Project Related to KMOS DATA

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B.Tech

by

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Aknowledgments

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Abstract

We investigate the colour composite images of HST data to classify the galaxies into merging galaxies or isolated galaxies. For that purpose we have used 214 galaxy images of Cosmic Evolution Survey of Hubble Space Telescope for K-band Multi-Object Spectrograph (KMOS) 3D catalog. We have used 3 types of mosaics F125, F160 and F814 to create the color composite HST images for given galaxies in KMOS Halpha catalog. This color composite images are then investigated to find whether the galaxies are mergers or not.

We try to find the Rotational Curves of High red shift galaxies. For this we use the data from K-band Multi-Object Spectrograph (KMOS) for Cosmic Evolution Survey (COSMOS), Great Observatories Origins Deep Survey (GOODS4) and Ultra Deep Survey-4 (U4) of Hubble Space Telescope Data. We used Bbarolo to find Rotational curves and Kinematic moment maps of this galaxies.

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Chapter 1

Finding Galaxy Mergers from HST images for KMOS data

1.1 Data

1.1.1 KMOS

K-band Multi Object Spectrograph (KMOS) is the second-generation instrument created for use on the VLT. The primary advantage of KMOS is its capacity to carry out Integral Field Spectroscopy for 24 objects concurrently in the near-infrared spectrum and also it performs an integral field spectroscopic survey of 739, log(M/M)>9, galaxies at 0.6<z<2.7 (VLT). Through the spatially resolved and integrated characteristics of the Hα, [N II], and [S II] emission lines, KMOS3D offers a population-wide census of the kinematics, star formation, outflows, and nebular gas conditions both on and off the star-forming galaxy main sequence.

1.1.2 HST

The Hubble Space Telescope's near-infrared spectroscopic survey known as 3D-HST is intended to investigate the physical processes that give rise to galaxies in the far-off Universe. During Cycles 18 and 19, 248 orbits of HST time were allotted to this Treasury programme. With two orbits of primary WFC3/G141 grism coverage and two to four orbits of ACS/G800L coverage, 3D-HST is surveying 600 square arcminutes of well-researched extragalactic survey fields (AEGIS, COSMOS, GOODS-S, UKIDSS-UDS).

1.1.3 Different Surveys in HST images

COSMOS

The Cosmic Evolution Survey (COSMOS) is a HST Treasury Project to use the Advanced Camera for Surveys to survey a two square degree equatorial region (ACS). the biggest survey HST has ever conducted. The main objective of the research is to investigate the connections between galaxies' nuclear activity, galaxy formation, and the universe's large scale structure

(LSS). This includes a thorough examination of how the environment affects galaxy evolution.

GOODS

The Great Observatories Origins Deep Survey(GOODS), or GOODS, is an astronomical survey that uses infrared data from the Spitzer Space Telescope along with optical and near-infrared imaging taken with the Advanced Camera for surveys on the HST, the Very Large Telescope, and the 4-m telescope at Kitt Peak Observatory. These are combined with previously collected x-ray data from the Chandran X-ray Observatory and two fields of the ESA's XMM-Newton, each measuring 10' by 16' and focused on either the Hubble Deep Field North (12h 36m 55s, +62° 14m 15s) or the Hubble Deep Field South (3h 32m 30s, -27° 48m 20s).

UDS

Ultra Deep Survey(UDS) is galactic survey at the postion of RA postion: 02h 17m 24.0s and Dec postion:-5° 12' 0.0". It is focused on the Subaru-XMM Deep Field (J0218-05). By tiling 4 observations taken with the UKIRT wide-field camera, a survey area of 0.8 sq. degrees is produced. The UDS represents the deepest J,H,K imaging survey performed to date across a broad region.

HST AND KMOS DATA

I used the KMOS Hα catalogue from `link:https://www.mpe.mpg.de/ir/KMOS3D/data`. The Hα catalogue contains the aperture fluxes and upper limits for nondetections for every galaxy having observed H-line emission. The HST images are obtained from `https://archive.stsci.edu/prepds/3d-hst/`. The specific galaxy's ID, RA, and DEC are obtained from the Hα catalogue in order to locate it in HST images of COSMOS field and obtain image of paricualr galaxy.

We used data from the three separate mosaics by different filters : F125w, F160w, and F814w in the COSMOS field.

1.2 STEPS

1.2.1 Creating cut out images

To make cutout images of a specific galaxy using data from the Hα database, we use the astropy module in Python. I made use of COSMOS data. We prepared three fits files for each galaxy in the Hα database using F125w, F160w, and F814w respectively. The picture is 3X3.

