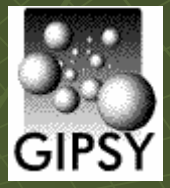
ALMA 3D: VO-compliant archive and datacube analysis



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Spanish exploitation of ALMA
Madrid 18 June 2008

AMIGA
Analysis of the Interstellar Medium of Isolated GAlaxies

OUTLINE

- **Context:** AMIGA project
- **Motivation:** ALMA, e-Astronomy
- **Previous work:** VO-archives & tools
- **ALMA exploitation:** VO-compliant
  - Archive
  - Tools for high level analysis

ASTRONET proposal

Kapteyn Institute, IAA, Obs. Paris, SVO +

interest from ALMA European Computing Manager

CONTEXT

AMIGA project:

Analysis of the interstellar Medium of Isolated GAlaxies

Starts in 2003 @IAA with funding from PNAYA

Since 2006 Coordinated project (L. Verdes-M)

IAA-group + IRAM-30m @ Granada (PI R. Mauersberger)

+ International collaboration:

Obs. Marseille, Obs. Paris, CfA, ASIAA-Taiwan, MPIfA (Bonn), Univ. Alabama, UMASS, Mc Donald Observatory,Arcetri, UNAM, IAC, Kapteyn Institute

CONTEXT

Need for a reference sample of isolated galaxies

Multiwavelength statistical study of ISM ~1000 galaxies

Build & analyse the catalog (ISM – SF – AGN)

Make it public: VO interface with search utilities

Results

10 +1 Papers + 1 submitted

PhD: 1-2005, 1-2006, 2-2008, 1- 2009, 2- 2010

MOTIVATION: ALMA

Interests:

ISM in galaxies and connection with dynamics, SF, nuclear activity, bars

Based on intensive analysis of 3D data:

need for powerful soft package for datacube analysis

Observational expertise:

- single dish + interferometry
- cm, mm, extension to submm:

- intensive use of SMA

- calibration tasks for SMA (participation in ALMA CSV)

(See Dani Espada's talk)

MOTIVATION: e-Astronomy

We find:

- Few radio data available in archives (not to mention VO…)
- Optical/IR data more often available, but too diverse queries
- VO Essential for multi-λ astronomy

VO is part of general context of e-Science:

enhanced Astronomy

Actions:

Start to work on radio-VO: access + exploitation of archives

Lead 1st activity to coordinate regional e-Science:

e-CA project (e-Ciencia Andaluza)

Funded as *Proyecto de Excelencia* by *Junta de Andalucía*

Involves > 40 research groups + companies

PREVIOUS WORK: ARCHIVES

- DSS-63 Robledo antenna (+LAEFF-INTA)
- 30m-IRAM

No data model existed for radioastronomical data

RADAMS:

Radio Astronomy DAta Model for Single-dish telescopes

- VO-compliant: based on existing IVOA data models + development of new specific standards
- Extensible: additional metadata can be provided for different instruments, observing modes, switching modes…

(J. Santander 2006, DEA; IVOA Note 0.66, Sep 06)

PREVIOUS WORK: TOOLS

- Existing VO-enabled analysis tools are mostly optical
- Existing radio astronomy tools not VO-aware

Need for VO-enabled radio oriented analysis tools

Solution: INTEROP

Not producing new soft but adding VO functionalities

Intercommunication in the least intrusive way

PREVIOUS WORK: TOOLS

MOVOIR Development

MOdular Virtual Observatory Interface for Radio-astronomy

Tools: MASSA/MADCUBA (Herschel packages for HIFI, usable with 30m data developed by J. M. Pintado's group)

Data services:

Access to standard FITS imported by the MOVOIR from VO SDSS, HST, MAST, FUSE, IUE, ISO, XMM-Newton, VizieR, AMIGA*, IRAM 30m*, Robledo*…

Applications

Aladin, Topcat, VOPlot, Mirage…

PREVIOUS WORK: EXPERTISE

Last but not least: **since 2005 formation of a team of 3 software developers with complementary profiles**

- Development of scripts for access to antenna data: filling VO data bases
- Design of IVOA standards: data modeling and VO communication protocols (part of Data Model Working Group of IVOA)
- Interfaces for use cases: web services for query and access to VO data

Fully integrated in the scientific team

1 PhD in 2008 to be followed by a postdoc, 1 PhD starting

ALMA EXPLOITATION

Key to the success of ALMA:

data accessible to the community at large, not only domain of experienced radio astronomers.

