NH$_3$ and CH$_3$OH Observations in SNRs Using the GBT and the VLA

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Overview

• Motivation & Goals

• Observations
  – GBT Ammonia (NH₃ (3,3))
  – VLA Methanol (CH₃OH)

• Results
  – NH₃ and CH₃OH association
  – Distribution of other molecular gas

• Future Work
SNR/MC Interaction Regions

- Trigger star formation?

- Source of cosmic rays?
MASERs as SNR/MC Tracers

- 1720 MHz OH masers ~10% of SNRs
- Class I (collisionally pumped) CH$_3$OH masers
  - 36 and 44 GHz masers found associated with shocked regions of a few SNRs
- Use modeling to probe physical conditions and better understand the distribution of CH$_3$OH masers we detect in SNRs

McEwen et al. (2014)
36 GHz in line with shock in Sgr A East

(Pihlström et al. 2011)
NH$_3$ in Sgr A East

(Sjouwerman et al. 2010)
W28

(Nicholas et al. 2011)  (Pihlström et al. 2014)
Distribution Trends

- Positional association between NH$_3$ and CH$_3$OH masers

- CH$_3$OH masers found offset from 1720 MHz OH masers
  - Trace different shocked regions or different regions of the shock
• Bright 36 GHz CH$_3$OH masers trace regions closer to the shock front (higher density regions)

• OH masers trace post shocked gas

• Less clear: Bright 44 GHz masers possibly trace star forming regions (lower density regions)?

Mainly based on Sgr A East observations
GBT & VLA Observations

• GBT:
  – Mapped 5 SNRs for 23.87 GHz NH₃ (3,3) emission
  – IC443, W44, W51C, G1.4-0.1, & G5.7-0.0
  – Jan-May of 2013 (onsite and remote)
  – 7-beam KFPA

• VLA:
  – 36 & 44 GHz CH₃OH maser emission
  – Pointed at NH₃ peaks
  – W44, W51C, & G5.7-0.0
  – D-configuration
Results

- **NH$_3$ (3,3) emission detected towards all SNRs**
- **NH$_3$ in G5.7-0.0, IC443, W44, & W51C**
  - Compact clumps of emission
  - Narrow linewidths (2 to 3 km/s)
- **NH$_3$ in G1.4-0.1**
  - Extended clumpy emission
  - Broader linewidths (10 to 16 km/s)
- **36 & 44 GHz CH$_3$OH masers detected in G5.7-0.0, W44, & W51C**
NH$_3$ Spectral Profiles

G1.4-0.1 (A)
G5.7-0.0 (a)
W51C (b)
IC443 (a)
W44 (c)
CH$_3$OH Spectral Profiles

W51C (B36-1)

G5.7-0.0 (A44-1)

W44 (K36-1)
NH₃ and CH₃OH Association

- Association found spatially and in velocity
- 36 and 44 GHz CH₃OH were both detected towards the brightest NH₃
- NH₃ and 36 GHz CH₃OH could be tracing shocked regions
- CH₃OH offset from OH in all SNRs
W44

- Orientation of MC
- CO observations
W51C

- HII complex near NH$_3$ and CH$_3$OH detections

- Are HII regions responsible for bright 44 GHz CH$_3$OH masers??
Future Work

• Develop a general picture of the distribution of masers and molecular gas in SNR/MC interaction regions

• Increase sample size
  – More maser detections in a larger sample of SNRs

• Working on more complete surveys of Sgr A East and W28

• Investigate different tracers of SF in regions where we find bright 44 GHz emission
Thank you!
GBT Observations

- Observations:
  - Mapped 5 SNRs for 23.87 GHz NH$_3$ (3,3) emission (IC443, W44, W51C, G1.4-0.1, G5.7-0.0)
  - Jan-May of 2013 (onsite and remote)
  - 7-beam KFPA
  - 50 MHz bandwidth
  - \(~600\) km/s velocity coverage
  - \(~0.5\) km/s velocity resolution
  - DECLAT/RALONG mapping modes (3.6\arcsec/\s)

- Data reduction & imaging
  - GBTPipeline, GBTIDL, AIPS
VLA Observations

• Observations:
  – 36 & 44 GHz CH$_3$OH maser emission
  – Pointed at NH$_3$ peaks
  – W44: 17 (44 GHz) & 11 (36 GHz) pointings
  – W51C: 14 & 12 pointings
  – G5.7-0.0: 1 pointing at each frequency
  – D-configuration
  – 128 MHz
  – ~1.9 km/s channel width

• Data reduction & Imaging:
  – AIPS