Microwave radio astronomy in Ukraine

Oleksii Patoka

Who we are:

Credit by Alisa Shevtsova

Who we are:

Credit by Alisa Shevtsova

Department of Millimeter Wavelength Radio Astronomy

was founded in 1996

Who we are

Our Leader is Professor

Valery Shulga

Doctor of Physical and Mathematical Sciences, Academician of the National Academy of Sciences of Ukraine

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Valery Shulga

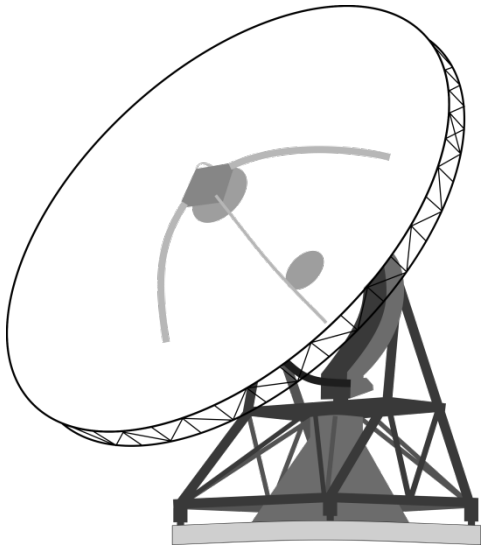
Doctor of Physical and Mathematical Sciences, Academician of the National Academy of Sciences of Ukraine

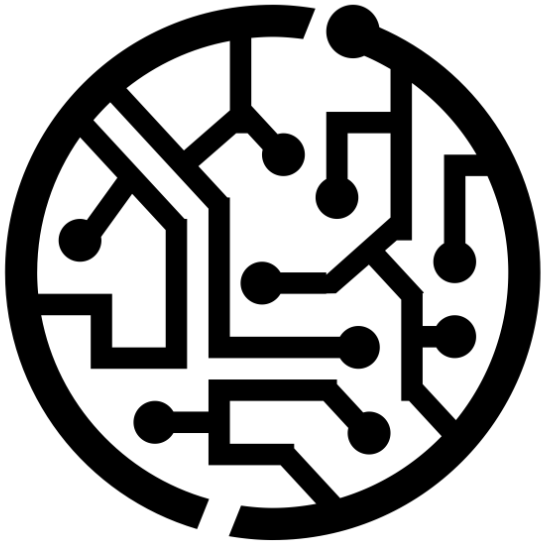
STAFF

8 researchers

7 engineers

Who we are





Created by Rohith M S
from Noun Project

Are not official logos

Radioastronomical observations, Astrophysics

R&D
Receiver systems

Dynamics in the mesosphere.

Receiver systems

RT-22, Crimean Astrophysical Observatory, Ukraine

Receiver systems

A 3mm cryogenic mixer receiver

Frequency range:

85-115 GHz

T_{rec} = **55 K** at the 110 GHz (DSB)

Piddyachiy et al. 2005

doi: 10.1007/s10762-005-7605-6

FFT Spectrometer

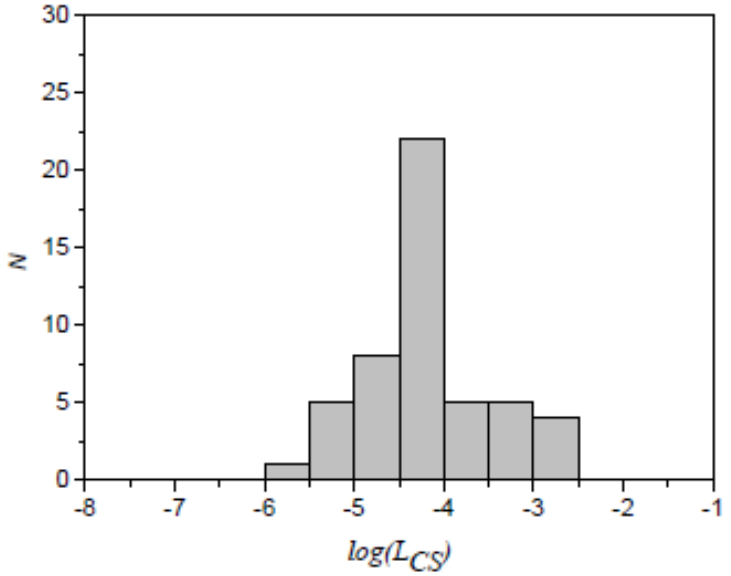
Frequency bandwidth:

14 or 8 MHz

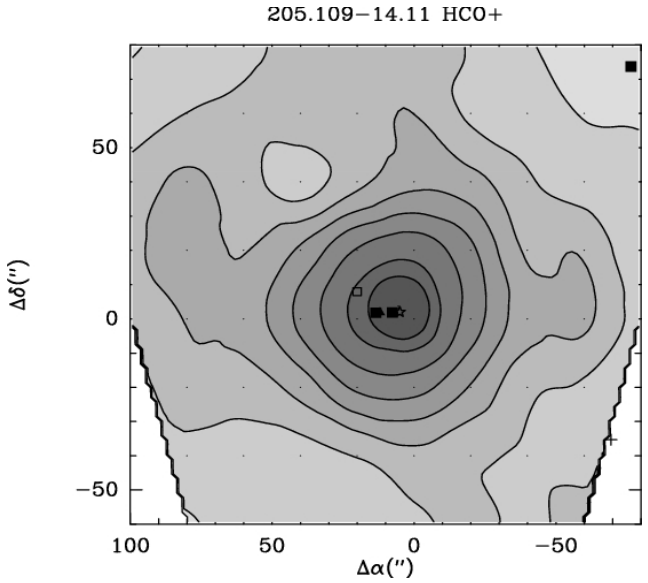
Number of channels = 2048

Antyufeyev et al. 2005

Regions with Methanol Masers



Survey of Regions with Methanol Masers in the CS (J = 2–1) and HCN(J=1-0) Lines



Studies of massive cores with complex spatial and kinematic structures

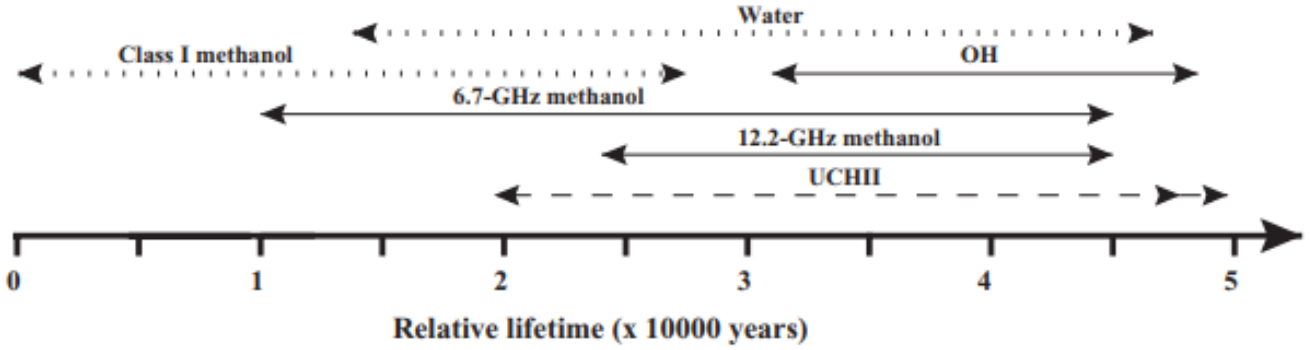
Regions with Methanol Masers

Survey of Regions with Methanol Masers in the CS (J = 2–1) Lines

2007–2013

164

We compiled the most complete catalog
of the emission parameters in the CS (*J* = 2–1) line towards of methanol masers
manifestation at various transitions in the northern celestial hemisphere



