A study of the angular momentum content of WHISP early-type galaxies

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The HI/Story of the Nearby Universe

Overview

1 Introduction

2 Data set

3 Rotation curves

4 Comparison to the data

5 Preliminary

6 Summary

Introduction 1

- Angular momentum (AM) is a fundamental galaxy property.
- In a CDM Universe, AM is closely linked to a galaxy's formation history.
- High-precision studies of the AM content of various types are made possible by current and forthcoming instruments.

Introduction 2

- Fall and his collaborators have shown that early-and late-types have different amounts of AM.
- High-precision studies show a well-defined relationship between $j_{\rm b}$ and $M_{\rm b}$.
- However, all high-precision studies so far have focused on late-types.

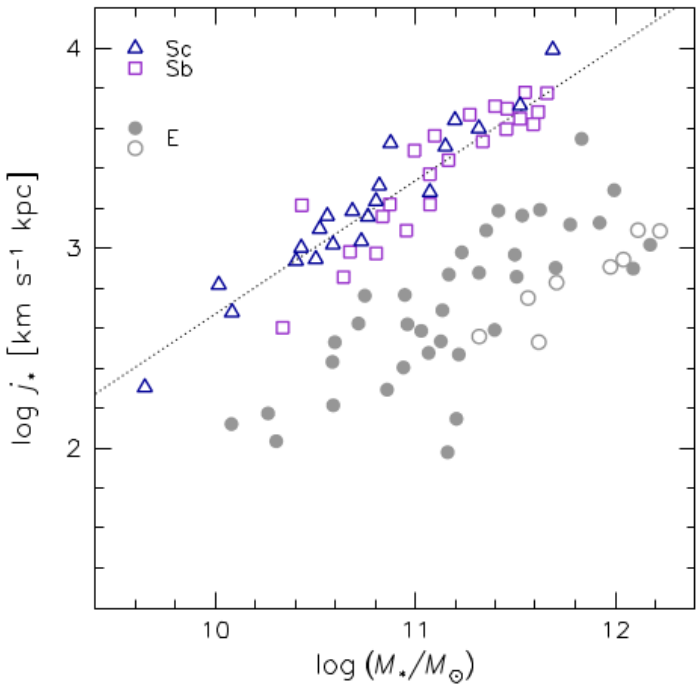


Figure : Traditional study of $j_\star$ - $M_\star$ relation (Romanowsky & Fall (2012)).

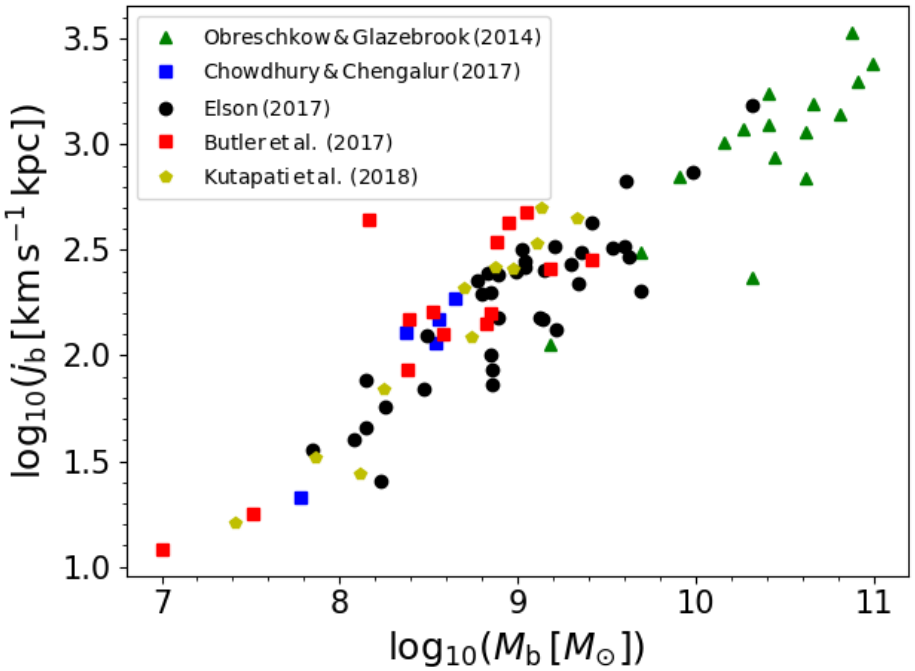


Figure : High-precision studies (using rotational curves and radial profiles) of $j_{\rm b}$ - $M_{\rm b}$ relation from several studies.

This work

- This study serves as an investigation into the angular momentum of early-type galaxies from WHISP.
- We would like to know whether their AM properties differ significantly from the late-type samples that have already been studied.

Angular momentum measure

Total baryonic mass is given by:

$$M_{\rm b} = \int_0^{\rm R_{out}} \Sigma_{\rm b}({\rm R}) \cdot 2\pi {\rm R} \cdot {\rm dR}$$

- $\Sigma_{\rm b}({\rm R})$ is azimuthally averaged baryonic mass surface density distribution.

Total baryonic angular momentum $J_{\rm b}$ is given by,

$$J_{\rm b} = \int_0^{\rm R_{out}} 2\pi {\rm R} \cdot \Sigma_{\rm b}({\rm R}) \cdot {\rm V_{rot}} \cdot {\rm R} \cdot {\rm dR}$$

where $\Sigma_{\rm b}({\rm R}) = \Sigma_{\rm HI+He}({\rm R}) + \Sigma_{\star}({\rm R})$

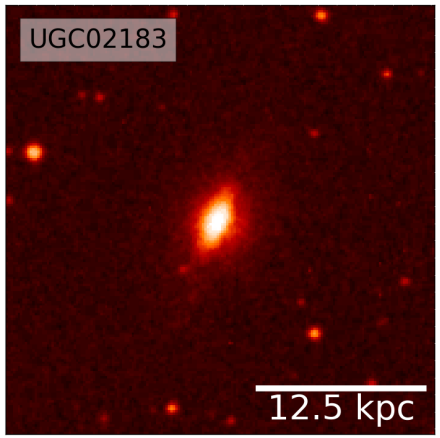
Data set

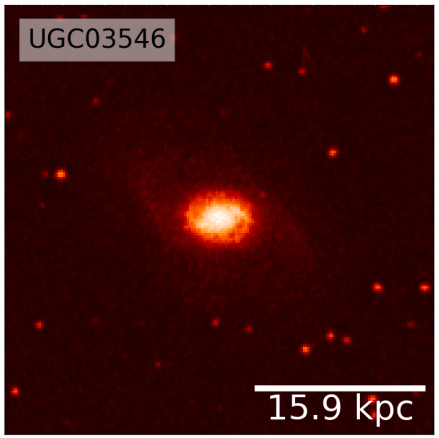
- Primary data set: 30 arcsec HI data cubes from WHISP.
- Sample of 11 galaxies selected from the sample of 68 WHISP early-types from Noordermeer et al. (2005)

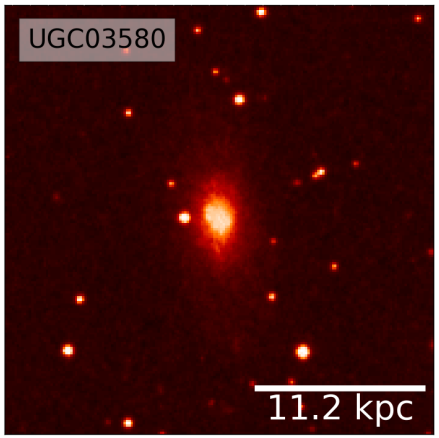
Sample selection criterion

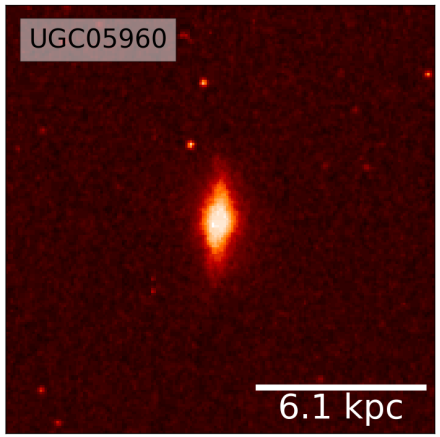
- $D_{HI} > 180$ arcsec (6 beams) and
- $40^\circ < i_{HI} < 75^\circ$.

