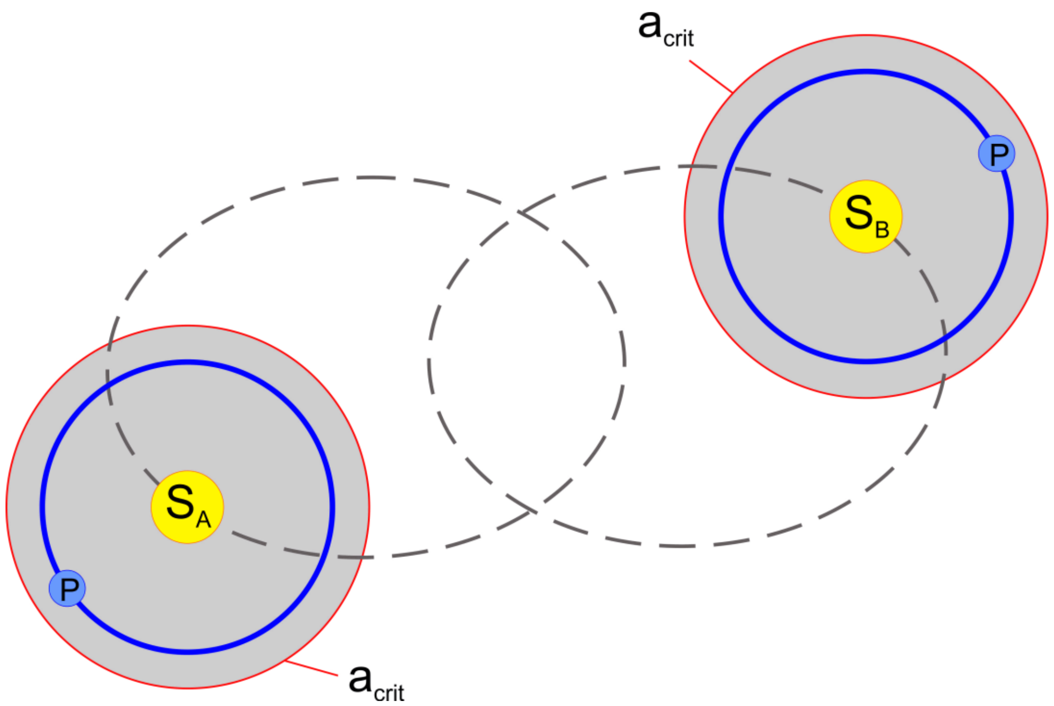
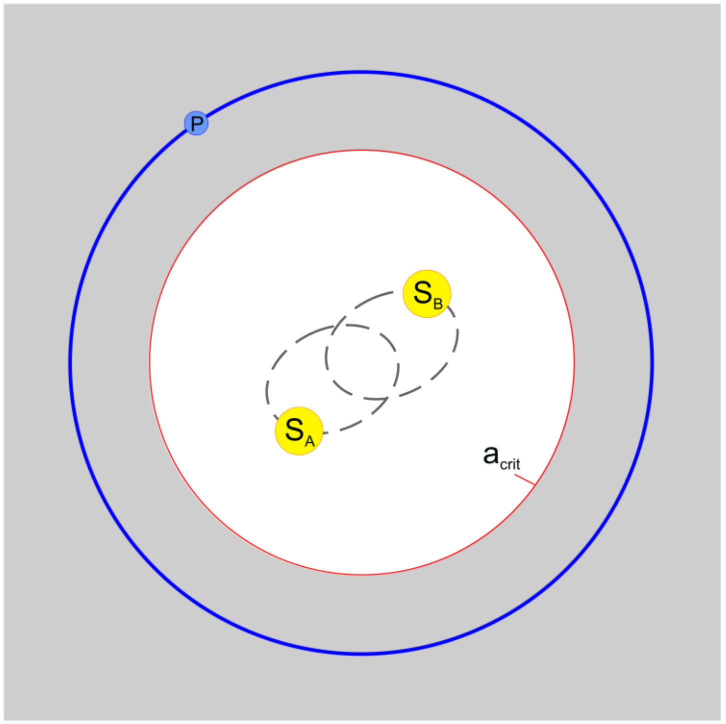
Stability of planetary motion in binary stars

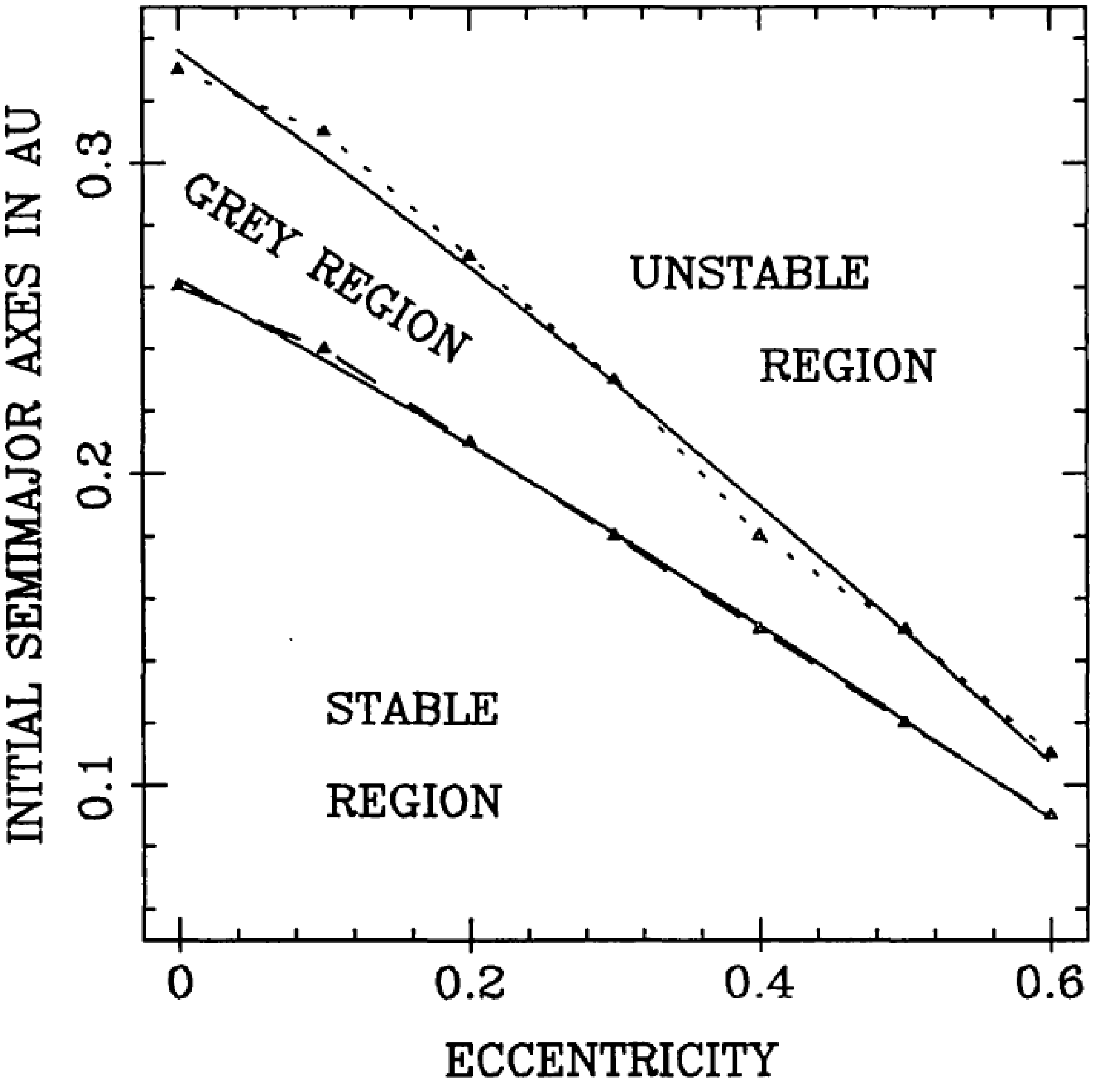
Types of planetary motion in binary stars:



