falPot (Galaxy potential nicked from Dehnen's falcON)

This documentation is just here to explain how to compile and use falPot. See Section 2.3 of Dehnen & Binney (1998) for a fuller explanation of how it works. Or read the source code. How to compile the library should be clear from the instructions in the makefile "make.falPot". The command "make falPot" makes the libraries, and "make testfalPot" makes the example executable.

N.B. In all cases here, the length unit is kpc, the time unit is Myr, and the mass unit is $M_\odot$. For reference, $G = 4.49866 \times 10^{-12}\mathrm{kpc}^3\mathrm{Myr}^{-2}\mathrm{M}_\odot^{-1}$. A velocity of 1 kpc Myr^{-1} = 977.77km s^{-1} (See Units.h for further).

1 Input

The file that is given as the input file for the potential must be of the following form:

3						# No. Disks ($0 \leq$ No.disks ≤ 3)
8.90e7	1.8	0.04	0	0		# Param. for each of the three disks.
3.50e7	1.2	-0.15	0	0		# **N.B** *essential* to give 5 param.
1.30e7	1.1	0.25	0	0		# No. lines of param. = No. disks
2						# No. Spheroids ($0 \leq$ No.sph. ≤ 2)
4.0e7	0.8	-0.5	1.4	10	50	#
2.0e7	0.2	-1.5	3.4	10	50	# *essential* to give 6 parameters

1.1 Disk

The disk parameters, as given in that file are (in order) Σ_0, R_d, z_d, R_0, ϵ.

Σ_0 is the disk's central surface density (in $\mathrm{M}_\odot\mathrm{kpc}^{-2}$ and the absence of a cutoff), R_d is the disk scale radius, z_d its scale height (though note there is a difference between negative and positive values), and R_0 is an inner cutoff radius (all in kpc). The term ϵ is a funny little parameter that I don't really understand. In numerical terms (cylindrical polars), these give a surface density

$$\Sigma(R) = \Sigma_0 \exp\left(-\frac{R_0}{R} - \frac{R}{R_d} + \epsilon\cos\left(\frac{R}{R_d}\right)\right), \tag{1}$$

i.e. a standard exponential disk with optional hole in the middle and/or weird ϵ term modulation.

The vertical structure of the density is either an exponential in $|z|$ (if $z_d > 0$), or isothermal (if $z_d < 0$), i.e.

$$\rho_d(R,z) = \begin{cases} \frac{\Sigma(R)}{2z_d} \exp\left(\frac{-|z|}{z_d}\right) & \text{for } z_d > 0 \\ \frac{\Sigma(R)}{4(-z_d)} \mathrm{sech}^2\left(\frac{z}{2\,z_d}\right) & \text{for } z_d < 0. \end{cases} \tag{2}$$

N.B. There is a factor of two in the denominator of the sech^2 profile. That is so that they tend to the same thing as $z \to \infty$.

1.2 Spheroids

The spheroid parameters are (in order) ρ_0, q, γ, β, r_0, r_{cut}.

ρ_0 is a scale density (in $\mathrm{M}_{\odot}\mathrm{kpc}^{-3}$; q is the axis ratio ($q < 1$ is flatter than a sphere, $q > 1$ is prolate); γ is the inner density slope, β the outer density slope; r_0 is a scale radius and r_{cut} is a cutoff radius (both in kpc). This corresponds to a density profile

$$\rho_s = \frac{\rho_0}{(r'/r_0)^{\gamma}(1 + r'/r_0)^{\beta-\gamma}} \exp\left[-\left(r'/r_{cut}\right)^2\right], \tag{3}$$

where, in cylindrical coordinates

$$r' = \sqrt{R^2 + (z/q)^2} \tag{4}$$

References

Dehnen W., Binney J., 1998, MNRAS, 294, 429