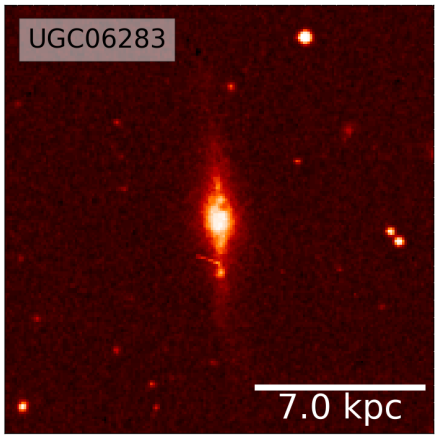
Optical imaging (Digitized Sky Survey 1)

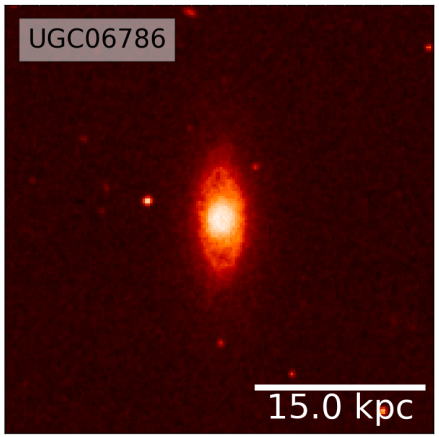


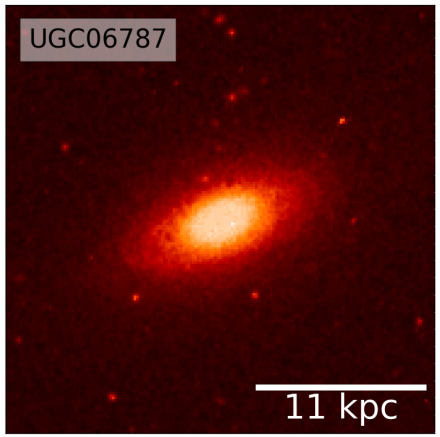


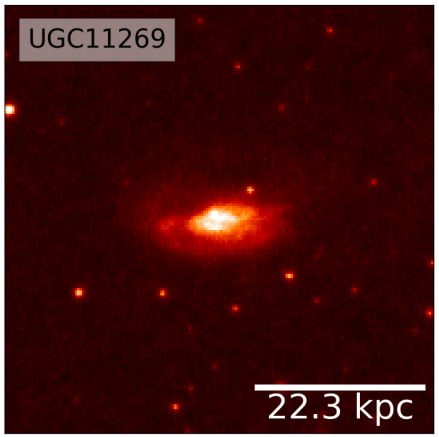









UGC06787
11 kpc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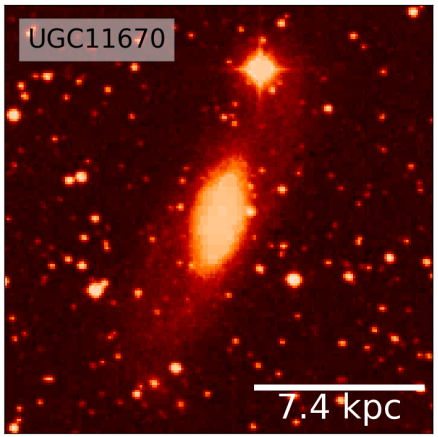
22.3 kpc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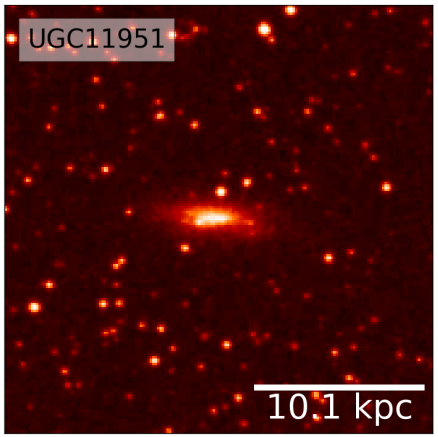
7.4 kpc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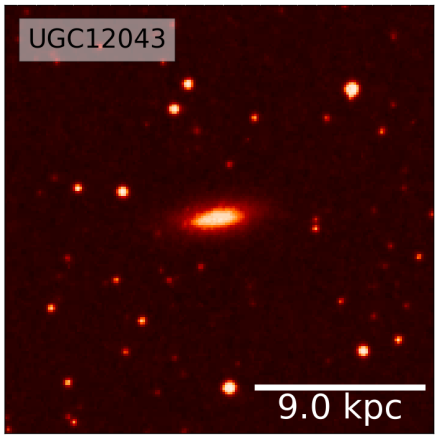
10.1 kpc


UGC12043
9.0 kpc

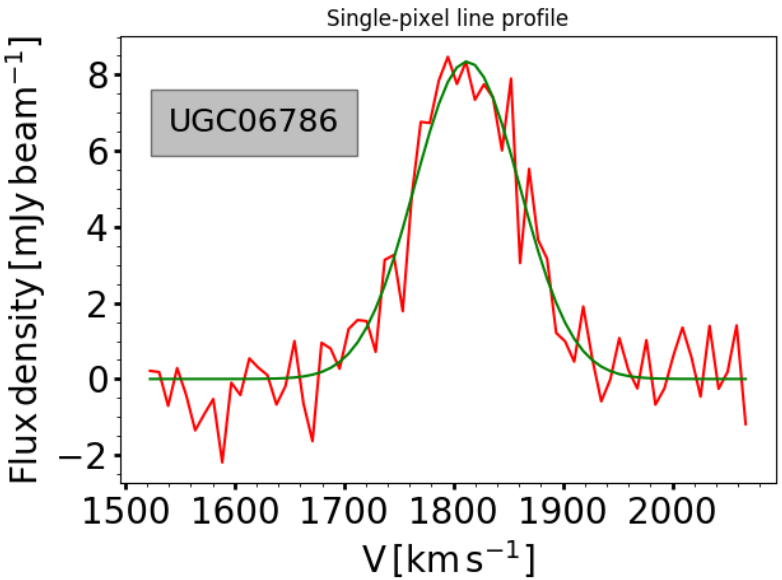
Some basic properties

Table : Sample properties (1) UGC number, (2) alternative name, (3) RA, (4) Dec, (5) morphological type, (6) absolute B-band magnitude, (7) heliocentric radial velocity from this study, (8) distance, (9) inclination angle from this study.