S-type or circumstellar motion

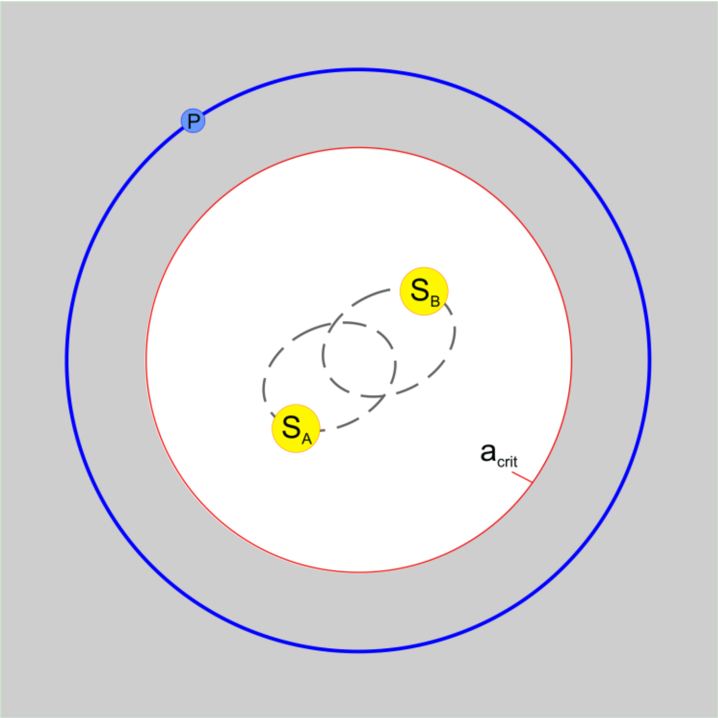


P-type or circumbinary motion



INITIAL SEMIMAJOR AXES IN AU
0.1
0.2
0.3
0
0.2
0.4
0.6
ECCENTRICITY
GREY REGION
UNSTABLE
REGION
STABLE
REGION

P-Type or CIRCUMBINARY MOTION



Critical Semimajor Axis in Units of the Binary Semimajor Axis for Each Pair of Values of the Mass Ratio and Eccentricity in the Outer Region

	μ				
e	0.10	0.20	0.30	0.40	0.50
0.0......	2.0	2.2	2.3	2.3	2.3
0.1......	2.4	2.7	2.7	2.8	2.8
0.2......	2.7	3.1	3.1	3.1	3.1
0.3......	3.1	3.5	3.5	3.3	3.2
0.4......	3.5	3.5	3.6	3.5	3.6
0.5......	3.8	3.9	3.9	3.6	3.7
0.6......	3.9	3.9	3.9	3.8	3.7
0.7......	4.2	4.3	4.3	4.1	4.1

Note.—These empirical results are from the 10^4 binary period numerical integrations.

Holman & Wiegert (1999)

$$
\begin{aligned}
a_c = {} & (1.60 \pm 0.04) + (5.10 \pm 0.05)e \\
& + (-2.22 \pm 0.11)e^2 + (4.12 \pm 0.09)\mu \\
& + (-4.27 \pm 0.17)e\mu + (-5.09 \pm 0.11)\mu^2 \\
& + (4.61 \pm 0.36)e^2\mu^2 \ .
\end{aligned}
$$

