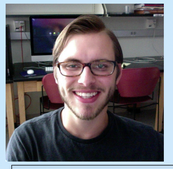


Understanding the Connection Between the X-ray and the Water Maser Emission in Galaxy Centers

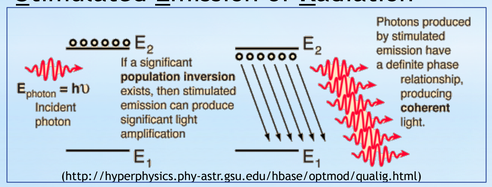
Noah Ripchick & Anca Constantin, Dept. of Physics & Astronomy, James Madison University

Abstract

Water maser emission that is millions of times more luminous than that found in regular star forming regions, and which is found in a disk-like configuration, provides one of the most accurate ways to determine distances to extragalactic sources as well as masses of supermassive black holes in galaxy centers. Water masers themselves are highly elusive with a detection rate of only about 3%, and those in disks only amount to 20% of all maser detections. In an attempt to improve the maser detection rates, we are investigating the multi-wavelength properties of all galaxies that have been surveyed in 22 GHz for maser activity in order to uncover the most common observables that correlate with the nuclear masing process. We present here preliminary results of a comprehensive study of the X-ray properties of galaxies with and without maser detection, with an emphasis on publicly available data from the *Chandra X-ray Observatory* and the *XMM-Newton* telescope. This analysis offers potentially new insights into the link between the process of accretion of matter onto the central supermassive black hole and the water masing activity.

Motivation/Background

❖ **MASER** = **M**icrowave **A**mplification by **S**timulated **E**mission of **R**adiation



(http://hyperphysics.phy-astr.gsu.edu/hbase/optmod/qualig.html)

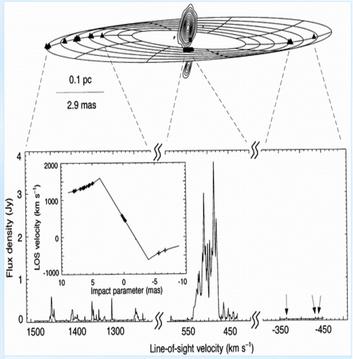
❖ **Megamasers** = 10^6 × more luminous than typical masers emission found in star forming regions in the spiral arms of our own galaxy (> $10 \times L_{solar}$)

❖ Very low detection rate ➔ need to identify more efficient ways of finding galaxies with water megamaser emission in their centers

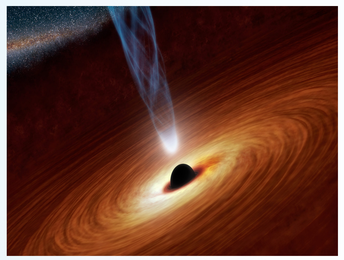
❖ This effort: Identify host galaxy traits that correlate with water maser emission

❖ Previous studies suggest strong association of maser disks with Supermassive Black Hole accretion (i.e., Active Galactic Nuclei, or AGNs; Herrnstein et al. 1999) and have identified a stronger correlation between disk maser emission and circumnuclear large obscuring columns detected in X-ray observations (e.g., Greenhill et al. 2008).

❖ The inner regions of AGN are strong X-ray emitters in galaxy centers (e.g., Elvis 2000)



A maser disk around an accreting supermassive Black Hole (Herrnstein et al. 1999)


An artist rendition of an AGN (http://www.astro.gsu.edu/AGNmass/agn.jpg)

❖ It is of interest to identify the degree to which the AGN activity, as measured by its X-ray emission correlates with the water megamaser and disk emission.

The maser sample: The Megamaser Cosmology Project (MCP)

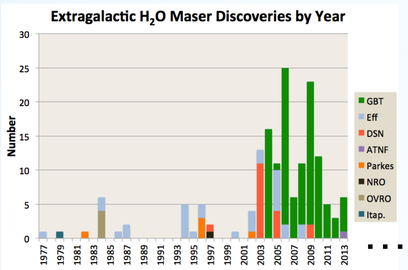
❖ MCP provides the largest catalog of galaxies surveyed for water maser emission in 22 GHz

❖ ~4500 galaxies surveyed, most with the *Green Bank Telescope*

❖ 163 galaxies found to host maser emission = Masers (the rest are Non-Masers)

❖ ~80% of all masers are Megamasers

❖ ~20% of all masers are Megamaser disks



(https://safe.nrao.edu/wiki/bin/view/Main/MegamaserCosmologyProject)

Very few masers found in the past few years …?

✧ 20 masers and 116 non-masers were observed with both Chandra and XMM → use this sample to test our conversion to a common 2-10 keV energy range.

✧ Goal: combine all X-ray data to increase the number statistics, and compare the X-ray properties of the various types of masers with those of non-masers

The X-ray Data

The Chandra Source Catalog (CSC)

❖ Includes calibrated measurements of counts, multi-band fluxes, hardness ratios and variability statistics, for about ~100k X-ray sources detected in public ACIS imaging fomr ~8 years of the Chandra mission (Evans et al. 2010).

❖ 0.5 – 7 keV energy range

The 3rd XMM-Newton Serendipitous Source Catalog (3XMM –DR5)

❖ This is the largest X-ray catalog to date; it contains measurements of fluxes, count rates, hardness ratios, and variability information for pointed observations as well as spurious source detections with the XMM-Newton telescope (~400k sources; 13 years of data; Rosen et al. 2010).

❖ 0.2 – 12 keV energy range

http://www.star.bris.ac.uk/~mbt/topcat/

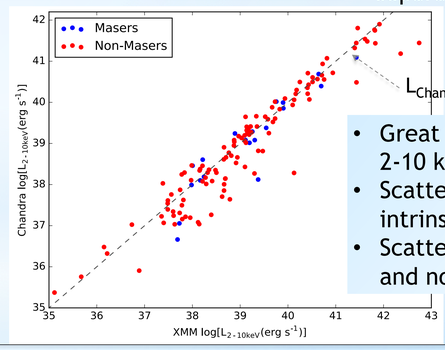
TOPCAT

Tool for OPerations on Catalogues And Tables

➢ TOPCAT is an interactive graphical viewer and editor of graphical data best used for analysis and manipulation of astrophysical source catalogs (Taylor 2005).

➢ We cross match the MCP sources with the CSC and 3XMM-DR5 catalogs within ~6 arc seconds; in case of duplicate matching we keep the match with the closest angular separation.

Cross Matching Results				
	Masers	Megamasers	Disk Masers	Non-Masers
Chandra	30	27	12	211
XMM-Newton	58	47	20	550



- Great match in the calculated 2-10 keV Luminosities
- Scatter is expected due to intrinsic variability
- Scatter is similar for the maser and non-maser sources

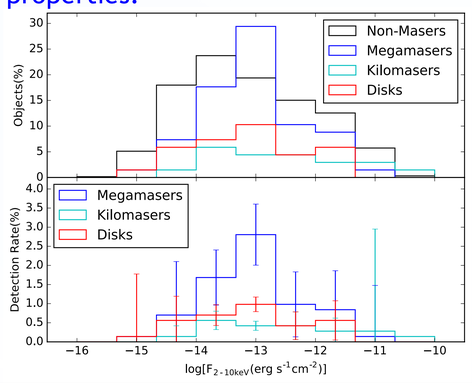
Results: Comparison between the X-ray fluxes and luminosities

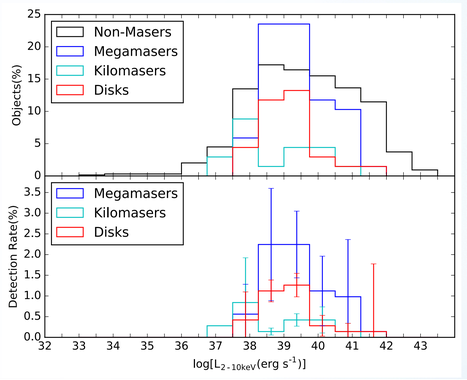
❖ Differences in the X-ray emission between types of masers and non-masers are weak

❖ Kilomasers are less X-ray active (lower luminosities)

❖ Megamasers and disks prefer moderate X-ray emitters as host galaxy centers

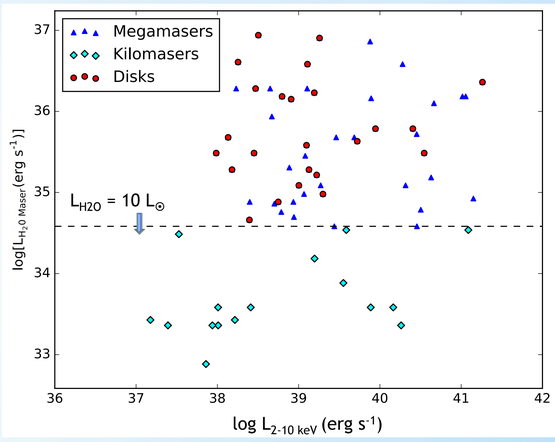
→ proves difficult to identify megamaser emission based on observed X-ray properties.





Results: No correlation between the observed (not corrected for intrinsic absorption) X-ray luminosity and the water maser power output

for any type of masers.



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