Gliese 225.2: an Old (Stable?) Quadruplet

V. Orlov[1], A. Tokovinin[2], O. Kiyaeva[3], M. Sterzik[4], A. Rubinov[1], and R. Zhuchkov[5]

[1] Sobolev Astronomical Institute, St. Petersburg State University, Universitetskii pr. 28, Staryj Peterhof, St. Petersburg 198504, Russia vor@astro.spbu.ru; rav@astro.spbu.ru,
[2] Cerro Tololo Inter-American Observatory, Casilla 603, La Serena, Chile atokovinin@ctio.noao.edu,
[3] Central Astronomical Observatory at Pulkovo, Pulkovskoe sh. 65/1, St. Petersburg 196140 Russia kiyaeva@gao.spb.ru,
[4] European Southern Observatory, Casilla 19001, Santiago 19, Chile msterzik@eso.org,
[5] Chair of Astronomy, Kazan State University, Kremlevskaya ul. 18, Kazan 420008, Russia zhr@ksu.ru

Summary. We discovered with adaptive optics a new component E in the nearby multiple system Gliese 225.2, making it quadruple. We derive a preliminary 24-yr astrometric orbit of this new sub-system C,E and a slightly improved orbit of the 68-yr pair A,B. The orientations of the A,B and C,E orbits indicate that they may be close to coplanarity. The 390-yr orbit of AB,CE computed by Baize (1980) was premature, the period is much longer. Large space velocities indicate that Gliese 225.2 belongs to the thick galactic disk and is not young. This quadruple system survived for a long time and should be dynamically stable.

1 Introduction

The multiple system HD 40887 = HIP 28442 = Gliese 225.2 has been known since long time. The wide sub-system A,C has been discovered by J. Herschel and is designated as HJ 3823. The closer pair A,B has been discovered by Hussey in 1911 and is named as HU 1399. This object, despite its brightness and proximity to the Sun, has received very little attention of observers. The location on the Southern sky has certainly contributed to this circumstance.

We are interested in this system because both the wide pair AB,C and the inner system A,B have computed visual orbits. The periods of pairs A,B and AB,C (68 and 390 yr, respectively) are such that the system does not satisfy any dynamical stability criterion. Is it really unstable?

A 12.8^m visual companion D at $20''$ from AB,C is listed in the WDS catalog under the name of B 2595. Rapid relative motion of this companion indicates that it is optical, hence it will not be discussed further.

2 Observations

High spatial resolution images of this object have been obtained using the NAOS-Conica adaptive optics system mounted at the VLT on November 9, 2004. The object was observed as a calibrator star for the program 74.C-0074(A). To our surprise, in addition to the three known visual components A, B, C we saw the fourth star E close to C (Fig. 1). Images in the narrow band around 2.12 μm and in wide photometric bands J, H, Ks, L' were taken. The new component is clearly seen in all images.

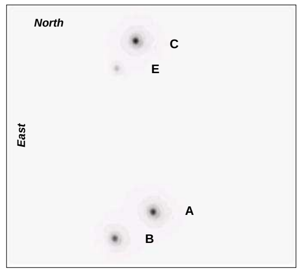

Fig. 1. Narrow-band image of HD 40887 at 2.12 μm. The components are marked by capital letters

3 The Orbits of Subsystems

The orbital elements of the system A,B were computed by Söderhjelm [1]. In order to re-analyze critically the orbits, we asked all archival observations from the WDS database. Those were kindly provided by Gary Wycoff from USNO. Adding the new 2004.86 measurement, we re-computed the orbit by applying differential corrections to the elements using the program ORBIT [2]. The result is similar to the Söderhjelm's one (Table 1). The systematic character of residuals (Fig. 2) indicates that this orbit is probably not quite satisfactory. However, no better result could be achieved.

