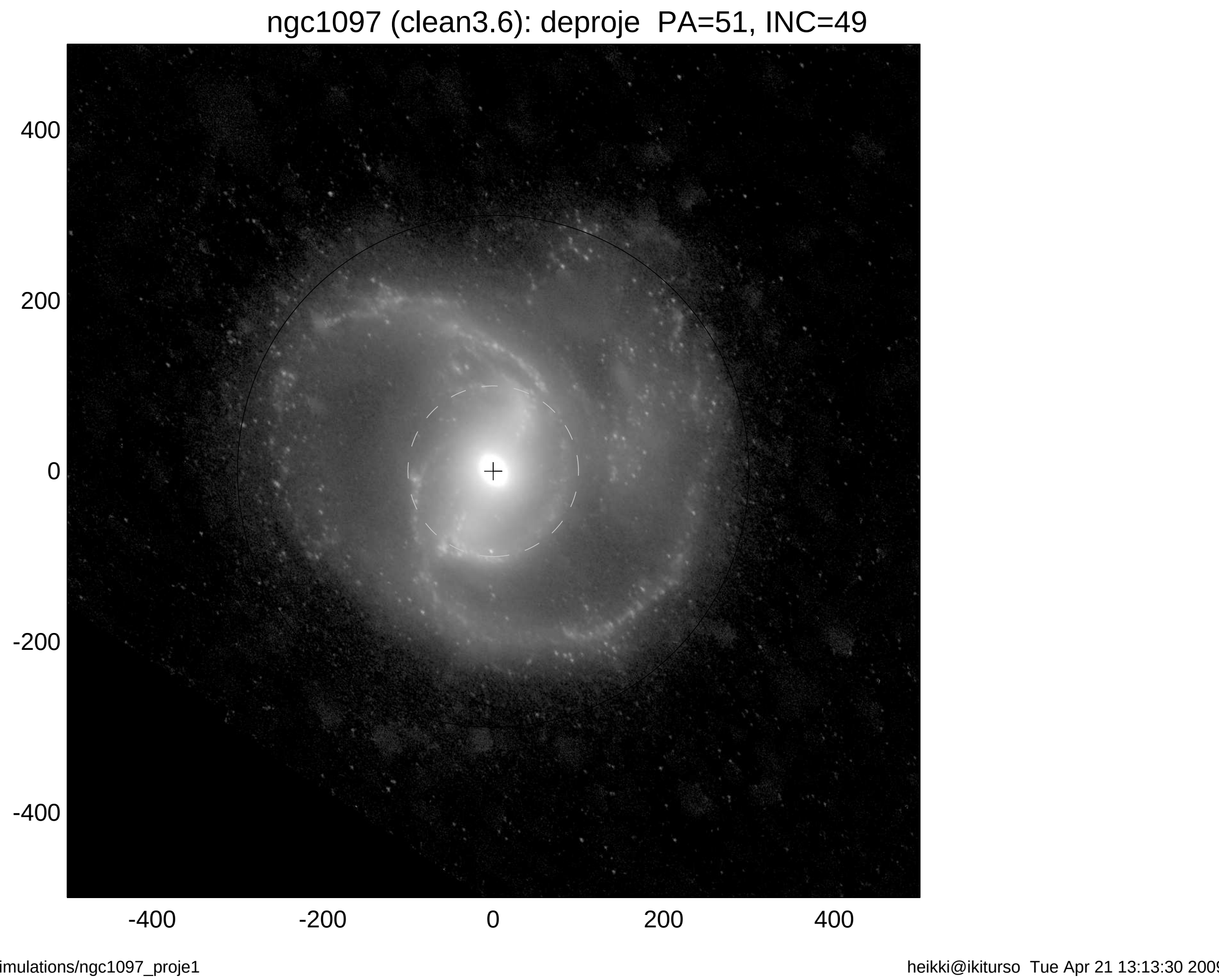
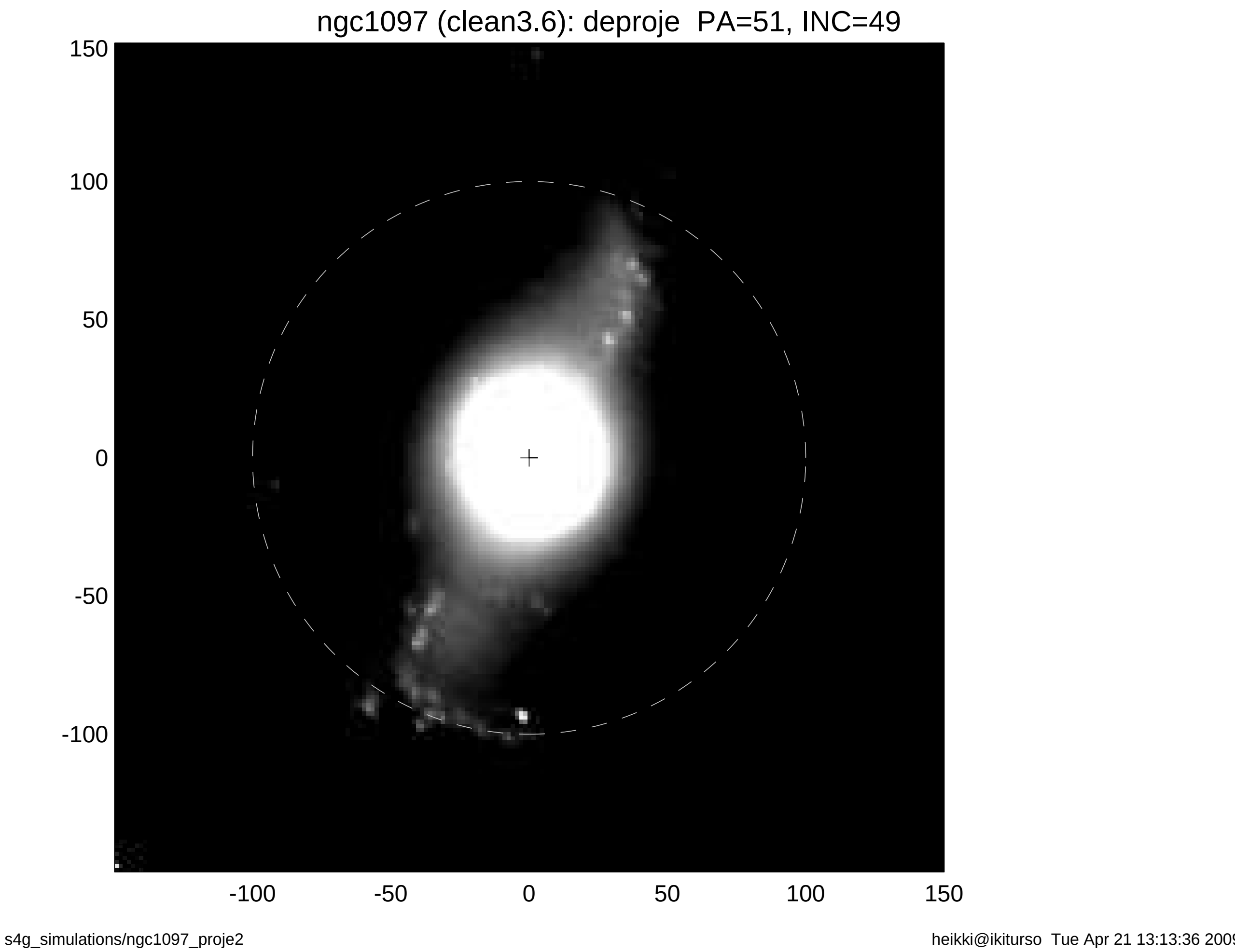
Example of preliminary sticky particle simulation for NGC1097 (210409)