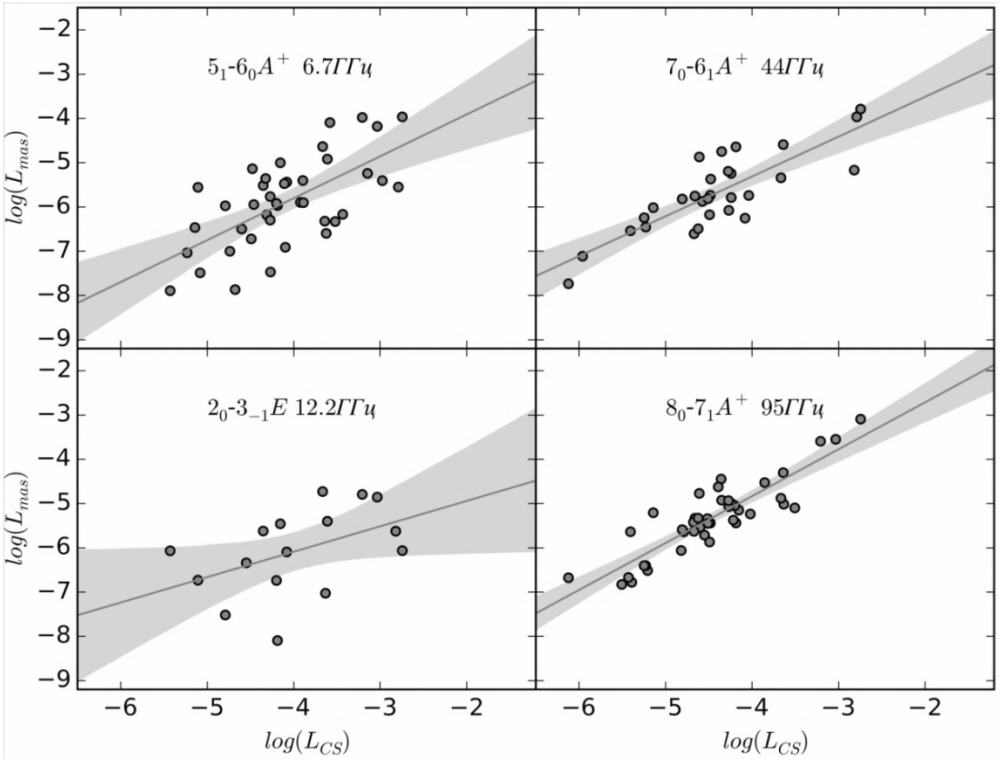
Proposed evolutionary timeline for the common maser species
2013MNRAS.429.3501E (*Ellingsen et al.*)

Regions with Methanol Masers

Survey of Regions with Methanol Masers in the CS (J = 2–1) Lines

«All sources»

«Class I»		«Class II»
«Only Class I»	«Class I и Class II»	«Only Class II»
«7_0–6_1 A^+ (44 GHz)»		«5_1–6_0A^+ (6.7 GHz)»
«8_0–7_1A^+ (95 GHz)»		«2_0 – 3_{-1}E (12.2 GHz)»



Patoka et al., 2018
doi: 10.3103/S0884591318050033

Patoka et al., 2017
doi: 10.15407/rpra22.03.173

Regions with Methanol Masers

Studies of massive cores with complex spatial and kinematic structures

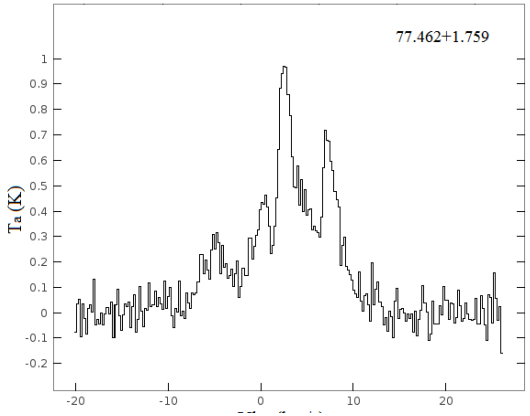
Onsala Space Observatory, Sweden

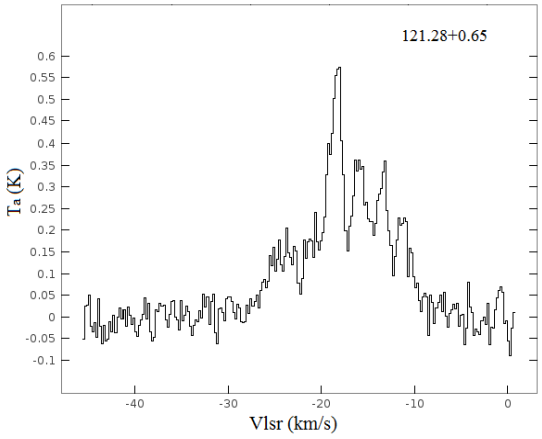
project IDs:

O2014b_04
O2015b_02

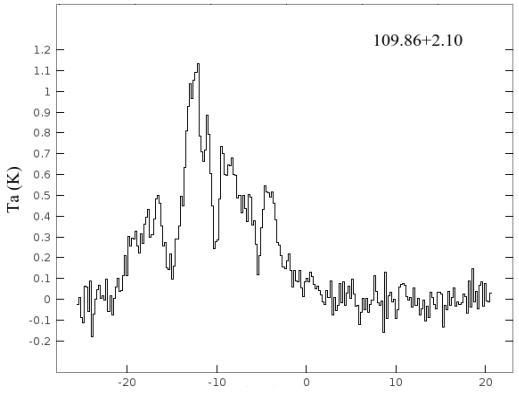
Regions with Methanol Masers

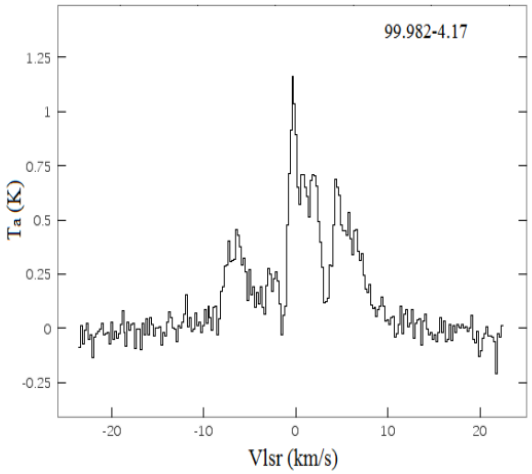
Studies of massive cores with complex spatial and kinematic structures





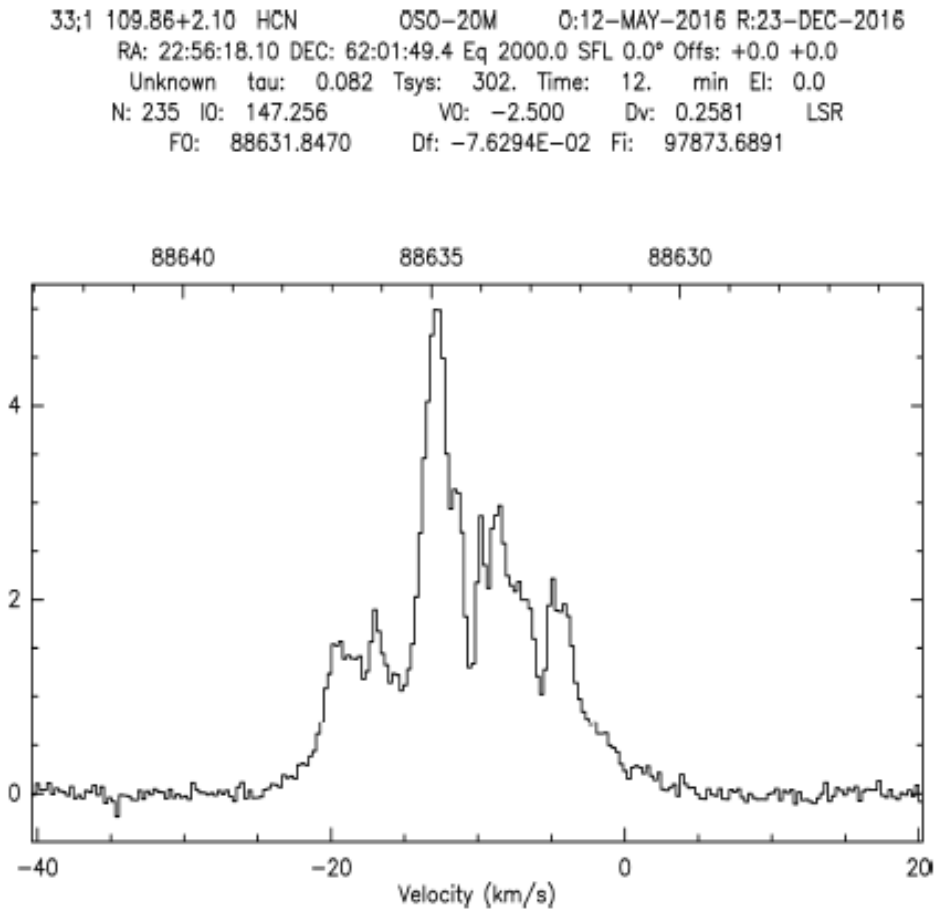
Name	Association	Coordinates (J2000)	
		RA	DEC
119.779-6.931	IRAS00259+5625	00:28:42.70	56:42:07.0
121.28+0.65	RNO 1B; L1287	00:36:42.20	63:28:30.0
123.05-6.31	IRAS00494+5617 NGC 281	00:52:19.9	56:33:17.0
133.749+1.198	W3	02:25:53.5	62:04:10.70
136.84+1.12	IRAS02455+6034 W5	02:49:23.10	60:46:26.0
205.109-14.111	RAS05445+0020 NGC 2071 I	05:47:04.1	00:21:42.1
34.403+0.233	G034.43 MM1	18:53:17.4	01:24:55.0
40.494+2.541	IRAS18537+0749 S76E	18:56:10.74	07:53:12.1
35.20-1.74	W 48	19:01:45.6	01:13:28.0
69.541-0.975	IRAS20060+3111 ON1	20:10:09.14	31:31:37.37
77.462+1.759		20:20:39.30	39:37:52.00
75.76+0.34	IRAS20198+3716 ON2	20:21:40.10	37:25:37.0
99.982+4.17	IC 1396; L1121	21:40:42.30	58:16:09.70
109.86+2.10	IRAS22543+6145 Cep A	22:56:18.1	62:01:49.4
111.53+0.76	IRAS23116+6111 NGC 7538 S158	23:13:45.4	61:28:10.6





Regions with Methanol Masers

Studies of massive cores with complex spatial and kinematic structures



Example of the processed spectrum

Data processing by standard methods using GILDAS package, CASSIS and our original programs was carried out.

