Assignment 3:

The triple system θ Muscae

Chapter 4 § 2.2 of the AMUSE book discusses the evolution of the Wolf-Rayet colliding wind triple system θ Muscae, in which three stars, the WC5/6 star WR48 in a 19 day orbit with a O6 star, and both stars are orbited by a the relatively low mass O9.5/B0Iab star.

In the example, presented in this chapter stellar evolution and the dynamical evolution of the triple were applied at very short and constant time intervals of only one-tenths of the inner orbital period. It is not really clear if such a small time step is needed to recover the correct physics. In this assignment we are going to study this.

In §4.5 of chapter 4 an alternative time-stepping strategy is discussed, but there are many others ways in which a time stepping strategy can be constructed. Implement an alternative time stepping scheme, by allowing the time step to depend on the rate of mass loss, not allowing the mass loss to exceed a certain criterion. If the time step becomes too large, the integrator will produce the wrong results, but for too small time steps the integration can last a long while. Use the interlaced temporal discretization method and study if this is really a preferred way of integrating two numerical solvers.

Run several simulations, subsequently reducing the time step for each of them and record the semi-major axis and eccentricity of the inner and the outer binary, and their relative inclination. One common time-step reduction strategy is by halving them in subsequent simulations. Make a plot of the orbital parameters and the wall-clock computer time as a function of the time step size. Based on these curves, can you decide what is the best time step size for simulation a triple system like θ Muscae.

find in the literature the masses, mass-loss rates of the three stars of θ Muscae and their orbital parameters. Generate a triple system with the appropriate orbital elements. You can do this by using the following amuse functions

```
orbital_elements = orbital_elements_from_binary()
```

in chapter 2 § 4.1.2, and

```
new_binary = new_binary_from_orbital_elements()
```

discussed in Chapter 7 § 3.2 (see listing 7.7 for an example).

Answer the following questions.

- Can you find a solution for which the result has converged in time step?
- What is the time step-size for which this results converges?
- What amount of time is spend in the amuse framework, rather than the stellar evolution code or the N-body code, by the time the code reaches convergence?
- The inclination of the two inner and outer binaries in θ Muscae is unknown. What effect does a high mutual inclination ($\gtrsim 50^\circ$) have compared to a low mutual inclination?