Assumption: structure represents quasi-steady response to a rigidly rotating bar potential. Potential calculated from the 3.6 micron image, assuming a constant M/L throughout the galaxy. In this preliminary example, decomposition results are NOT utilized.

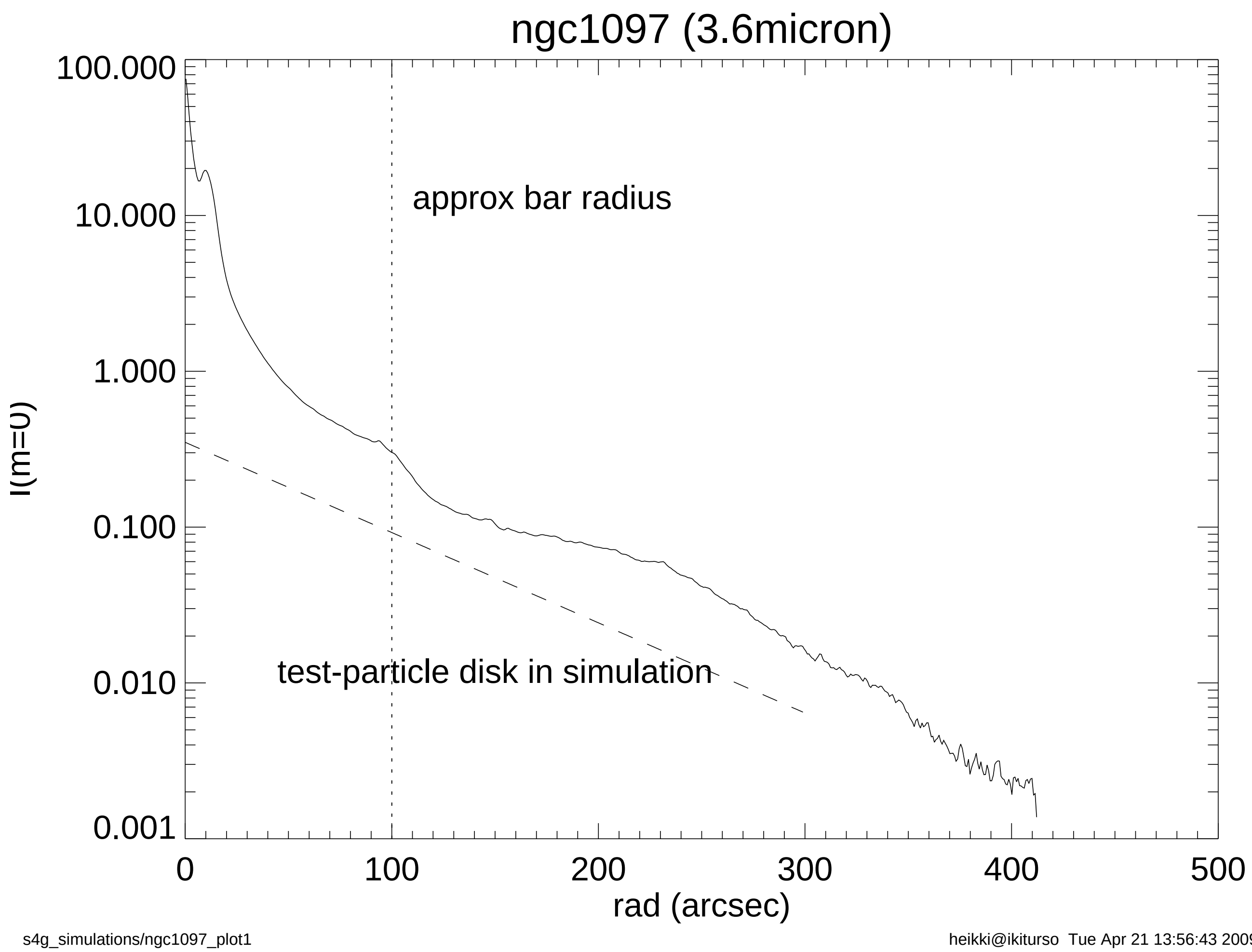


Shows the cleaned 3.6 micron image (deprojected to disk plane), used in the calculation of gravitational potential. 500 by 500 arcsec frame is displayed. The circles with radii 100" and 300" are marked

The assumed disk orientation calculated from outer isophotes. The companion NGC1097A has been removed