This requires access to:

- well documented+intuitive tools to inspect+analyse 3D data
- existing VO tools widely accepted by the community (e.g. Aladin, VOSpec, Topcat, etc)
- complementary data sets at same or different wavelengths

ALMA EXPLOITATION

- ASA Requirements Document states that ALMA Science Archive (ASA) will be VO-compliant.

Work planned and budgeted: core functionalities

- Support for proposals preparation via the ARCs
- Automatic processing: fully calibrated science products
- Data reduction: CASA

  Transformation UV-image

  Spectral line analysis, fitting, catalogs

  Fundamental image structure: cubes

  Processing of cubes (integration, rotation, filtering, clipping)

  Visualization + specific tools for SS objects and pulsars

ALMA EXPLOITATION: ARCHIVE

Planned collaboration with ESO-Archive team (pending on finantial support for 1 FTE):

- support from head of the Archive
- inputs from Archive Users
- interaction with IVOA Data Modeling Working Group

-Characterization of the ALMA Archive:

- study the relationship between Archive XML Schema, SQL structure, and ALMA Science Data Model (ASDM)
- mapping between the ASDM and VO Data Models

ALMA EXPLOITATION: ARCHIVE

-Development of a Radio Data Cube Data Model (RDCDM) suitable for the ASA, to be submitted for approval and discussion to the DMWG

Development of a suitable IVOA data model for radio-astronomical data cubes

-VO services:

- analysis of ASA Requirements draft Use Cases stating which use cases can be provided by already existing VO services
- VO spectral and image services will be deployed and tested

ALMA EXPLOITATION: TOOLS

High-level analysis tools for 3D data

- ALMA not expected to have them (ALMA community day 2007, 3D-2008 meeting last week)

- GIPSY (Groningen Image Processing System, developed at Kapteyn AI) one of oldest + most powerful systems available

GIPSY upgrade and integration in the VO, full compatibility with ALMA data, usability in order to make it available to a larger user base