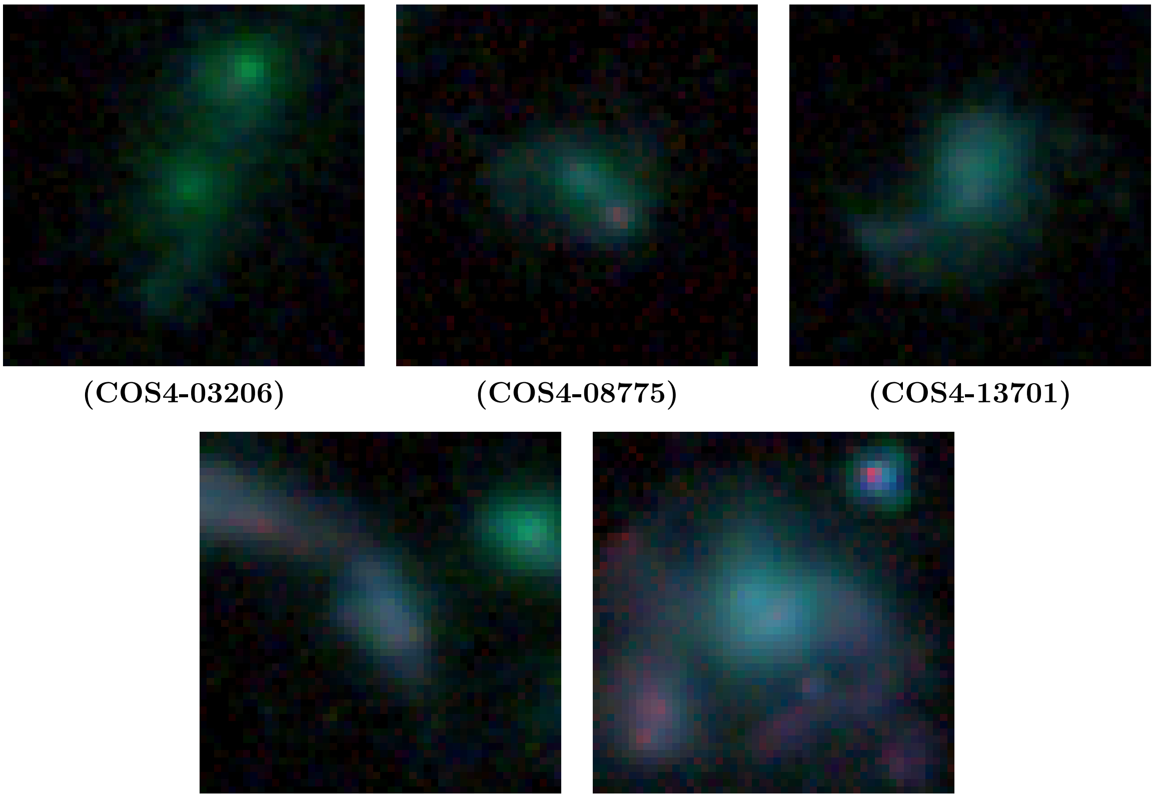
1.2.2 Creating colour composite images from cutout images

Using the Python astropy library, we produced colour composite images of all galaxies. To build colour composite images, we implemented the make lupton rgb function. While using the fuction we need to consider F125w filter as green, F160w filter as Red, F8814w filter as blue.
Making cutout images and RGB images is made simple using the astropy module. Numerous more methods can be used to produce images but Python is the easiest language, thus using astropy is quite simple.
With the use of the runbash function, I ran the code for all 214 galaxies in COSMOS.

codes can be found here:`https://github.com/harshinijangiti/HST-IMAGES-cosmos/tree/main`

1.3 Images

If two or more galaxies can be seen interacting with one another, then the galaxies are merging, according to observations of the galaxies.



(COS4-03206) **(COS4-08775)** **(COS4-13701)**

(COS4-13748) **(COS4-20618)**

Figure 1.1: HST images

Chapter 2

Getting Rotational Curves and Kinematic Moment maps from KMOS Data by Using Bbarolo

[1]

2.1 Data

The above data is used again. Hα cubes are created.

