Recovery of M/L of barred galaxies via axisymmetric dynamical models.

Lablanche P.-Y.[1,2], Cappellari M.[3], Emsellem E.[1,2], Bournaud F.[4], Michel-Dansac L.[1], Alatalo K.[5], Blitz L.[5], Bois M.[6], Bureau M.[3], Davies R. L.[3], Davis T.A.[3], De Zeeuw T.[1,7], Duc P.-A.[4], Khochfar S.[8], Krajnovic D.[1], Kuntschner H.[1], McDermid R.M.[9], Morganti R.[10,11], Naab T.[12], Oosterloo T.[10,11], Sarzi M.[13], Scott N.[3], Serra P.[10], Weijmans A.[14], Young L.M.[15]

[1]ESO Garching, [2]Observatoire de Lyon, [3]University of Oxford, [4]CEA Paris-Saclay, [5]UC Berkeley, [6]Observatoire de Paris, [7]Leiden University, [8]MPE Garching, [9]Gemini Observatory Hilo, [10]ASTRON, [11]Groningen University, [12]MPIA Garching, [13]University of Hertfordshire, [14]Dunlap Inst. Univ. of Toronto, [15]New Mexico Tech Socorro

Abstract

We investigate the recovering accuracy of basic stellar dynamical parameters determined from axisymmetric dynamical models of barred lenticular galaxies. Our goal is to find any potential systematic biases due to the presence of a bar. For unbarred simulations the mass-to-light ratio *M/L* is recovered with good accuracy (maximum of 2%). For barred simulations the *M/L* is on average (PA_{bar}=45°) nearly unbiased, but can be over/under estimated by up to 15% in our tests. The *M/L* of nearly face-on (inclinations $\lesssim$45°) simulations can be significantly in errors in all cases.

From N-body simulations of two regular axisymmetric galaxies (N4179axi and N4570axi) and two barred lenticulars (N4442bar and N4754bar) (see Fig1.) we build mock observations aimed to be used as input for the Jeans Anisotropic Multi-Gaussian Expansion (JAM) method. This method assumes (i) a constant *M/L* ; (ii) a constant anisotropy $\beta_z = 1 - (\sigma_z/\sigma_r)^2$ and (iii) an axisymmetric mass distribution (Cappellari 2008).

In the JAM modelling method the mass distribution is represented via a Multi-Gaussian Expansion (MGE) parameterization (Emsellem et al. 1994). The JAM method produces a prediction of the projected second velocity moment (V_{rms}) which is fitted to the observed V_{rms} in order to recover the inclination *i*, β_z and *M/L*.

We projected our simulations with four inclination angles : i=25° (i.e. near face-on) ; i=45° ; i=60° and i=87° (i.e. near edge-on) and also four position angles for the bar : PA_{bar}=18° (i.e. bar near side-on) ; PA_{bar}=45° ; PA_{bar}=60° ; PA_{bar}=87° (i.e. bar near end-on).

