Klaudia Kowalczyk
Nicolaus Copernicus Astronomical Center Warsaw, Poland

Estimating masses of dwarf spheroidal galaxies

Testing structure formation scenarios in small scales requires reliable methodes of the determining masses of the dark matter dominated dwarf spheroidal (dSph) galaxies. In our work we use N-body simulation of the tidal evolution of a dwarf galaxy orbiting a Milky Way-like host in order to generate the mock kinematical data sets to test one of such methodes.

As the initial conditions for our simulation we placed the exponential stellar disk embeded in spherically symmetric NFW-like dark matter halo in the apocenter of an eccentric, rather tight orbit around the host. Its evolution was then followed for 10 Gyr. During that time the large amount of the mass and the angular momentum was stripped causing changes in the internal properties of the dwarf, namely the original disk transformed into a spheroidal structure modeled in our study by a triaxial ellipsoid and the galaxy lost significant percent of its initial rotation around the shortest axis. The shape and kinematics of the dwarf measured within the constant radius of 0.5 kpc are presented as a function of time in Figure 1 in terms of the longest-to-shortest axis ratio c/a (dashed line) and mean rotation velocity around the shortest axis divided by mean velocity dispersion V/σ (solid line).

For the selected outputs, meeting the constraints on the spheroidal shape, set as $c/a > 0.5$ and the small fraction of the remnant rotation, here less than the half of its initial value, we generated 3 mock data sets along the princial axis of the stellar component, taking only the projected positions and the line-of-sight velocities of the stars. Then we calculated the half-light radii R_h by fitting the projected (2D) Plummer distribution and the line-of-sight velocity dispersions σ_{los}. Those quantities are shown in the Figure 2. The different colors match the observation along the different axis, so that we use red line for the observation along longest, green - intermediate and blue - shortest axis. To the such data we applied the simple mass estimator, firstly proposed by Wolf et al. (2010) and given with the formula:

$$M_{est}(r_3) = 3\ G^{-1}\sigma_{los}^2 r_3 = 3.7\ G^{-1}\sigma_{los}^2 R_h \tag{1}$$

The masses estimated in that way we compared with the true values (M_{true}) obtained by counting particles within the coresponding radii from the full simulation data set. Our results are presented in Figure 3 as the ratio M_{est}/M_{true} as the function of the two described earlier parameters, the shape in the top panel and the amount of rotation in the bottom panel. Depending on the line of sight the estimated values are either overestimated (like for the observation along the longest axis) or underestimated (for the observation along the shortest axis). The data points for the intermediate axis lie nicely along the black horizontal line indicating $M_{est}/M_{true} = 1$. It is clearly noticable that the estimation is more precise for objects that are more spherical and do not rotate as has been already stated in our previous work (see Kowalczyk et al., 2013).

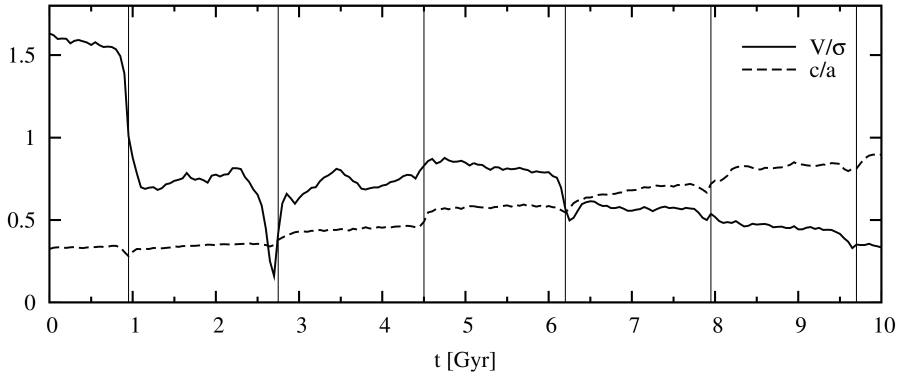

Figure 1:

Literature:

Kowalczyk K., Łokas E. L., Kazantzidis S., Mayer L., 2013, MNRAS, 431, 2796
Wolf J., Martinez G. D., Bullock J. S., Kaplinghat M., Geha M., Muñoz R. R., Simon J. D., Avedo F. F., 2010, MNRAS, 406, 1220

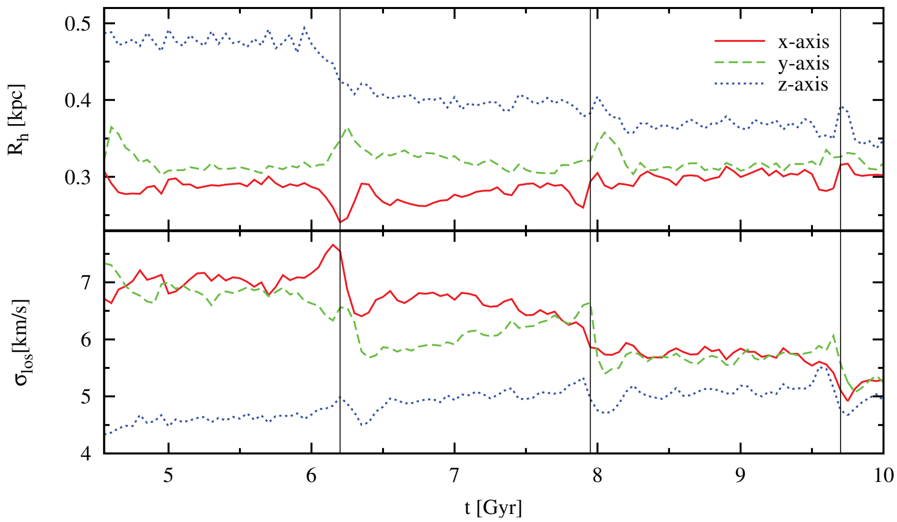

Figure 2:

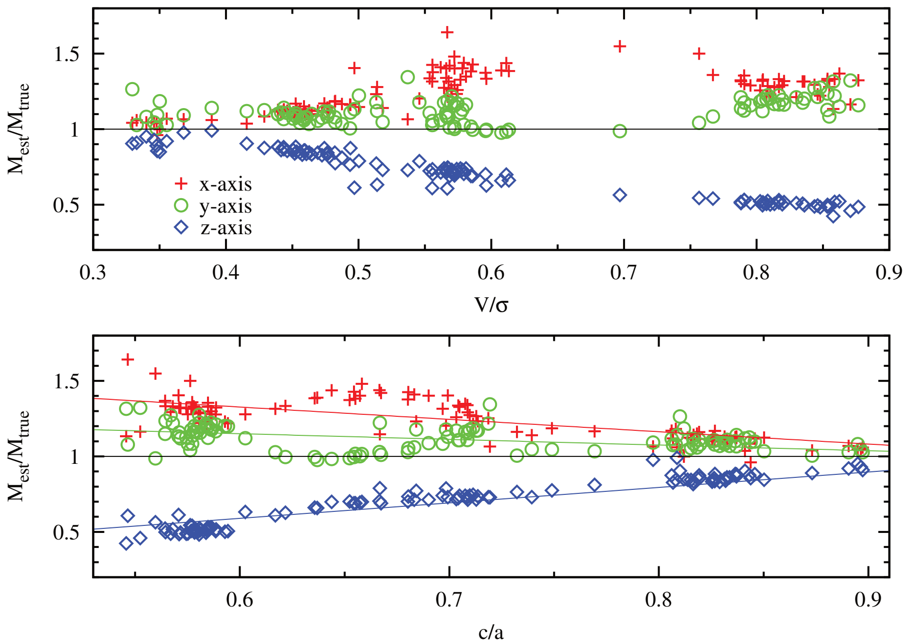

Figure 3: