

Water maser emission in hard X-ray selected AGN

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Water Mega Masers

Most observed line:

- ✓ Rest frequency 22.23508 GHz (λ =1.3 c
 - $6_{16} \rightarrow 5_{23}$ rotational transition
- \checkmark Trace a warm and dense gas
 - T > 300 K
 - N(H₂) > 10⁷ cm⁻³

 $L_{H2O} > 10^3 L_{SUN} \rightarrow$ found in the central regions of some AGN

Why MASER?

Probing AGN – jet masers

MRK348 (Peck et al. 2003)



- ✓ Broad line (<100 km/s) emission in the radio jet out to 30 pc from the core
 - → Jet and molecular cloud interaction
 - → Shock speed and jet densities

Why MASER?

Probing AGN – disk masers

Greenhill et al. 1995

Archetype megamaser galaxy NGC 4258



Why MASER?

Probing AGN – outflow masers



- ✓ The outflowing masers are irregularly distributed above and below the disk
- ✓ Outflow velocities up to ± 160 km s⁻¹
- ✓ Dusty, high-density, molecular material in a nuclear outflow

Greenhill et al. 2003

How frequent are water masers?

So far, more than 4000 galaxies have been searched for water maser emission and

detections have been obtained in about 178 of them (MCP update at August 2017), the majority in the local Universe (z < 0.05)

- → Fraction of water masers around 7% in galaxy surveys (Braatz et al. 1997)
- → However, it raises up to 26% in a complete distance limited sample (Panessa & Giroletti 2009)
- → High fraction among NLSy1 (7-21%, Tarchi et al. 2011)
- → High fraction among Compton Thick AGN (50%, Castangia et al. 2019)

H₂O masers and X-rays

 \rightarrow H₂O maser sources associated with

 \rightarrow high X-ray column density (N_H > 10²³ cm⁻²)

 \rightarrow Compton-thick absorbers (N_H > 10²⁴ cm⁻²)



Zhang et al. 2006, Greenhill et al. 2008, Castangia et al. 2013, Masini et al. 2016, Castangia et al. 201

H₂O and X-rays

✓ A rough correlation have also been found between maser isotropic luminosity and unabsorbed X-ray luminosity

(Kondratko et al. 2006)

✓ L_X may shape the accretion disk structure

→ The clumpiness of disk structures may depend on the unobscured luminosities of the central engin
Statistics is poor!

Lack of X-ray data for most of the known maser sources!



Open questions:

- → Why water mega masers are found only in a small fraction of AGN?
- → What is activating the maser? X-rays? Is there a threshold in luminosity, Eddington ratio?
- → Why only 50% of Compton thick AGN show maser emission? Geometrical effects (warp degree) and variability

UNBIASED VIEW: the hard X-ray sky





INTEGRAL hard X-ray AGN: characterizing water maser



INTEGRAL AGN sample 20-40 keV

→ Total sample 380 AGN

→ Water maser survey of a complete sample+literature
Panessa et al. in preparation

\rightarrow Complete sample 87 AGN

→ Water maser survey of a complete sample Castangia et al. in preparation

INTEGRAL hard X-ray AGN: characterizing water maser





INTEGRAL AGN sample 20-40 keV

INTEGRAL hard X-ray sky: statistics

→ Total sample 380 AGN

✓ 193 observed
 ✓ 29 water maser detection
 ✓ 187 not observed

→ 15 (+/-2.8) % detetion rate [7.6-56.8%]

→ Complete sample 87 AGN

✓ 65 observed

✓ 12 water maser detection

✓ 22 not observed

 \rightarrow 18 5 (5 3) % detetion rate

INTEGRAL hard X-ray sky: statistics among type 2

\rightarrow Total sample 163 type 2

✓ 103 observed
 ✓ 23 water maser detection
 ✓ 60 not observed

→ 22 (+/-4.7) % detetion rate [14.1-50.9]

\rightarrow Complete sample 34 type 2

✓ 29 observed

- ✓ 9 water maser detection
- \checkmark 5 not observed

→ 31 (+/-10) % detetion rate [26.5-41.2]

INTEGRAL hard X-ray sky: statistics



H₂O and X-rays



No significant correlation

H₂O and X-ray column density

Conclusions from an hard X-ray sample

→ Water maser detection rate from 15% up to 34% (sey 2)
 → high luminosity - low z AGN

 \rightarrow No confirmed correlation between X-ray and H₂O luminosit

 \rightarrow H₂O water masers are common in heavily absorbed nuclei

Panessa et al. in preparation

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Main topics:

- X-ray and gamma-ray emission from radio galaxies
- Space-VLBI results & prospects on jets launching and collimation
- Theory and simulations of accretion/ejection physics
- Census, restarting nuclear activity and jet-medium interaction
- Lessons from the multi-frequency/messenger approach

Thank you

https://sites.google.com/inaf.it/cospar-2020e1-17 http://gral.iaps.inaf.it/

The space view of radio galaxies

Sydney, Australia, 15-23 August 2020