GILDAS SOFTWARE

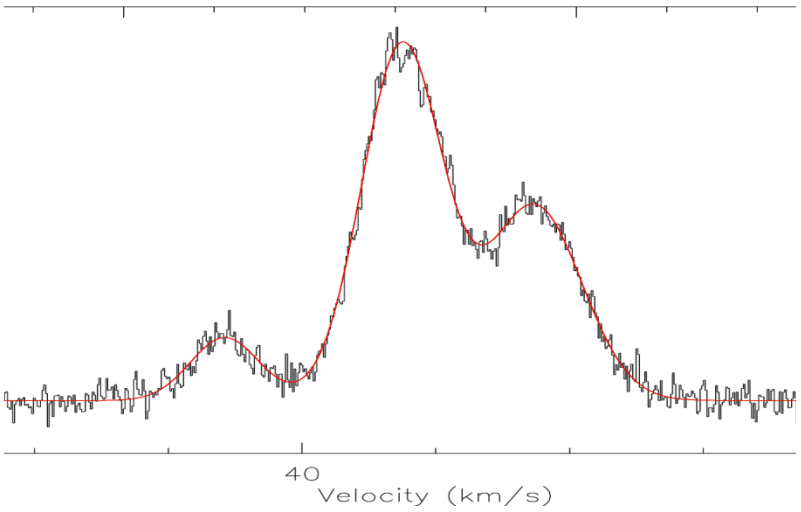
www.iram.fr/IRAMFR/GILDAS/

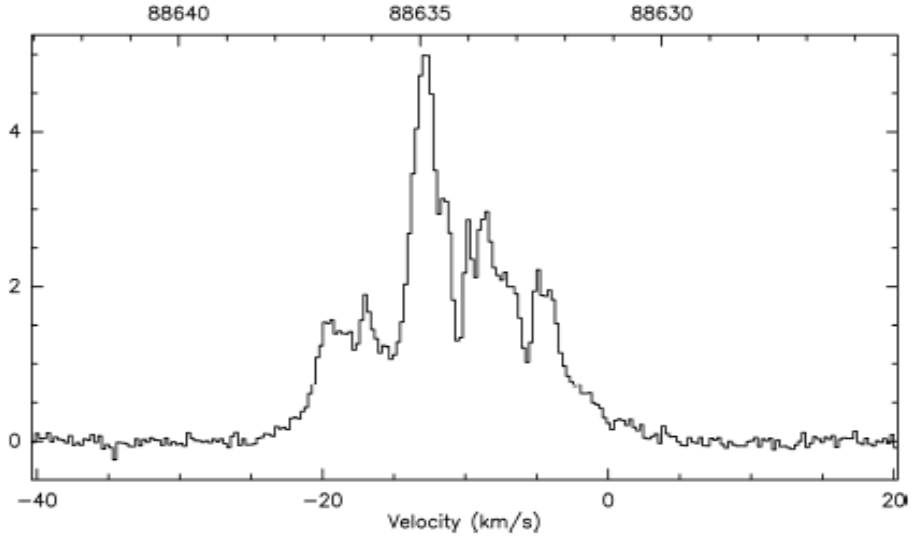
CASSIS
A free interactive spectrum analyser

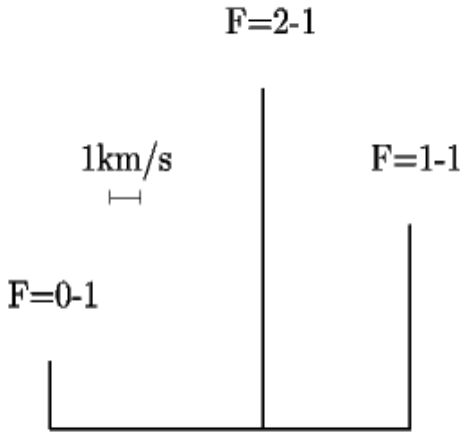
http://cassis.irap.omp.eu

Regions with Methanol Masers

Studies of massive cores with complex spatial and kinematic structures



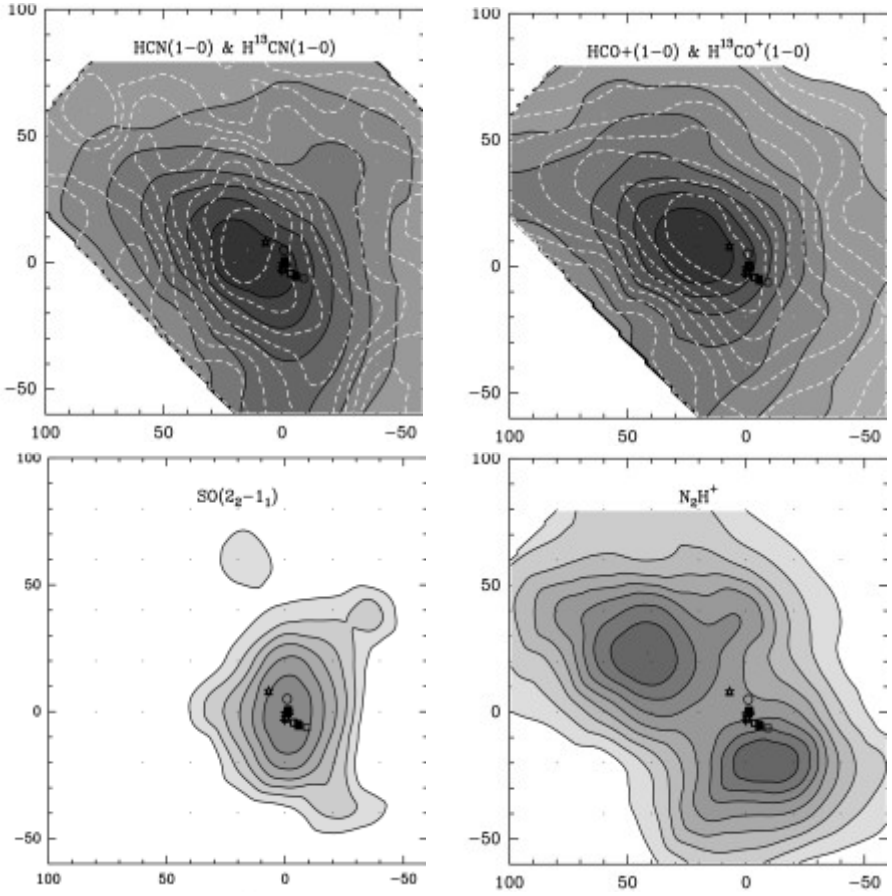




- Determine the physical parameters of the selected regions of the massive star formation associated with the methanol masers, for use in the model calculations.
- Determine the spatial distribution of molecules in observed regions.
- Determine the physical parameters of the observed regions.
- To model a complex spatial-kinematic structure of regions.