Collaboration IAA, Kapteyn Institute, SVO and Obs. Paris

ALMA EXPLOITATION: TOOLS

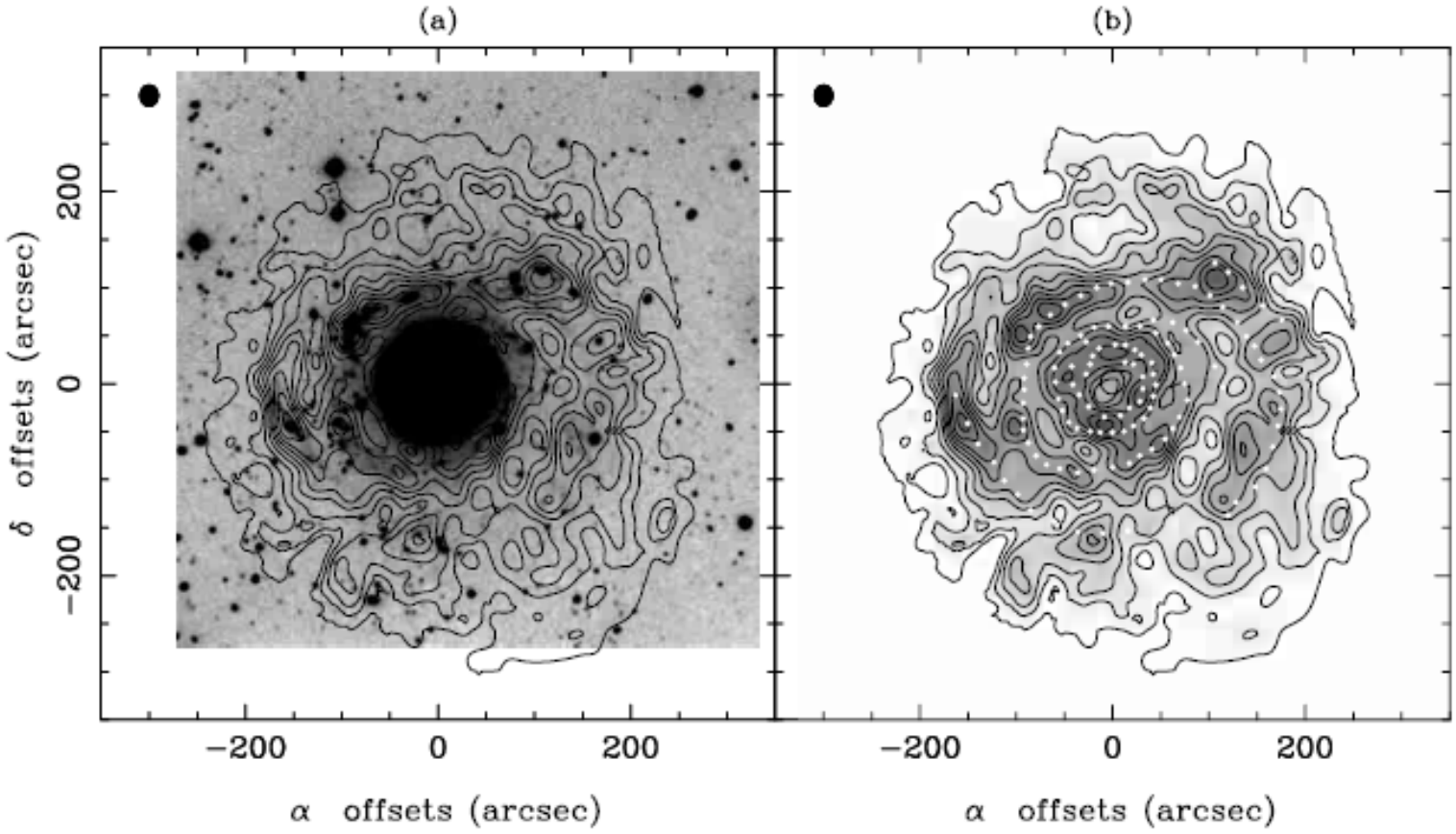

Fig. 6. a) Contour map of the HI column density distribution in NGC 3642 overlapped on the R image. The contours are 1.1, 3.4, 5.6, 7.9, 10.2, 12.4, 14.7, 16.9, 19.2 and 21.4×10^{20} atoms cm^{-2}. b) Greyscale map of the HI column density distribution with contours as in a). The main features are marked as dots. The synthesized beam ($21\farcs4 \times 18\farcs4 - \alpha \times \delta$) is plotted in the upper left of both panels.

