Studying nearby disk galaxies: NGC3982 a case for the CALIFA Survey

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ABSTRACT

The survey CALIFA, Calar Alto Legacy Integral Field Area Survey, will provide the largest and most comprehensive wide-field IFU survey of galaxies carried out to date, addressing several fundamental issues in galactic structure and evolution. We will observe a statistically well-defined sample of ~600 galaxies in the local universe using 210 observing nights (awarded) with the PMAS/PPAK integral field spectrophotometer, mounted on the Calar Alto 3.5m telescope. The defining science drivers for the project are:

- Model the stellar population & constrain the star formation histories.
- Trace the distribution of ionized gas and estimate gas-phase chemical abundances.
- Measure the kinematic properties of the galaxies, both from emission and from absorption lines. All these quantities will be recovered from maps covering the entire luminous extent of the galaxies in the sample.

The CALIFA project comprises researchers from a large number of institutions worldwide: 8 institution in Spain, 4 in Germany (CAHA funding countries) and 11 elsewhere for a total of 82 researchers. CALIFA will provide a valuable bridge between large single-aperture surveys such as SDSS and more detailed studies of individual galaxies with PPAK (e.g. PINGS), SAURON, VIRUS-P, and other instruments.

SCIENCE DRIVERS FOR CALIFA

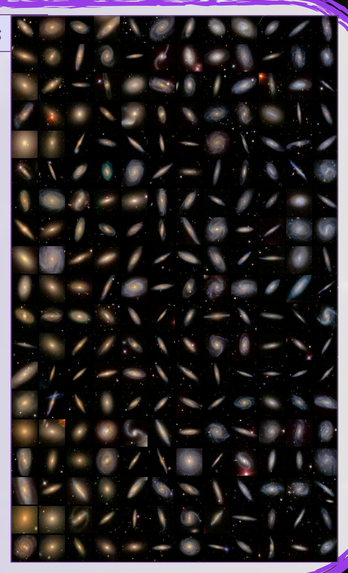
~ GALAXY MASS DISTRIBUTION

~ STELLAR POPULATIONS
- Star formation in green valley galaxies
- Early-type galaxies
- Star formation history of disk galaxies
- Stellar populations and environment

~ PROPERTIES OF THE IONIZED GAS

~ NUCLEAR ACTIVITY IN GALAXIES (AGN)

~ STELLAR AND GAS KINEMATICS
- Kinematic substructures
- Fast and slow rotators
- Chemodynamics
- Scaling relations



OUR INTEREST AT UCM

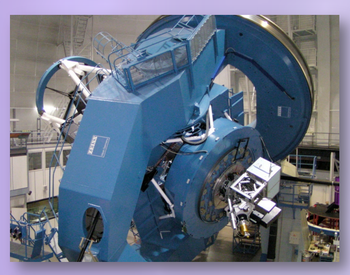
STELLAR POPULATIONS DISK GALAXIES

The formation and evolution of galaxy disks is a complex process as many are the mechanisms that might alter their photometric, chemical, and kinematical properties. Many important questions remain unanswered: How old are the disks seen in the spiral galaxies today? How did they chemically evolve? Are they growing inside-out, as proposed to explain the color and metallicity gradients in our own Milky Way? Do they have an edge? How efficient is the stellar radial diffusion? To well understand the mechanisms governing the evolution of spiral galaxies, and to known precisely the SF and chemical history of these objects is needed. Our effort is committed to add another dimension to the study of nearby disk galaxies thanks to the use of 3D data and to take advantage of large number of *spaxels* provided by these CALIFA observations.

PROPERTIES OF IONIZED GAS DISK GALAXIES

The few studies on the chemical composition of HII regions (that trace the sites of massive SF) at large galactocentric distances suggest that the extended disks are relatively unevolved systems. The study of nebular abundances is therefore crucial for understanding the chemical evolution of galaxies. Our aim is to determine metal abundances at different radii using strong-line methods in order to establish the chemical evolution of disks as a function of galaxy mass and environment. In those cases where T_e measurements would be available we will also improve the empirical calibration of the strong-line methods, again, as a function of radii, galaxy mass, and environment.