UGC	Alternative name	RA (2000) h m s	Dec (2000) ° ′ ″	Type	M_B	V_{hel} km s^{-1}	D Mpc	i °
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2183	NGC 1056	02 42 48.3	28 34 27	Sa:	-19.60	1535	21.5	60
3546	NGC 2273	06 50 8.7	60 50 45	SB(r)a	-20.16	1834	27.3	50
3580	-	06 55 30.8	69 33 47	SA(s)a pec:	-18.19	1198	19.2	66
5960	NGC 3413	10 51 20.7	32 45 59	SO	-17.39	637	10.5	63
6283	NGC 3600	11 15 52.0	32 45 59	Sa?	-17.17	710	12.0	71
6786	NGC 3900	11 49 9.4	27 01 19	SA(r)O+	-19.94	1790	25.9	63
6787	NGC 3898	11 49 15.4	56 05 04	SA(s)ab	-20.25	1168	18.9	66
11269	NGC 6667	18 30 39.8	67 59 23	SABab? pec	-20.11	2633	38.3	63
11670	NGC 7013	21 03 33.6	29 53 51	SA(r)O/A	-19.53	769	12.7	68
11951	NGC 7231	22 12 30.1	45 19 42	SBa	-19.14	1082	17.4	67
12043	NGC 7286	22 27 50.5	29 05 45	SO/a	-17.15	1005	15.4	67

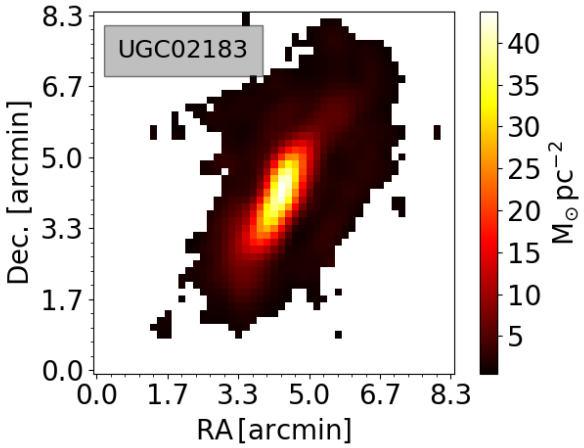
HI cube parameterisation

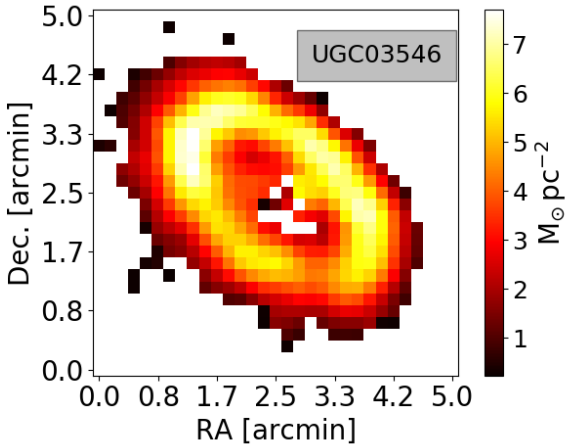
1. Line profiles in HI cube were fitted with Gaussians.
2. For all fitted Gaussians with peak amplitude $> 3\sigma$:
   - Areas of Gaussians $\rightarrow$ HI total intensity map.
   - Peak-velocities $\rightarrow$ Velocity field.
   - Dispersions $\rightarrow$ HI dispersion map.

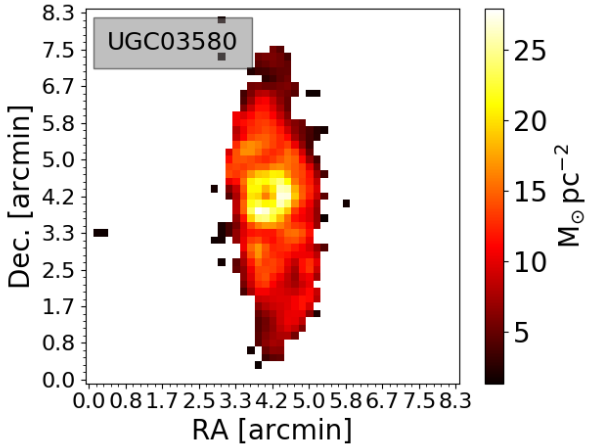


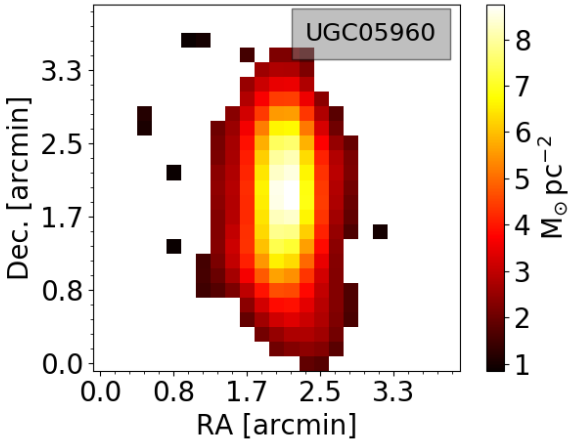
HI total intensity maps & velocity fields

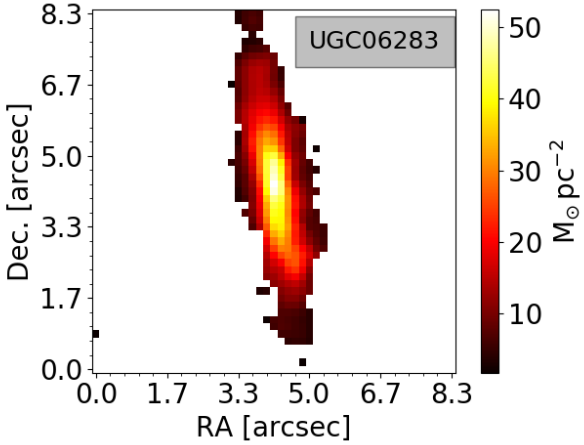
1. HI total intensity maps:

