# A review of (sub)mm band science and instruments in the ALMA era



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EUROPEAN ARC ALMA Regional Centre || Italian SISSA – March 2018

# <u>Outline</u>



## CASA

CASA (Common Astronomy Software Applications) is the designated data analysis package for ALMA and the JVLA.

Used for all offline processing of ALMA data.

CASA is developed by NRAO, ESO, and NAOJ (under NRAO management); for details see http://casa.nrao.edu e.g., Petry et al., 2012, "Analysing ALMA data with CASA", ADASS XXI, ASP conf., 461, 849

Latest release is CASA 4.7.1.

The ALMA pipeline is an optional add-on of CASA, not available in all the past CASA versions.

CASA deals with data files in the Measurement Set (MS) structure.

- Tutorial on CASA
  - ssh -cX scheduler@ira.inaf.it
  - User: almauser#
  - Pwd: alma#passwd

>casapy-setup

>casa

[#]> viewer()

# Exercise:

- Open image with CASAviewer
- Extract flux and noise
- Extract spectral line spectrum
- Determine source redshift
- Compute momentum maps
- Estimate integrated line emission

# Peak flux and flux density



In each pixel we measure the integrated flux in the synthesized beam (Jy/beam)

#### sdp9.cont.image-raster

+8.83403e-05 Jy/beam Pixel: 879 937 0 0 09:07:39.996 -00.41.59.240 I 187127 km/s (topo/radio velocity)

## The flux density is the integrated flux over the selected area (Jy)

Regions											
Properties	Statistics Fit File Histogram										
-sdp9.cont.image											
Stokes	Velocity	- Frame	<ul> <li>Doppler</li> </ul>								
L	187127km/s	LSRK	RADIO								
Frequency 2.59864e+11	BrightnessUnit Jy/beam	— BeamArea —	- Npts								
Sum 2.679466e-02	FluxDensity 4.831792e-04	— Mean 9.603820e-05	- Rms 1.025743e-04								
Std dev 3.609459e-05	Minimum 2.388688e-05	Maximum 1.641514e-04	<ul> <li>region count</li> <li>1</li> </ul>								

# Image noise and flux errors



The uncertainty in the measured flux is:

 $\sqrt{(rms)^2 + (0.10 \times F)^2}$ 





Found 95 lines, showing 1 - 95 Click on the chemical formula below for more information about that species.

0	Species	Chemical Name	Ordered Freq (GHz) (rest frame, redshifted)	<b>Resolved QNs</b>	CDMS/JPL Intensity	Lovas/AST Intensity	E <sub>L</sub> (cm <sup>-1</sup> )	Е∟ (К)	Linelist
1	COV = 0	Carbon Monoxide	115.27120180, 115.27120180	1-0	-5.01050	60.0	0.0000	0.0000	CDMS
2	COV = 0	Carbon Monoxide	230.53800000, 230.53800000	2-1	-4.11970	70.	3.8450	5.5321	CDMS
3	COV = 0	Carbon Monoxide	345.79598990, 345.79598990	3-2	-3.61180	70.00	11.5350	16.5962	CDMS
4	COV = 0	Carbon Monoxide	461.04076820, 461.04076820	4-3	-3.26570	60.	23.0695	33.1917	CDMS
5	CO v = 0	Carbon Monoxide	576.26793050, 576.26793050	5-4	-3.01180		38.4481	55.3179	CDMS
6	COV = 0	Carbon Monoxide	691.47307630, 691.47307630	6-5	-2.81930	100.	57.6704	82.9744	CDMS
7	COV = 0	Carbon Monoxide	806.65180600, 806.65180600	7-6	-2.67160	110.	80.7354	116.1596	CDMS
8	COV = 0	Carbon Monoxide	921.79970000, 921.79970000	8-7	-2.55900		107.6424	154.8725	CDMS
9	COV = 0	Carbon Monoxide	1036.91239300, 1036.91239300	9-8	-2.47510	17.5	138.3904	199.1118	CDMS
4.0	00 0	C 1 11 11	44E4 00E 10000 44E4 00E 10000	10.0	0 14500	100000000000000000000000000000000000000	470 0700	010 0750	00110







# The signals





The spectrum of each molecular cloud in the submm is rich of rotational molecular transition ladders and atomic fine structure lines, which shapes and relative abundances can be used to trace physical and dynamical properties of the ISM and the mechanisms of SF and AGN activity In the local and high-z Universe.

# The instruments



# Why should I go (sub)mm?

# Why shouldn't I go (sub)mm?

# Enjoy the ALMA era!

ALMA science portal: almascience.eso.org

ALMA archive: almascience.eso.org/alma-data/archive

ALMA documents and tools: almascience.eso.org/documents-and-tools

Italian ARC node: www.alma.inaf.it

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