red circle. The dashed and dotted lines correspond to the dynamical stability criteria by Mardling & Aarseth (2001) and Tokovinin (2004), respectively.

of such systems from the current (2016) version of the Sixth Catalog of Visual Binary Stars (Hartkopf et al. 2001) is shown in Figure 5. Points above both curves are due to the wrong orbital elements (visual orbits with long periods and small coverage lack credibility). Even such a famous binary as ζ Aqr had outer orbits with periods ranging within a factor of two (Table 2). There is a group of several other triples with similar outer eccentricities and period ratios on the order of 20. Three triple systems in this group have inner secondary components of very low mass discovered by Muterspaugh et al. (2010).

Properties of multiple stellar systems are related to their origin. The orbital architecture of ζ Aqr is suggestive of chaotic dynamical interactions, rather than dissipative evolution in accretion disks associated with coplanar multiple systems like HD 91962 (Tokovinin et al. 2015). However, the masses of the main components Aa and B and their axial rotation are remarkably similar (a twin binary). It is likely that the axes of stars Aa and B are aligned with each other and, possibly, with the outer orbit, rather than with the inner orbit. The outer binary Aa,B could have been formed by a collapse of a rotating core with subsequent accretion that made the components' masses nearly equal. In this case, the third star Ab is an intruder that met the binary Aa,B at a later time and was captured on a nearly perpendicular orbit that is now undergoing Kozai-Lidov oscillations. The dynamical capture of Ab could happen in the nascent cluster from which this system formed, or in an unstable quadruple system where a pair of low-mass stars was disrupted, leaving one of its components bound to A,B and ejecting another. Some other multiple systems with a high mutual inclination of their orbits could be produced by such dynamical interplay. Heintz (1984) noted

the similarity between ζ Aqr and the nearby quadruple system ξ UMa (ADS 8119). The latter consists of two solar-mass stars on a 60-year outer orbit (Heintz 1996). Each star has a low-mass close companion. The orbit of Aa,Ab is inclined to the outer orbit A,B by 130° and has a substantial eccentricity, just like Aa,Ab in ζ Aqr. The subsystem Ba,Bb with a period of 4 days and a minimum Bb mass of only 0.04 $\mathcal{M}_\odot$ could be a product of Kozai-Lidov cycles with tidal dissipation if its initial orbit were nearly perpendicular to the orbit of A,B. However, the orbital periods in ξ UMa are $\sim$10 times shorter than in ζ Aqr.

The next periastron passage in the inner subsystem of ζ Aqr will occur in 2032.6. Knowing that the orbit is very eccentric, this event should be observed by spectroscopy and imaging. RV variations near the periastron, if detected, will inform us on the exact inner eccentricity and inclination. Meanwhile, the motion of Aa,Ab should be monitored by speckle interferometry in the visible, while imaging in the near-infrared is needed to secure differential photometry and to measure the colors of Ab. The pair Aa,Ab is now approaching its maximum separation of almost 0.″7, facilitating its resolved photometry and, possibly, spectroscopy.

Facilities: SOAR

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