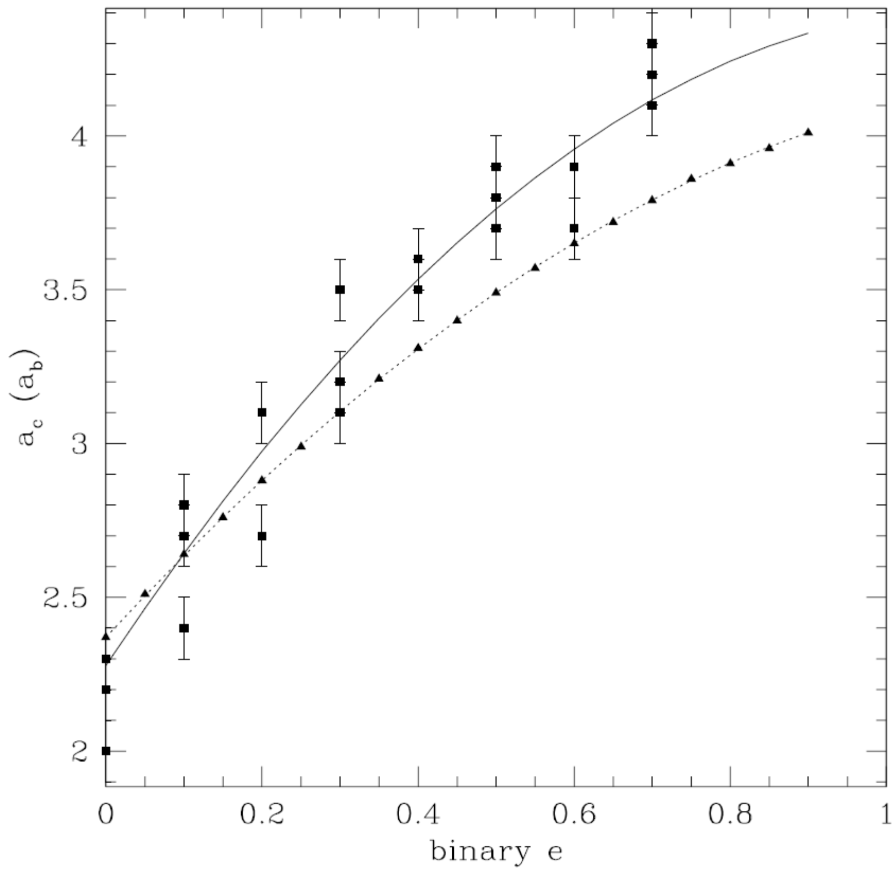


FIG. 4.—Critical semimajor axis as a function of eccentricity in the outer (P-type) region. The square data points are our results (note: four different values of μ from 0.1 to 0.5 are used); the triangles, those of Dvorak et al. (1989). Our least-squares fit (up to quadratic in e, eq. [5]) is shown by the heavy line; that of Dvorak et al. (see text), by a dotted line. Our simulations were run 20 times longer (10^4 binary periods) and indicate that there is an erosion of the stable outer region over time, at least at higher eccentricities.