Regions with Methanol Masers

Studies of massive cores with complex spatial and kinematic structures



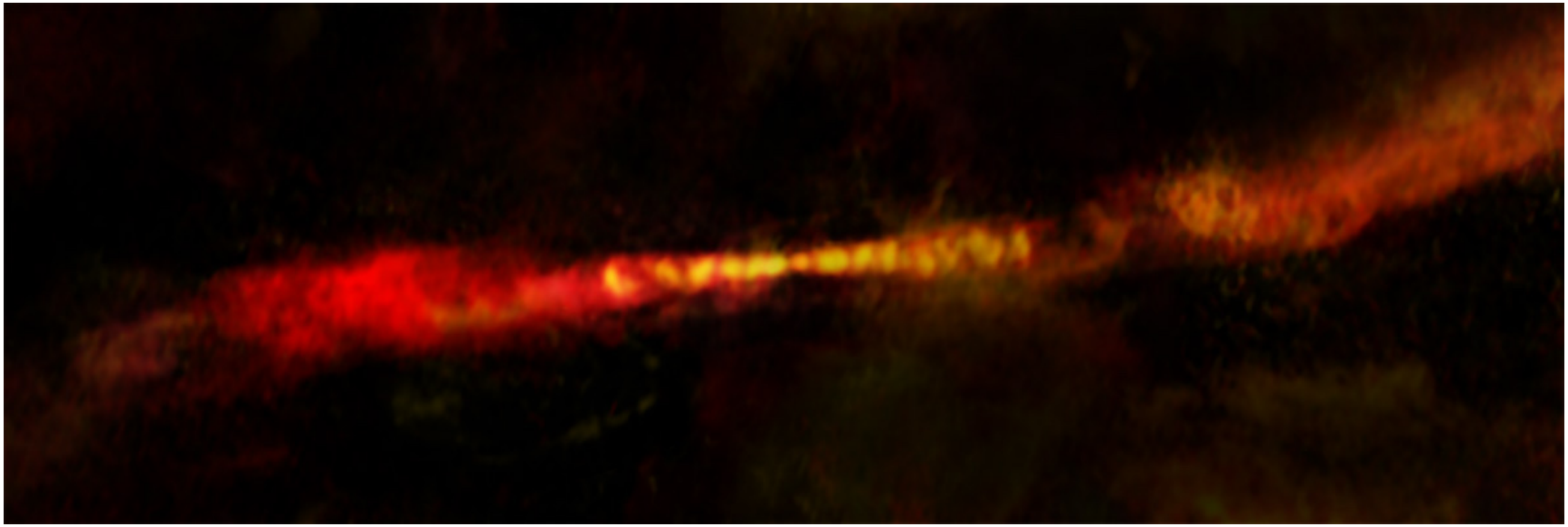
Example of Maps of 109.86+2.10

- For observed 15th objects obtained maps (about 180) in more than 13 molecular lines.
- We defined the physical parameters of the dense cores, including the sizes of the emission regions.
- We determined expanding and infalling (or perhaps contracting) sources.
- We detected feature like bipolar outflows in the observed objects in HCO^+(J=1-0) and SiO line.

Pirogov et al.
doil: 10.1134/S106377291610005X

Molecular outflows

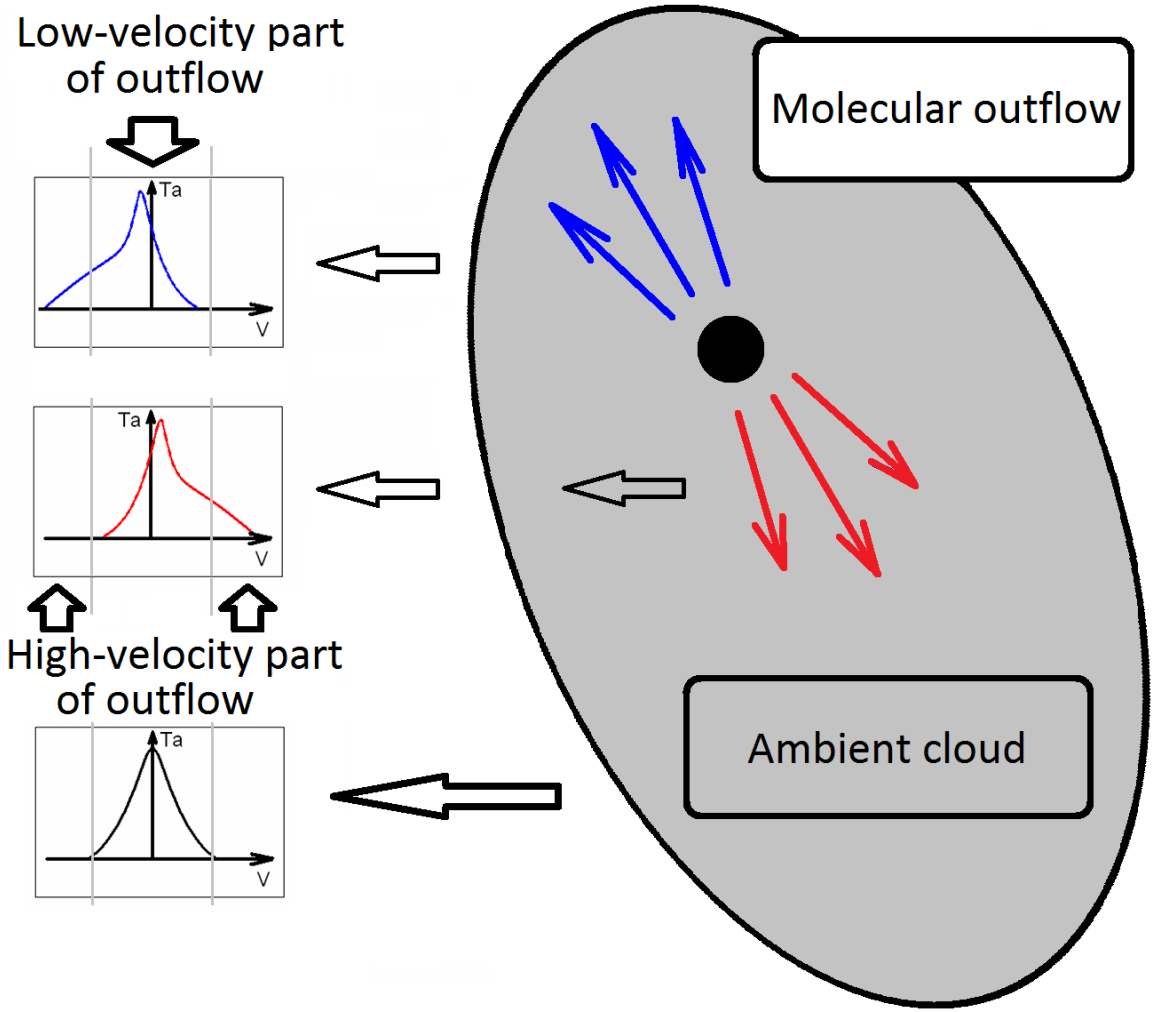
Low-velocity part of molecular outflow in massive star forming regions



ALMA image of the CO J=2-1 emissions from the molecular outflow from a protostar in the Serpens South molecular cloud.
Plunkett et al. doi:10.1038/nature15702
Credit: B. Saxton (NRAO/AUI/NSF); A. Plunkett et al.; ALMA (NRAO/ESO/NAOJ).

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions



- **Asymmetry of profiles**
- **Presence of wings**
- **Systematic shift of the entire line profile**

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

METHOD FOR CALCULATING PARAMETERS OF LOW-VELOCITY PART OF THE MOLECULAR OUTFLOW

(MLVMO)

molecular cloud consists of two components: ambient cloud and molecular outflow

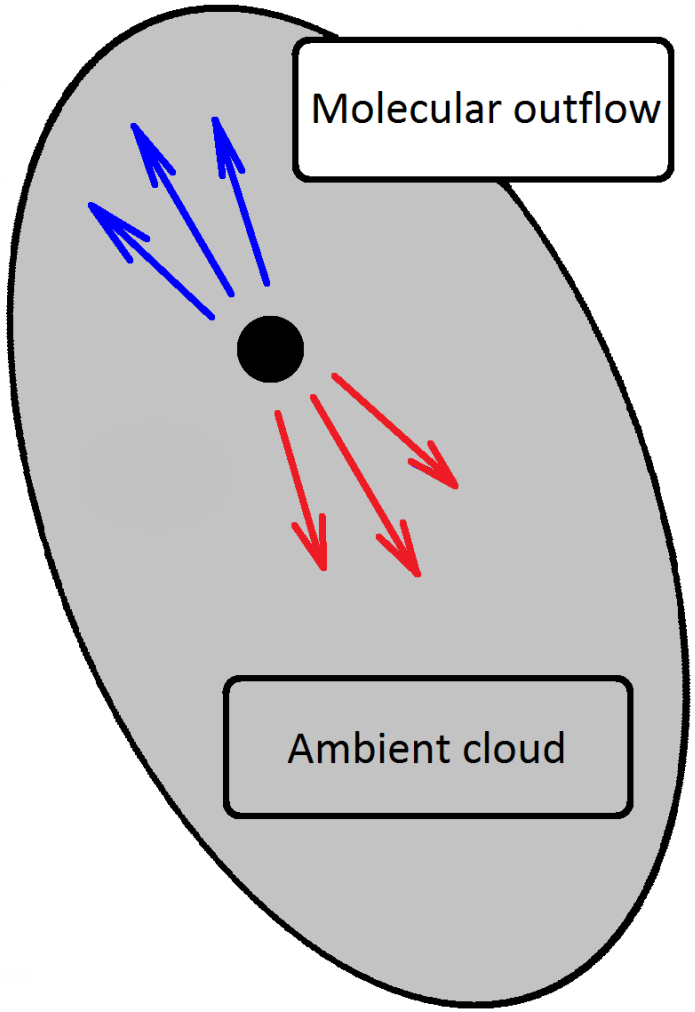
The spectra of the ambient cloud are approximated by Gauss function. The central velocity of the ambient cloud is determined from the spectra of the cloud, where the bipolar outflow is absent. Other parameters of the Gaussian function are fitted according to a special algorithm.