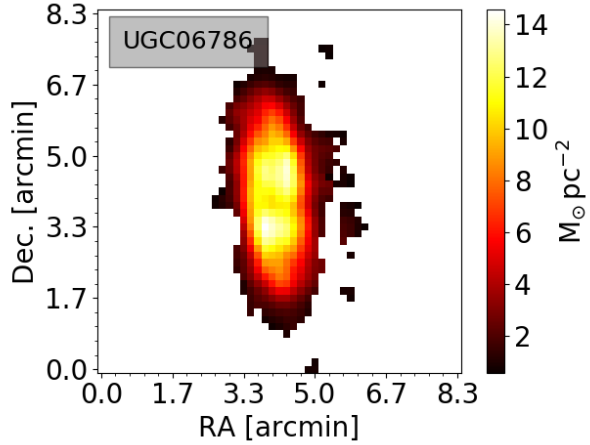




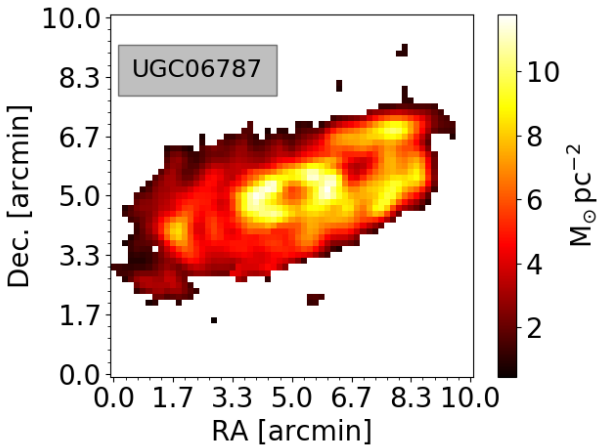


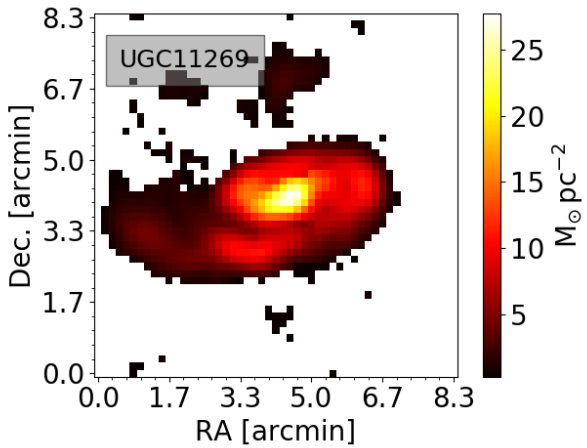


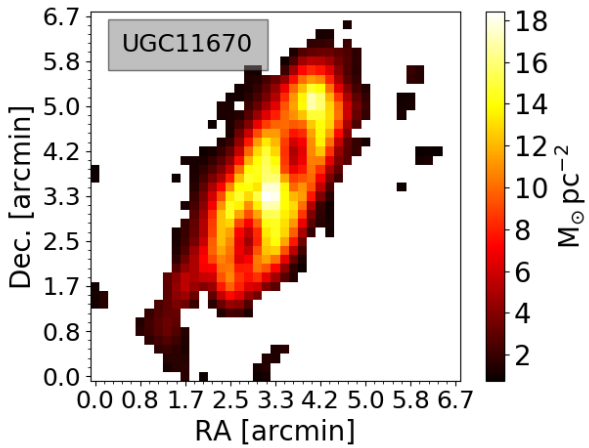


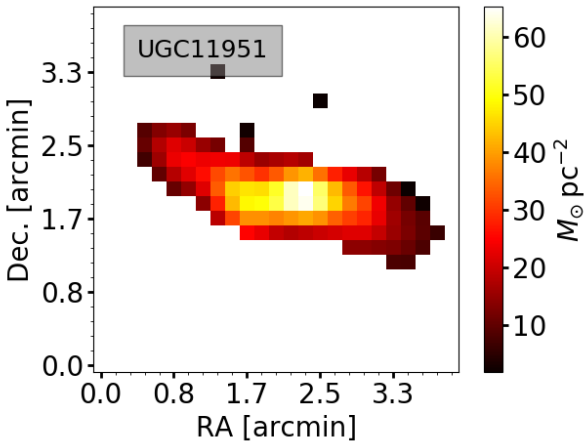


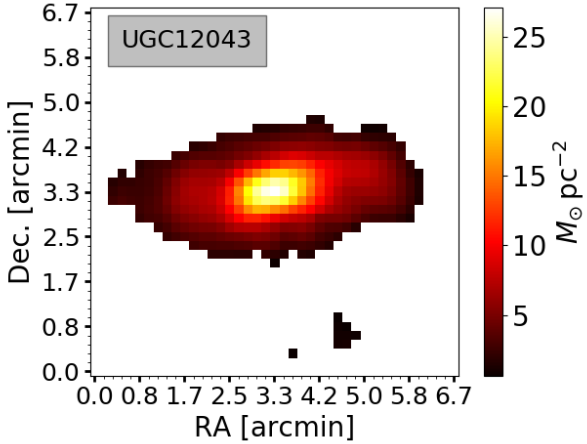
HI total intensity maps & velocity fields





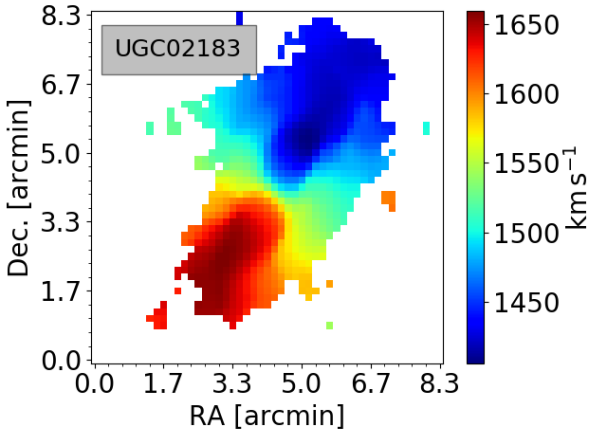


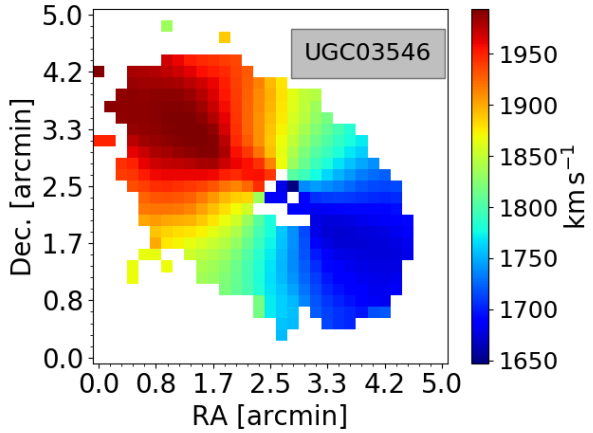


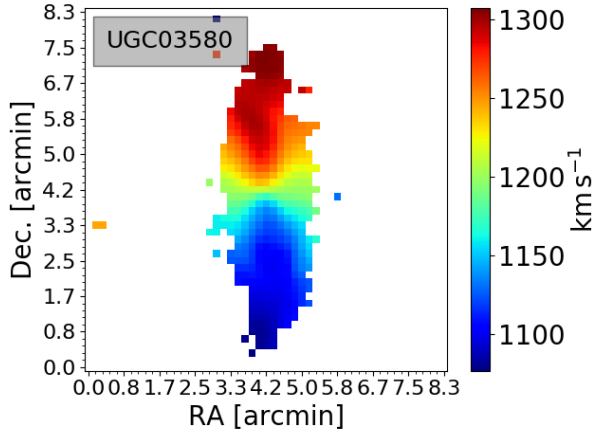


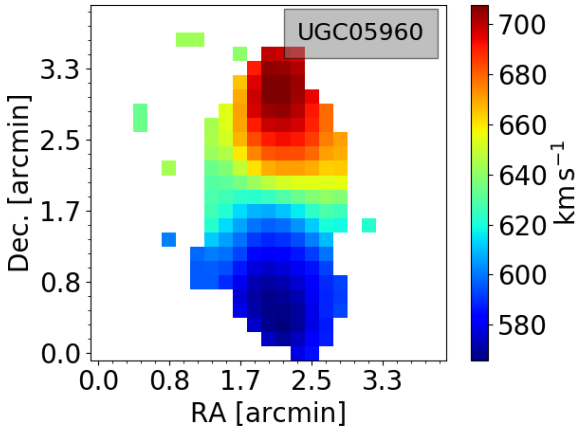
HI total intensity maps & velocity fields

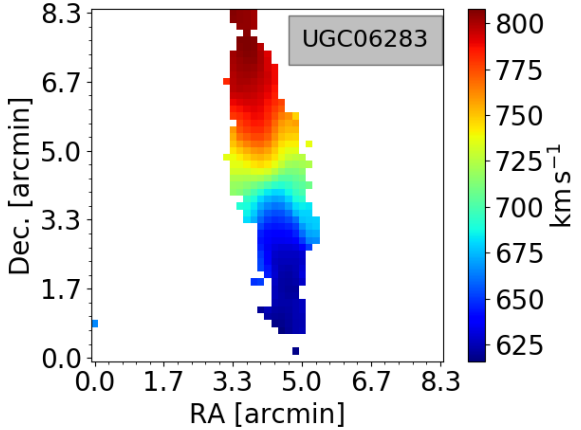
2. Velocity fields:

