ModSim Poster 101

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I. Introduction

In the classical three-body problem, three masses with an inital set of positions and velocities are situated in the same system. Their subsequent motions as a result of the gravitational forces can then only be modeled numerically because of the complex interaction within the system. Chaos is also introduced by including a fourth body with a slightly different initial condition from one of the bodies and tracking its gradual divergence from the control body. This could be an interesting model to international space programs as researcher may launch satellites with slightly different initial conditions in locations around the world. Account for the potential divergence would be important for satellites that are supposed to go together.

II. Model

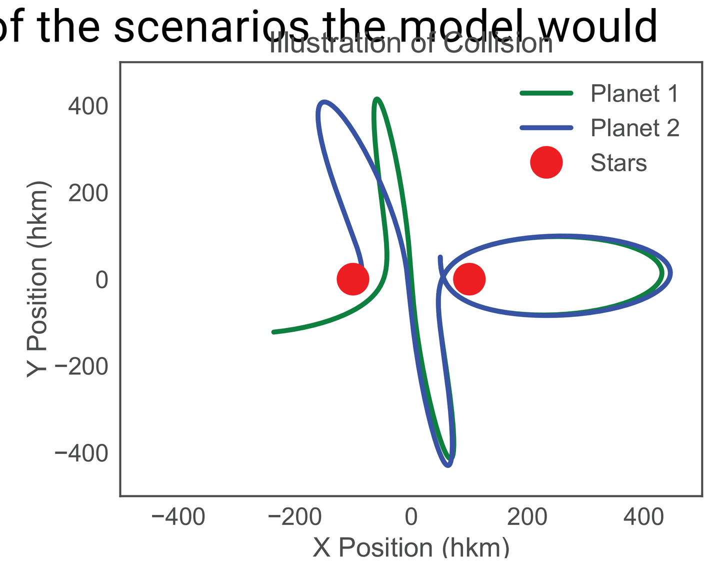
Conditions:
- mass of the stars = 2*10^9 Yg (10^24 gram)
- G constant = 6.67 * 10^-5 (hkm)^3/Yg-s^2
- Stars stationary at (100, 0)hkm and (-100, 0)hkm
- mass of the control body doesn't matter
- Control Satellite:
  initial position (hkm): (50, 50)
  initial velocity (hkm/s): (0, -65)

$$\vec{F_g} = G \times \frac{m_1 \times m_2}{r^2}$$

$$\vec{p} = m\Delta\vec{v} = \int \vec{F(t)}dt$$

$$\vec{V_{new}} = \frac{m_p \cdot \vec{V_{old}} + (G \times \frac{m_1 \times m_2}{r^2})dt}{m_p} \rightarrow \vec{V_{old}} + (G \times \frac{m_2}{r^2})dt$$

After a period of time, the satellite might collide into one of the stars. That is one of the scenarios the model would