CALIFA OBSERVATIONS



The CALIFA observations will be performed using PMAS at the Calar Alto (CAHA, Spain) observatory 3.5m telescope in the PPAK mode (efective FWHM ~1.6" when the 3 dithered pointing are combined). The spectra will be covering the range 3700–7000Å in 2 overlapping setups, the red zone 4300–7000Å @ R~850 and blue one 3700–5000Å @ R~1650. PPAK offers a combination extremely wide FOV > 1' with a high filling factor in one single pointing (65%), good spectral resolution, and sensitivity across the optical spectrum.

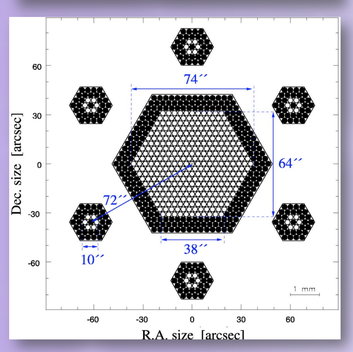


Fig.1 *Cassegrain focus of the 3.5-m telescope in Calar Alto with layout and dimensions of the PPak-IFU.*

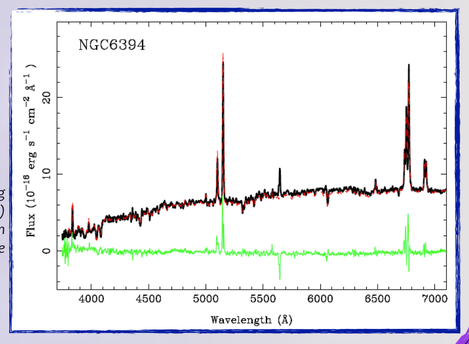


Fig.2 *Typical spectrum extracted from the V500-grating data. We present the PPAK (thick back solid-line) datacubes compared with the corresponding spectrum obtained by the SDSS (thick red dashed-line), and the difference between both spectra (thin green solid-line).*

REFERENCES & INFOS

- Marino, R. A. et al. 2012, 2012arXiv1205.5051M, ApJ in press
- Sánchez, S. et al. 2006, AN, 327, 850
- Sánchez, S. et al. 2012, A&A, 538, A8

THE SAMPLE

The CALIFA survey is obtaining spatially resolved spectroscopic information of a diameter selected sample of 600 galaxies in the Local Universe (0.005< z <0.03). CALIFA has been designed to allow the building of two-dimensional maps of the following quantities: stellar populations (ages and metallicities), ionized gas (distribution, excitation mechanism and chemical abundances) and kinematic properties. We chose diameter limits of 45" < D_{25} < 80" which allows covering the entire galaxy in one single PPAK field. This parent sample covers a substantial fraction of the galaxy LF at this redshift.

The CMD is also well covered and well-sampled with enough galaxies to perform proper statistical analysis. We will cover a range of ~7 mag in luminosity and ~2 mag in color, with about ~40 objects in each box of 1 × 0.5 mag. We estimate that there are over 200 early-type galaxies in our sample. On the other hand, 2/3 of the galaxies in the CALIFA sample are disk-dominated. The sample is dominated by field galaxies, but will effectively include galaxy populations in groups, low-density clusters, and even dense environments such as the Coma cluster which is fully covered by the CALIFA footprint and redshift range.

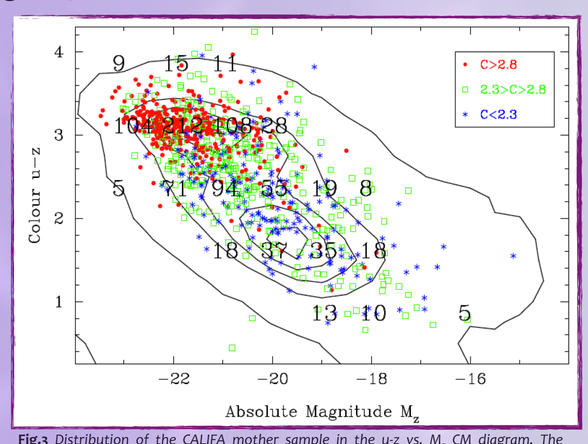


Fig.3 *Distribution of the CALIFA mother sample in the u-z vs. M_z CM diagram. The overplotted numbers indicate the number of galaxies in bins of 1 mag in M_z and 0.75 mag in u-z. Diferent colours and symbols represent a classification into bulge- and disk-dominated galaxies as well as intermediate cases, as suggested by the concentration index C.*