2.2 Rotational Curves

The rotation curve of a disc galaxy is a graph of the orbital speeds of the visible stars or gas in that galaxy against their radial distance from the galaxy's centre (also known as a velocity curve). The data observed from each side of a spiral galaxy are frequently asymmetric, thus data from each side are averaged to generate the curve. It is typically shown graphically as a plot. The experimentally observed curves and the curve obtained by applying gravity theory to the stuff detected in a galaxy differ significantly. Dark matter theories are the primary hypothesised explanations for the discrepancy.
From the innermost to the outermost regions of galaxy discs, detailed identification of the rotation curves is necessary for all these fields of study. The so-called "tilted-ring model" is used to describe the kinematics of spiral galaxies most frequently.

2.3 Why Bbarolo?

[2]The standard approach to link the tilted-ring model to observations is through the fitting of 2D velocity fields.
When applied to high-resolution velocity fields, all of the aforementioned 2D techniques produce good kinematic models and trustworthy rotation curves. However, there are a many drawbacks.

However, beam smearing is the most serious issue when attempting to derive the kinematics from the velocity field.

2.3.1 Beam Smearing

The line emission smears on the surrounding regions as a result of a telescope's finite beam size. The result is that each spatial pixel's line-profiles get wider while the gradients in the velocity fields tend to get flatter. To put it another way, a portion of the rotational velocity is converted into line broadening, which is sometimes mistaken for gas velocity dispersion and results in a degeneracy between these two quantities. The resultant rotation curves will typically climb very slowly in the inner regions as a result of the beam smearing, with potentially significant implications for the interpretation.
As the spatial resolution of the data lowers and the galaxy's inclination angle rises, the effect becomes more and more obvious.

2.3.2 Solution for Drawbacks in 2D fitting

A 3D modelling of the data-cubes is the obvious answer to all the problems. We apply the method to automatically fit emission-line data cubes with 3D tilted ring models. Barolo, which stands for "3D-Based Analysis of Rotating Objects from Line Observations," is the name of the programme. The 3D FITS images that this programme supports have two spatial dimensions and one spectral dimension (velocity, frequency or wavelength). In order to determine which set of geometrical and kinematical parameters best matches the data, Barolo constructs a number of models in the form of synthetic 3D observations and compares them with the input cube.

2.4 What is Bbarolo?

[2] Barolo, which uses emission-line measurements to generate galaxies' rotation curves. With a variety of observations, including Hi and molecular lines as well as optical/IR recombination lines, this software can fit 3D tilted-ring models to spectroscopic data-cubes. In terms of velocity field performance, the main algorithm outperforms the conventional 2D method significantly. Even in galaxies with only two resolution elements, Barolo can reconstruct the real rotation curve and calculate the intrinsic velocity dispersion if the signal to noise ratio of the data is greater than 2-3. It is excellent for the analysis of huge 3D datasets because of its source-detection and first-estimate modules, which may also be executed automatically.

Due to these characteristics, 3D Barolo is a particularly helpful technique for obtaining reliable kinematics for both nearby and high-redshift galaxies from a variety of different detectors, like as the new-generation IFUs, ALMA, and the SKA pathfinders.

for Documnentation on Bbarolo `https://bbarolo.readthedocs.io/en/latest/`

2.5 Steps in Bbarolo

2.5.1 Basic assumption under BAROLO

The "tilted ring model," on which Barolo is based, assumes that the velocity of the gas and stars is that of a ring-shaped orbit. No functional evolution of kinematic quantities is assumed (e,g.,). As a result, free parameters in Barolo are estimated in the annuli of increasing distance from the galaxy's centre without making any assumptions about how they would evolve with radius.

2.5.2 Intialising Bbarolo

Three geometrical parameters, including the coordinates of the galactic centre in the datacube (x_c,y_c), the inclination angle (θ_1), the position angle (PA), and three kinematic parameters, including the redshift (z), rotation velocity (v_c), and velocity dispersion of ionised gas (σ), are needed to model the Barolo galaxy. In our modelling, we free the two kinematic parameters (v_c and H_α) but set the geometrical parameters and redshift (with the exception of PA, which is covered below). The photometric galactic centre positions, taken from H17, are as follows. Barolo has a number of useful ask, which are especially important or useful for high-z low S/N data.We are executing the kinematic modelling with 3DFIT TASK from Barolo. First, using predetermined initial conditions and 3D observational space, Barolo created fake observations (x,y,). where is the coordinate of the spectral axis and () denotes the spatial axis. These models were then fitted to the observed datacube in the same 3D space while concurrently accounting for the beam smearing. A successful run of Barolo produces the kinematic models, rotation curve (RC), dispersion curve (DC), stellar surface brightness profile, and beam smearing adjusted moment maps.