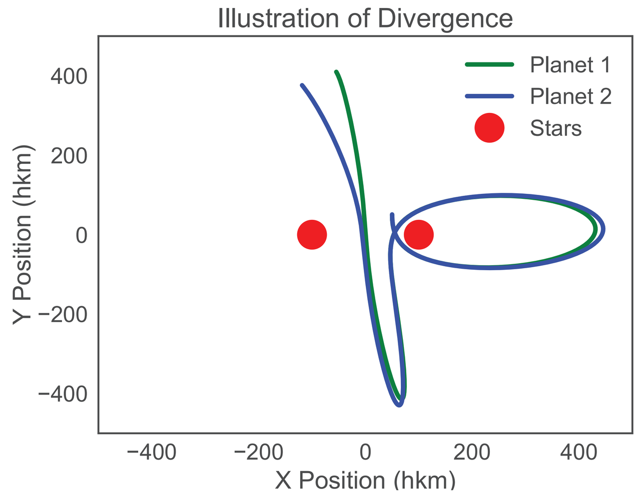


Figure 2 Caption

Abstract

III. Question

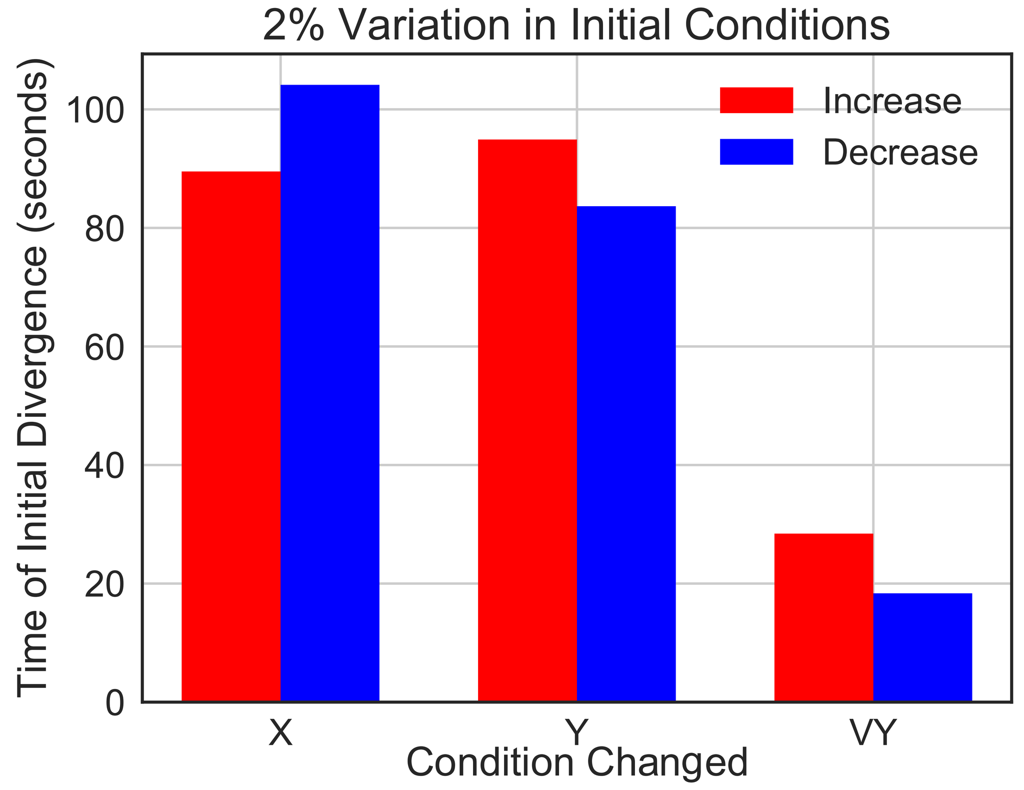
Which initial condition of the second satellite will result in the longest and shortest time before a significant divergence?

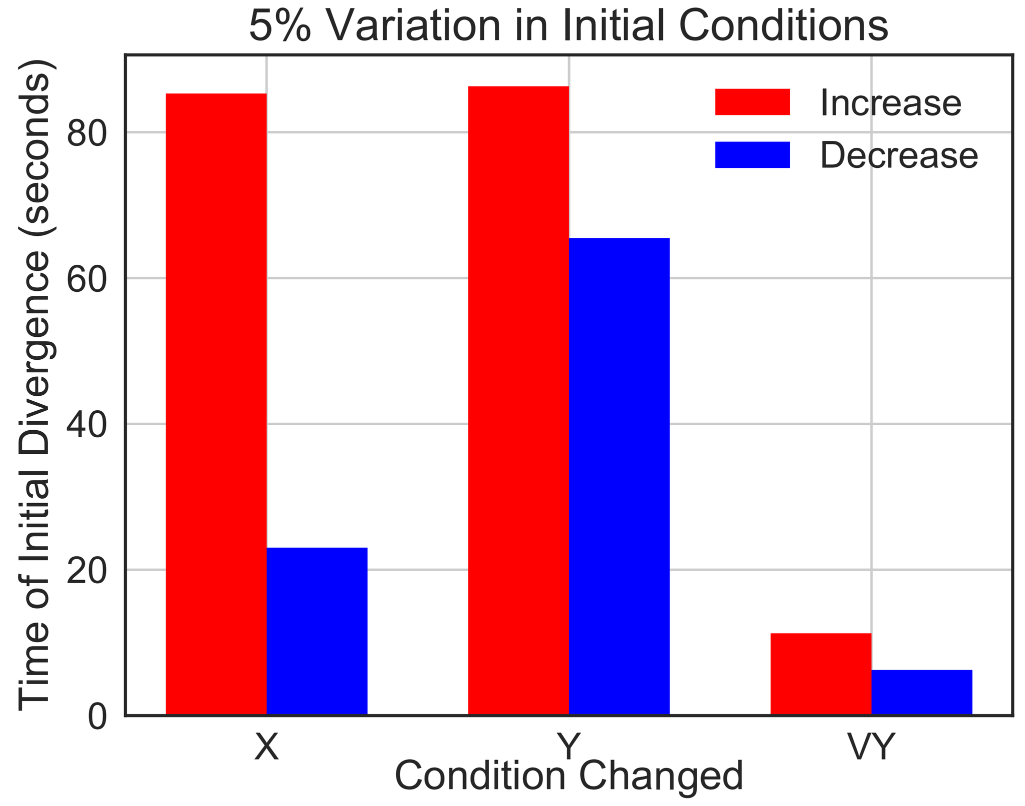
IV. Results

2% bar graph:
- Most chaotic = Vy decrease (18.35 seconds)
- Least chaotic = X decrease (104.14 seconds)