ALMA EXPLOITATION: TOOLS

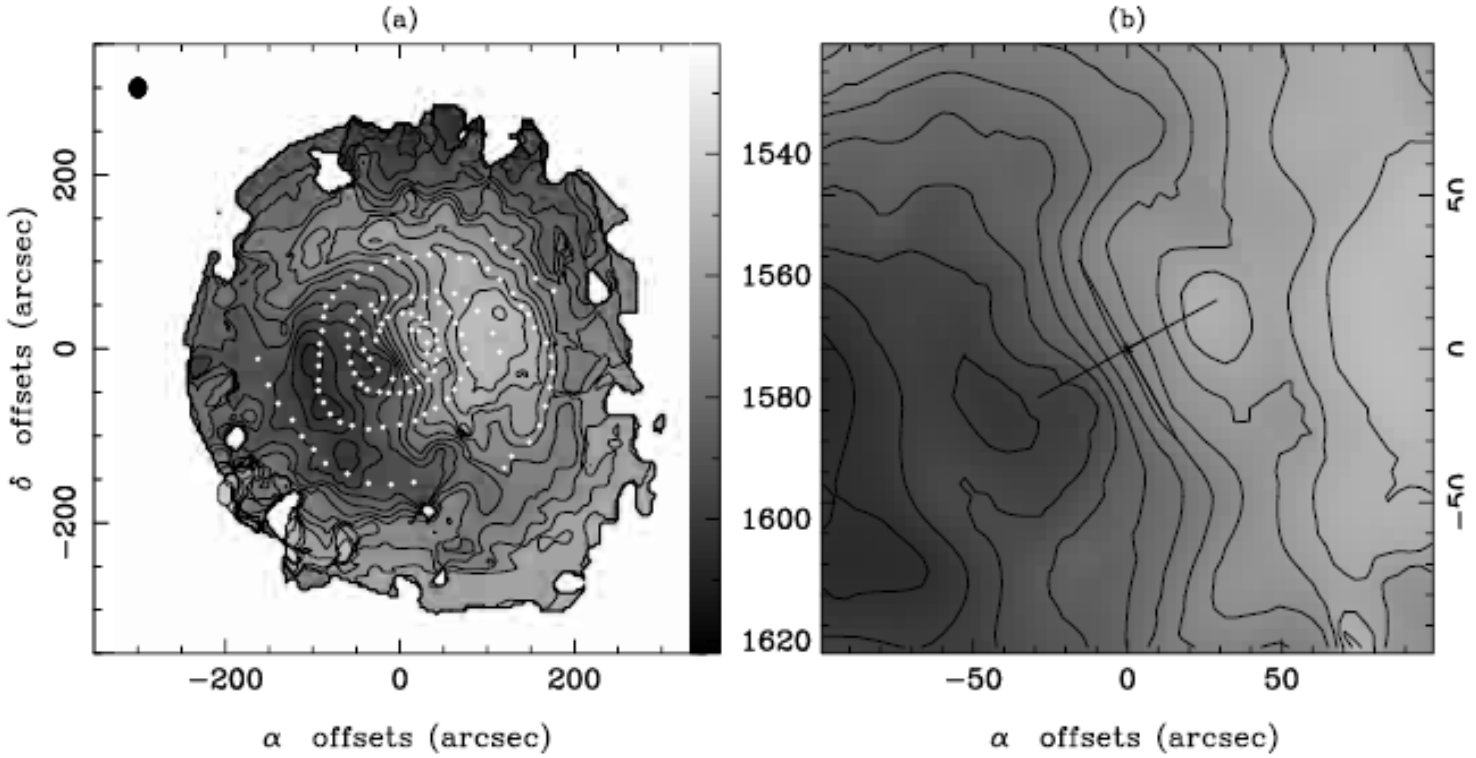

Fig. 7. a) Map of the first–order moment of the radial velocity field where both iso-velocity contours and greyscale are shown for clarity. The scale goes as in the wedge, where the numbers indicate heliocentric velocities in km s^{-1}. The contours go from 1532 to 1602 km s^{-1} with a step of 5 km s^{-1}. The main spiral features are marked as dots. The straight line indicates the direction of the position-velocity cut shown in Fig. 8. The beam size is $21.''4 \times 18.''4$ and is plotted in the upper left. b) Central part of the velocity field shown in a). The major and minor axis directions are indicated, and a cross indicates the optical center position (see Sect. 3.2).