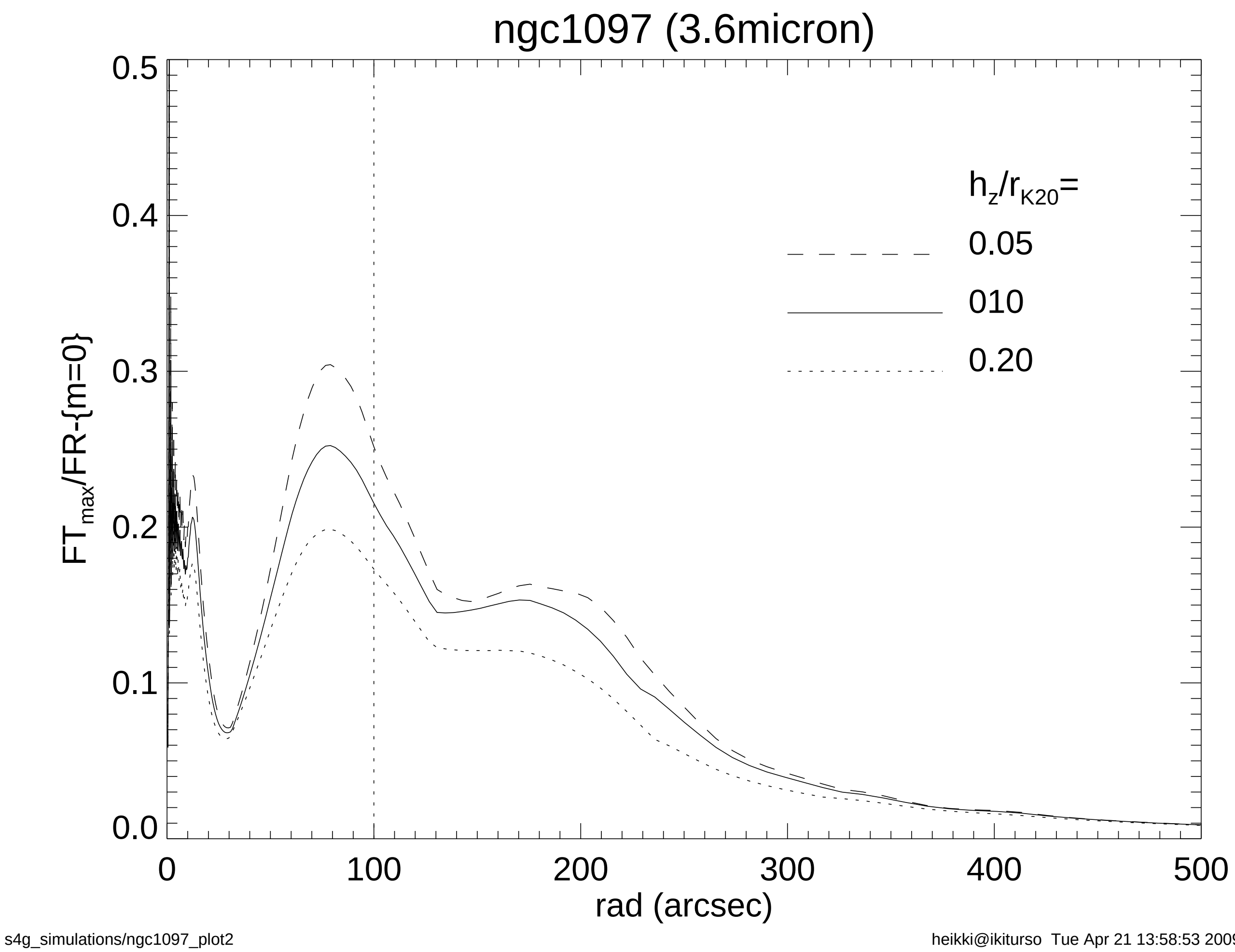


-Blow up of the central parts in a linear scale chosen to highlight the star formation regions along the bar. Likely to correspond to dust lines, would be useful in detailed simulation matching.



-The calculated m=0 component of intensity. No decomposition made: the image is deprojected with the above indicated orientation parameters, assuming that everything is flat.