5% bar graph:
- Most chaotic = Vy decrease (6.26 seconds)
- Least chaotic = Y increase (86.29 seconds)

10% bar graph:
- Most chaotic = Vy decrease (3.09 seconds)
- Least chaotic = Y increase (28.85 seconds)





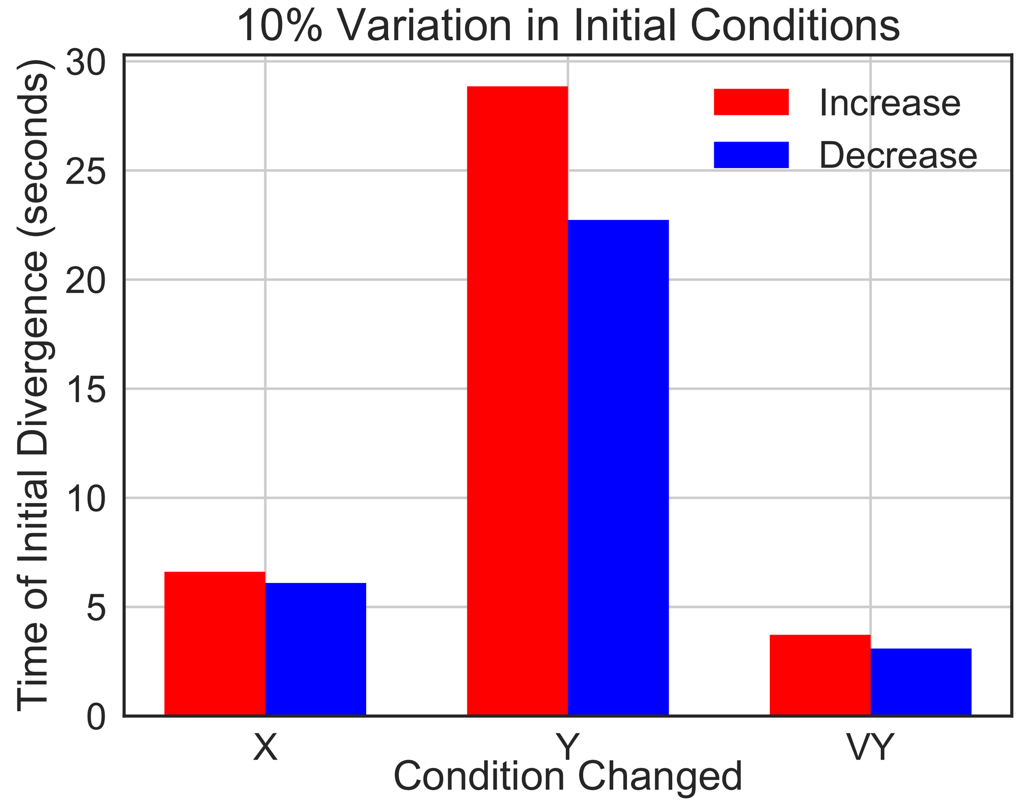


Figure 4 Caption

V. Interpretation and Validation

Across all three levels of percentage of change (and a wide of range of Vy values tested with the model), an decrease in the numerical value in Vy would always give out the shortest time to a significant divergence.

Figure 5 Caption

VI. Limitation

- Stational binary star: Equivalent to a reference frame that is rotating along with the binary stars. This reduces the complexity of the computing heavy model significantly.
- unrealistic gravitational constant
- model only applies to this specific set of conditions

VII. Conclusion and Future Work

- Test and generalize model with more severe initial conditions
- Implement rotating binary stars
- Test change in velocity in X direction
- HKM SHOULD TOTALLY BE A THING

Reference

- Allain, Rhett. "This Is the Only Way to Solve the Three-Body Problem." Wired, Conde Nast, 3 June 2017, www.wired.com/2016/06/way-solve-three-body-problem/.
- 3-Body Gravitational Problem, faraday.physics.utoronto.ca/PVB/Harrison/Flash/Chaos/ThreeBody/ThreeBody.html.