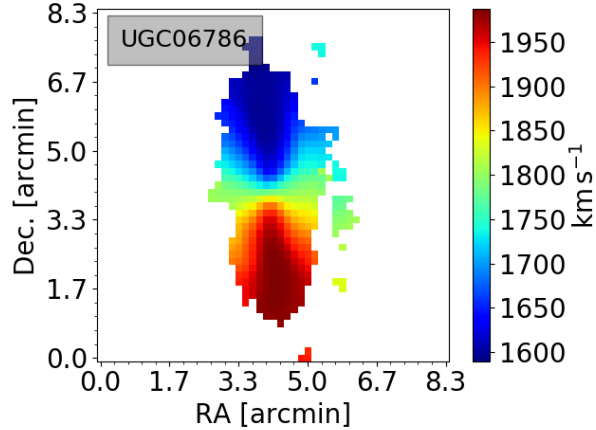




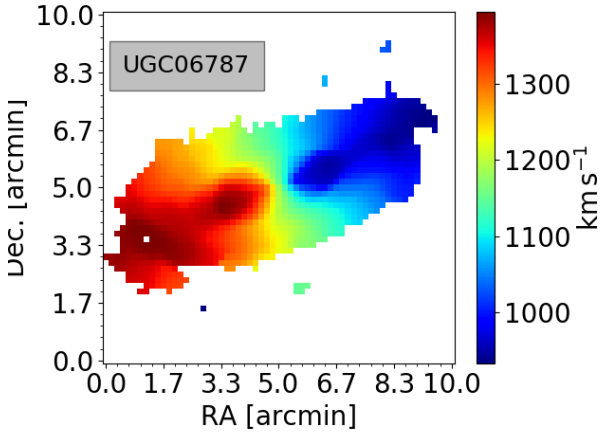


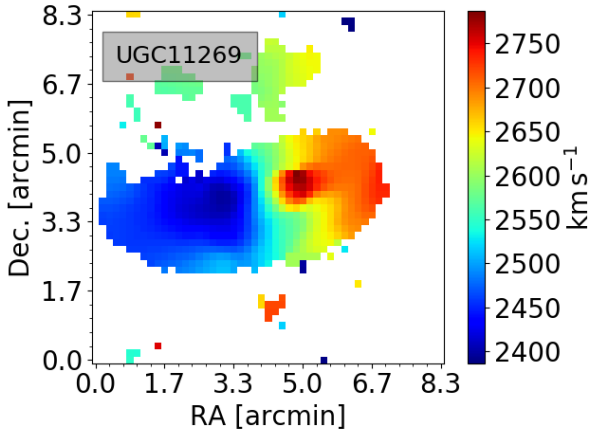


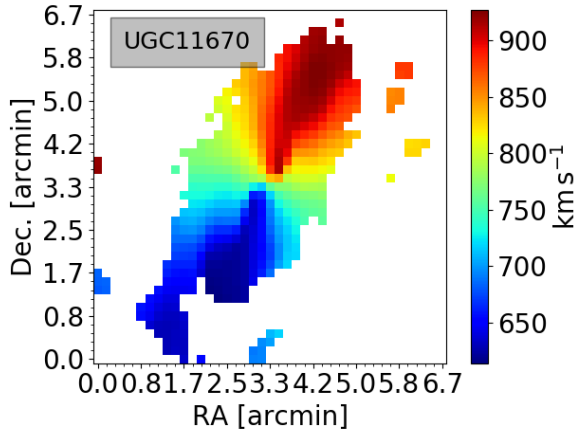


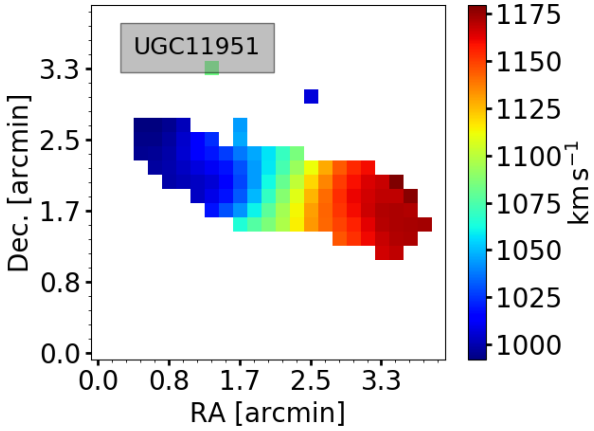


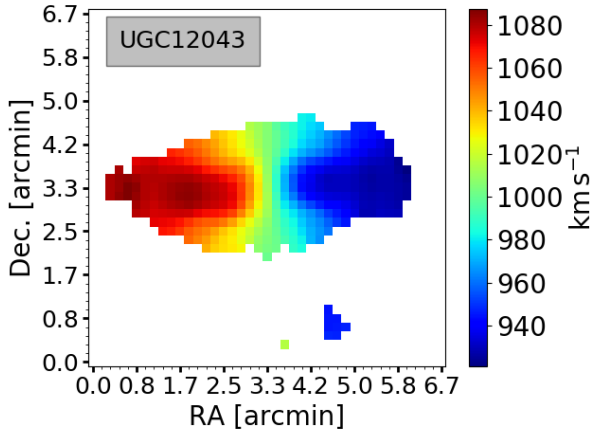
HI total intensity maps & velocity fields