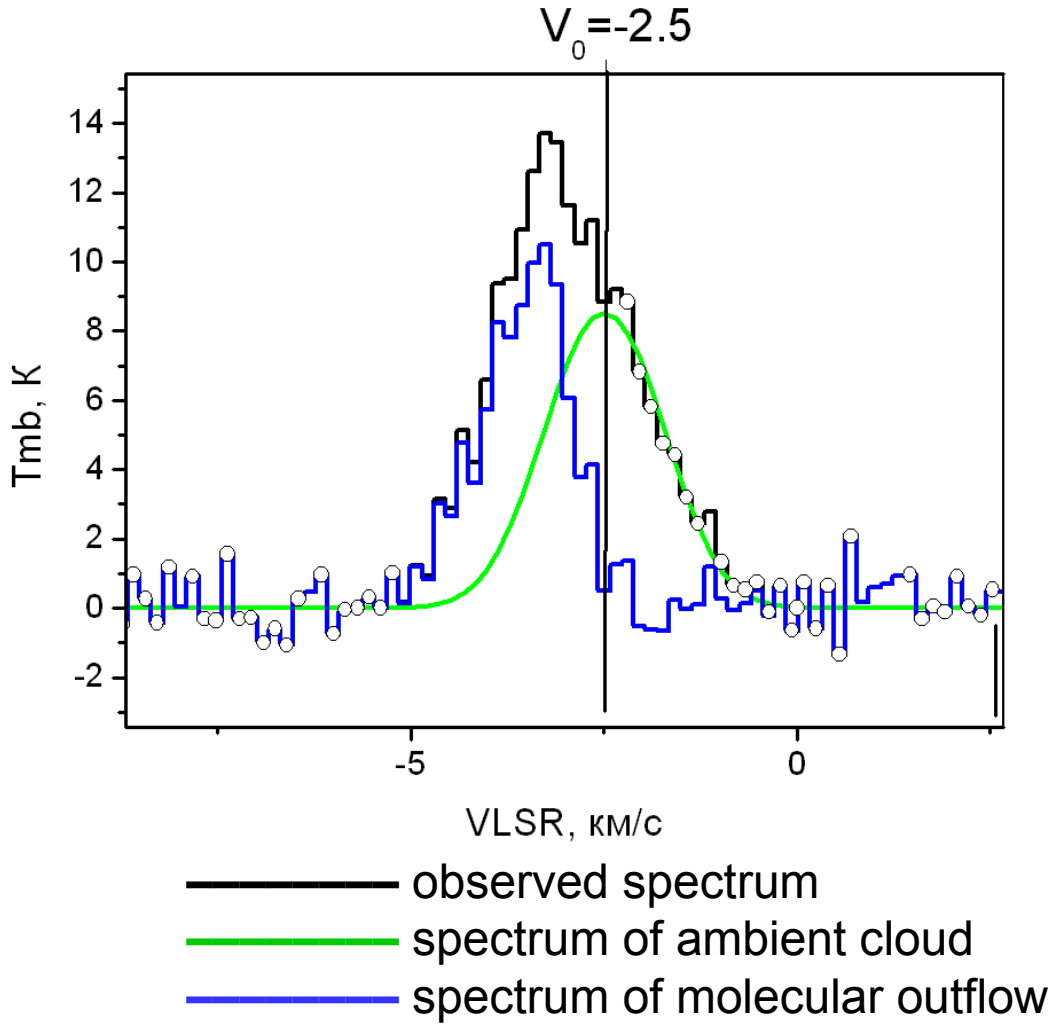
The differences between the observed spectra and spectra of the ambient cloud are considered to be the bipolar outflow spectra.

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

Example of using MLVMO



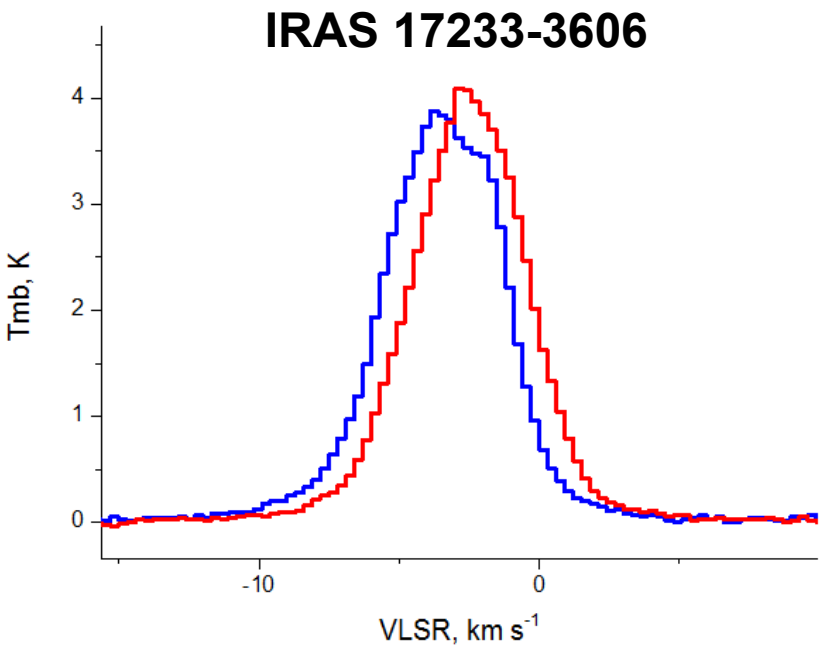


Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

Molecules $^{13}CO(2-1)$ and $C^{18}O(2-1)$ Frequency ~220 ГГц

By Jgardiazabal - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=32621120

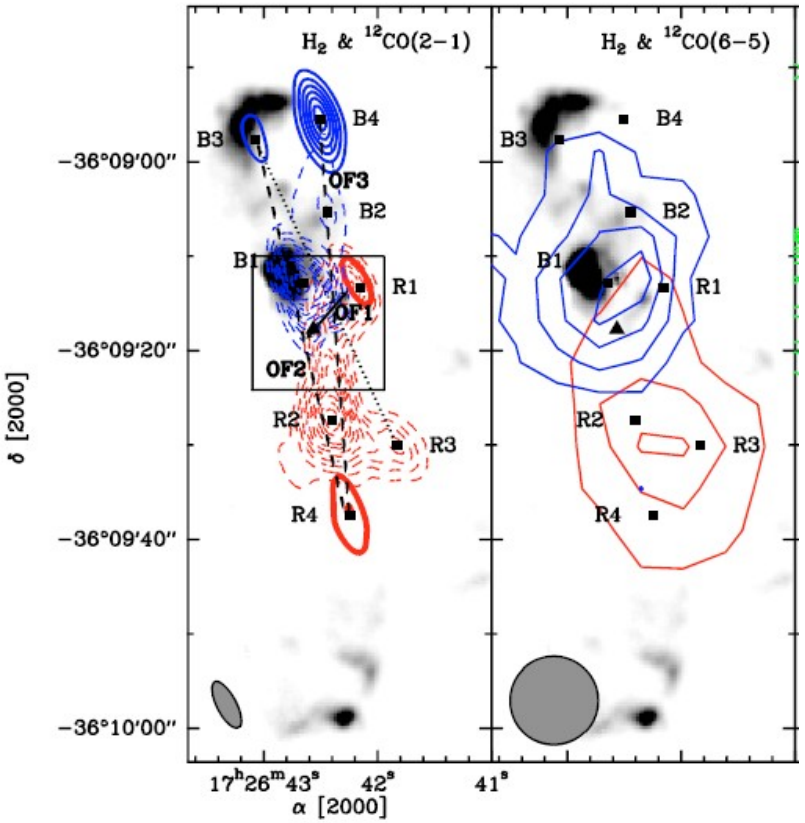


The averaged spectra of the $C^{18}O$ (J=2-1) emission lines from blue-shifted and red-shifted parts of the cloud