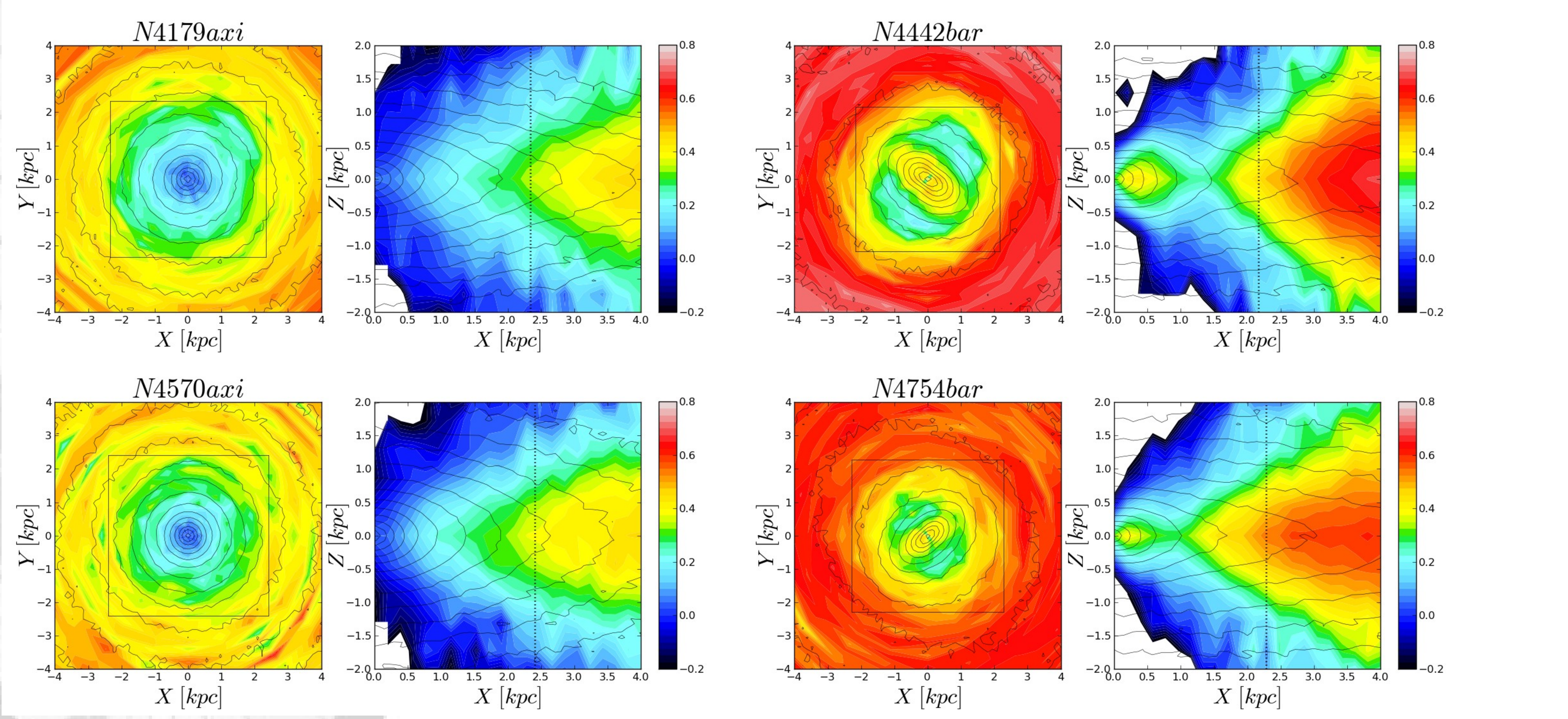
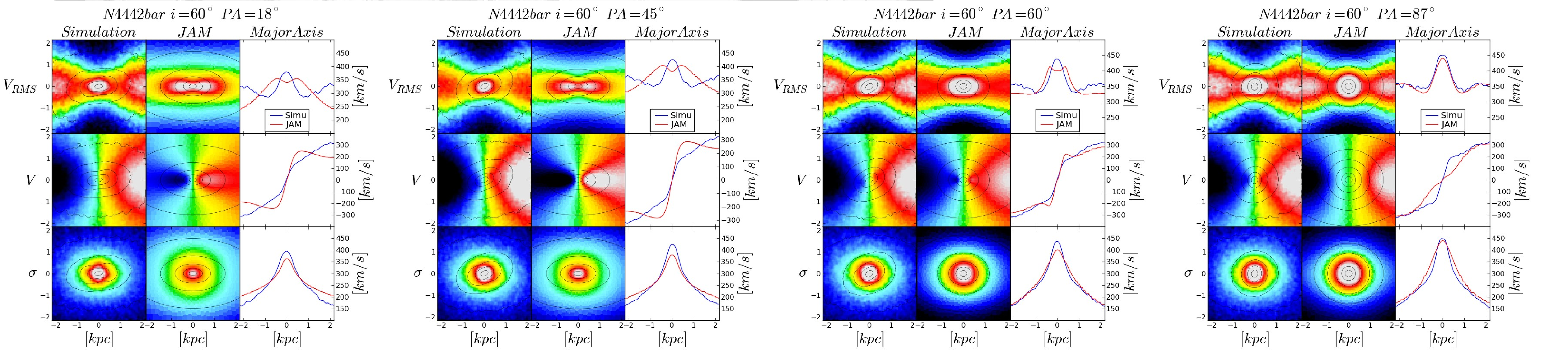


