Masers with ATNF instruments

Max Voronkov | ATUC Science meeting – 08 November 2022

Masers - Intro

For the purpose of this talk - masers are just spectral lines which are often strong and narrow, correspond to compact sources and arise in some specific circumstances

Many species

H_2O

CH_3OH (two classes)

OH

NH_3

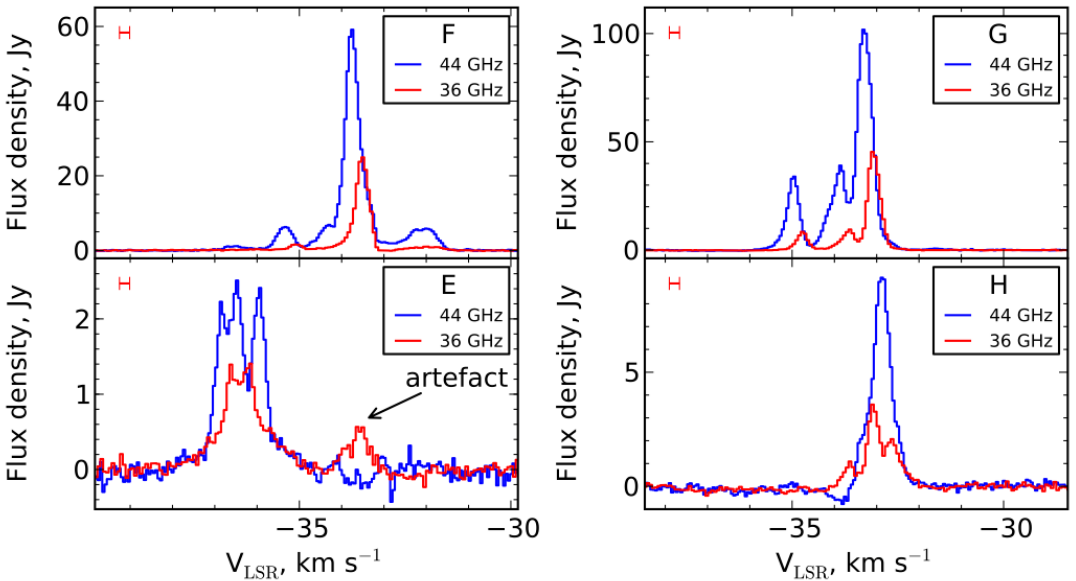
SiO

H-CHO

SiS

HCN

HC_3N

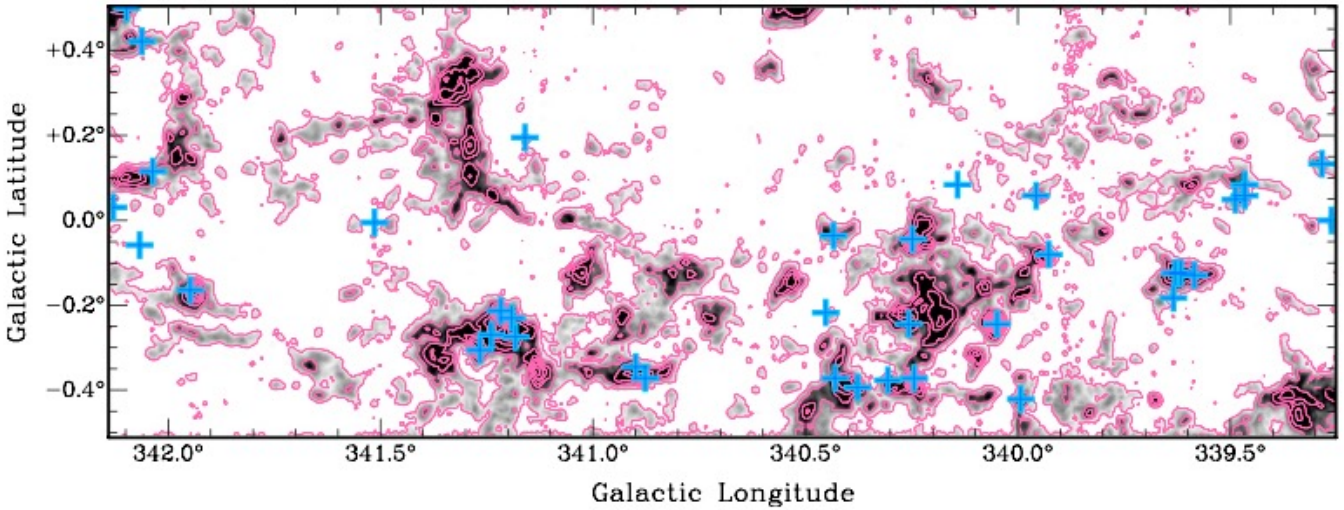


Selected emission components of class I methanol masers in G305.37+0.21 (Voronkov et al.; 2014, MNRAS, 439, 2584)

1. Blind surveys of widespread masers

Star **F**ormation **I**n the **S**outhern **H**emisphere (PI: S.Breen)

Contours/greyscale: CS (1-0), symbols – class I methanol masers at 44 GHz. Image credit: S.Breen



Transition	Frequency, GHz	Transition	Frequency, GHz
SiO (1-0) v=3	**42.51934**	H51α (RRL)	48.15360
SiO (1-0) v=2	**42.82048**	$C^{34}S$ (1-0)	48.20694
H53α (RRL)	42.95197	$CH_3OH\ 1_0\text{-}0_0\ A^+$	48.37246
SiO (1-0) v=1	**43.12203**	$CH_3OH\ 1_0\text{-}0_0\ E$	48.37689
SiO (1-0) v=0	43.42376	OCS (4-3)	48.65160
$CH_3OH\ 7_0\text{-}6_1A^+$	**44.06941**	CS (1-0)	48.99095

ATCA is used as 6 single dishes

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More on maser surveys

Interferometric follow-ups are necessary for S.D. detections (labour-intensive, automation is inhibited by bad uv-coverage)

Frequency agility is the key, more bandwidth -> more transitions can be covered, greater chance for serendipitous discoveries (hard to justify a blind survey for rare masers)

Observations of different transitions are not always easy to combine together:

- uv-coverage
- sensitivity
- array configuration
- spectral resolution

2. Parallaxes / structure of the Galaxy

Methanol masers (class II) have advantages over H_2O masers (more stable VLBI maps on a few years timescale)

Still more parallaxes in the Northern Hemisphere (with VLBA, VERA, EVN)

In the south: Krishnan et al. (2015, ApJ, 805, 129) + future LBA+AuScope work

-Overhead reduction?
-More frequent scheduling?
-Improvements in calibration?
-Dedicated calibration array(s)?
-Upgrade to 12 GHz?