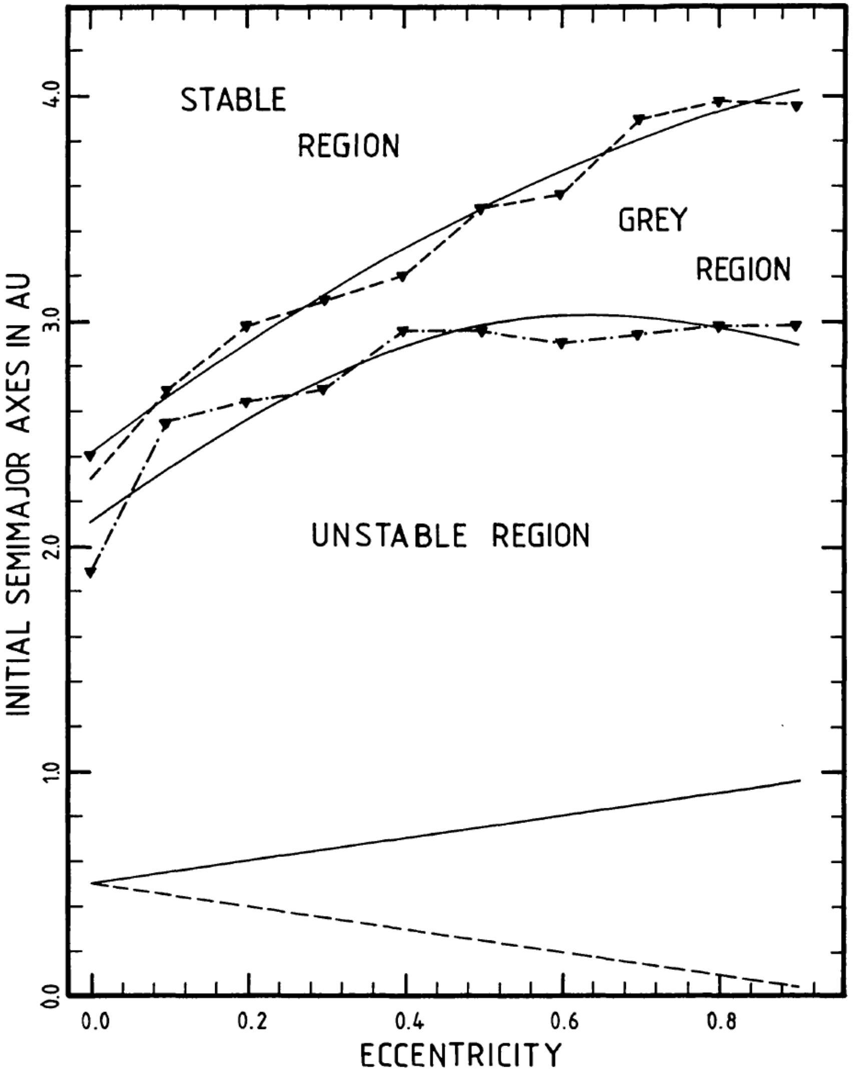


Fig. 4. Critical orbits depending on the eccentricities of the primaries. The triangles mark the UCO and the LCO due to the results of the numerical experiments (Table 5). The two parabolas represent the UCO and LCO given by a least square fit. The two lines at the bottom indicate the initial distance of the nearer primary for starting in the apoapsis (upper line) and in the periapsis (lower dashed line)

