Radial-velocity studies of certain multiple systems

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Summary. Continued (and continuing) observations are progressively elucidating the outer orbits in a number of spectroscopic triple systems whose inner orbits are already documented.

The speaker has effectively full-time use of the 36-inch reflector on the Cambridge site. It is used with a radial-velocity spectrometer patterned after Mayor's 'Coravel'. The principal programme of observations is the monitoring of the radial velocities of a number of stars whose velocities have been found to change. They include a small proportion of systems that are more complicated than simple doubles, quite apart from the association of additional visual components with an appreciable proportion of the spectroscopic binaries.

Certain triple systems whose orbits have already featured in the speaker's long-running series of papers in *The Observatory* have been retained on the observing programme, with a view to documenting at least a part of the 'outer' (long-period) orbit. They include HD 7426 (Paper 80), HR 965 (Paper 88), HR 2879 B (Paper 119), 24 Aqr (Paper 128), and V455 Aur (Paper 160).

In the 17 years since the 1600-day inner orbit of HD 7426 was described [1], the γ-velocity continued to rise, but the rise now appears to have levelled off. It is possible to fit a plausible outer orbit to the graph of the variation of the γ-velocity, but only by fixing the period; 20,000 days is a suitable value at which to fix it, but the observations so far cover only about 12,000 days, and there is still a lot of uncertainty in the true length of the outer period. A beneficial side-effect of the continuing observations is that the inner orbit, which was indistinguishable from a circle in the original publication, is now seen to have a definite eccentricity of about 0.07, five times its standard deviation.

The existence of a downward drift in the γ-velocity of HR 965, a discovery that came as a surprise to the author when he went to write up the short-period (1100-day) orbit [2], has been fully confirmed, but has now levelled out. Radial-velocity measurements in the literature, ante-dating those measured by the speaker, allow the outer period to be estimated at 16,000 days (44 years). The eccentricity of the inner orbit, which in the published paper was attributed a value of 0.06 ± 0.03, of very marginal significance, currently appears to be 0.03 ± 0.01, so it is still somewhat marginal. Part of the difficulty in obtaining an accurate eccentricity for the inner orbit arises from the period being extremely close to the exact value of three years (it is six days short), which conspires with the location of the star in the sky, only 5 degrees from the north celestial pole, to limit the phase coverage that can be obtained with the Cambridge instrument.

HR 2879 B underwent a dramatic periastron passage in its outer orbit ($e \sim 0.66$) about five years ago; the outer period is now quite well estimated at close to 10,000 days (27 years). The mass ratio between the components in the outer orbit, one of which is the well documented 27-day double, is now determined to be very close to the anticipated value of two to one — the larger but comparatively ill-determined ratio that was implied by the published observations [3] has given place to a much more acceptable figure.

24 Aqr continues to follow accurately the course laid out for it, on the basis of a minor adjustment to the visual orbit, in the published paper [4]. Each year it is possible to obtain radial-velocity traces in which the two observable components are infinitesimally better separated than they have been previously; eventually there should come a time, near the periastron passage, when they can be seen completely separated, thereby enabling their individual profiles to be accurately ascertained and all previous observations to be reduced with increased precision and confidence. Unfortunately the periastron passage is still about fifteen years away.

V455 Aur (HD 45191), which exhibited such a major change of γ-velocity between the two seasons' observations reported in the published paper [5], has scarcely changed at all since then. Evidently the outer orbit is of much longer period than seemed likely at first, and must have a high eccentricity.

Among other multiple systems under current observation, one particularly interesting one is HD 117078, which proves to be quadruple. Two components are visible in radial-velocity traces, but their velocities vary in different periods, about 6 and 204 days, and demonstrate that the system consists of two single-lined binaries. The γ-velocities have varied considerably, in anti-phase with one another as would be expected, and enough of the outer orbit has been seen to enable its period to be estimated, seemingly quite well, at about 13,000 days or 36 years.

A final example of a system that exhibits two periods of radial-velocity variation is enigmatic. It is 32 Cyg, one of the best-known ζ Aur binaries, whose orbital period has long been accurately established from the eclipse cycle of 1147 days. During the last two cycles the radial velocities, systematically measured once a month, have shown a very distinct subsidiary variation with a period of about two years and a peak-to-peak amplitude of about 1 km s^{-1}. It seems most unlikely that the system could include a component with a 2-year period when the known orbit is of 3 years. Possibly the 2-year variation represents azimuthal differences of spectrum or surface brightness in the K-supergiant primary; the period is close to the pseudo-synchronous one.

References

1. Griffin, R.F., 1988, Observatory, 108, 90
2. Griffin, R.F., 1989, Observatory, 109, 180
3. Griffin, R.F., 1994, Observatory, 114, 268
4. Griffin, R.F., Carquillat, J.-M., Ginestet, N, & Udry, S., 1996, Observatory, 116, 162
5. Griffin, R.F., 2001, Observatory, 121, 315