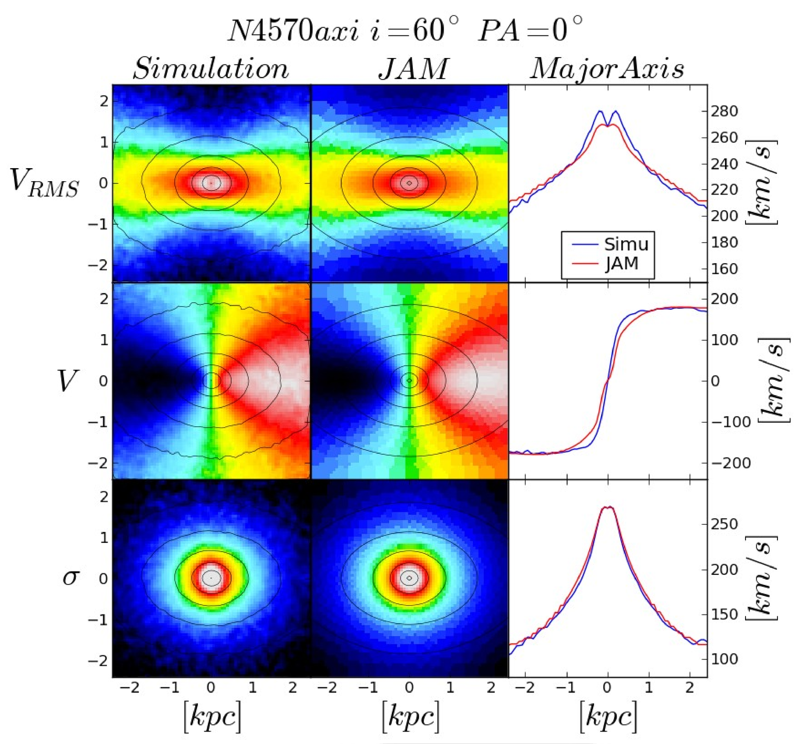
Fig 1. - Local anisotropy computed in the equatorial plan and in the meridional plan for the final state of our simulations. Color gradient go from β_z=-0.2 ($\sigma_z > \sigma_R$) to β_z=0.8 ($\sigma_z < \sigma_R$). The field of view used in our study is represented by the the solid square for the equatorial plan and by the dot line for the meridional plan.

Fig 2. - These four figures give an example of the best fit produced by the JAM machinery for N4442bar with i=60° and with increasing PA_{bar} from left to right.

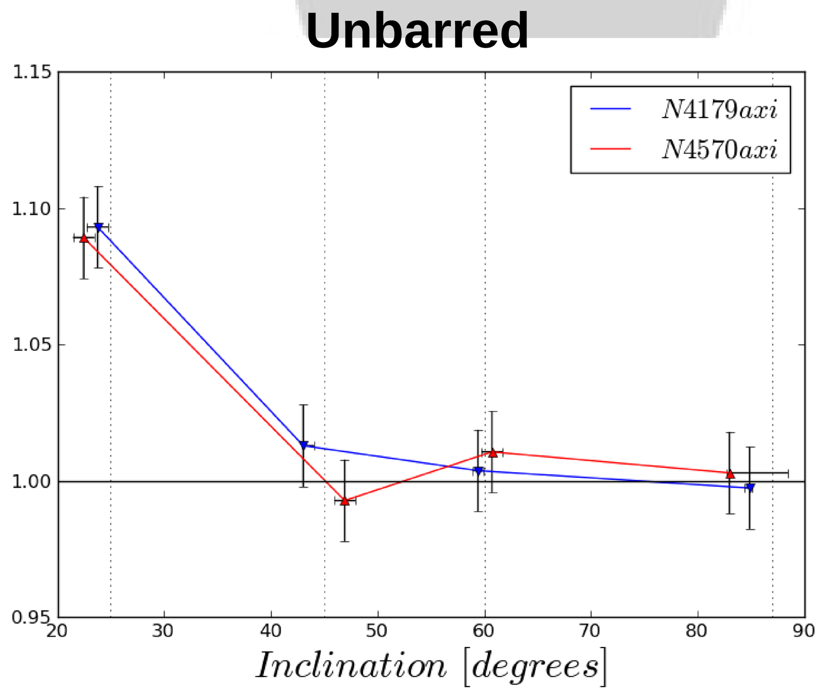


The MGE parameterization intrinsic axial ratio highly influences the general shape of the computed second velocity moment map and consequently the recovery of β_z, while the *M/L* is only sensitive to the real dynamic of the system and its impact on the projected V_{rms} map. Considering that the global anisotropy is not a well defined quantity in barred galaxies and is therefore not consistently recovered (see Lablanche et al. In prep.) we only present here results on the *M/L* recovery.

