Eclipse timing Variations Of Planets In P-Type Binary Star Systems

R. Schwarz 1, N. Haghighipour2, S. Eggl1, B. Funk3, and E. Pilat-Lohinger1

1 Institute for Astronomy, University of Vienna, A-1180 Vienna, Türkenschanzstrasse 17, Austria; 2 Institute for Astronomy and NASA Astrobiology Institute, University of Hawaii-Manoa, Hawaii, USA; 3 Department of Astronomy/Eötvös University, H-1117 Budapest, Pázmány Péter setany 1/A, Hungary

1 INTRODUCTION

Approximately 70% of all stars in the solar neighborhood are members of binary or multiple star systems. This fact has led to speculations that many more planets may exist in binary systems, and that the knowledge of the dynamics of planets in binary systems is crucial. In general, one can distinguish different types of stable orbits for planets in binary systems (Rab2 & Dvorak 1988) (Figure 1): (i) S-Type, where the planet orbits one of the two stars, (ii) P-Type, where the planet orbits the entire binary. We focus on P-Type orbits, because many of close eclipsing binaries lie in the CoRoT discovery space.

Eclipse timing variations (ETVs):

We calculated ETVs for the transiting star by subtracting the time of the eclipse of the unperturbed case (t2, start-star-planet of 1 M J . The x-axis shows the number of transits whereas the y-axis depicts the timing variation (σ).

4 RESULTS

Our numerical simulations were carried out using the following two integration methods (a) the Lie-Series and (b) the Bulirsch-Stoer method. For the analysis of the stability we used the Fast Lyapunov Indicator (FLI) on the one hand and on the other hand the maximum eccentricity (emax). For the emax we examined the behaviour of the eccentricity of the planet along the integration. If the orbit becomes parabolic (i.e. ebin =1), the system is considered to be unstable. All numerical simulations used the full three-body problem as a dynamical model; here m1 is the primary star, m2 the secondary star and m3 the planet. We used 3 different types of binaries (sorted by total mass):

model 1: m1 = m2 = 0.3 Msun
model 2: m1 = 1, m2 = 0.5 Msun
model 3: m1 = m2 = 1 Msun

2 MODELS AND METHODS

We calculated ETVs for the transiting star by subtracting the time of the eclipse of the unperturbed case (t2, start-star-planet of 1 M J . The x-axis shows the number of transits whereas the y-axis depicts the timing variation (σ). Subtraction of the constant rate of apsidal precession yields the eclipse timing variation (δ).

3 STABILITY OF THE SYSTEMS

The stability study for the different models was necessary in order to identify stable configurations for the analysis of the ETV signals. We used a separation of the binary of a=0.05 AU which corresponds to a period of approximately 3 days for sun mass stars (1M_sun) and 5 days for stars with 0.3 M_jup.

Figure 2. Stability map for 1 M_J for model 1. The stability was investigated by the emax (left) and the FLI (right). The violet and blue region depicts stable and the yellow region chaotic motion.