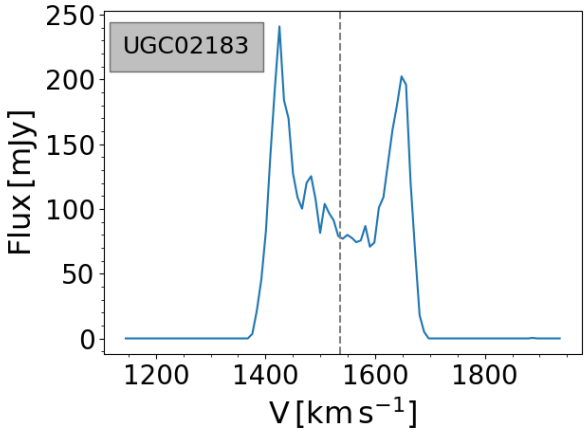


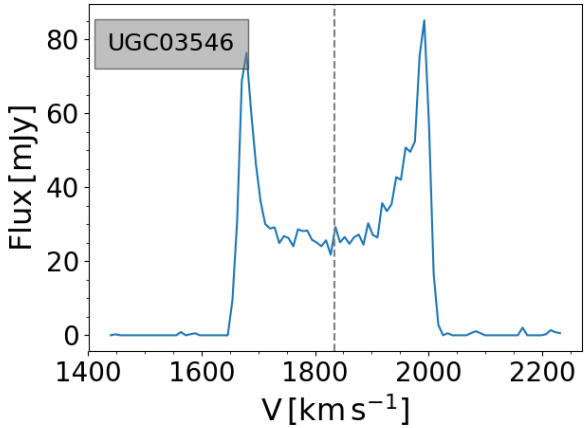


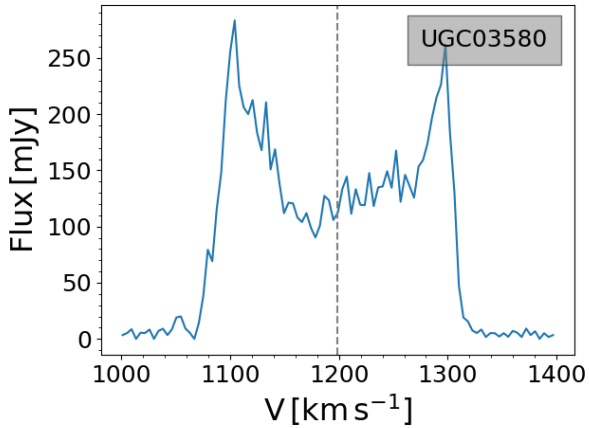


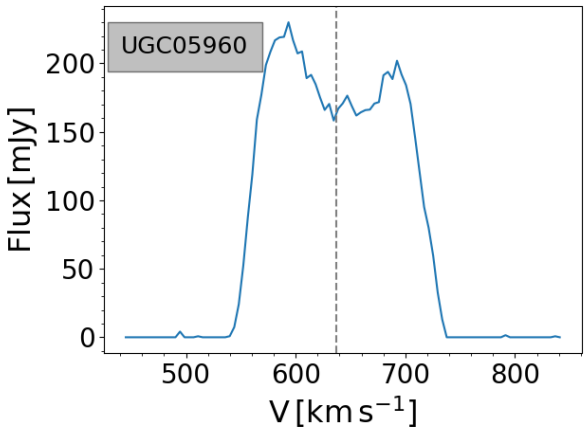


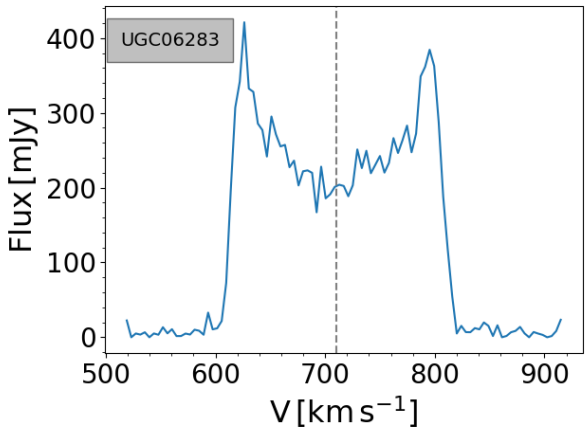
Observed HI Global Profiles

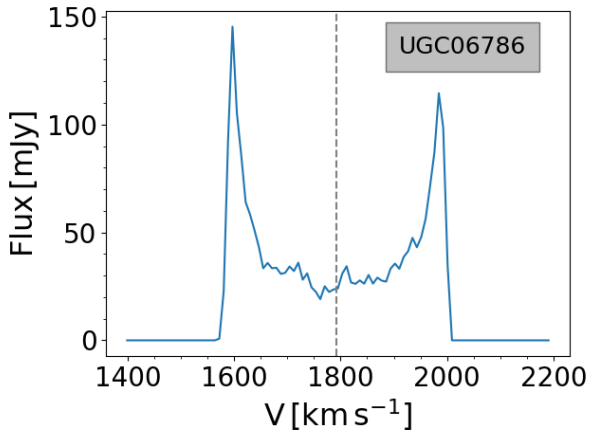




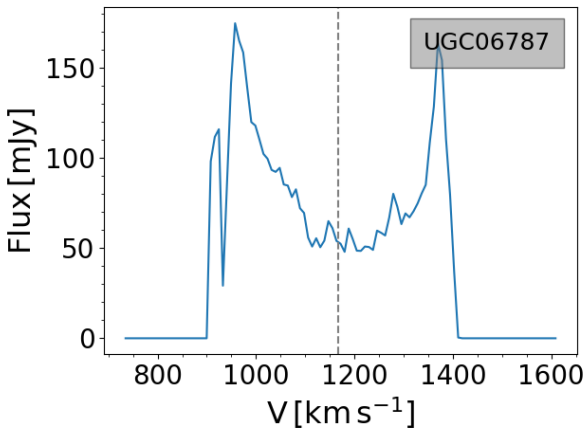


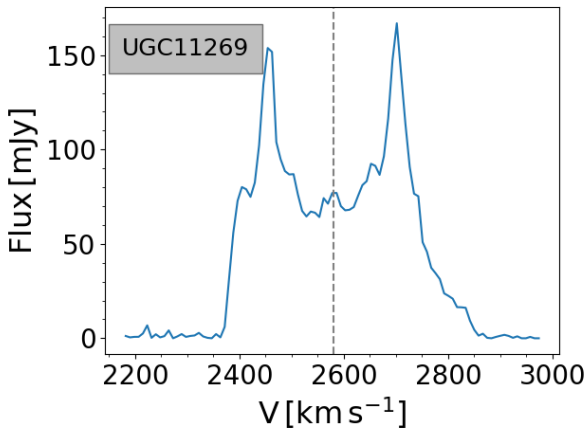


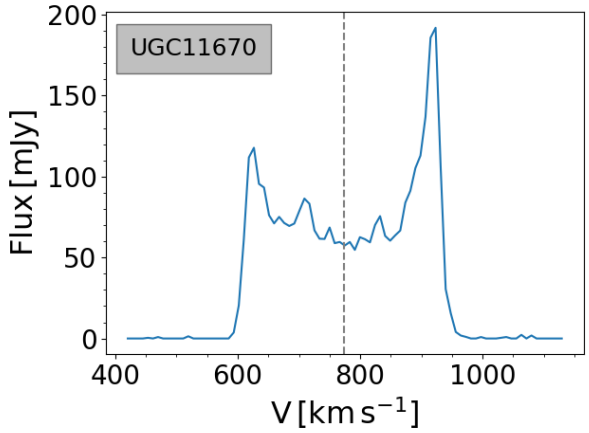


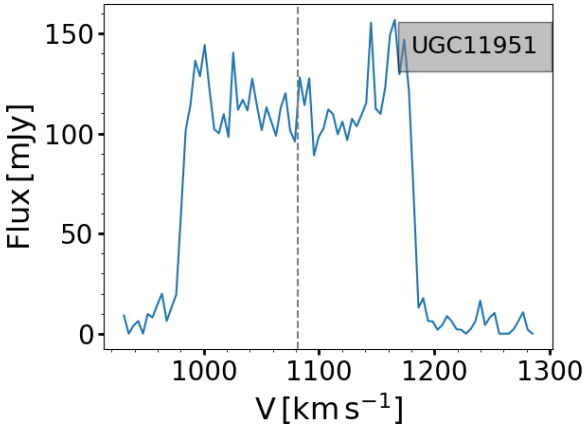


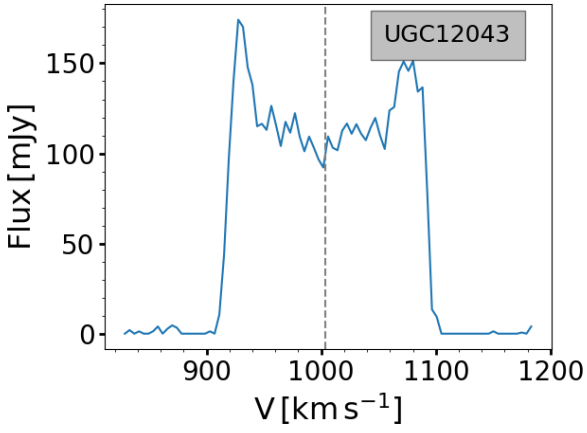
Observed HI Global profiles cont ..











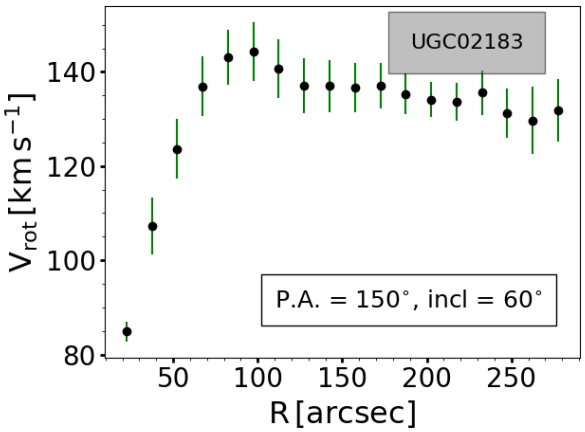
Derive roatation curves

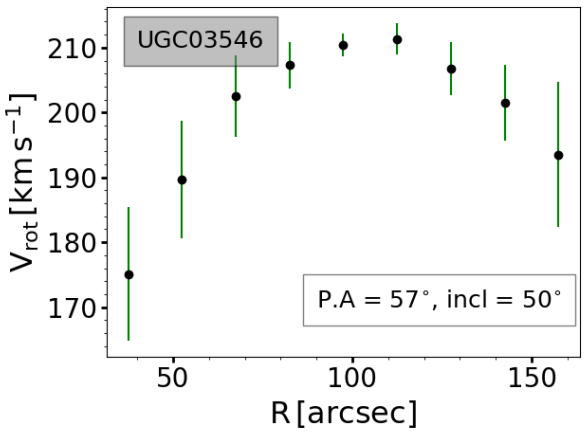
We used ROTCUR routine in GIPSY to derive rotation curves.

