THE ALGOL-TYPE BINARY QS AQL

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QS Aql is an eclipsing- and a (probably double-lined) spectroscopic binary with a period of 2.5133 days. However, from 1962 to 1968 the period was 2.5134 days. QS Aql is part of the visual double star Kui 93 with $m_A = 6.5$ mag and $m_B = 6.7$ mag or $\ell_A:\ell_B = 1.2:1$ **(0)**. The system is also detected in X-rays (White & Marshall, 1983).

The 25 micrometer measurements (1934-1959) and 12 speckle-interferometric measurements (1976-1986) available do not as yet give a unique orbital solution. For periastron passages ($\equiv T_{per}$) between 1940 and 1955 the orbital solutions have statistically equally best fits. The two extreme orbital solutions provide for T_{per}, a_ℓ'' and $\mathcal{P}_\ell$ (years):
1940; 0.514; 383 **(1a)** and 1955; 0.450; 471 **(1b)** respectively.

UBV photometry yields for the whole system Q = -0.468 mag → B5V and E(B-V) = 0.1 **(2)**. From spectroscopy Holmgren (1987) finds: $K_1 = 58$ km/s, $K_2 = 223$ km/s and $q_{sp} = 0.26$ **(3)**. Preliminary results from UPS lightcurves are: $r_1 = 0.318$; $r_2 = 0.183$ (both components well within their Roche lobes); $q_{ph} = 0.27 \pm 0.01$ **(4)** and $\ell_{th} = 2.5\ \ell_Q$ **(5)**, where ℓ_{th} and ℓ_Q are the luminosities of the "third" light and of QS Aql respectively (in spite of the fact that the UPS filters provide measurements in spectral continua the UPS lightcurves show as much scatter as other lightcurves).

To satisfy (0) as well as (5), an extra component designated by a suffix E has to be introduced. A physically credible model can be obtained by putting $\ell_B = \ell_Q + \ell_E$ **(6)**. Support for this is given by the positional measurements of Kui 93. These observations show a wiggle around the orbital solution [see (1a) and (1b)]. The period of this wiggle $\mathcal{P}_s \sim 17.5$ year **(7)** and the projected semi-major axis $(a_s)_{proj} \sim 0\overset{''}{.}022$ **(8)**.

Now (0) transforms into $\ell_A : \ell_Q : \ell_E = 1.2 : 0.63 : 0.37$ **(9)** causing the fractional distance β of the photocentre from the centre of the more luminous star (ℓ_Q) in the (Q,E) system to be 0.37 **(10)**.

The radial-velocity and the lightcurve interpretation result in a total mass $\mathcal{M}_Q = 6\mathcal{M}_\odot$ **(11a)** and $(M_V)_Q = -1.50$ mag **(11b)** for QS Aql. In

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the same way (9) implies $(M_V)_E = -1.40$ mag **(12)** and $(M_V)_A = -2.20$ mag **(13)**. According to Straizys and Kuriliene (1981) (13) can refer to a star with spectral type B4.2III, B3.1IV or B2.4V which has a mass of 6.8; 7.5 or $8.8\mathfrak{M}_\odot$ respectively **(14a,b,c)**. From (13), (0) and (2) follows the photometric distance d = 478 pc **(15)**.

Define the mass of the (Q,E) system as $x\cdot\mathfrak{M}_Q$ and the total mass of Kui 93 as $y\cdot\mathfrak{M}_Q$. Kepler's third law applied to both orbits results in the formula:

$$y = x\left(\frac{x-1}{x} - \beta\right)^3 \left(\frac{a''_\ell}{0.022}\cos i_s\right)^3 \left(\frac{\mathcal{P}_s}{\mathcal{P}_\ell}\right)^2 \qquad \text{with } y > x, \qquad \textbf{(16)}$$

where i_s and $\mathcal{P}_s$(~ 17.5 years) are the inclination and period of the (Q,E) system and a''_ℓ and $\mathcal{P}_\ell$ the semi-major axis and period of Kui 93 [see (1a) and (1b)]. Note that $\mathfrak{M}_E = (x-1)\cdot\mathfrak{M}_Q$ **(17)** and that $\mathfrak{M}_A = (y-x)\cdot\mathfrak{M}_Q$ **(18)**. According to (14 a,b,c) and (18) (y-x) = 1.14; 1.26 and 1.48 **(19)**. As a first approximation $i_s = 0^o$ **(20)** will be assumed. Orbital solution (1a) yields with (16), (9) and (19) for $\mathfrak{M}_E$, $\mathfrak{M}_{Kui\ 93}$ and d the surprising results:

$(17 \mp 0.4)\mathfrak{M}_\odot$; $(30 \mp 1.5)\mathfrak{M}_\odot$ and (321 ∓ 5) pc. **(21a)**

This distance is by more than 30% shorter in comparison with the photometric distance (15). In the same way orbital solution (1b) results in:

$(31 \mp 0.4)\mathfrak{M}_\odot$; $(44.6 \mp 1.6)\mathfrak{M}_\odot$ and (477 ∓ 6) pc resp. **(21b)**

Now the distance is about equal to the photometric distance [see (15)]. However $\mathfrak{M}_E \sim 31\mathfrak{M}_\odot$ (21a) or $\mathfrak{M}_E \sim 17\mathfrak{M}_\odot$ (21b), whereas $(M_V)_E$ should be -1.40 mag (12). This is difficult to understand.

Of course the assumptions (8) and (20) are approximate. The orbit of the photocentre of the (Q,E) system has to be determined more carefully. Even the period of this orbit (7) can be in error. More speckle-interferometric measurements are urgently needed. Besides QS Aql can be of later spectral type. For the other stars in Kui 93 can be chosen such that the combined B-V and U-B indices provide the observed Q value (2). Finally the lightcurves are poor due to the scatter and do not allow for accurate photometrical solutions. However, it seems that the total mass of Kui 93 has to be rather high in order to explain the photometric distance.

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