THE PHYSICS OF MEGAMASERS

MASER – Microwaves Amplified by Stimulated Emission of Radiation

Megamasers – $10^6$ times more luminous than typical galactic masers

Optical image of NGC4258
Megamasers in a disk-like configuration:

1. **Measure direct distances** to their host galaxies
   - Constrain geometry of the universe
   - Independent constraint to the age of the universe
   - Better understand nature of dark energy

2. **Measure the masses of the central supermassive black hole**
To find more water megamaser disks, we must know how to search for them!

- ~3% of all galaxies host maser emission
- ~20% of galaxies that host megamaser emission in a disk-like configuration
- Previous searches: no systematic analysis of properties of galaxies with maser emission and those without
Systematic search to identify galaxy traits connected to the megamaser disk phenomenon

How?

- Collect fluxes from public databases
- Build Spectral Energy Distributions (SEDs) = total flux emitted across the electromagnetic spectrum
- Quantify the degree to which various energetic components contribute to the total galaxy light
- Find links to megamaser emission to design more efficient maser survey selection methods

(Hickox & Alexander 2018)
WISE: all-sky survey with the best sensitivities in mid-IR wavelengths (W1=3.4μm, W2=4.6μm, W3=12μm, W4= 22μm)

Cross-match positions of 46 H₂O megamaser disks
- Infrared Processing and Analysis Center (IPAC) table
- Input: count, galaxy name, right ascension, declination

Search parameters
- Test a range of cone search radii to match the angular resolution of WISE filters
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**RESULTS OF CROSS-MATCHING**
THE NATURE OF DUPLICATES

- Cone–search radius \( r \) = 15 arcseconds
- Both WISE detections are included
- SQL query to select smallest separation to the input source
THE MYSTERY OF NGC1068

- $\Delta s = 14.92$ arcseconds
- Diameter = 170,000 light years

WISE Image Search: mid – IR detection encompasses the $\Delta s$
SPECTRAL ENERGY DISTRIBUTIONS

NGC4258

\[ \nu F_\nu \text{ (jyHz)} \]

\[ \nu \text{ (Hz)} \]

\[ \nu (\text{Hz}) \]

\[ 3 \mu \text{m} \]

3 m 3 cm 0.3 mm 3 \mu m 30 nm 3 \AA

Radio Far-IR Near-IR Optical Soft X-ray

Hard X-ray

\[ 10^5 \quad 10^7 \quad 10^9 \quad 10^{11} \quad 10^{13} \quad 10^{15} \quad 10^{17} \]

\[ 10^8 \quad 10^{10} \quad 10^{12} \quad 10^{14} \quad 10^{16} \quad 10^{18} \quad 10^{20} \]
IN THE FUTURE...

- Compare the optical and mid-IR images for NGC1068
- We will be adding the mid-IR data to the SEDs
- Proceed with SED fitting to quantify the contribution of AGN compared to stellar light and other energetic phenomena in these galaxies
THANK YOU

Dr. Anca Constantin

4-VA Collaborative at James Madison University

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