Prospects with ALMA Leonardo Testi ESO







ALMA and its Science Goals ALMA and Solar Mass Stars ALMA Status, Early Science and Full Science Operations

Atacama Large Millimeter Array



- At least 50x12m Antennas
- Frequency range 30-1000 GHz (0.3-10mm)
- 16km max baseline (<10mas)
- ALMA Compact Array (4x12m and 12x7m)
- 1. Detect and map CO and [C II] in a Milky Way galaxy at z=3 in less than 24 hours of observation
- 2. Map dust emission and gas kinematics in protoplanetary disks
- 3. Provide high fidelity imaging in the (sub)millimeter at 0.1 arcsec resolution







ALMA Science Requirements

+ High Fidelity Imaging.

Precise Imaging at 0.1" Resolution.

- Routine sub-mJy Continuum Sensitivity.
- Routine mK Spectral Sensitivity.
- Wideband Frequency Coverage.
- Wide Field Imaging Mosaicing.
- Submillimeter Receiver System.
- Full Polarization Capability.
- System Flexibility.





Technical Specifications

- ◆ 54 12-m antennas, 12 7-m antennas, at 5000 m site
- Surface accuracy ±25 μm, 0.6" reference pointing in 9m/s wind,
 2" absolute pointing all-sky.
- Array configurations between 150m to ∼16km.

10 bands in 31-950 GHz + 183 GHz WVR.

✤ 8 GHz BW, dual polarization.

Flux sens. 0.2 mJy in 1 min at 345 GHz (median cond.).

- Interferometry, mosaicing & total-power observing.
- Correlator: 4096 channels/IF (multi-IF), full Stokes.
- Data rate: 6MB/s average; peak 60-150 MB/s.
- All data archived (raw + images), pipeline processing.





Front Ends

Chajnantor - 5000m, 0.25mm pwv



Sensitivity and Resolution







ALMA Science

- Star Formation, Proto-planets in nearby disks
- Astrochemistry
- Interstellar medium (Galaxy, Local Group)
- High-redshift deep fields

+ ALMA Science is for everyone

- High resolution/sensitivity 3D instrument at mm-wl
- 100% service observing with full dynamic scheduling
- Complete e2e data flow system
- · Science quality images (cubes) delivered to the users
- Raw, calibrations, pipeline processed data and recipes in archive
- Friendly and widespread User Support through ARCs
- + 130 projects in first 3yrs DRSP 2.0
 - http://www.eso.org/sci/facilities/alma/science/drsp/















Multiplicity, disk vs pseudodisk, role of B

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Disk Evolution

 There is evidence that disk evolution and planet formation systems may occur on timescales of a few million years





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Scattered light: Burrows et al. 1995

Gas density maxima and grain trapping





Birth of Planets





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ISM Molecules

	H_2	HD	H ₃ +	H_2D+					
	СН	CH ⁺	C ₂	CH ₂	C_2H	*C ₃			
	CH ₃	C_2H_2	C ₃ H(lin)	c-C ₃ H	*CH ₄	C_4			
	$c-C_3H_2$ $H_2CCC(lin)$		C_4H	*C ₅	*C ₂ H ₄	C_5H			
	$H_2C_4(lin)$	*HC ₄ H	CH_3C_2H	C ₆ H	*HC ₆ H	H_2C_6			
	*C ₇ H	CH_3C_4H	C ₈ H	*C ₆ H ₆		_ •			
	OH	CO	CO+	H ₂ O	HCO	HCO+			
	HOC+	C_2O	CO_2	H_3O+	HOCO+	H ₂ CO			
	C ₃ O	CH ₂ CO	HCOOH	H ₂ COH+	CH ₃ OH	CH ₂ CHO			
	CH ₂ CHOH	_	CH ₂ CHCH	0	HC ₂ CHO	C_5O	CH ₃ CHO	$c-C_2H_4O$	
	CH ₃ OCHC	CH ₂ OHCH	-0	CH ₃ COOH	CH ₃ OCH ₃	CH ₃ CH ₂ OF	+ CH ₃ CH ₂ (СНО	
	(CH ₃) ₂ CO HOCH ₂ CH ₂ OH			$C_2H_5OCH_3$ (CH ₂ OH) ₂ CO					
	NH	CN	N_2	NH ₂	HCN	HNC			
	N_2H^+	NH ₃	HCNH ⁺	H ₂ CN	HCCN	C_3N			
	CH ₂ CN	CH ₂ NH	HC ₂ CN	HC ₂ NC	NH ₂ CN	C ₃ NH			
	CH ₃ CN	CH ₃ NC	HC ₃ NH⁺	*HC ₄ N	$C_5 N$	CH ₃ NH ₂			
	CH ₂ CHCN HC ₅ N		CH ₃ C ₃ N	CH ₃ CH ₂ CN HC ₇ N		$CH_3C_5N?$	HC ₉ N	$HC_{11}N$	
	NO	HNO	N20	HNCO	NH2CHO			, in the second s	
	SH	CS	SO	SO+	NS	SiH			
	*SiC	SiN	SiO	SiS	HCI	*NaCl			
	*AICI	*KCI	HF	*AIF	*CP	PN			
	H ₂ 5	C ₂ S	50 ₂	005	HCS+	C-SIC ₂		DEMIRM	*
	SICN	[°] SINC	^INACIN	^IMIGUN	^IVIGNC *с:ц	^AINC			*
Lednardo Testi: ALMA & Solan Mass Stars, 5 Mar 2010 SIG4									
	$\Box \Box_3 \Box \Box$	U50	FEO						ALM