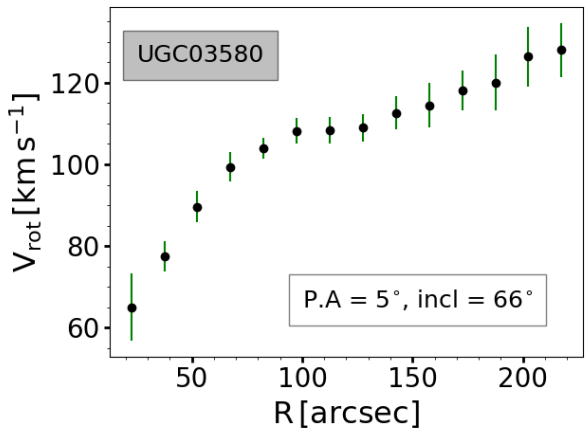
ROTCUR approach

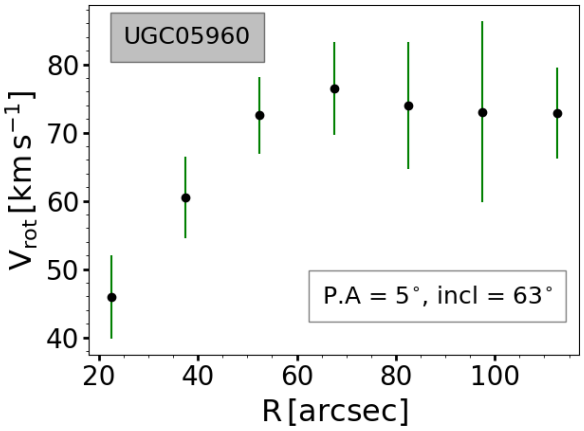
- Fitting tilted-rings to the velocity fields (both halves) in two iterations:
- 1st iteration: all parameters set free.
- 2nd iteration: all parameters (except V_{rot}) set to median values from previous iteration.

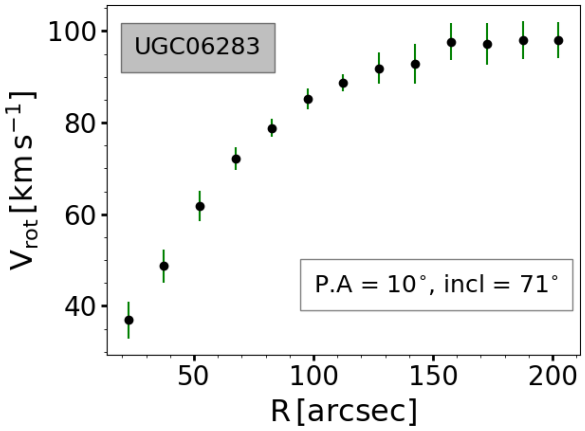
Rotation curves

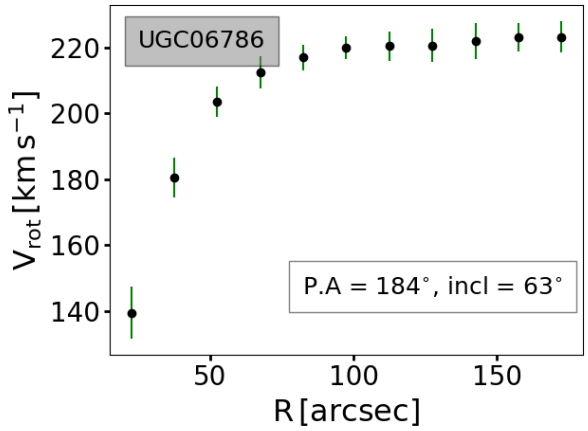




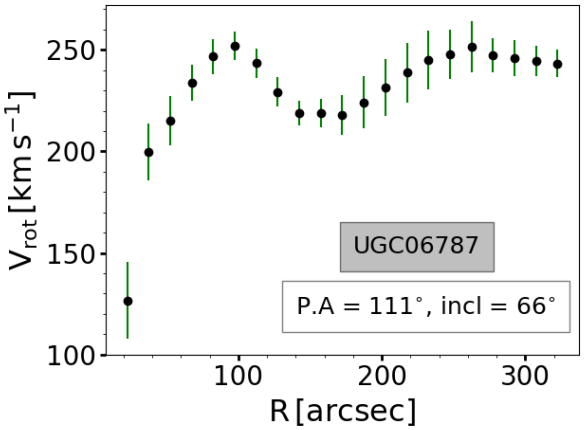


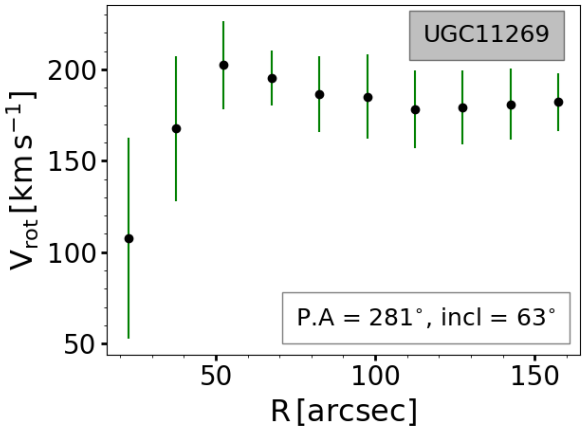


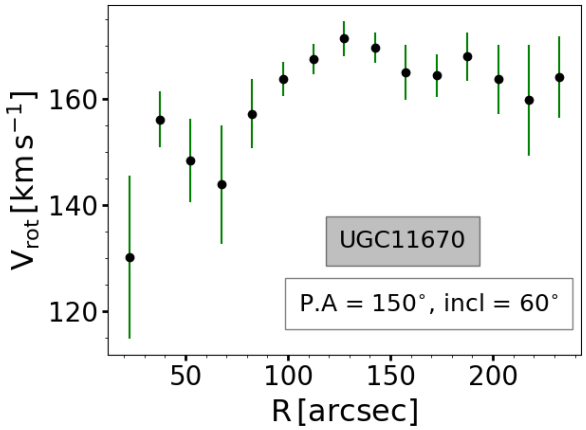


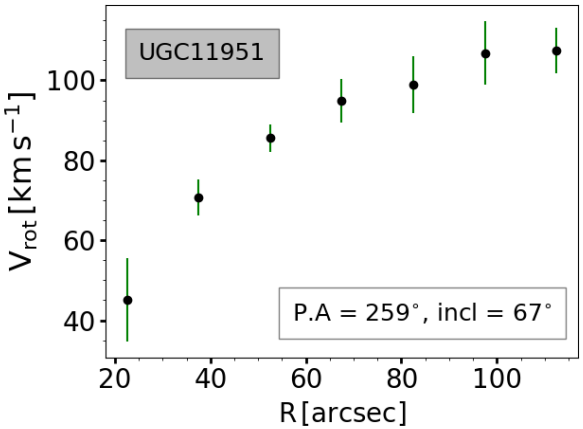


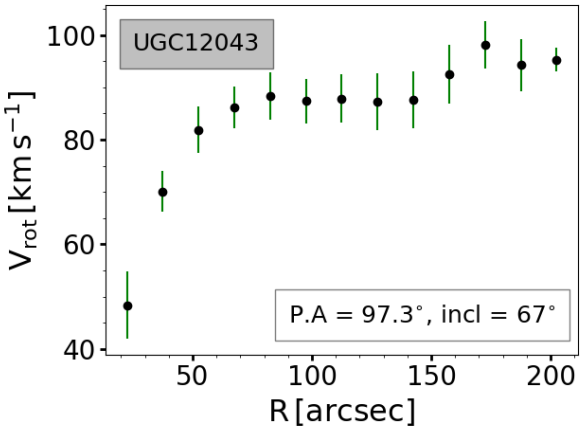
Rotation curves cont ..