Table 1. The orbits of A,B

Element	P, yr	T	e	a,″	Ω, °	ω, °	i, °
Söderhjelm, 1999	68.0	1998.0	0.45	0.9	125	279	103
This work	67.70	1996.805	0.513	0.912	127.54	275.69	100.38

Let us consider the orbit of AB,C. The angular separations of A,B and A,C are comparable. Thus, before computing the orbit of AB,C we must

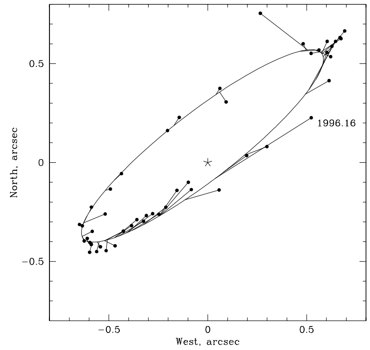

Fig. 2. The visual orbit of the A,B sub-system. The A-component is marked by the star at the coordinate origin, the measured positions of the *B*-component are joined to ephemeris locations

remove the motion of A in the A,B orbit. The "waves" caused by this motion are apparent in the plots of raw data. We subtracted this correction and analyzed the motion of C around the center-of-mass AB.

The two very first measurements made by J. Herschel in 1835.48 and 1836.86 are very discordant in separation (3.3 and 4.84 arcsec, respectively). It seems evident now that the second measurement was more correct. However, Baize [3] averaged those two critical points. Moreover, he did not subtract the reflex motion of A around AB, the orbit of A,B was not known at the time. Thus, the 390-yr orbit computed for AB,C by Baize is incorrect and contradicts modern observations (see Fig. 3). Using the Baize's orbit led Orlov and Zhuchkov [4] to the conclusion that the triple system AB,C is dynamically unstable.

The apparent motion of AB,C is almost rectilinear. The systematic "waves" in the residuals can be explained by the motion of C in the C,E orbit. We fitted these data to a preliminary astrometric orbit (see Table 2).

Table 2. Preliminary astrometric orbit of C,E

	P, yr	T	e	$a,''$	Ω, °	ω, °	i, °
Element	23.7	1980.4	0.17	0.120	132	171	124
Error	0.5	1.1	0.04	0.004	10	22	13

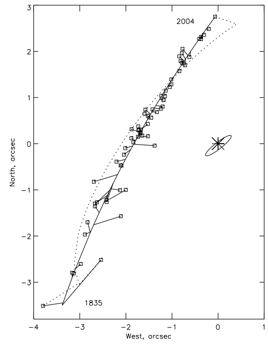

Fig. 3. The apparent motion of AB,C. The observations are plotted as squares, the orbit of Baize [3] as dotted line (connected to two first and one last observations). The solid line shows the quadratic ephemeris. The center of mass AB is marked by a large star at coordinate origin. The small ellipse shows the motion of A around AB

4 Discussion

We discovered a new component E in the system and derived its preliminary astrometric orbit. Interestingly, the inclinations and position angles of nodes of A,B and C,E indicate that these pairs may be close to coplanarity. Unfortunately, no radial velocity data is available to determine the acsending nodes of both orbits without ambiguity.

Our study has shown that the visual orbit of the outer sub-system AB,C was premature. The observed motion shows only slight curvature and corresponds to a large, yet unknown orbital period. The fact that AB and CE are seen close to each other may be explained by projection.

Large proper motion and large radial velocity (+102 km/s) indicate that Gl 225.2 belongs to the thick Galactic disk and is not young. Its space velocity module is about 110 km/s. The absence of detectable X-ray radiation also suggests that these stars have no active chromospheres and are old. This quadruple system thus survived for a long time and should be dynamically stable.

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References

1. S. Söderhjelm: A&A **341**, 121 (1999)
2. A. Tokovinin: Speckle Spectroscopic Studies of Late-Type Stars. In: *Complementary Approaches to Double and Multiple Star Research, IAU Coll. 135*, ed by H.A. McAlister, W.I. Hartkopf (ASP, San Francisco, 1992) p 573
3. P. Baize: Inf. Circ. IAU Comm. 26. **80** (1980)
4. V.V. Orlov, R.Ya. Zhuchkov: Astron. Rep. **49**, 201 (2005)