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Astronomy & Astrophysics

Stability limits in double stars

A study of inclined planetary orbits

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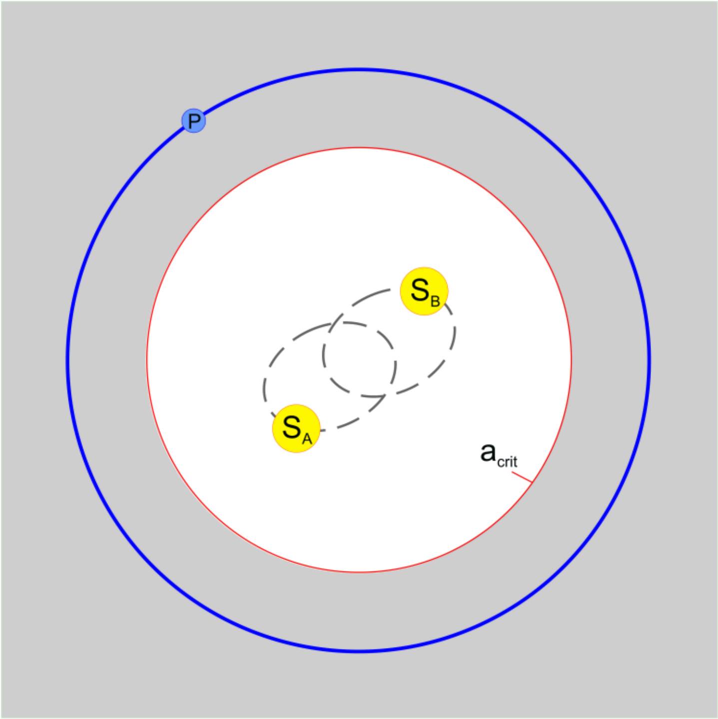
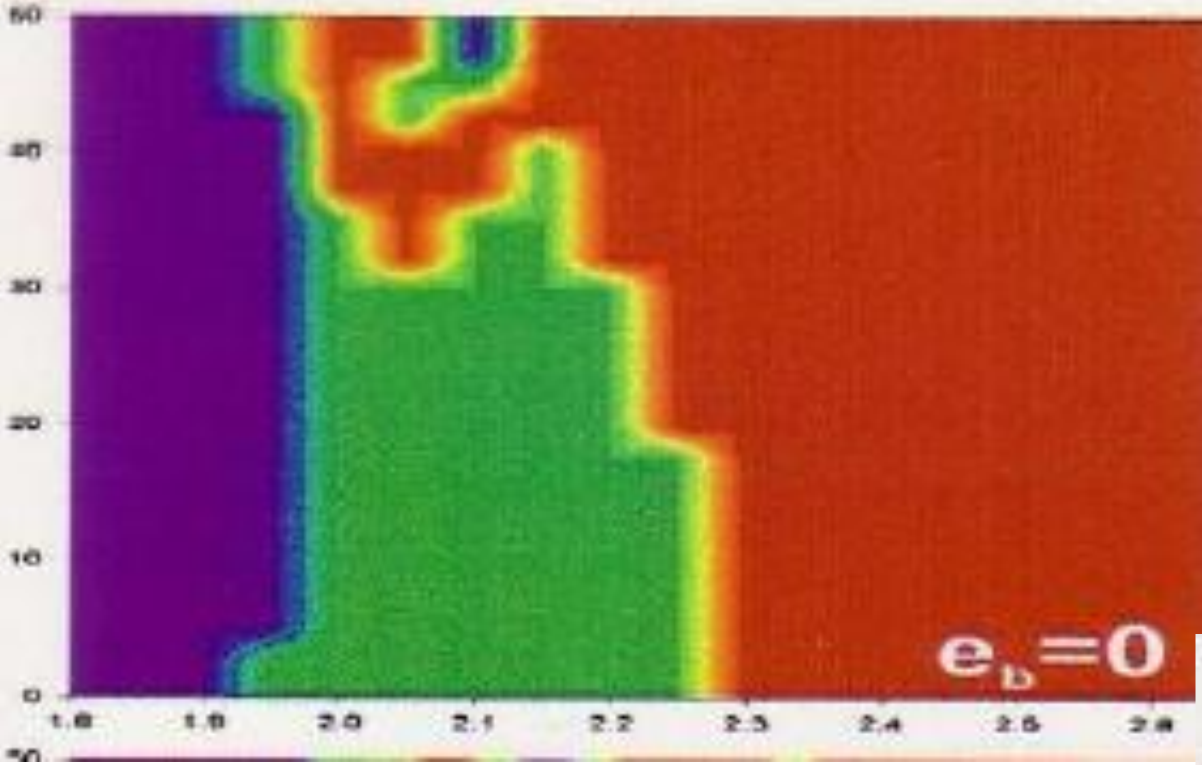
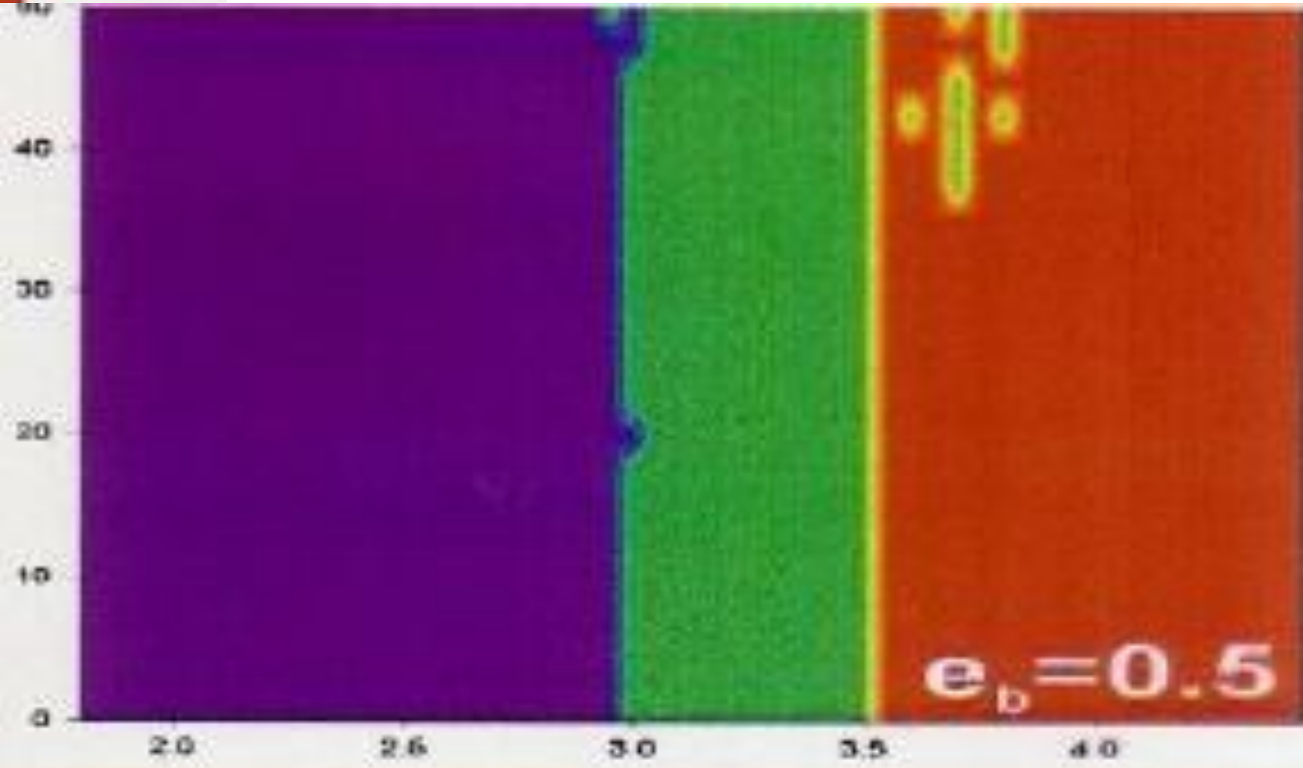