Molecular outflows

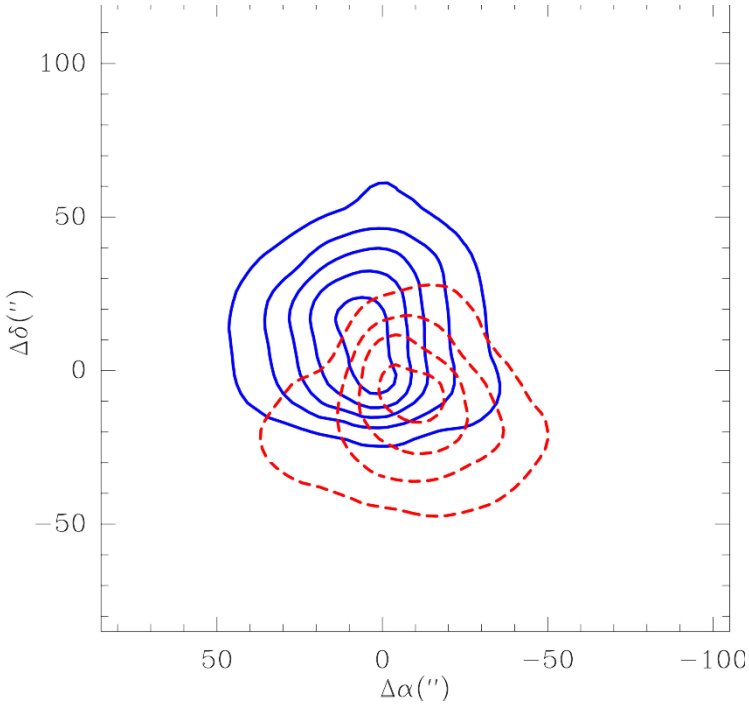
Low-velocity part of molecular outflow in massive star forming regions

^{12}CO(2-1) and ^{12}CO(6-5)



Leurini et al.,
doi: 10.1051/0004-6361/200912783

^{13}CO(2-1)



