Astrophysics Elective: Q4 Final Requirements

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Activity 3: Interpret `evolve_two_disks()` function

Output : Create any word document that interprets the function and includes the syntax of the `evolve_two_disks()` function. Please refer to the `gycol.py` file or the book for the syntax details.

Problem Set 2: Recreate outputs in fig. 4.13

Make a **10-second video simulation** of the collision example:

1. from t= 0.000 Myr to t = 450.0 Myr
2. `N_steps` = 10,000
3. fps = 100 (fixed based on the `anim_two_disks_3d()` function)
4. `N_snapshots` = 1000

Output: 10-second simulation; `filetype=mp4,avi,etc.`
(*no need to submit the code since it was already given in the book*)

Final Project:

1. The head-on collision of two disks can result in a Cartwheel-like galaxy. The name refers to the large outer ring which gives the galaxy the appearance of a wagon wheel. In this case, the intruder moves in z-direction toward the target and its normal is aligned with the direction of motion. The plane of the target disk is parallel to the intruder's disk. Vary the relative velocity and the impact parameter. **Can you produce a post-collision galaxy of a similar shape as the Cartwheel Galaxy?**

   You must set or adjust your own simulation parameters (`N_steps,N_snapshots,time_step,etc`) to have the best output demonstrating the formation of Cartwheel Galaxy

2. Analyze trajectories of ejected stars in the Cartwheel galaxy simulation. Since you cannot predict which star in the initial disks will be ejected, take 5-10 random samples of stars of the target galaxy and plot their orbits with your **own** `galcol.show_orbits_3d()`.

   You can check the 3D visualization functions in `galcol` package to create your own `galcol.show_orbits_3d()` function. You can add the function to the `galcol.py` package or call it inside your Project Notebook.

3. Compute and plot the time-dependent specific orbital energy

$$\epsilon(t) = \frac{1}{2}v(t)^2 + \frac{G\,M_1}{r_1(t)} + \frac{G\,M_2}{r_2(t)}$$

   for your sample of stars. The distances $r_{1,2}$ from the two galaxy centers are defined by **Eq.(4.74) in the book subchapter**. To compute the kinetic energy per unit mass, $v^2/2$, you need to modify `galcol.evolve_two_disks()` such that the position and velocity data are returned for each snapshot. Compare ejected stars to stars that remain bound to the target galaxy and describe the differences. **Why is $\epsilon(t)$ in general not conserved?**

4. How sensitive is $\epsilon(t)$ to the numerical time step?

Outputs:

1. Python Project Notebook with #comments; file type = Jupyter Source File (ipynb);
2. Ten-second simulation, `filetyle=mp4,avi,etc`.

Organize all your answers in the Python Notebook

Submit the Activity 3 and PS 2 on or before May 22, 2023, in KHub.
Submit the Final Project on or before May 28, 2023 in KHub.

Good luck!

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