2.6 OUTPUTS

Only few galaxies are shown here:

2.6.1 COS4-05656

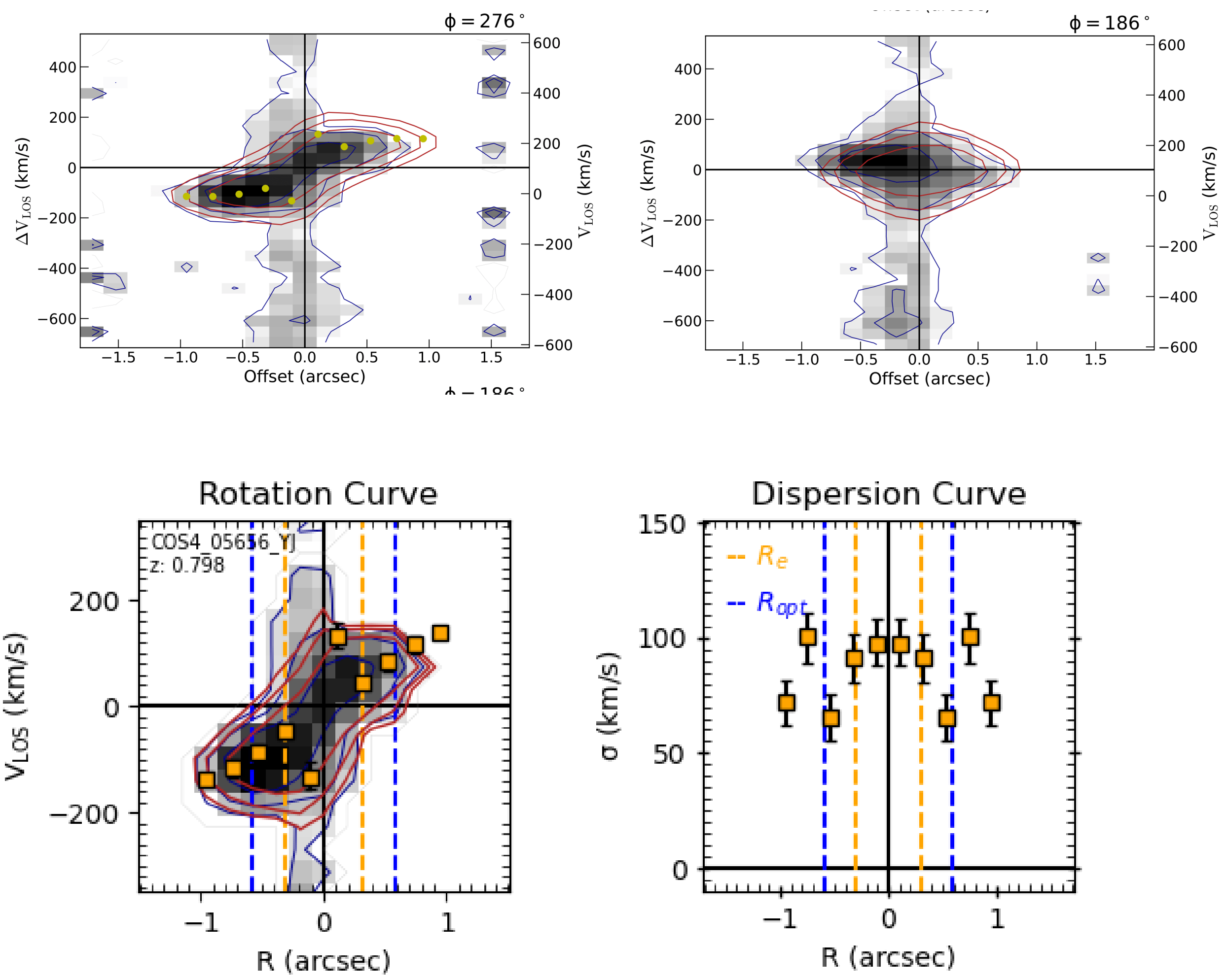


Figure 2.1: COS4-05656

2.6.2 U4-37219

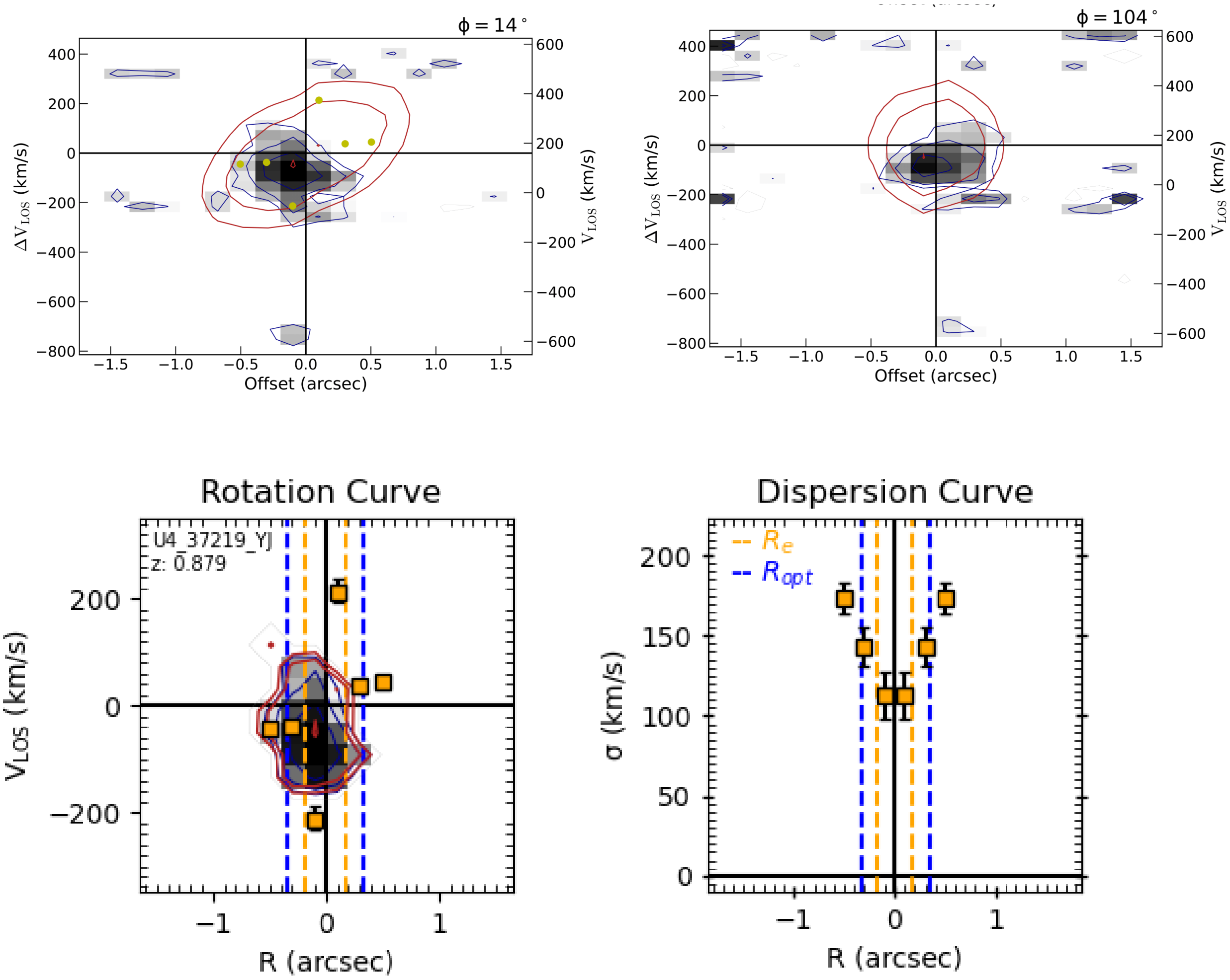


Figure 2.2: U4-37219

2.6.3 COS4-03179

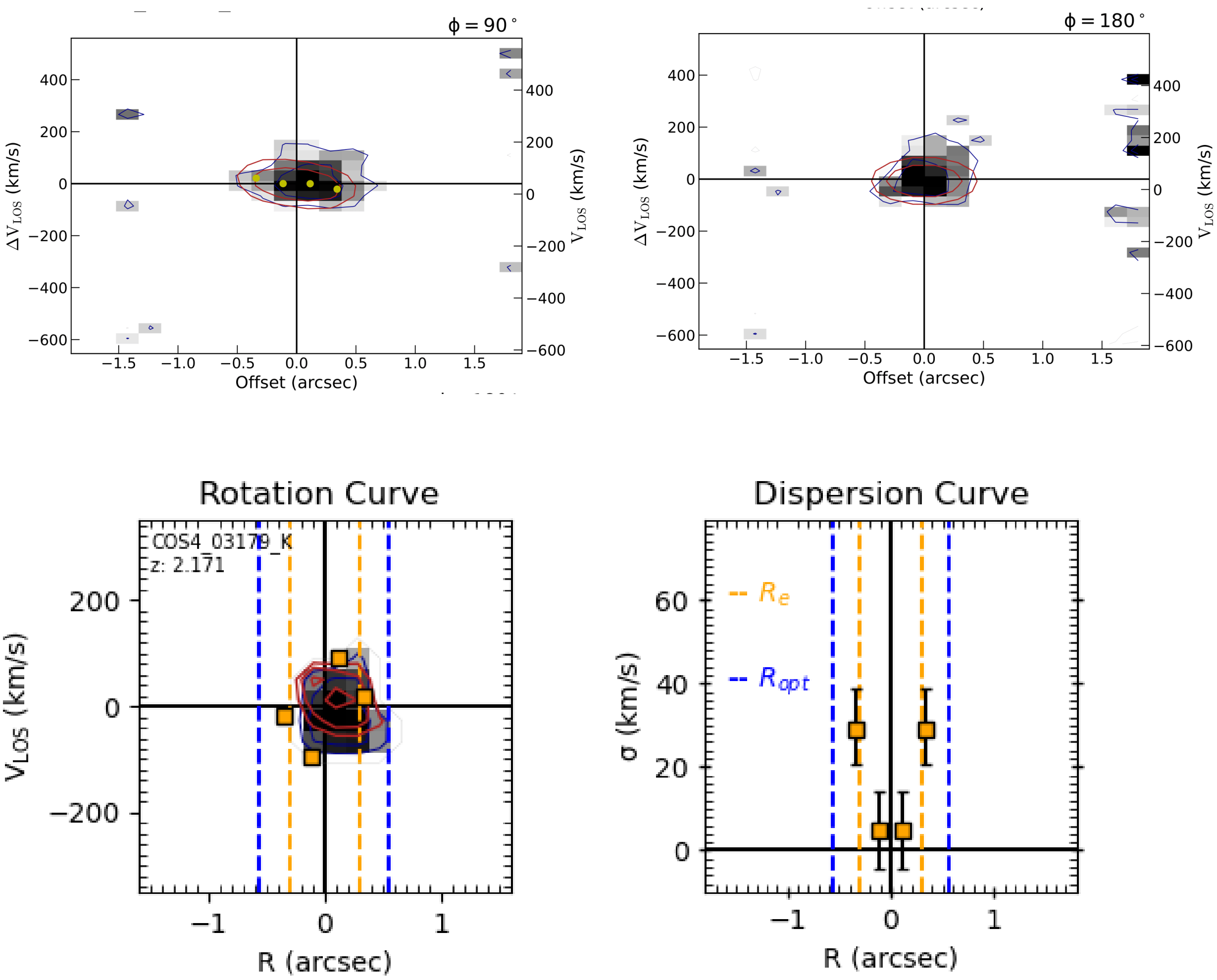


Figure 2.3: COS4-03179

2.7 Future Work

The project "Getting Rotational Curves and Kinematic Moment maps from KMOS Data by Using Bbarolo" is still in progress. On that undertaking, I'm continuing working.

There are 267 galaxies in total, some of which I have already finished. We can learn a lot about the mass distribution, dark matter, and other things from the Rotational Curves and Kinematic Moment Maps of every galaxy.

Bibliography

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[2] EM Di Teodoro and Filippo Fraternali. 3d barolo: a new 3d algorithm to derive rotation curves of galaxies. *Monthly Notices of the Royal Astronomical Society*, 451(3):3021–3033, 2015.

2.8 Abbrevations

KMOS:K-band Multi Object Spectrograph
HST:Hubble Space Telescope
COMOS:Cosmic Evolution Survey
GOODS:Great Observatories Origins Deep Survey
UDS:Ultra Deep Survey
ACS:Advanced Camera for Surveys
WFC:Wide-Field Channel
AEGIS:All-Wavelength Extended Groth Strip International Survey
RA:Right Ascension
DEC:Declination
RC:Rotational Curve
DC:Dispersion Curve
BBAROLO:3D-Based Analysis of Rotating Object via Line Observations
IFU:Integral Field Units
ALMA:Atacama Large Millimeter Array
SKA:Square Kilometer Array
PA:Position Angel
ID:Identity