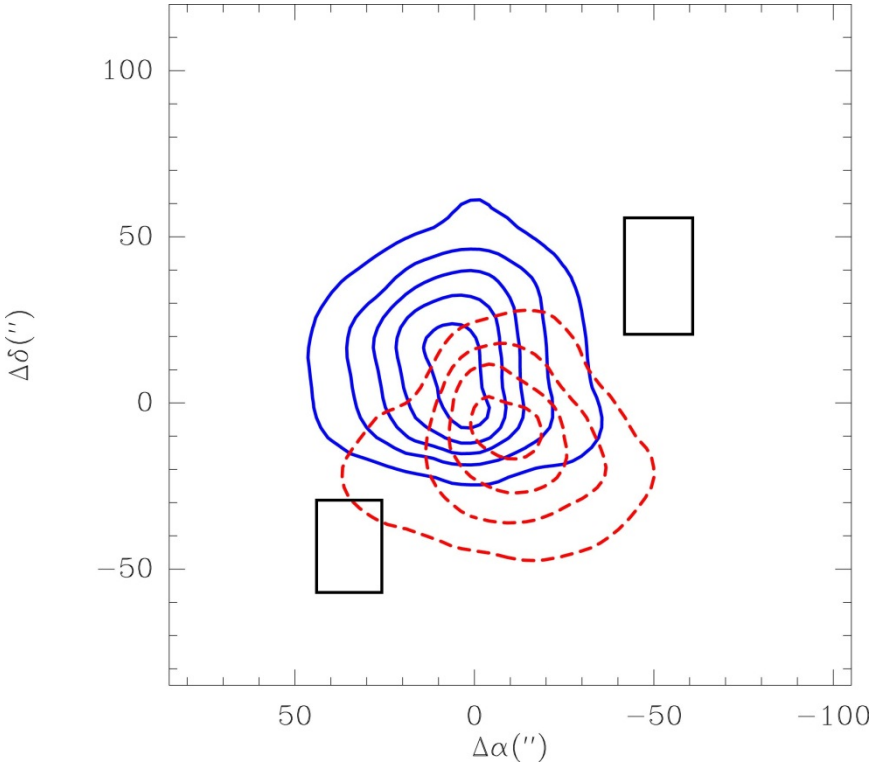
Our data

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

IRAS 17233-3606

The central velocity of the ambient cloud -2.8 km/s

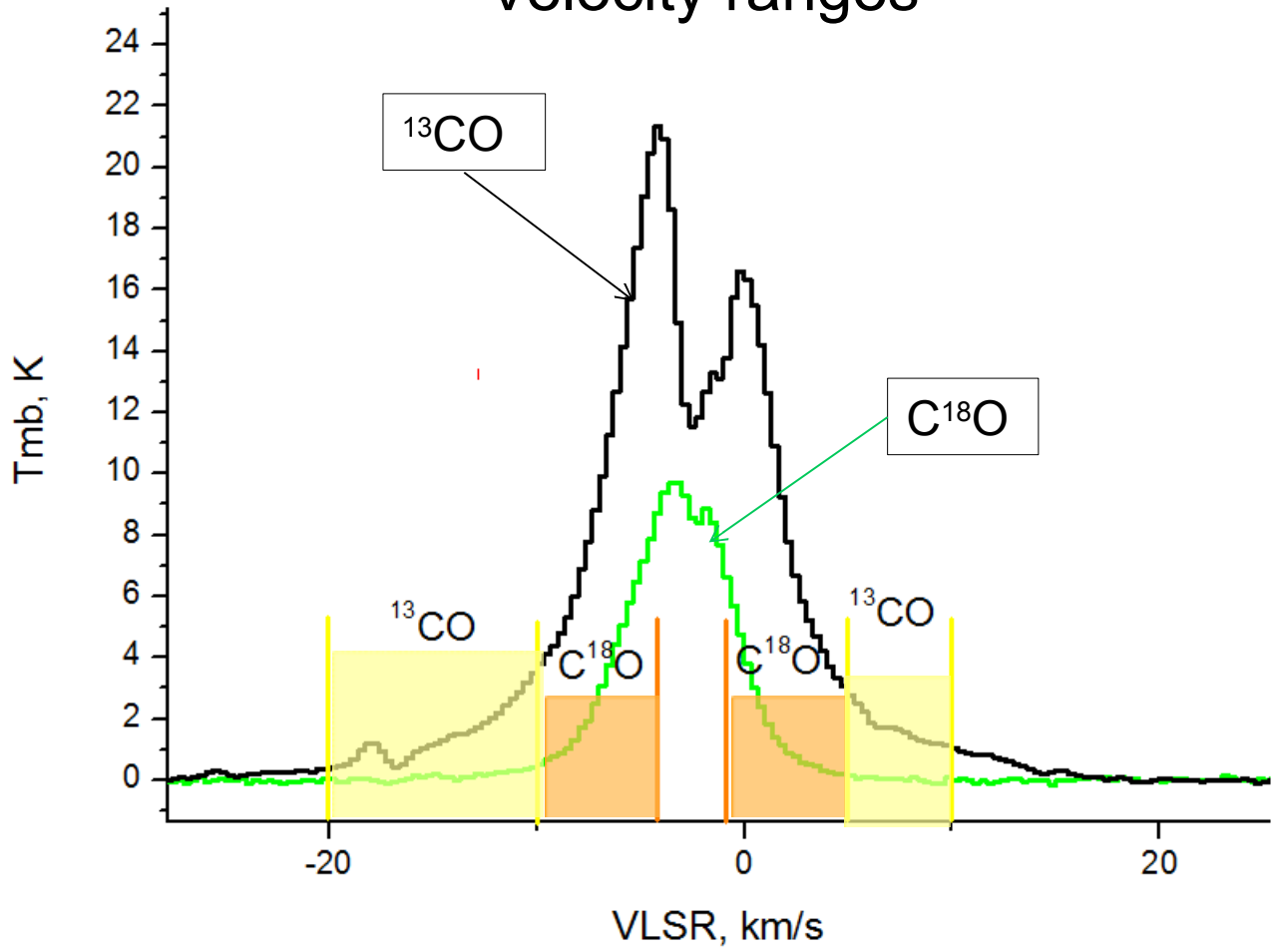


Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

IRAS 17233-3606

Velocity ranges

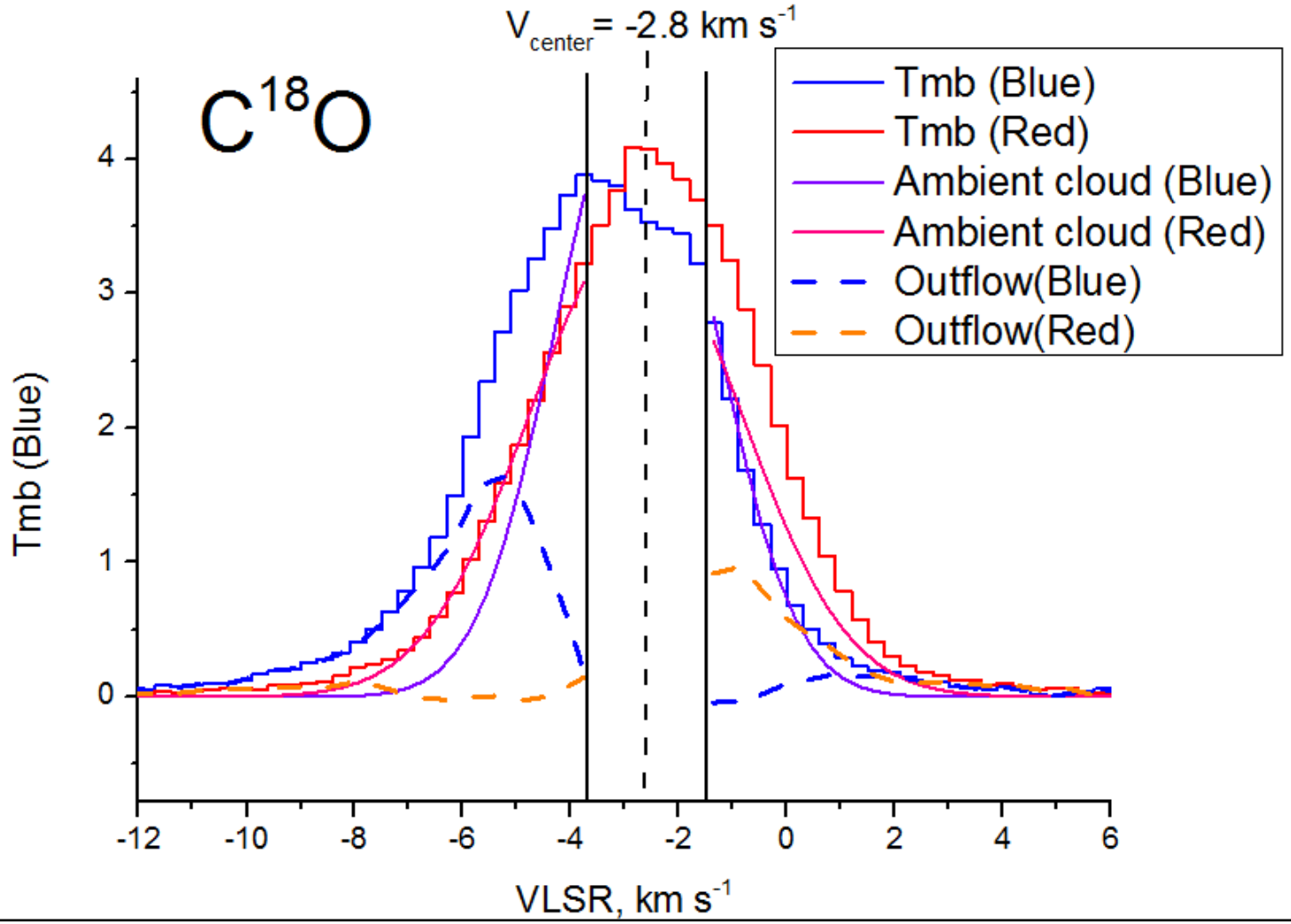


Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

IRAS 17233-3606

Method for calculating parameters of low-velocity part of the molecular outflow



Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

Assumptions used to calculate the parameters
of the low-velocity part of the molecular outflow

Abundances

$n(H_2)/n(C^{18}O)=53.3\cdot10^5$
$n(H_2)/n(^{13}CO)=8.9\cdot10^5$
$n(^{13}CO)/n(C^{18}O)=6$

Liu et al.
doi: 10.1088/2041-8205/775/1/L2

Exitation temperature

Tex = 50 K

Leurini et al.
doi: 10.1051/0004-6361:200809475

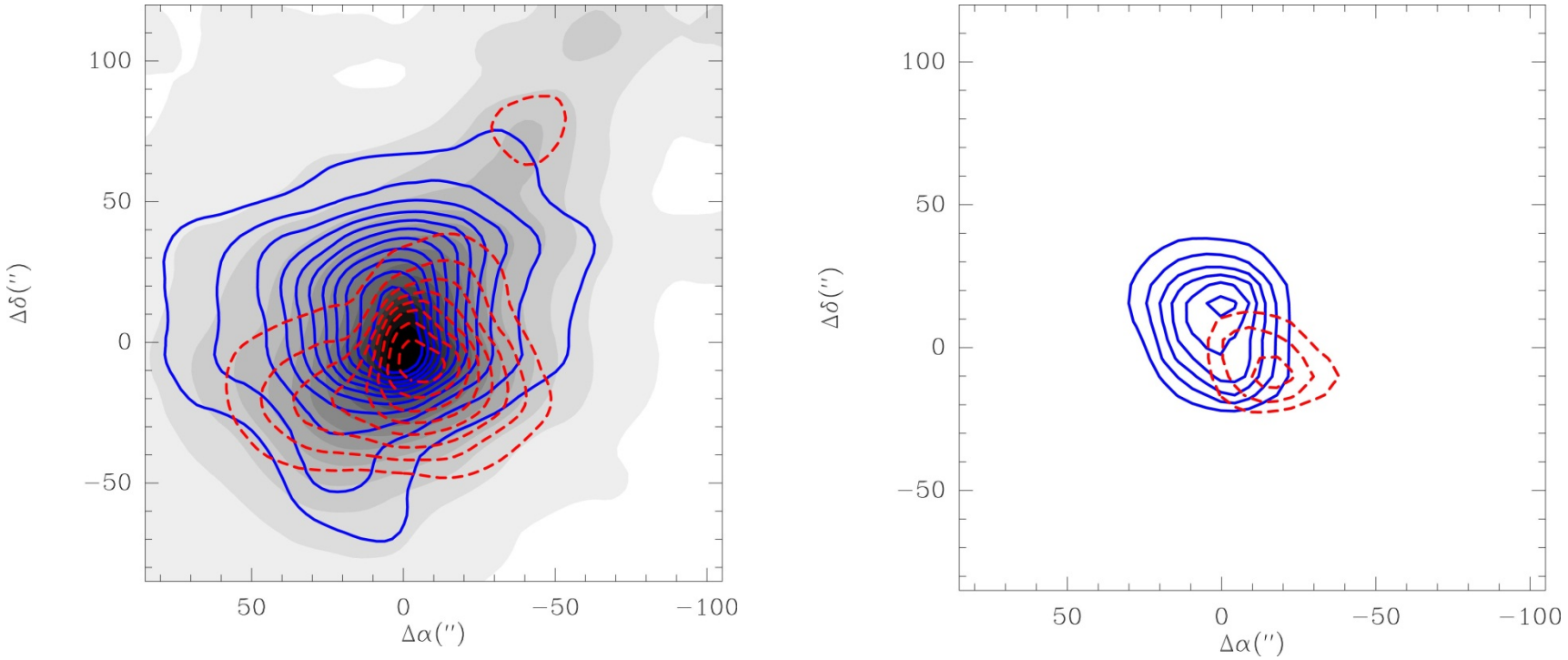
Opacity and optical depth

Molecule	Optical depth τ	$\tau/(1-\exp(-\tau))$
$C^{18}O$	0.077	1.04
^{13}CO	0.46	1.25

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

Superposition of the blueshifted and redshifted
$C^{18}O(2\text{-}1)$ and $^{13}CO(2\text{-}1)$ emission



Gray scale: integrated emission of $C^{18}O(2\text{-}1)$

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

The parameters of the molecular bipolar outflow in IRAS 17233-3606

	$C^{18}O$	^{13}CO	$C^{18}O+^{13}CO$	^{12}CO
Velocity range, km s^{-1}	(-10… -3.5) (-1.5… 5)	(-20… -10) (5… 10)	(-20…-3.5) (-1.5…10)	(-200...-25) (16...50) (90…120)
Core mass, $M_\odot$	721			
Mass of molecular outflow, $M_\odot$	156	17	173	2.4
Momentum of molecular outflow, $M_\odot \times$ km s^{-1}	490	185	675	99
Energy of molecular outflow, 10^{46} ergs	1.8	2.1	3.9	6
Dynamical timescale, 10^4 yr	3.9	0.56		0.048
Mass entrainment rate, $10^{-4}\ M_\odot \times yr^{-1}$	40	30	70	30
Mechanical force, $10^{-3}\ M_\odot \times$ km $s^{-1} \times yr^{-1}$	13	33	46	100
Luminosity, $L_\odot$	4	35	39	760
	Our results			

Leurini et al.,
doi: 10.1051/0004-6361/200912783

Molecular outflows

Low-velocity part of molecular outflow in massive star forming regions

Antyufeyev et al. doi: 10.3103/S088459131106002X

Antyufeyev et al. doi: 10.1615/RadioPhysicsRadioAstronomy.v3.i1.40

Antyufeyev et al. doi: 10.3103/S0884591308050012

Antyufeyev et al. doi: 10.3103/S0884591314030027

Antyufeyev et al. doi: 10.3103/S0884591316060027

Research of Galactic Masers

Latvijas Zinātnes padome

Funding:
Latvian Council of Science

Project Nr.:
lzp-2018/1-0292

Research of Galactic Masers

Ventspils International Radio Astronomy Centre

Latvian Council of Science

lzp-2018/1-0292

Research of Galactic Masers

We'll observe about 430 points of existence of methanol masers at the transition frequency of 6.7 GHz in order to search for radiation from ex-OH masers in the northern celestial hemisphere and study magnetic fields in selected star-forming regions using emission from the ex-OH masers.

