Mass Distribution of Galaxies

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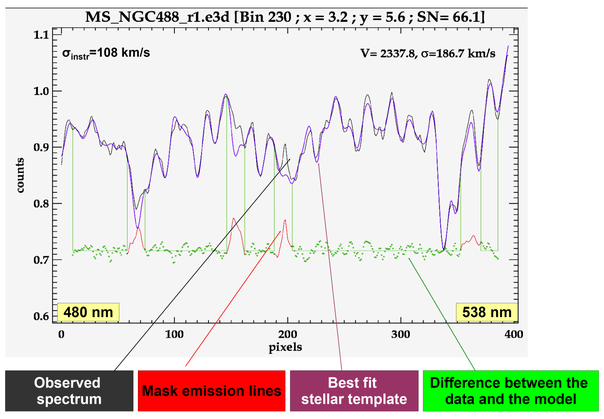
Abstract

Knowing the mass distribution of galaxies is essential in understanding their structure and evolution. We can infer the total (including dark) matter distribution of a galaxy by constructing dynamical models that fit the observed motions of its stars and/or gas. Here, we focus on measuring the mass distribution of a sample of 18 spiral galaxies, using two-dimensional stellar kinematics obtained with the integral-field spectrograph SAURON. We decompose these galaxies into bulge and disk components and fit the observed second order velocity moments with solutions of the axisymmetric Jeans equations. Good fits are already obtained especially for the Sb/c spirals, but to improve the inferred mass distribution we are extending the models, including dynamical bulge-disk decompositions, as well as investigating more general (orbit-based) dynamical models.

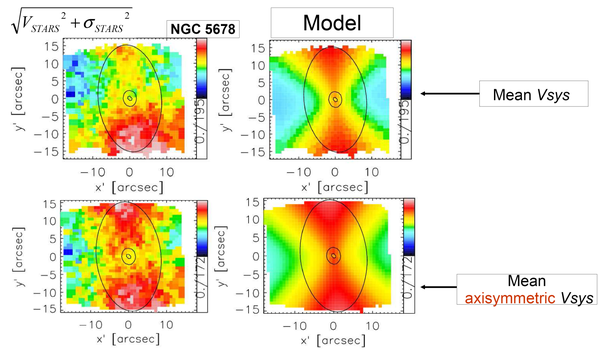
Observations

Extracting stellar kinematics



1. Spectrum: Off-center spectrum with S/N > 60 achieved by combining individual spectra within the same spatial bin (using the Voronoi binning code of *Cappellari & Copin, 2003*). Stellar absorption line kinematics are derived by fitting convolved MILES stellar templates (*Vazdekis et al., 2011*) directly in pixel space using pPXF (*Cappellari & Emstellem, 2004*). Errors on the stellar kinematics are obtained by Monte-Carlo simulations.

Systemic velocity

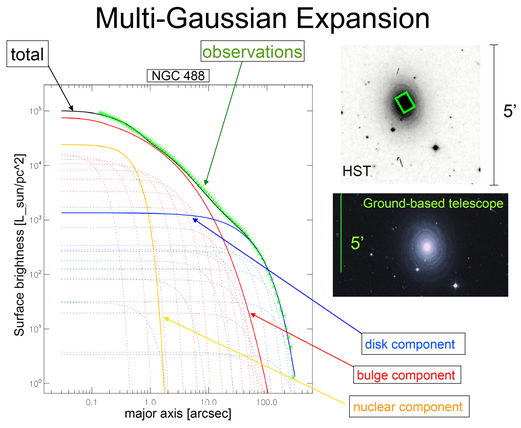


2. Systemic velocity: When measuring the systematic velocity (Vsys) we enforce point - symmetry to avoid biases due to foreground stars, dust lanes and systematic errors in certain spatial bins, which in some cases can cause a significant offset in Vsys.

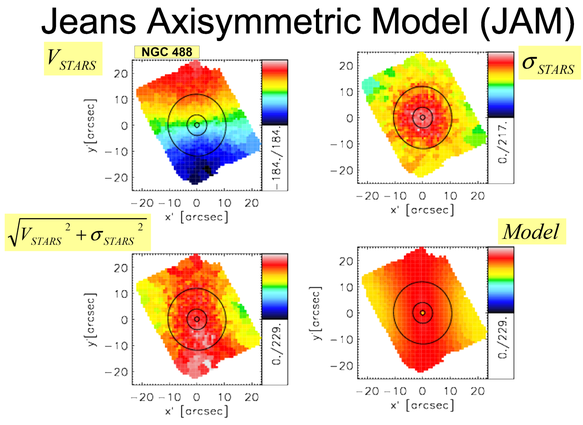
Axisymmetric dynamical model

We are fitting Jeans Axisymmetric MGE models (*Cappellari 2000, 2008*) to the observed second velocity moment $\sqrt{V^2+\sigma^2}$ with the following parameters: inclination *i*, meridional plane velocity anisotropy ß (profile), and mass -to- light ratio (profile) M/L.