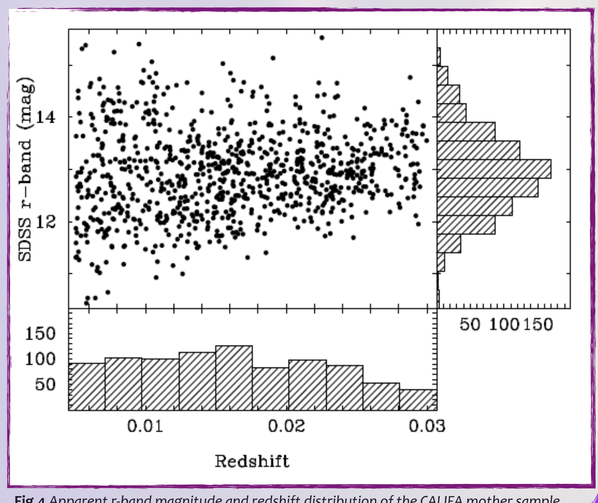


Fig.4 *Apparent r-band magnitude and redshift distribution of the CALIFA mother sample.*

THE CASE OF NGC3982

We have observed the nearly face-on spiral galaxy NGC3982 with the PPAK IFU of PMAS at the Calar Alto (CAHA, Spain) observatory 3.5m telescope. We used the PPAK mode that yields a total field-of view (FoV) of 74x64", hexagonally packed covering a range of 3700-7131Å (R = 500). The reduction was carried out using R3D and following the procedures described in Sánchez et al. (2006) as showed below.

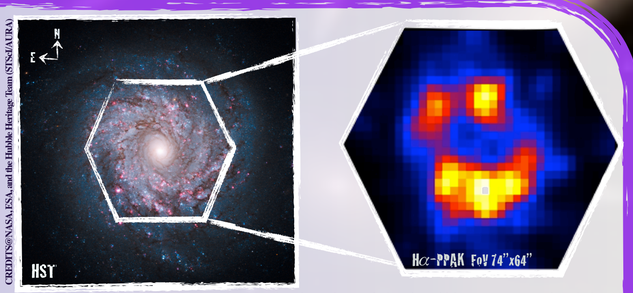
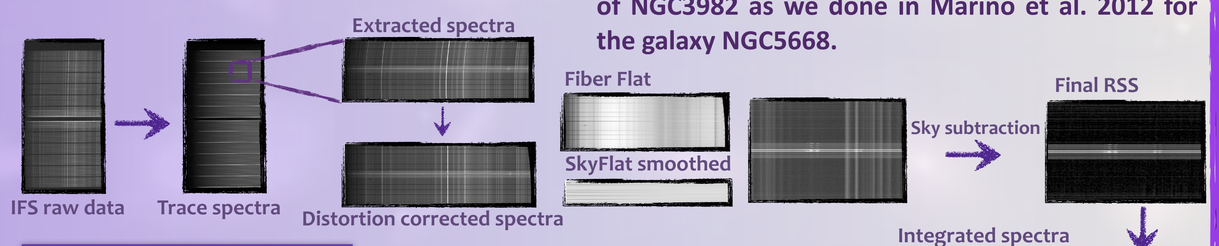


Fig.5 ***Left:*** *HST composite image of NGC3982, the color code is V-band blue-cyan, Hα red and I-band red-yellow.* ***Right:*** *Hα PPAK synthetic map of NGC3982.*

We are carring out an extensive and detailed study of the chemical and photometric properties of NGC3982 as we done in Marino et al. 2012 for the galaxy NGC5668.



