

# Eclipsing Binary Simulator – Technical Manual

## Overview

The eclipsing binary simulator allows one to control the mass, radius, and surface temperature of both members of a binary system. The user can also control the separation, inclination, eccentricity, and longitude (orientation of the semi-major axis) of the orbit. One can view the effects of these changes on both the physical system and on the light curve. The changes are visible regardless of whether not the simulator is presently animating.

## Changing Parameters

There are four ways to change parameters: by dragging the slider corresponding to that parameter, by selecting a preset, by dragging a point on the HR diagram, and by restricting a star to the main sequence.

The sliders controlling the stellar parameters can be limited by several factors. One obvious limitation is the actual parameter range for each slider which cannot be exceeded. However, when using the eclipsing binary simulator one will often find that part of the slider's range is unavailable and appears shaded. There two primary restrictions which can cause this to occur:

- A star may not leave the HR Diagram.
- The two stars may not physically overlap.

The restrictions preventing physical overlap apply to stellar sizes, separation, and eccentricity and are shown in the figure to the right. As eccentricity becomes large this restriction can be especially limiting since it is enforced at perihelion. The constraints related to restricting a star to the main sequence are similar in flavor to those already discussed, but are much more complicated and beyond the scope of this document.

$$e_{\max} = 1 - \frac{r_1 + r_2}{a}$$
$$a_{\min} = \frac{r_1 + r_2}{1 - e}$$
$$r_{\max} = a(1 - e) - r_{star2}$$

## Visualization

The 3D visualization panel is normally used with the show orbital plane and the show orbital paths options selected. This panel shows the view seen from Earth by default. If one deselects “lock on perspective from Earth” the visualization panel header changes to “click and drag to change perspective”. One can now change to any perspective and a red arrows appears indicating the direction to Earth. This is especially useful for looking down onto the plane of the orbit.

Note that information on the scale of the visualization is conveyed by the spacing of the grid lines on the orbital plane. For example, if one were looking down on the plane of the binary and increase the separation between the stars the apparent size of the orbits would not change. However, the spacing between the grid lines and the sizes of the stars would decrease reflecting your need to pull back to see the entire (now larger) orbits.

One can also view the light curve of the system in terms of the normalized flux. The light curve displays the phase range from 0.5 to 0.5 by default. However, one can drag anywhere in the light

curve panel and shift the curve in phase as has been done here. The vertical red line identifies the current phase depicted in the visualization panel. When the system is in motion the vertical cursor will advance in phase over time. One can grab the vertical red line and drag it to any phase and the system will advance to that state whether or not the system is animating.

## Presets

There are a large number of presets – sets of values of binary system parameters – that are already entered into the simulator. When one selects one of the presets the simulator instantly reflects the parameters specified in that preset. Note that changing to a new preset affects all of the parameters related to the stars and orbit. However, it does not affect current states of the perspective shown in the 3D visualization window, the phase range or current phase shown on the light curve, or whether or not the system is currently in motion.

There are three distinct types of presets. Examples are sets of parameters carefully chosen for their instructional value. Datasets with Complete Parameters contain actual photometric datasets of as well as parameter values for the simulation so as to match the data as closely as possible. Datasets with Incomplete Parameters are similar, except that some parameters are assigned their minimal data values and the user is expected to experiment with these parameters in an effort to match the photometric data. Descriptions of many of the presets and the knowledge one should gain from using them can be found in the student guide. In addition, many other datasets can be found at the bottom of the preset window under More datasets.