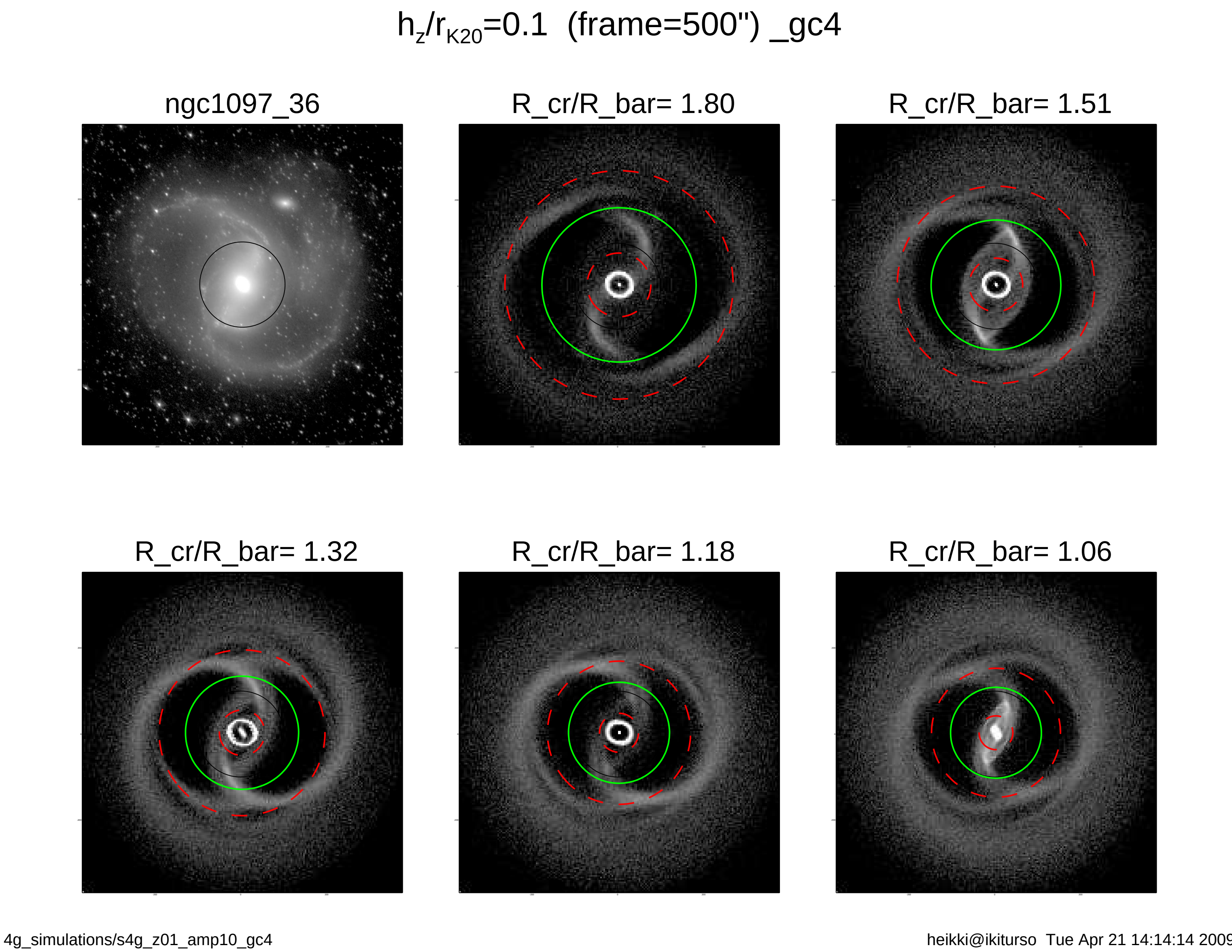
Also indicated are the approximative bar radius (100 arcsec), and the slope of the test particle disk utilized in simulations (dashed line indicates scale length of 75 arcsec, exponential profile extends over 4 scale lengths, then decays to zero between 4-5 scaler lengths)



Results of force calculation (via polar integration using m=0,2,4,6,8,10 Fourier components), for three different assumed vertical thicknesses of the galaxy. Exponential vertical profile $\rho(z) \propto \exp(-|z|/h_z)$ is assumed, with h_z constant over galaxy. The values of h_z are estimated from r_{K20}. What is plotted is radial profile of the maximum tangential force at each distance, normalized by the mean radial force at the same distance.

The value $h_z = 0.1 r_{K20} = 16$ arcsec is chosen as a nominal value. In terms of $r_e = 75$ arsecs, this corresponds to $h_z/r_e \approx 0.2$ For this assumed vertical thickness, the maximum relative tangential perturbation associated with the bar (often denoted as Q_b), occurring slightly inside the bar radius, is about 0.25.