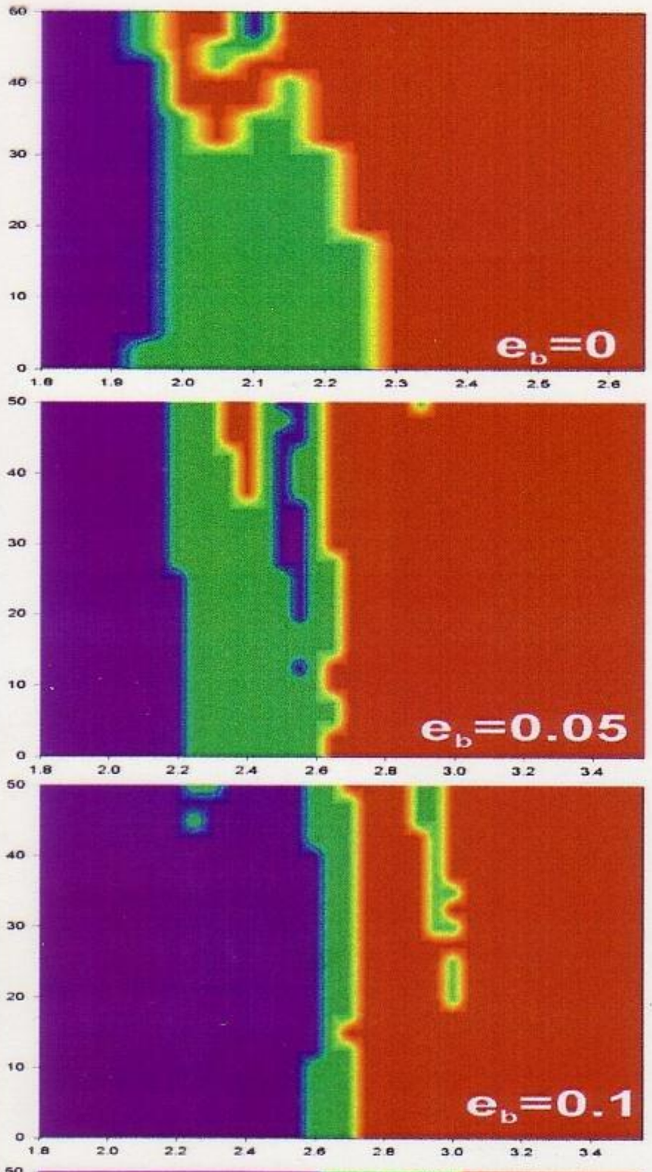
To examine the phase space around such a binary with mass-ratio (μ) equal 0.5, we varied the initial conditions in the following way:

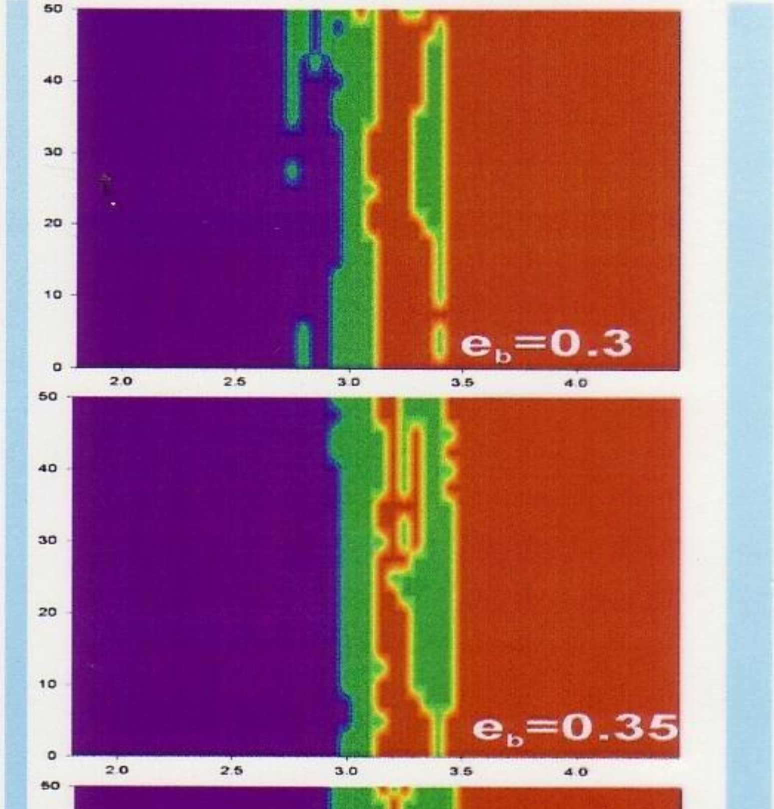
1. for the orbits of the binary:
   (a) the eccentricity e was increased from 0 to 0.5 with $\Delta e = 0.05$;
   (b) for the starting positions of the primaries we used the apo-astron and peri-astron (for $e > 0$);
2. for the planetary orbits:
   (a) the inclination i of the planetary orbit to the plane of motion of the binary was increased from 0° to 50° with a step size of $\Delta i = 2.5°$;
   (b) the initial distance (**A**) of the planet from the barycenter of the binary was varied from 1.8 to either 3.5 AU (for $e \leq 0.15$) or 4.5 AU (for $e \geq 0.2$) with $\Delta\mathbf{A} = 0.05$ AU and
   (c) for each **A** we used 4 starting positions for the planets which are defined by the following angles of the planetary orbit to the connecting line of the primaries: $\alpha = 0°, 45°, 90°$ and 135°.


$e_b=0$
0
10
20
30
40
2.0
2.1
2.2
2.3
2.4
2.5


$e_b=0.5$
0
10
20
30
40
2.0
2.5
3.0
3.5
4.0

P-type Orbits





P-type Orbits