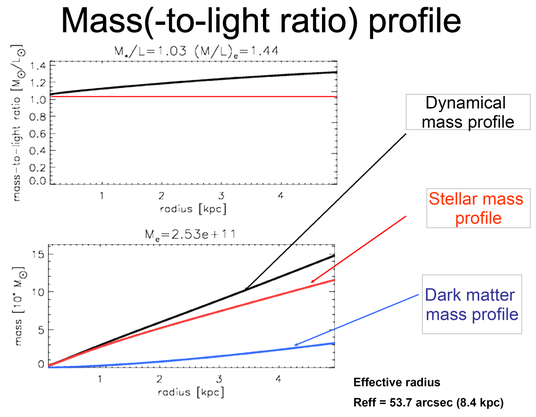
Multi-Gaussian Expansion



Jeans Axisymmetric Model (JAM)



Mass(-to-light ratio) profile

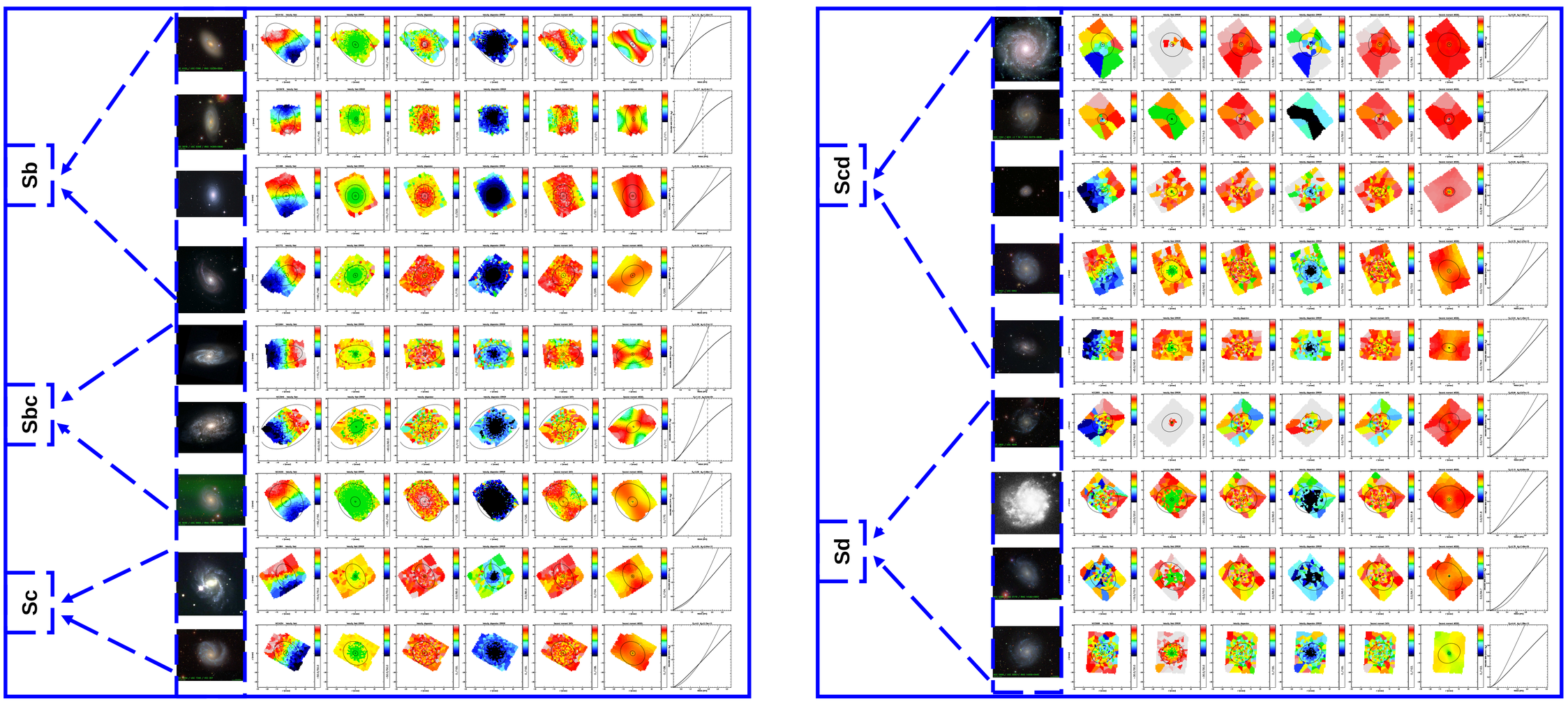


Applying the model to all sample

Sample

SDSS and other ground-based images of 18 spiral galaxies of type Sb-Sd observed with the integral-field spectrograph SAURON (*Ganda et al., 2006*).

Currently improving and extending isotropic mass-follows light models



From left to right: image of the galaxy, maps - velocity field, velocity field error, velocity dispersion, velocity dispersion error, second moment data, second moment model and dynamical mass profile (thick curve - enclosed projected mass , thin curve - enclosed intrinsic mass & dotted curve – effective radius).

Results

1. Accurate SAURON stellar kinematics maps (including errors) for 18 spiral galaxies
2. Accurate systemic velocity avoiding systematic mismatches with the model
3. Already good dynamical model fits, especially for the Sb/c spirals
4. Accurate total (including dark) matter profiles

CALIFA Survey

Future work

1. Quantify decomposition of stars/dark matter in the galaxies.
2. Dynamical bulge-decomposition
3. Extended dynamical models, including Schwarzschild orbit-based models
4. Pilot project for measuring mass distribution of galaxies in the CALIFA Survey

CALIFA Survey: PMAS/PPAK integral-field spectroscopic data of ~600 nearby galaxies being obtained as part of the Calar Alto Legacy Integral Field Area (CALIFA) Survey. The results on the mass distribution will be connected with properties of the stars and gas to help understand the evolution of galaxies from the blue cloud to the red sequence.