AGN accretion disk physics using H_2O megamasers



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UVa/NRAO

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Background

- The Megamaser Cosmology Project (MCP) has collected a large dataset of single-dish H_2O maser spectra using the GBT
  - The primary goal of this project is to use disk maser systems to measure geometric distances to their host galaxies and therefore make a measurement of the Hubble constant
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  - A secondary goal is to make precise measurements of SMBH masses
- What ancillary science can be investigated using such a comprehensive and rich dataset?

Spiral shock model

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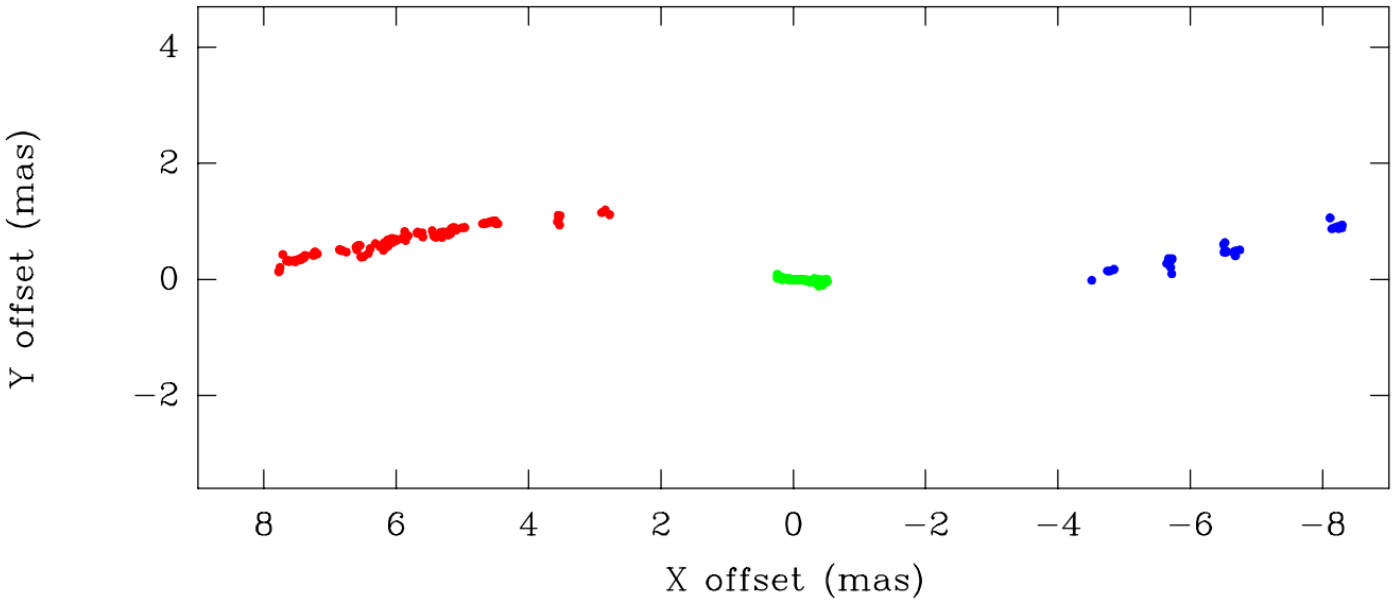

Humphreys et al. (2013)

