Phys 535 **Exercises**

Deadline: Friday 30 September 2005

Question 1 *Two-body problem*

The code for this problem can be found in `obelix:~wdobler/Phys535/idl/2body`.

(a) Run the scripts. What is the meaning of the diagnostic quantities printed? If you are unsure, consult `run.pro`.

(b) Play with parameters, in particular the initial conditions.

(c) Modify ***err***. Which value of ***err*** do you consider acceptable?

(d) Add a weak $1/r^4$ force (potential $\Phi \propto 1/r^3$) and watch the effect on the Runge–Lenz vector (Perihel direction). If the additional force is attractive, does the Preihelion rotate prograde (in the same direction as the masses) or retrograde (opposite direction)?

(e) Which file defines the routine '`rk`' that is used in '`run.pro`' (you can use '`help, /source`' to get the answer)? Use another Runge–Kutta scheme to do the time integration:

1. comment out the line '`@rk_ck45`' in '`start.pro`',
2. compile the new routine using

   ```
   IDL>  .r rk
   ```

   and
3. eliminate the arguments ***error*** and ***dtmax*** from the call to `rk` in '`r.pro`'.

Which file defines '`rk`' now? Is the new scheme sufficiently accurate?

Question 2 *Three-body problem*

The code for this problem can be found in `obelix:~wdobler/Phys535/idl/3body`.

(a) Make sure '`start.pro`' uses the initial conditions '`init_eject.pro`' and run the scripts.

(b) How would you characterize the dynamics of the system (periodic, multi-periodic, chaotic, ...)? What is the final configuration?

(c) Adapt the file '`Curtiss-Hirschfelder/print.pro`' to '`3body/`'.

(d) Understand and briefly discuss *all* parameters in '`start.pro`' and '`run.pro`'.

(e) Vary the error tolerance ***err***, trying at least the following values: $\{10^{-6}, 10^{-7}, 10^{-8}, 10^{-9}, 10^{-10}, 10^{-11}, 10^{-12}\}$. (You can increase the parameter ***dtplot*** to accelerate the calculation). Explain.

(f) For '`err=1e-6`', rescale the problem by a factor 2 (parameter ***scalefact***). Verify analytically that the scaling is done correctly; why do you get different behaviour, then?

(g) Use the initial conditions for the Trojan asteroids ('`@init_Lagrange`' in '`start.pro`'). Add a perturbation '`pert=1e-3`' in '`start.pro`'. Is the orbit stable?

(h) At the IDL command line, set '`corot=1`' and repeat the calculation.

(i) (Keeping '`corot=1`', vary m_2 (keeping $m_1 = 1$ and $m_3 = 0$) and find approximately the value m_2/m_1 that separates stable from unstable orbits. If you encounter an interesting trajectory, plot it (and indicate the mass ratio).

(j) [Reset ***pert*** und ***corot*** to 0.] Play with the 'figure-eight' solution ('`@init_fig8`' in '`start.pro`'). Is this solution stable (set '`perturb_all=1`' and e.g. '`pert=1e-2`')?

What about the H1 figure-eight solution ('`@init_fig8_h1`' in '`start.pro`')?