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Binary Stars

A question that many astrophysicists wonder about is whether a binary star system can support a planet, and if so, at what distances could the planet be situated. This is the question we asked in our experiment. Our initial hypothesis was that it is possible, and that this gets easier as the planet gets further away from the system, until the point at which the stars’ gravity is no longer strong enough to keep the planet in orbit. 

To run this experiment, we started by simulating two stars of equal mass orbiting each other in the predicted ellipses, as shown:

Through research, we knew that this is the path actual binary stars follow, so we proceeded to add a planet of mass 1/1000of the mass of the stars under the force of the two planets at an initial distance 75 times the initial distance between the two stars’, with an initial velocity of 100 units (compared to the stars’ .6). See left for picture of the orbit of the planet (in green).

Throughout the experiment, the velocity of the planet was not changed while initial distances were varied. There was definitely a lower limit for stability, below which the planet spiraled into the orbit of the stars. However, because of the ode45 function had error, for the extreme values of distance, results were unreliable. Furthermore, this “stability” is only comparative. As seen below, especially on the right, the orbit of the planet is not along a single line, but rather—wobbles. The picture on the left shows the planet at an initial distance of 75 and the right at a distance of 30. It is obvious that the amount of wobbling is less as the planet moves further away from the stars.



This makes sense physically because the cause of the wobbling is less noticeable at a distance. We would expect planet orbits to wobble because the stars exert more force on the planet when the stars and planet are oriented such that they are in a line than when the stars form a line perpendicular to the planet. Thus, at various times the planet’s orbit will shift translationally as the stars orbit each other.

The results of our experiment fit those of our hypothesis. Not only this, it makes physical sense. If we consider the binary star system as a rotating “point” mass at the center of mass of the two stars, then we are essentially modeling a planet circling around a very massive sun. This accounts for the fact that there is a region of stability. The wobbling has already been accounted above. There are limits to the applicability of this program because ode45 accumulates too much error when using large numbers. However, for our purposes, it remains informative.