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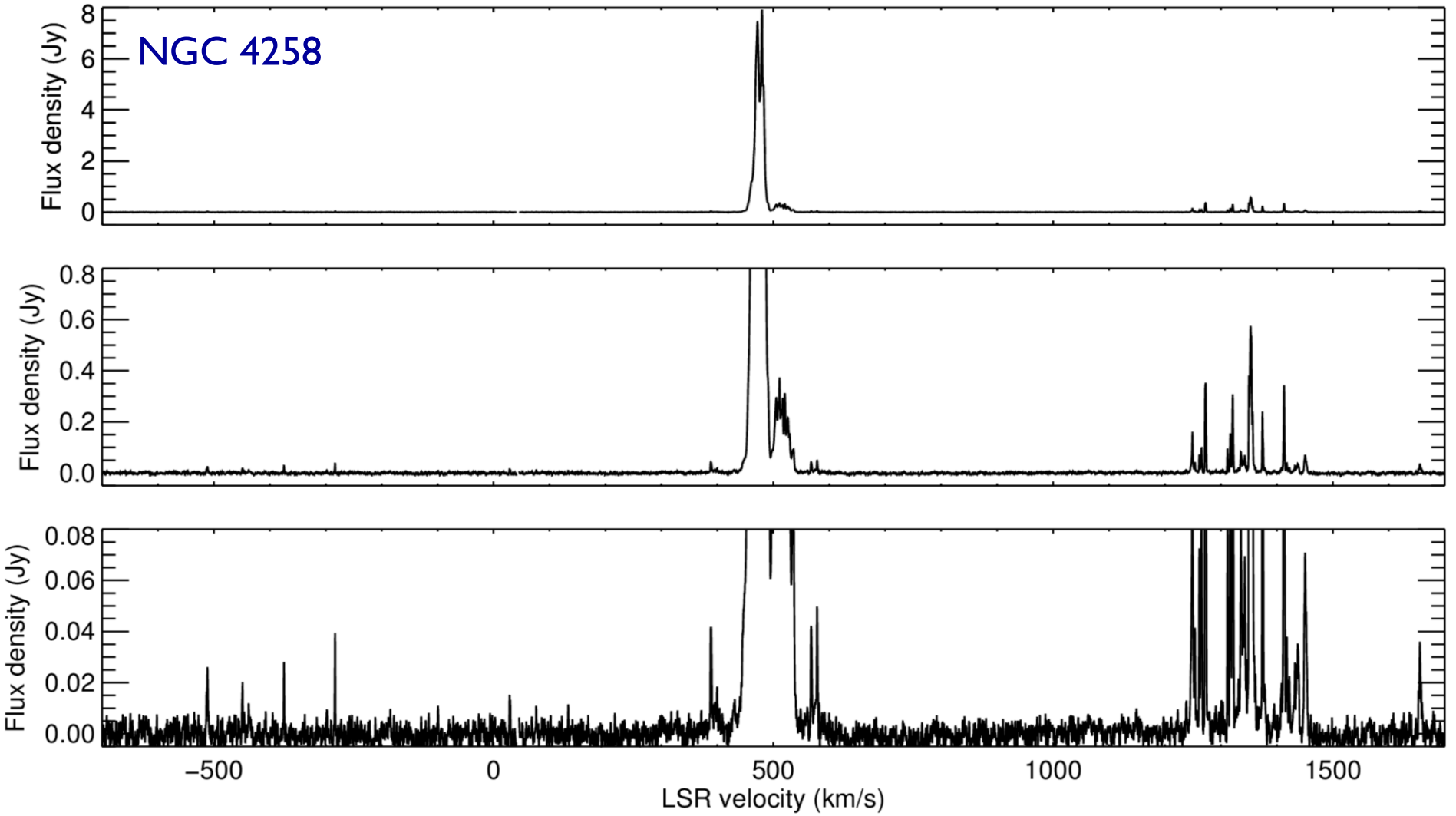