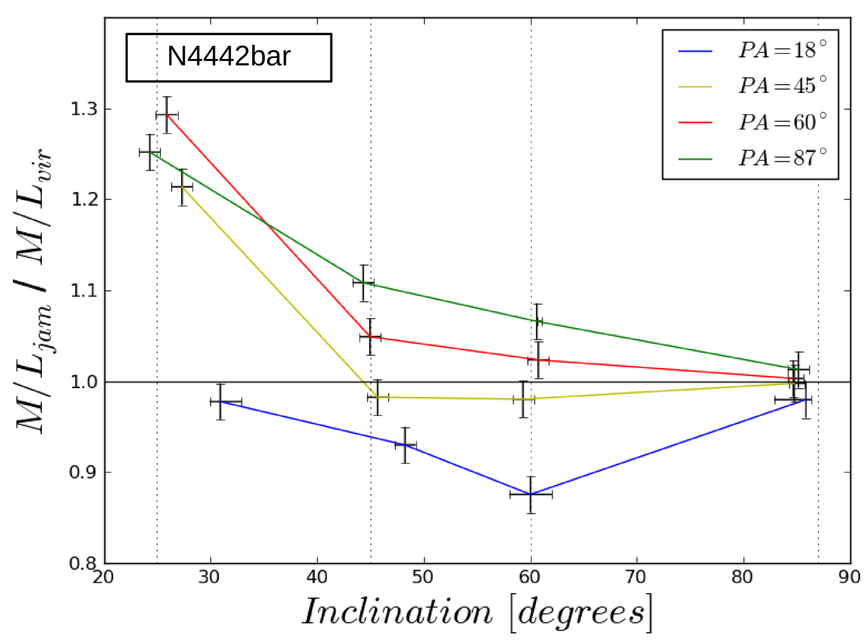
From an analytic test done in Cappellari et al. (2006) *M/L* is expected to be significantly overestimated at low inclination (e.g. i=25°). We confirm this fact in the following and that is why we only focus on higher inclination.



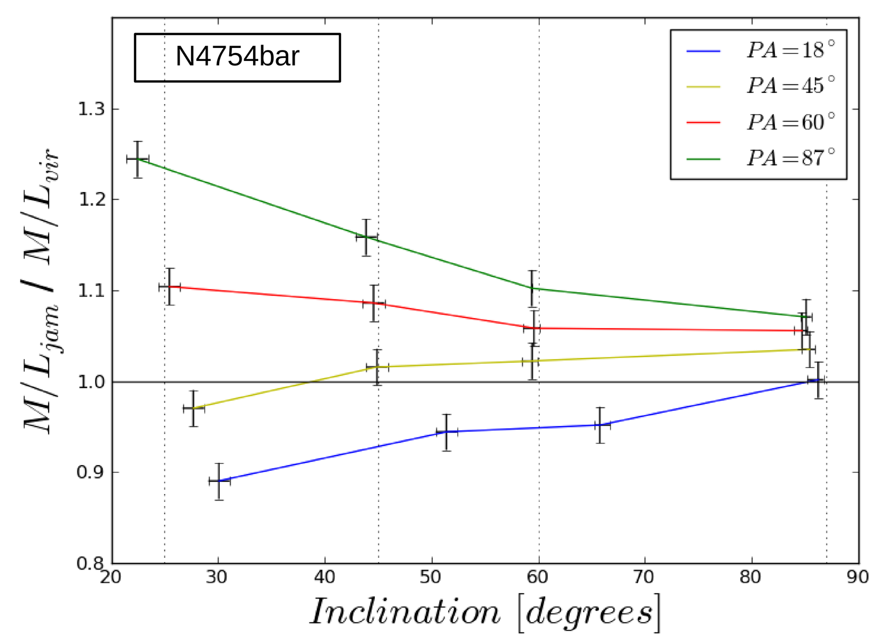
Unbarred



Barred 1



Barred 2



Axisymmetric case

The left figure above presents an example of a JAM fitting for N4570axi with i=60. The right figure shows the accuracy recovery of M/L as a function of the inclination angle for N4179axi and N4570axi.

We see that the for regular axisymmetric simulations that resembles observed fast rotators early type galaxies, the JAM modelling method is able to well reproduce the observed V_{rms}.

Consequently we found that *i* (and β_z) are accurately recovered but also that the *M/L* is well recovered with an error of less than 2%.

Barred case

The figures above show the accuracy recovery of *M/L* as a function of the inclination angle for N4442bar (left) and N4754bar (right).

Both figures show that the error on *M/L* is correlated with PA_{bar} and can be up to ~15%. PA_{bar} = 45° is an intermediate case. For lower PA_{bar} (bar close to side-on) *M/L* tends to be underestimated while for higher PAbar (bar close to end-on) it tends to be overestimated.

This is only due to the impact of the bar dynamic on the V_{rms} map which creates features (like a peak in the bar region) that biased the fit. Thus by minimizing the influence of the bar in the field of view (FOV) we can reduce the induced bias (e.g. by increasing the size of the FOV).

References :

- Emsellem E., Monnet G., & Bacon R. 1994, Aap, 285, 723
- Cappellari M. et al. 2006, MNRAS, 366, 1126
- Cappellari M. 2008, MNRAS, 390,71
- Lablanche P.-Y. et al. (in prep.)