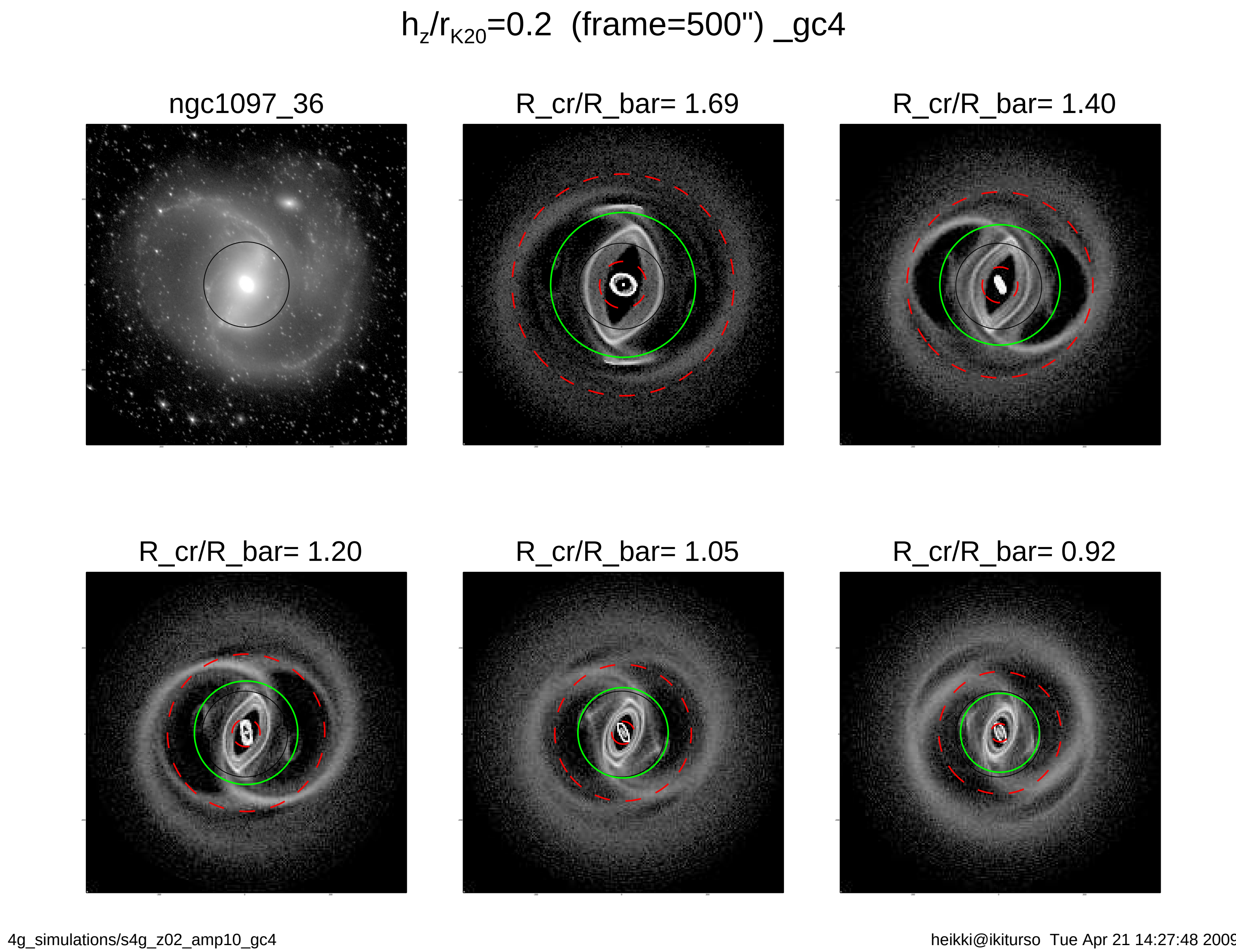
Assuming twice as thick (or half as thick) disk reduces (increases) FT/FR by about 20%.



Results of 5 different simulations, all using the nominal vertical thickness, and assuming different pattern speeds. The pattern speeds Ω_{bar} are characterized by the ratio $R = r_{cr}/r_{bar}$, where r_{cr} is the coration distance

The corotation circles, as well as locations of ILR and OLR (calculated from linear approximation) are also marked in the plots, as well as the bar radius.

The morphology of inelastically colliding sticky particles is shown after 4 bar rotations



Same as the previous plot, except that twice thicker disk was assumed (weaker perturbation).

Summary

According to these very preliminary models (worth 2 hours of pc time - using 8 cores) the overlaa best morhology seems to correspond to nominal amplitude, R=1.8, so a slow bar. This conclusion is based mainly on the outer morphology: a break in the spiral arms at 200 arcsec. Inner structure would allow faster bar (smaller (r_{cr}/r_{bar}).

How to improve

Here dark halo contribution is not modeled: ideal would be to use kinematic data to estimate halo force. Alternatively, one could use maximum disk assumption, and compare several models. Basically adding halo corresponds to weaker bar perturbation / slight outward shift in resonances..

Use decomposition results for extracting the bulge before disk deprojection. Also, in cases like this, with Seyfert nucleus, one should take into account its different M/L. Also, the ring is probably not as massive as its brightness would suggest. Together, these would probably remove the inner peak in the force profile plot within 30 arcsec (nevertheless, the nuclear ring region is not reliably modeled by these simple simulations).

Overall, one should make a grid of models (varying, Ω_{bar}, h_z, initial distribution of test particles, test-particle parameters, halo-contribution), to see how robust the fitted features are.