Complex Organic Molecules Detected Not (yet) detected



Acetic acid



Ethanol



Di-methyl ether



Sugar





Methyl cyanide **Methyl formate**







How far does chemical complexity go? Can we find pre-biotic molecules in Disks?





Pyrimidine



Caffeine













Purine



Glycine

AGB Stars



Discussed in K. Menten talk!

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ALMA In Search of our Cosmic Origins

Dec 2009

First Fringes at OSF







ALMA

First antenna at 5000m









Closure phase



Time (hrs)

- Closure phase achieved at the end of 2009
- CSV started on Jan 22, 2010

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ALMA CSV, Early and Full Science

CSV Team

- Sci IPT plus Ops Astr.
- Community involvemer
- > SV call for ideas in ear
- + Early Science: 16 ants, at
 - Configurations probabl
 - ➢ Bands: 3mm, 1.3mm, (
 - > We expect to issue the
 - Demonstration/Tutorial
- Science Operations >75% expected in 2012



Leonardo Testi: ALMA & Solar Mass Stars



Dear all, we are glad to present the third issue of the ALMA newsletter. The Atacama Large Millimeter/submillimeter Array (ALMA) will be a (sub)millimeter wave interferometer consisting of at least 66 antennas located on the Chajnantor plateau in the Atacama Desert of northern Chile at 5000m altitude. As ALMA makes progress in construction and transitions into operations, we will seek to keep the scientific community abreast of the latest information with a high-level account of events, including summaries of ALMA meetings and the achievement of major milestones. In so doing, this newsletter is a reflection that the project is becoming a real observatory which will serve the global community.

Read more >



Focus on...

On September 17, the first ALMA antenna was brought to the Array Operations Site (AOS) at 5000m



Progress with contruction at the AOS and OSF

At the AOS, antenna pads, power and signal connections are being constructed to get AI MA ready for



ALMA Events

This section contains some details and pictures about the last ALMA Commissioning and Science

ALMA Science Operations sites OSF, Santiago and the ARCs









ALMA

ALMA Operations: Three ALMA Regional Centres - ARCs



ALMA beyond ALMA

- ALMA will allow transformational science thanks to the sensitivity, angular resolution, spectral coverage and image fidelity, but...
- The baseline ALMA project will only achieve a fraction of the full potential of the site and instrument
- Incomplete Receiver Complement
- Limited Wide Field Capabilities
- Limited Correlator and Data Rate Capabilities
- Extended baselines (30-50km), VLBI (200-10000km)
- Advanced Calibration, Software, Science Tools....



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Examples of Scientific Limitations

- Limited Band 5 Complement
 - ➢ Eu FP6 6 B5: just a glimpse at B5
 - ➤ Water in the Universe
 - > [CII] in the range 8 < z < 11
- <u>No Band 1 & 2</u>
 - ➢ High-z low excitation CO
 - Sunyaev-Zeld'ovich effect
 - Dust Evolution in Protoplanetary Disks
- Limited correlator capabilities
 - Line surveys, chemistry studies very time consuming
- <u>Continuum Wide Field Mapping Efficiency</u>
 - SZ and Molecular Clouds applications very time consuming
 - Instantaneous wide field of view for solar physics



183 GHz H2O maser in NGC3079 (SMA, Humphreys et al 2005)



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The ALMA Development Program

- ALMA development budget is proposed to ramp up starting in 2013 to reach ~10M\$/yr from ~2015
- A process has been initiated to plan the development program
- Working Group has prepared a preliminary report, this has been integrated with other ideas from project and community
- Next steps:
 - Feasibility and order of magnitude cost/effort estimate
 - Evaluation of technical readiness
 - Possible impacts on other aspects of the project
- Aim to maintain ALMA at the forefront of astrophysics in the ELT
 and SKA era

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