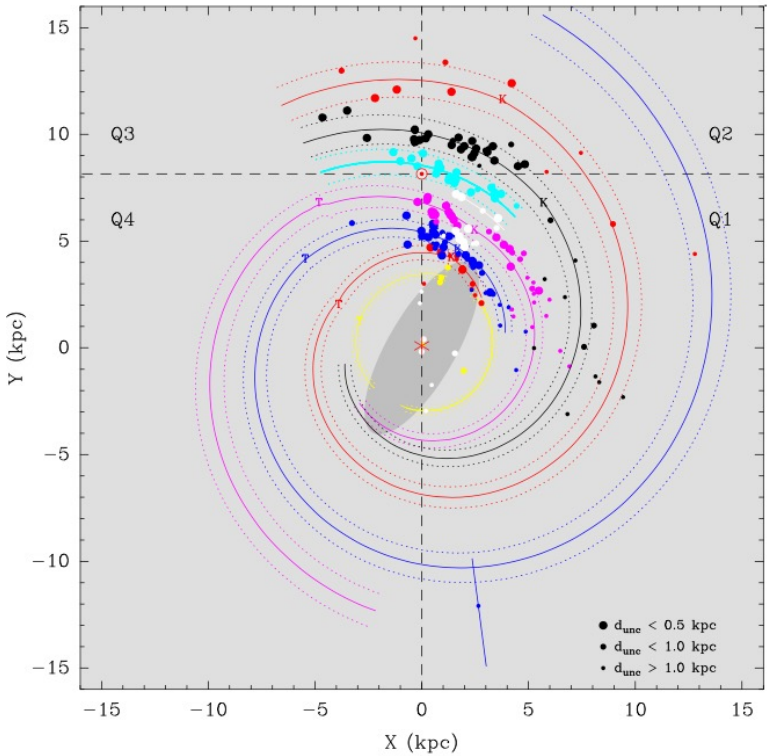
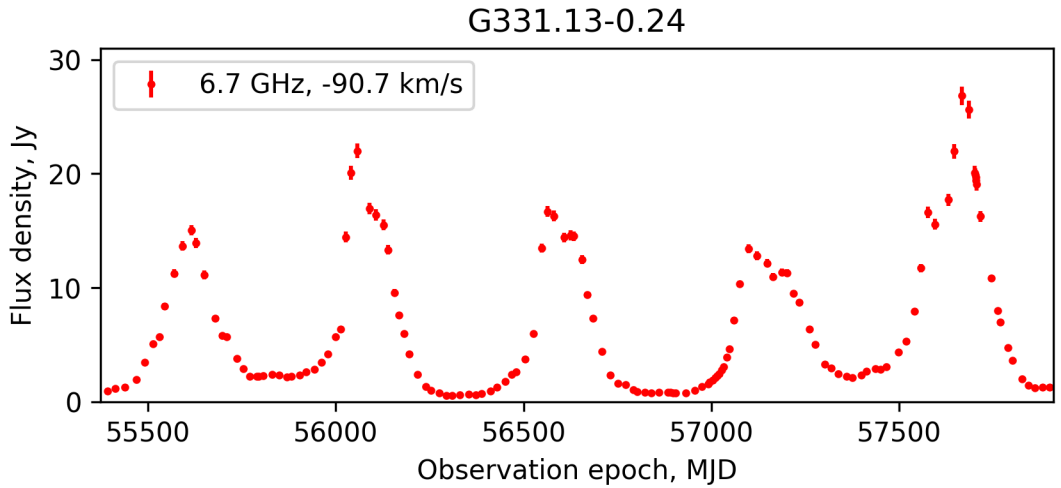


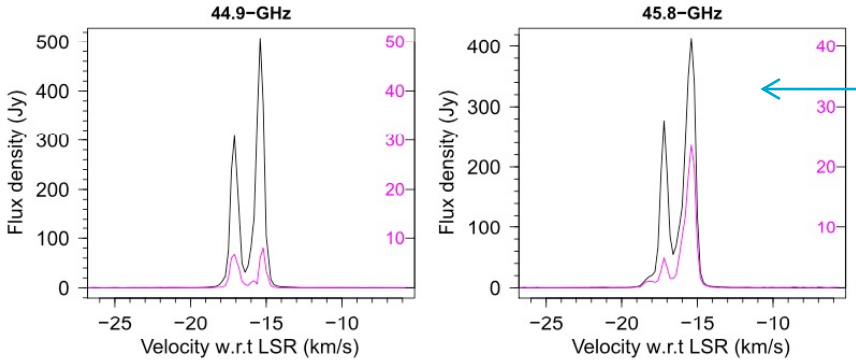
Figure from Reid et al. (2019, ApJ, 885, 131)

3. Periodic variability and bursts

About 30 (quasi)periodic masers known (largely class II methanol)

Example from my own monitoring work with ATCA





Flare in G358.931-0.030 (Breen et al., 2019, ApJ, 876, 25)

Lots of unusual transitions!

Summary / Wishlist

Ridiculous points

- New ATCA antennas
- New LBA stations capable to observe at 6.7/12 GHz
- Ability to bring CA06 to the main track
- Small antenna in space to observe at 60.5, 57.0, 57.3, 68.3 GHz

Not so ridiculous points

- Get Mopra back (handy for monitoring and quick checks)
- Mopra 3mm receivers at ATCA to get above 105 GHz
- Upgrade to be able to observe at 12 GHz on all facilities
- Ability to observe at 44 and 36 GHz simultaneously at ATCA
- Make autocorrelation work (as in StarFISH) properly supported (+ may be allow different pointings for different antennas)
- Streamline astrometry with LBA
  - (ionosphere) calibration arrays? E.g. an MWA-like array at every station or something based on cryo-PAF?
- ATCA fast response with good spectral resolution

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Thank you

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