Model-data comparisons

We compared TR models to data in different ways:

1. Velocity fields comparisons.

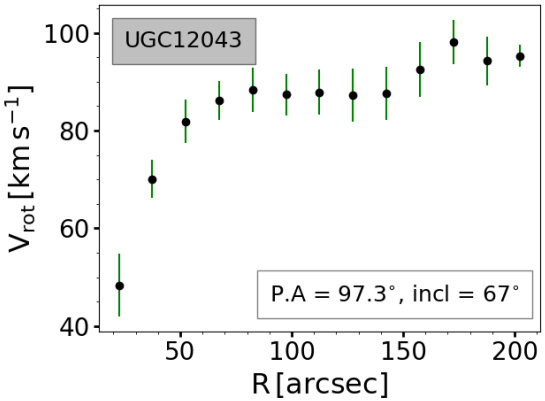
2. Used TR models to generate 3D model cubes (GALMOD) in order to comapare directly to HI data cubes:

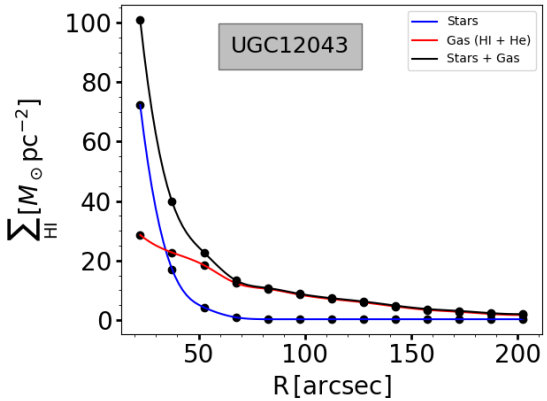
   - Major axis pv-slice model-data comparisons.
   - Full-channel-by-chanel comparisons.

Main conclusion: Rotation curves are accurate.

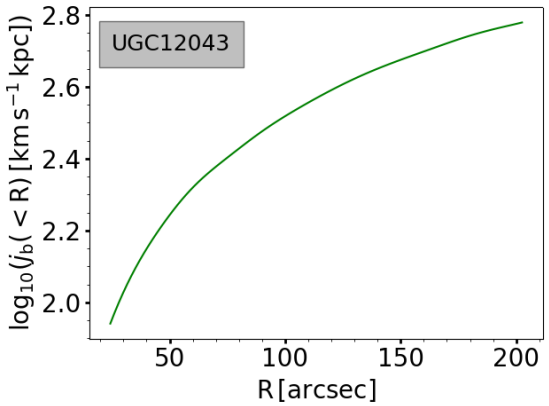
Preliminary

UGC12043

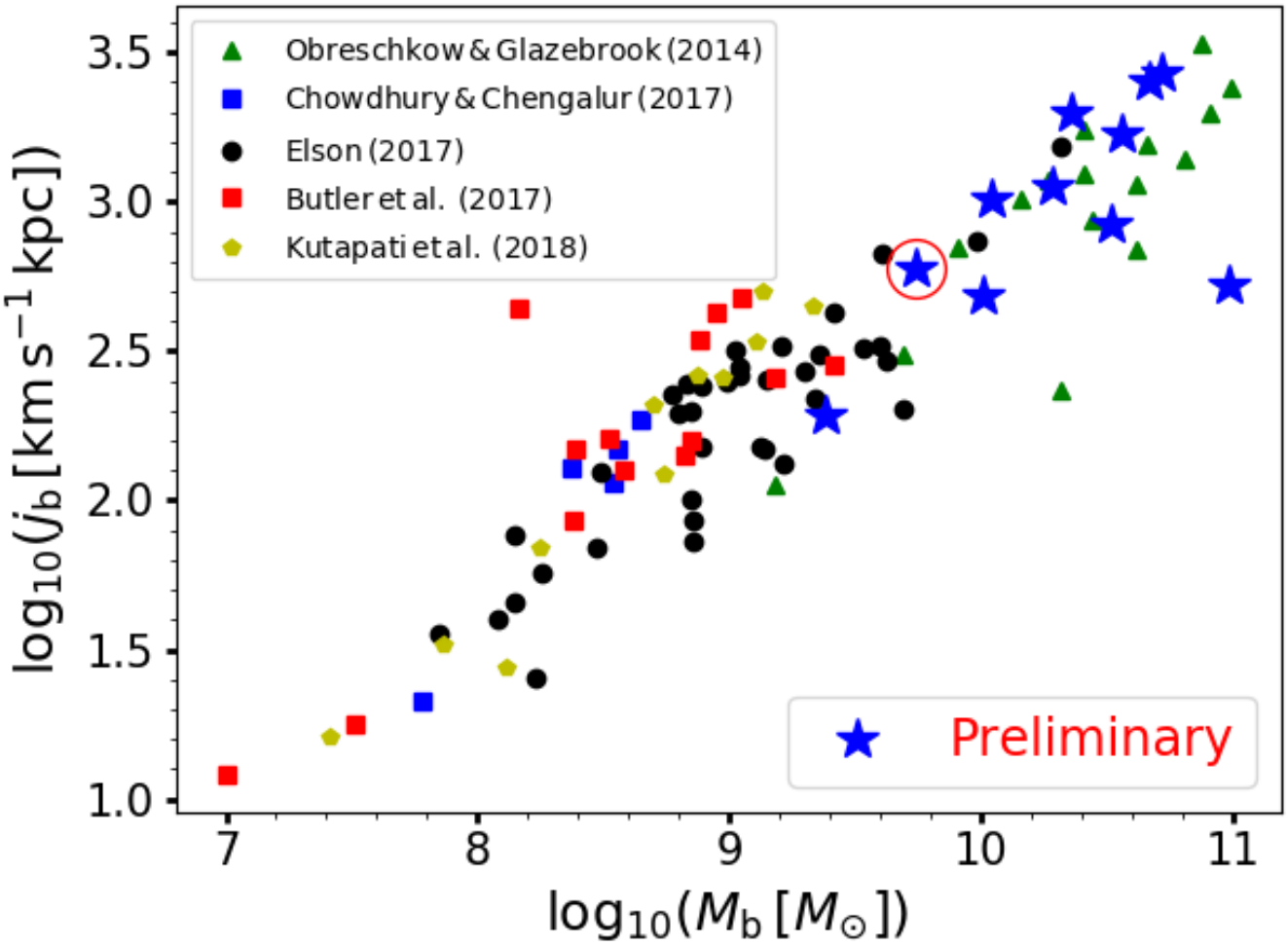




$\Sigma_\star$ profiles .. W1 imaging from Tom Jarrett.



Preliminary



Summary

- 11 early-type WHISP galaxies used to study baryonic $j_{\rm b}$ - $M_{\rm b}$ relation.
- We re-derived all HI data products and rotation curves.
- Careful model-data comparison show our rotation curves to be acurate.
- No evidence found for an off-set in baryonic angular momentum content of early-types.
- Currently: carefully checking our measurements for all our galaxies.