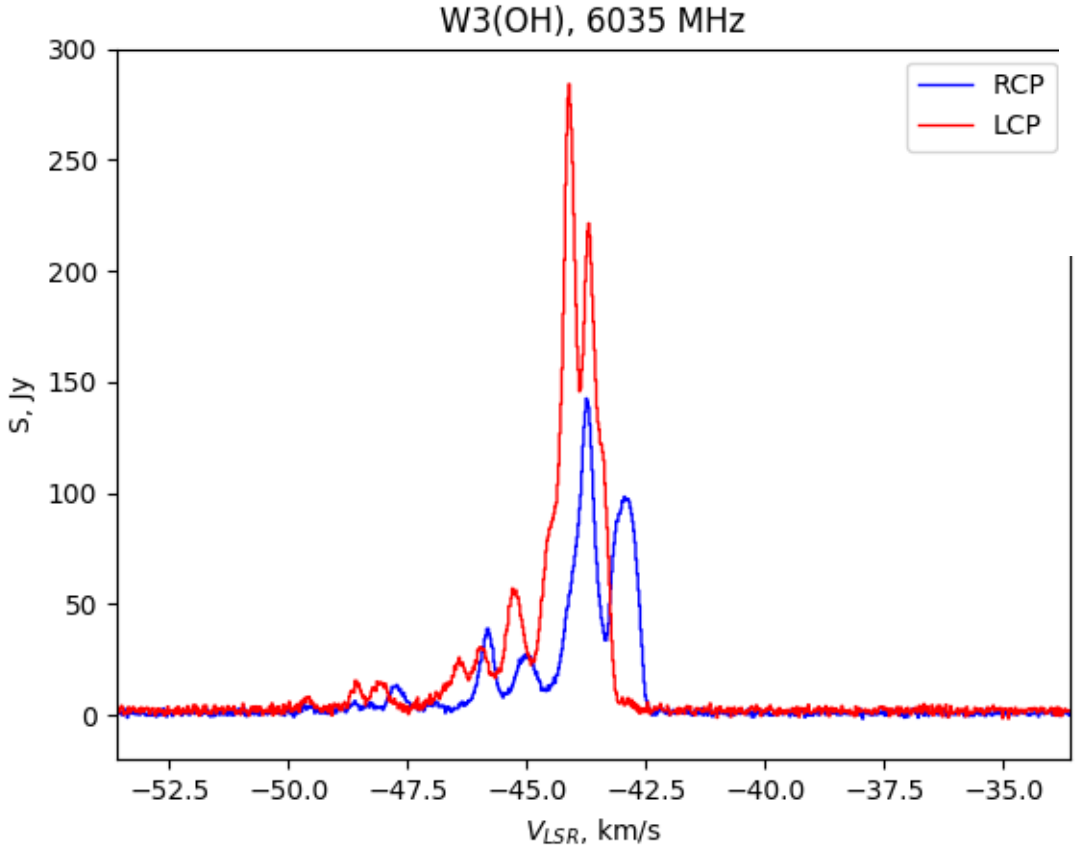
Observing frequency: 6030, 6035 and 6668 MHz
RHCP and LHCP

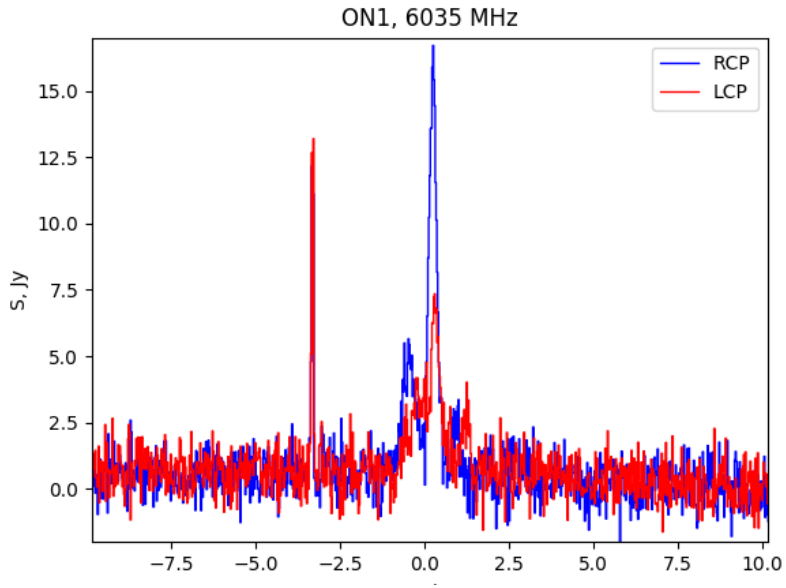
Latvian Council of Science

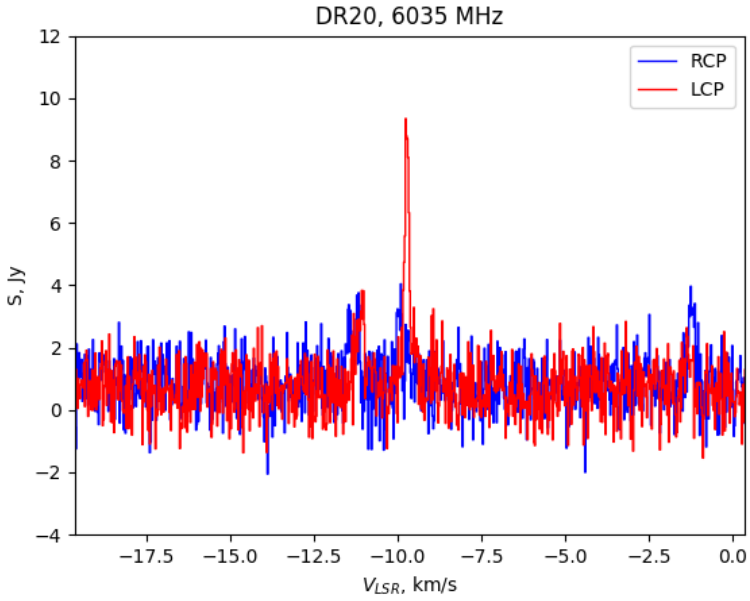
lzp-2018/1-0292

Research of Galactic Masers

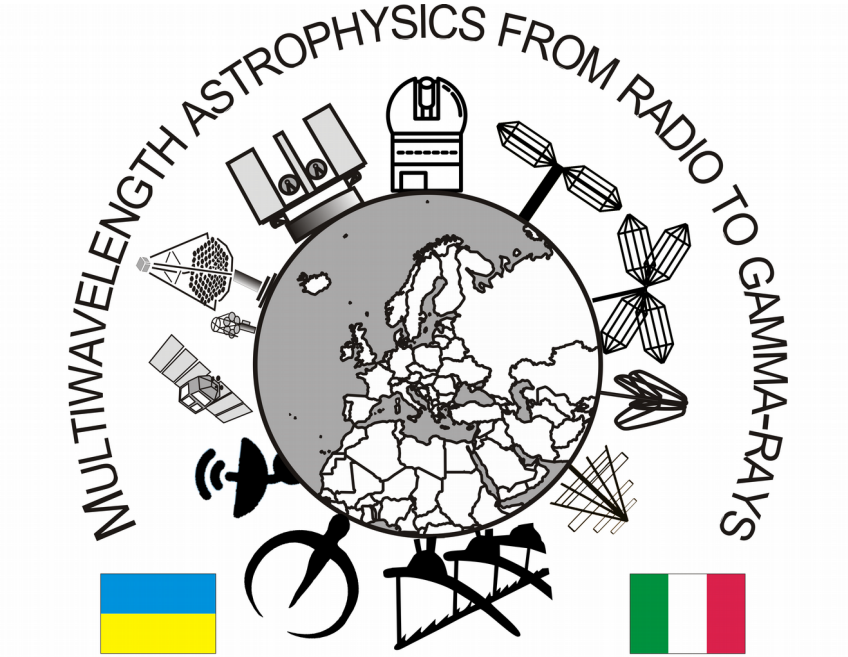
RT-16
2018, September 13-14
Frequency resolution — 488 Hz







Latvian Council of Science
lzp-2018/1-0292



SECOND ITALY-UKRAINE MEETING IN ASTRONOMY

KHARKIV, SEPTEMBER 25-27, 2018

Thank you for your attention