ASTRONOMY AND SPACE SCIENCE
eds. M.K. Tsvetkov, L.G. Filipov, M.S. Dimitrijević, L.Č. Popović,
Heron Press Ltd, Sofia 2007

On Some Ambiguities in Defining the Nature of Observed Double Systems on the Basis of Their Radial Velocity

G. Triffonova[1], **D. Petkova**[1], **V. Shkodrov**[2]

[1]Shumen University, Faculty of Science, 9700 Shumen, Bulgaria

[2]Institute of Astronomy, Bulg. Acad. Sci., BG-1784 Sofia, Bulgaria

Abstract.

This text presents an analysis of the orbital motion of quasi-spectral and star-plane binary systems, arguing that it is often impossible to distinguish them from each other on the basis of their spectral observation.

The motion of the quasispectral binary system is modeled and the theoretically obtained amplitudes are compared with the observed ones in the extrasolar planetary systems, showing that the amplitude of radial velocities in the two types of systems are of the same order and could not present a certain ground for these systems' definition.

1 Introduction

As scientists have long discovered, a type of narrow double solar systems exists, in which the movement evolves in a plane, perpendicular, or almost perpendicular to the line of sign. These are cases, in which the angle between the orbital plane and the plane, tangential to the celestial sphere is close to zero $i \approx 0°$. Spectral observations of such systems are often irresolvable difficulties. The amplitude of radial velocity's variations is either zero, or close to zero. Usually in these cases, within the possible precision of the spectral observations, such double systems are treated as single stars of some variability. Such double systems are unidentifiable with the means of spectral observation. When their motion plane concludes a narrow angle, the amplitude of the radial velocity is of minimal value. It is comparable to the amplitude of exoplanet systems. This is the reason that spectrally double narrow solar systems and extra-solar planetary systems can be undistinguishable from each other. The aim of this short presentation is to show that there are cases, in which the movement of an exoplanet can not be distinguished from the movement of a spectrally double solar system, as their amplitudes are too similar.

2 Theoretical Model of Double System's Movement

We examine a system, composed by bodies A and B, which evolve along a common mass center. We assume that B is a sphere, whose substance is spread evenly. A's spherical symmetry is disrupted, which causes disturbance of the Kepler's movement of the system. To describe the implications in the radial velocity, we use the model, described in [1] (in this article the amplitude is marked with). It is build with the conditions, described earlier. The initial connection between the radial velocity and the orbital elements is expressed with the usual formula

$$\frac{\mathrm{d}z}{\mathrm{d}t} = V_r = K\left[e\cos\omega + \cos(\omega + \nu)\right] \tag{1}$$

where $K = n\bar{a}\sin i(1 - e^2)^{-1/2}$ is the amplitude of the radial velocity; ω – argument of the periastron, υ – the actual anomaly; $n = 2\pi/P$ – the average motion; a – the semimajor axis of the orbit; e – the eccentricity.

The gravitation potential U, used here, is defined by:

$$U = \frac{fM}{r}\sum_{nm}\left(\frac{a}{r}\right)^n A^*_{nm}\Im_{nm}(\theta_r, \lambda_r) \tag{2}$$

Here f is the constant of gravity, M is the mass of the deformed body A, a is the equatorial radius of the star A, inducing the gravitational pull in the system, r is the radius-vector, determining the position of the star B with spherical distribution of substance towards the star A, A^*_{nm} are coefficients, related to the distribution of substance at star A, $\Im_{nm}$ – spherical functions, θ_r and λ_r – spherical co-ordinates.

Developing a solution where $i = 0°$, the following relation for radial velocity is obtained:

$$\frac{\mathrm{d}z}{\mathrm{d}t} = K\sin(\vartheta + \omega)\cos\omega\cos\Omega\cos^2 i \tag{3}$$

where Ω is a positional angle of line of the nodes, and the amplitude is defined by the expression

$$K = \frac{fM}{na^2}\left(\frac{a}{r}\right)^2 A^*_{20}6\sqrt{5}\cos^2 i'\sin i' \tag{4}$$

A^*_{20} is the second zonal harmonics in the potential of star A.

The results of the specific calculations of the amplitude as a function of the declination i are presented in Table 1.

Table 1. Values of the model amplitudes

i°	0	1	2	3
K ([m/s])	0	37.9	75.8	113.4

3 Analysis of the Observed Amplitudes of Extra Solar Planetary Systems

The observation of a system star-planet and its definition as such is a peculiar task, when it concerns spectrally double systems. We can say in advance that the amplitudes of the periodic motions of these systems are minor, as they are mostly due to gravitation disturbances, caused by the planet to the moving star. For instance the Sun is moving around the baricenter of the Solar system due to the effect of the orbital movement of all the planets. The influence of Jupiter is the most essential, as this planet's mass is the greatest. Its impact is of about 13 m/s [2]. Precise measurement of the radial velocity V_r are needed, to detect the perturbations of the planet's solar movement.

The existence of permanent radial velocity amplitude is considered as evidence that the observed double system is in fact a star-planet system [3, 4]. But this conclusion may be ungrounded considering the results, received from analysis of the movement amplitudes of spectrally double star systems as in Table 1.

For comparison, Figure 1. shows the distribution of amplitudes of the planetary systems (Figure 1) [5].

The figure shows that the most populated amongst the discovered planetary systems are those, which amplitude is between 30–50 m/s. There is no scientific

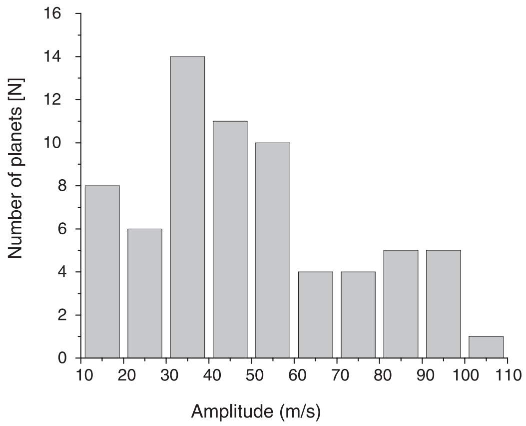

Figure 1. Distribution of exoplanets' amplitudes

explanation of this fact so far. It is not clear whether this is due to the monitoring selection, or to their bigger number in proximity to the Sun. However it should be noted, that the amplitudes of the already discovered planetary systems are within the limits between 11.1 to 1813 m/s.

Comparing the data in Table 1 with those in Figure 1 one finds similar range of amplitudes. An amplitude may be constant in time, but if it is small, the movement in these two types of systems is undistinguishable.

4 Conclusions

The performed comparative analysis has its limitations, but it nevertheless shows that the double systems in question are indistinguishable in the mentioned cases. We acknowledge that this is a preliminary research, which would be a subject of additional clarification of various dynamic characteristics in comparing double systems. Similar pattern of the radial velocity's amplitude can be observed in the pulsation of variable stars. This will in fact be a task for a next comparative analysis.

References

[1] J. Schneider (2004) *Extra-solar Planet Catalog*, http://exoplanets.org/planet.table.html.

[2] G. R. Trifonova, V. G. Shkodrov (2004) *Scientific Report* **120** 128.

[3] D. F. Gray (1998) *Nature* **391** 153.

[4] G. M. Marcy, R. P. Butler (1997) *Aastron. & Astrophys. Supl.* **191** 2005.

[5] D. F. Gray, A. P. Hatzes (1997) *Astrophys. J.* **90** 412.