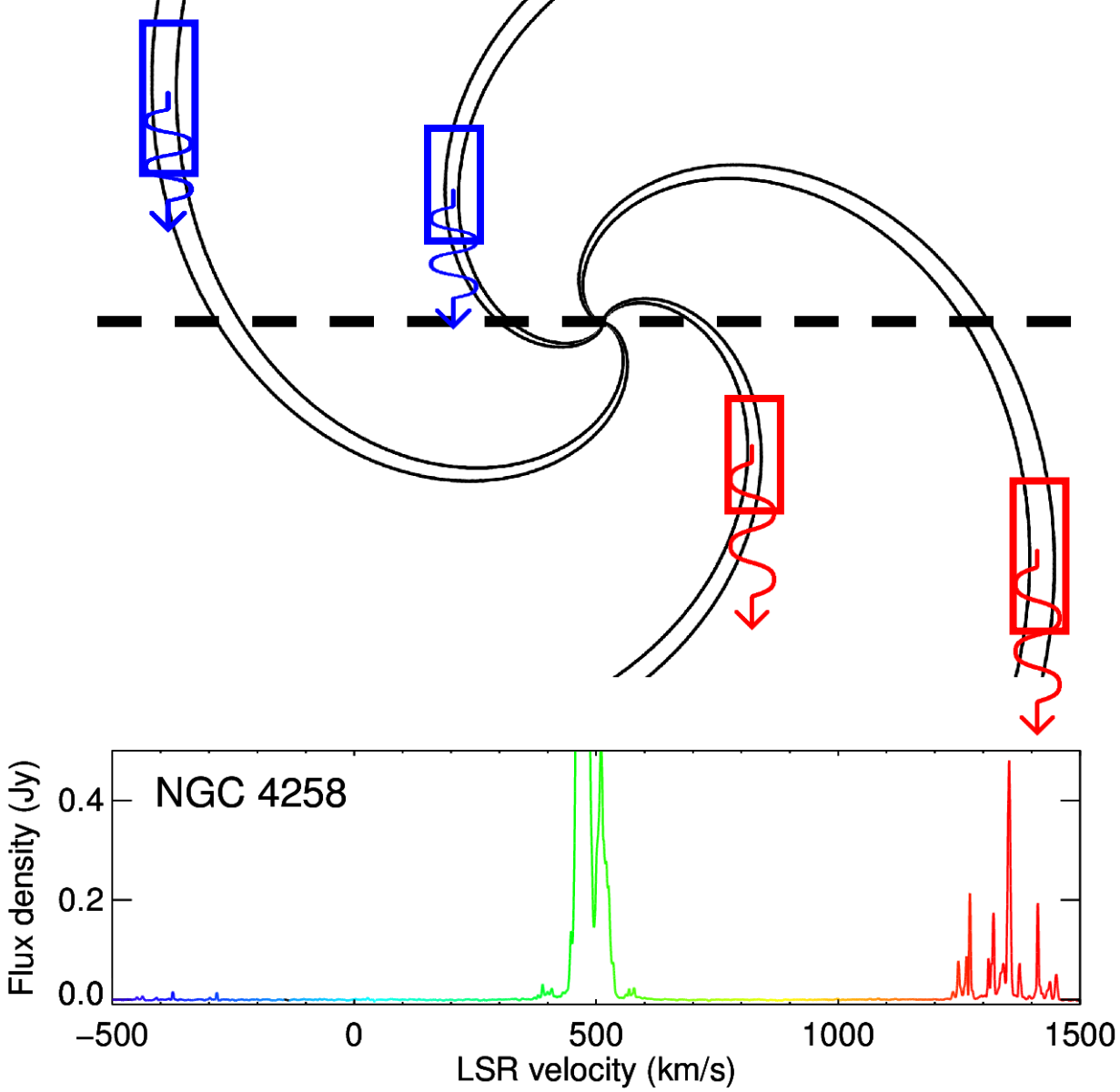
  2. Stronger redshifted features


