## NH<sub>3</sub> and CH<sub>3</sub>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 (CH<sub>3</sub>OH)
  - Results

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- NH3 and CH3OH association
- Distribution of other molecular gas
- Future Work

### **SNR/MC Interaction Regions**

Trigger star formation?

igodot



Source of cosmic rays?

### **MASERs as SNR/MC Tracers**

1720 MHz OH masers ~10% of SNRs

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#### Class I (collisionally pumped) CH<sub>3</sub>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<sub>3</sub>OH masers we detect in SNRs



# **36 GHz in line with shock in Sgr A East**

#### O 36 GHz CH<sub>3</sub>OH



(Pihlström et al. 2011)

### **NH3 in Sgr A East**



- NH3 (3,3) contours

#### + 36 GHz CH<sub>3</sub>OH

(Sjouwerman et al. 2010)

### **W28**



#### (Nicholas et al. 2011)

(Pihlström et al. 2014)

### **Distribution Trends**

- Positional association between NH3 and CH3OH masers
- CH<sub>3</sub>OH masers found offset from 1720 MHz OH masers – Trace different shocked regions or different regions of the
  - shock





- Bright 36 GHz CH<sub>3</sub>OH masers trace regions closer to the shock front (higher density regions)
- OH masers trace post shocked gas

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- 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 NH<sub>3</sub> (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 CH<sub>3</sub>OH maser emission
- Pointed at NH<sub>3</sub> peaks
- W44, W51C, & G5.7-0.0
- D-configuration



### Results

NH<sub>3</sub> (3,3) emission detected towards all SNRs

- NH3 in G5.7-0.0, IC443, W44, & W51C
  - Compact clumps of emission
    Narrow linewidths (2 to 3 km/s)
- NH3 in G1.4-0.1
  - Extended clumpy emission
  - Broader linewidths (10 to 16 km/s)
- 36 & 44 GHz CH<sub>3</sub>OH masers detected in G5.7-0.0, W44, & W51C











### **NH3 Spectral Profiles**



### **CH3OH Spectral Profiles**



### **NH3 and CH3OH Association**

Association found spatially and in velocity

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- 36 and 44 GHz CH<sub>3</sub>OH were both detected towards the brightest NH<sub>3</sub>
- NH3 and 36 GHz CH3OH could be tracing shocked regions

CH<sub>3</sub>OH offset from OH in all SNRs

### W44

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- Orientation of MC
  - CO observations



# **W51C**

- HII complex near NH3 and CH3OH detections
- Are HII regions responsible for bright 44 GHz CH3OH 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<sub>3</sub> (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''/s)

Data reduction & imaging – GBTPIPLINE, GBTIDL, AIPS



### **VLA Observations**

- Observations:
  - 36 & 44 GHz CH<sub>3</sub>OH maser emission
  - Pointed at NH3 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