ALMA EXPLOITATION: TOOLS

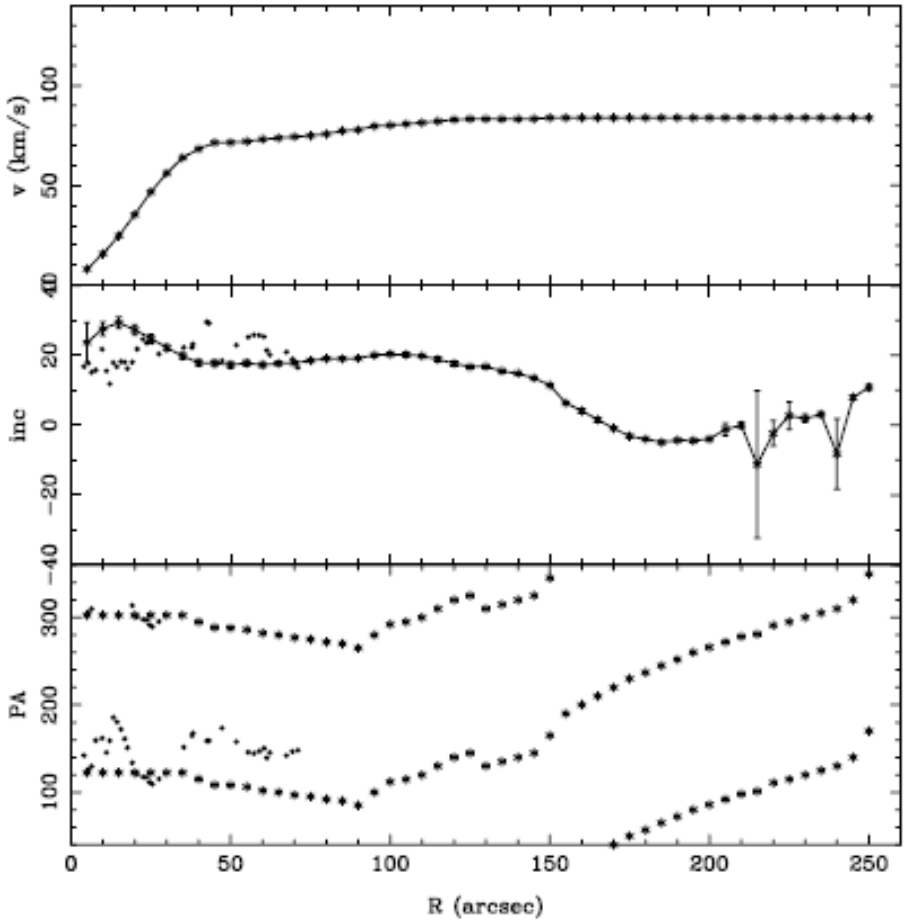

Fig. 9. a) Rotation curve assumed for the modelling of the velocity field. The best fit to this curve and to the observed velocity field is given by the combination of inclination and position angle plotted in b) and c) respectively. Filled dots correspond to the isophotal fitting of the optical *R* image (Fig. 4). Angles are measured from North to East.

Obtained with ROTCUR task

ALMA EXPLOITATION: TOOLS

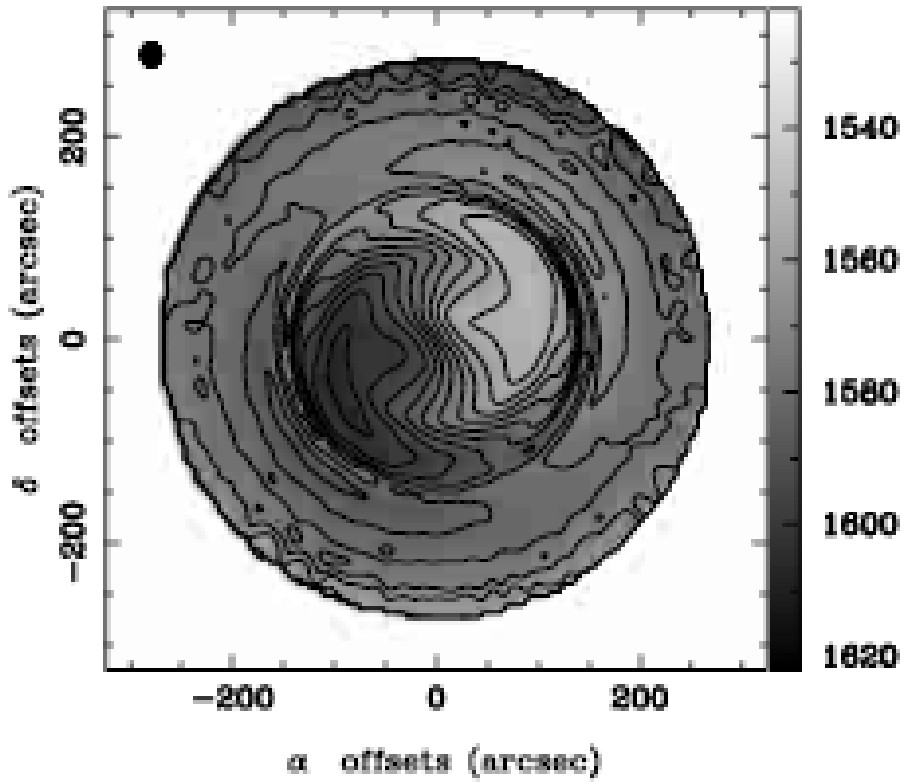

Fig. 10. First-order moment of the modeled channel maps obtained with the geometrical parameters plotted in Fig. 9.

Obtained with GALMOD task

ALMA EXPLOITATION: TOOLS

Definition of functional and technical specifications:

Use cases will be elaborated by scientists via a survey

Intuitive graphical user interfaces:

Needed to fully exploit the potential of GIPSY

Ensure data compatibility, in particular with ALMA archive:

Integration in the data environment of ALMA and the CASA core system

Implementation of VO tools:

interoperability ensures communication with any data provider or service included in a VO-Registry (catalogs, images, spectral libraries, etc)

Coordinated integration of GIPSY + ALMA archive in VO

CONCLUSIONS

Aimed contribution to

- ALMA VO-compliant archive
- First high-level, friendly, VO-aware analysis package for radio 3D data, applicability to multiλ datasets fully compatible with ALMA
- IVOA standards to cube data models

Non “measurable” results: Formation of a group where developers of radio-VO software (few in the world!) for ALMA work in **direct contact** extragalactic scientists preparing to make the best use of ALMA