Assignment 2: Minimal energy orbit

The `AMUSE` package is installed on the local machines in the following directory: `/software/amuse/amuse-11`. You can access `AMUSE` from any Sterrewacht computer by loading it as a module:

```
module load amuse
```

L_1 Lagrangian point

Lagrangian points in a self-gravitating system of two bodies are locations at which there is either a peak or a saddle point in the effective potential surface in the frame rotating with the bodies. An N-body code can easily be adapted to draw such an equipotential surface. Fig. 1 presents an example for the case of the Sun and a $0.2\,\mathrm{M}_\odot$- mass companion at a distance of 1 AU. The script to generate these equipotential surfaces can easily be adapted to any binary system, including those with nonzero eccentricity.

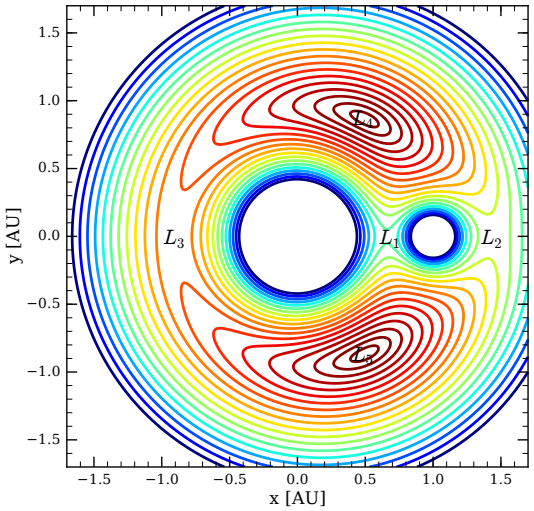

Figure 1: Equipotential surfaces for a 2-body system. In this example we adopted a primary mass of $1\,\mathrm{M}_\odot$ with a $0.2\,\mathrm{M}_\odot$ companion in a circular orbit at a distance of 1 AU (to the right). The classical five Lagrange points are indicated by L_1 to L_5. The script to generate this figure can be found in `examples/textbook/lagrange_points.py` in your `AMUSE` directory.

Interplanetary travel is expensive in terms of time and fuel. Moving through Lagrange points provides an efficient way to travel from one celestial body to another (although they can also lead to objects becoming trapped in a local orbit, as is the case with Jupiter's Trojan satellites). In Fig. 1 the most efficient way to travel from the star to the left to the one to the right is through L_1. This trajectory can be most easily calculated by starting at L_1 and allow a test mass to "fall" into the potential well to the left, or to the right.

Calculate the most energy-efficient orbit between two planets or moons in the Solar System. Plot this trajectory in Cartesian coordinates.

Hint: Start by calculating the equipotential surfaces of the isolated two body system you selected (see Fig. 1). From that calculation you can find the L_1 point. In the next step you initializing a particle on the first Lagrangian point of the selected two-body system and give it a small velocity toward one of your selected bodies. Repeat with a small velocity in the direction of the other body.