NGC 4258
Flux density (Jy)
8
6
4
2
0
Flux density (Jy)
0.8
0.6
0.4
0.2
0.0
Flux density (Jy)
0.08
0.06
0.04
0.02
0.00
−500
0
500
1000
1500
LSR velocity (km/s)


NGC 4258
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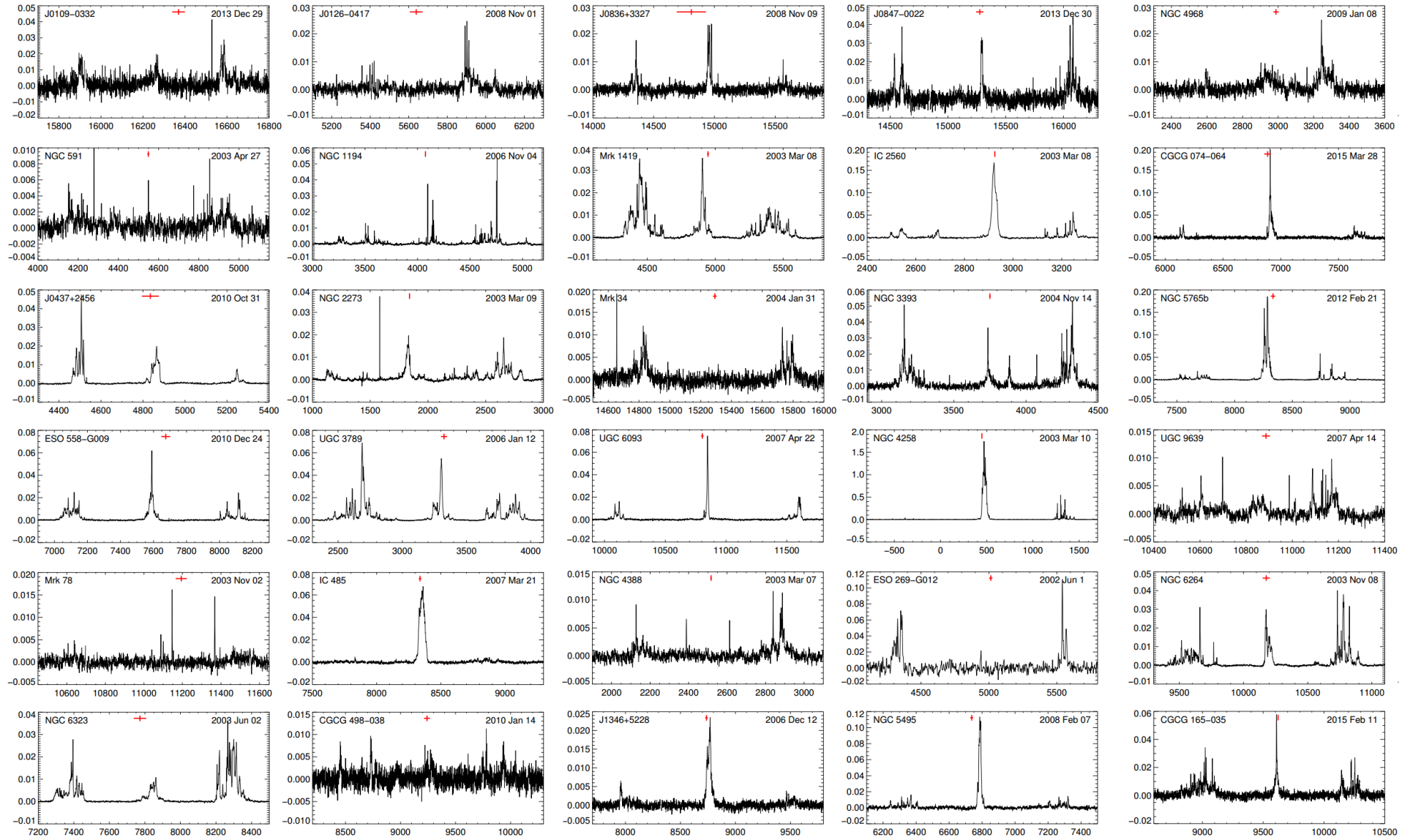
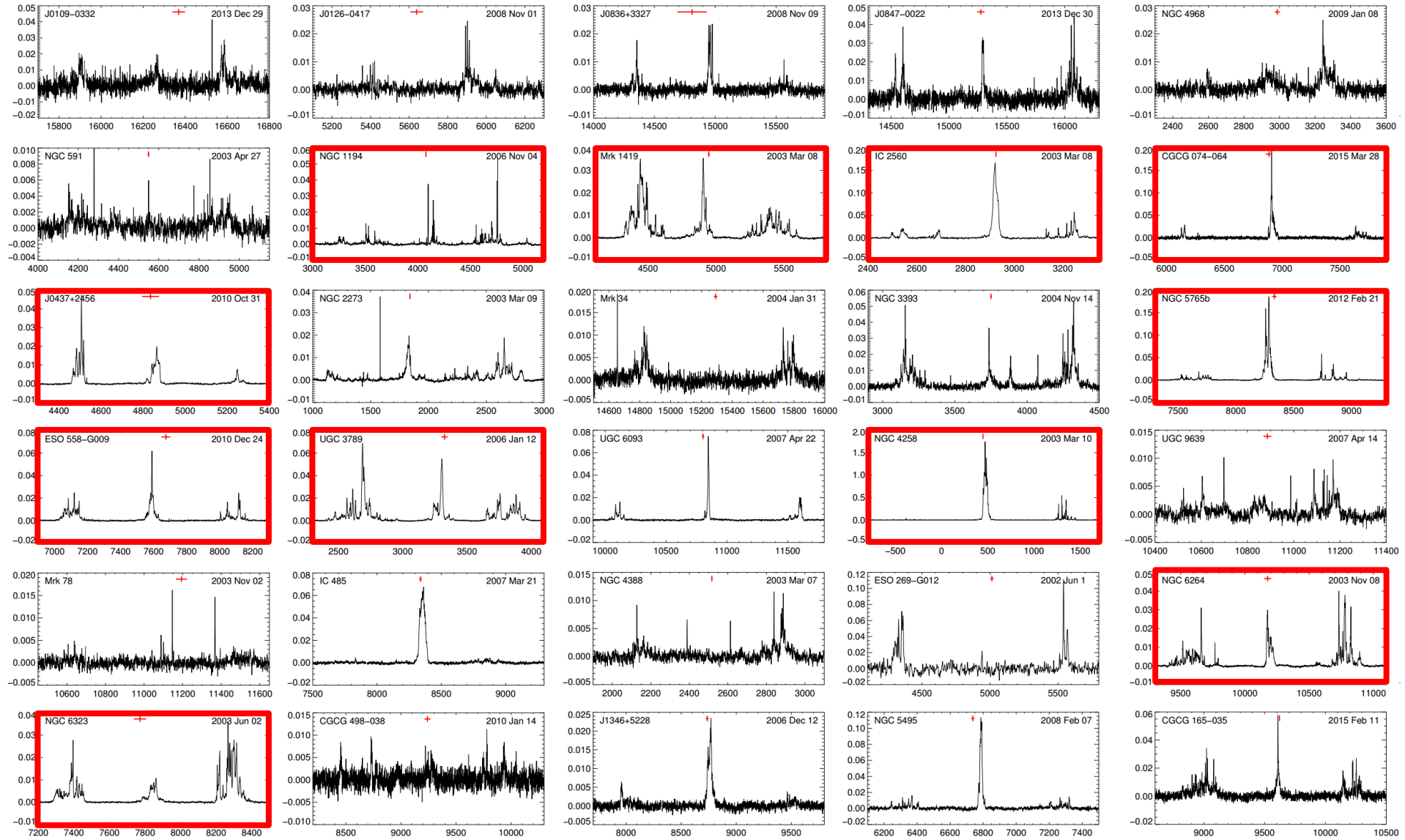
- What about for disk maser systems in general?



