

Hard X-ray Properties of Water Maser Galaxies Eugenia Litzinger

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Overview

- Water (H₂O) emission at 22.2 GHz \simeq 1.35 cm
- Microwave Amplification by Stimulated Emission of Radiation
- collisional pumping by X-ray source or shock waves ⇒ inverse population
- Megamaser: $L > 10 L_{\odot}$



0.5 ly

Credit: J. Herrnstein, et. al., NRAO/AUI and CfA.

NGC 4258



- survey of AGN to search for water maser emission, especially in a circumnuclear disk
- VLBI and single-dish observations
- 162 maser galaxies detected; ~20 confirmed disk masers



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Keplerian curve

- determination of M_{BH}
- geometrical distance
 - $D = r/\theta$ $a = v_r^2/r$

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- $D = v_r^2/a\theta$
- + disk modeling: \implies independent measurement of $H_0 = 68.6\pm5.6$ km/s/Mpc
- (Kuo+ 2011, Reid+ 2013)







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 soft X-rays
- determination of N_H: high fraction Compton thick
- very complex models (see poster F19 by K. Leiter) hard X-rays
- unaffected by absorption; less complex models (?)





Sky Map





Sky Map



- BAT sources (70 month survey)
- Maser sources
- \diamond BAT detected maser sources ($\sigma > 2.0$)













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Spectral Fitting

- fitted spectra in the 20–100 keV range of BAT with a simple power law
- photon index Γ well constrained for 30 sources
- determined the luminosity $L_{20-100 \text{ keV}}$
- estimate for "bad" sources and upper limits for undetected sources
 - \Rightarrow comparison with radio luminosities



Luminosity

 L_X vs. L_{H_2O}

- weak correlation p=0.39
- comparable with soft X-rays (Kondratko et al. 2006)





Luminosity

 L_X vs. L_{H_2O}

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- comparable with soft X-rays (Kondratko et al. 2006)

L_X vs. L_{20cm}

- stronger correlation ρ=0.54
- upper limits also follow the correlation





Luminosity

Disk maser

- strong correlation for radio continuum *ρ*=0.47
- no correlation for maser luminosity
 variability, radio lags?





Are the maser galaxies special in hard X-rays?



Redshift

- masers peak at low redshifts <0.02
- BAT AGN shifted towards higher redshifts ~0.03, all kind of AGN





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- masers peak at low redshifts <0.02
- BAT AGN shifted towards higher redshifts ~0.03, all kind of AGN
- better sample: AGN with same classification





Are the maser galaxies special in hard X-rays?

Water maser galaxies:

- mostly Seyfert 2
- thousands of galaxies surveyed: detection of 162 maser galaxies

Comparison sample: Zhang et al. 2012, A&A 538, A152

- 89 nearby Seyfert galaxies
- already surveyed for H₂O emission
- 31 detected with BAT with σ > 4.8



Luminosity

- compared in the 14–195 keV range
- similar photon indices
- maser seem to be more luminous





Summary

- detection of 55 maser sources in the BAT 70 month survey (significance>2σ)
- strong correlation between the hard X-rays and the radio continuum luminosity, also for disk-maser weak correlation between the hard X-rays and the maser luminosity, no correlation for disk-maser (variability?)
- maser tend to be more luminous than non-maser sources

Outlook

- power law does not fit all maser spectra
 combine hard X-ray spectra in the 14–195 keV range with soft X-rays (2–10 keV; see poster by K. Leiter)
- checking variable sources in X-ray (*XMM-Newton*) and radio (GBT, VLA) for radio lags/connection
- possible detection of maser galaxies in the X-rays?