NAME	NGC3982		
TYPE	SAB(rJb: : HII - Sy 1.9	DISTANCE	21.973 ± 2.212 Mpc
RA (2000)	11^h 56^m 28.129^s	INCLINATION	29.9º
Dec (2000)	+55º 07' 0.86"	POSITION ANGLE	25.1º
I MAGNITUDE	11.12 ± 0.30 mag	MAJOR DIAMETER	1.69'
B MAGNITUDE	11.77 ± 0.33 mag	MINOR DIAMETER	1.49'
L_{bol}	4.5 x 10^{42} erg/s	REDSHIFT	0.003699± 0.000020
RADIAL VELOCITY	1239 ± 6 km/s	SFR Ha	0.52 $M_\odot$/yr

Table 1. Main properties of NGC3982.

Fig.6 *The integrated-fibers spectrum of NGC 3982 is shown as a solid line. The SDSS g' and r' band photometry data are shown as blue squares.*

CALIFA: A NEW ERA FOR DISKS

The formation and evolution of galaxy disks is a complex process as many are the mechanisms that might alter their photometric, chemical, and kinematical properties. The study of NGC3982 demonstrates the strength of the combination of IFU and multi-wavelength imaging data. Our effort is committed to add another dimension to the study of nearby disk galaxies thanks to the use of 3D data and to take advantage of large number of *spaxels* provided by these CALIFA observations.

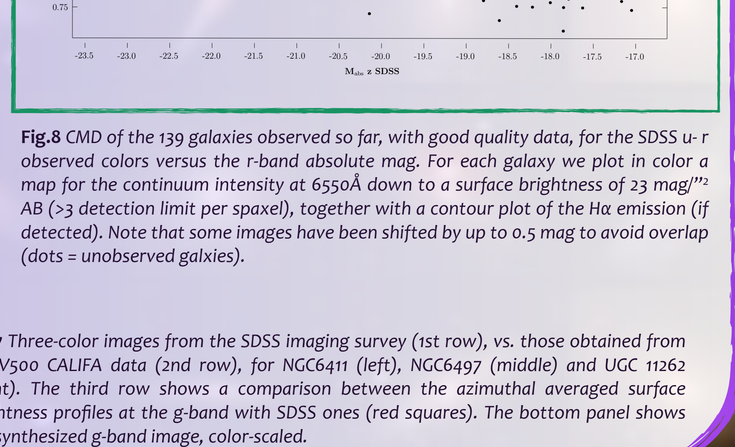


Fig.8 *CMD of the 139 galaxies observed so far, with good quality data, for the SDSS u- r observed colors versus the r-band absolute mag. For each galaxy we plot in color a map for the continuum intensity at 6550Å down to a surface brightness of 23 mag/"² AB (>3 detection limit per spaxel), together with a contour plot of the Hα emission (if detected). Note that some images have been shifted by up to 0.5 mag to avoid overlap (dots = unobserved galxies).*

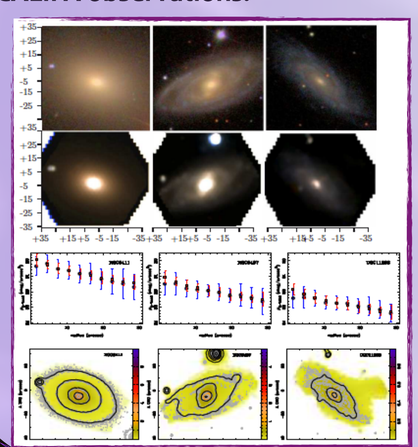


Fig.7 *Three-color images from the SDSS imaging survey (1st row), vs. those obtained from the V500 CALIFA data (2nd row), for NGC6411 (left), NGC6497 (middle) and UGC 11262 (right). The third row shows a comparison between the azimuthal averaged surface brightness profiles at the g-band with SDSS ones (red squares). The bottom panel shows the synthesized g-band image, color-scaled.*