Pesce et al. (2015)



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Spiral shock model

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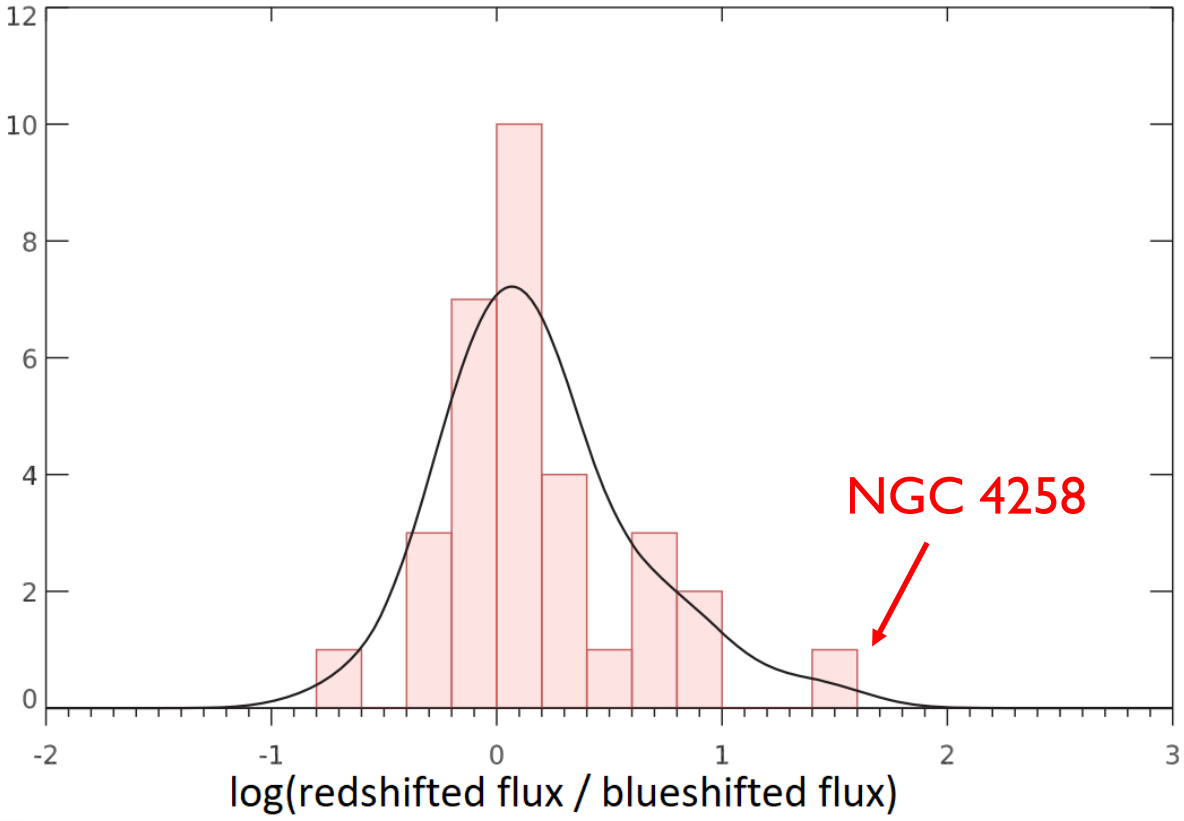

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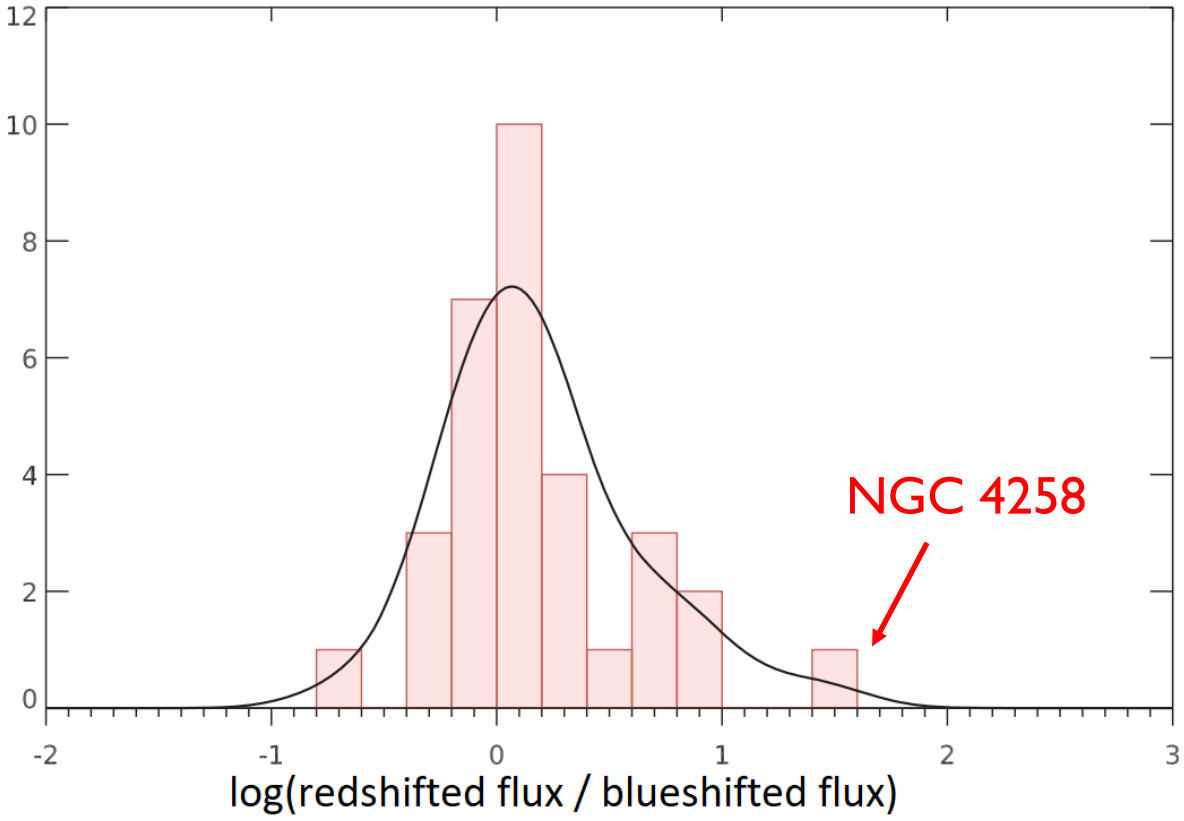


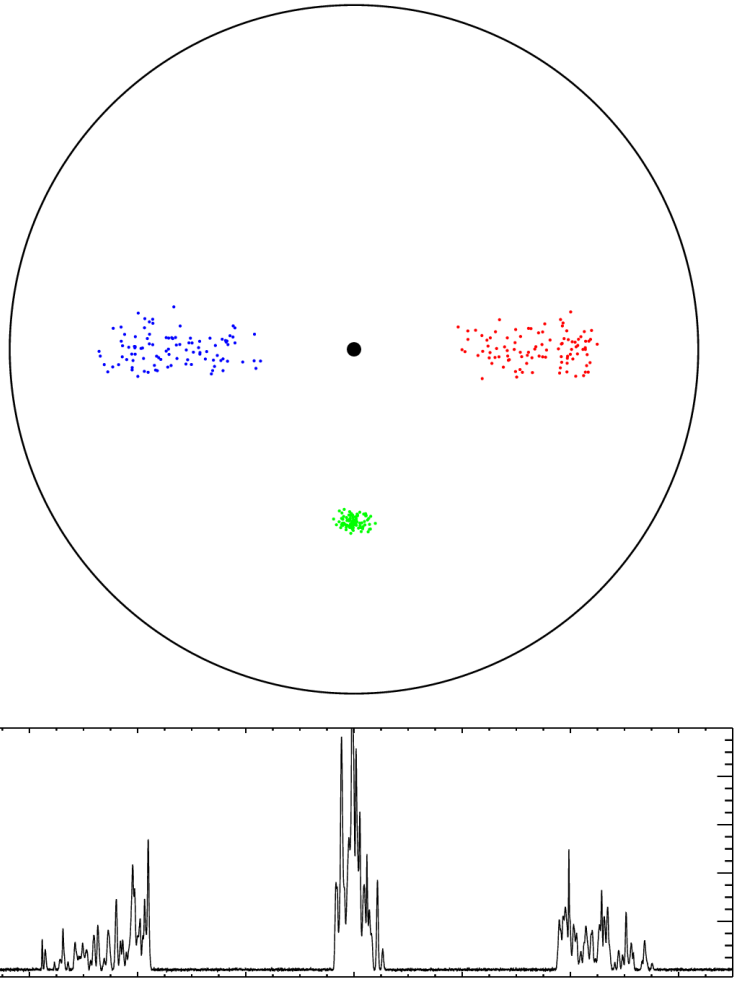
Not really

Pesce et al. (2015)

Spiral shock model

- Do these systems show a systematic preference for stronger redshifted features?
- We also found no evidence for the predicted velocity drifts in the high-velocity features, using the 11 galaxies with sufficient monitoring

Disk reverberation



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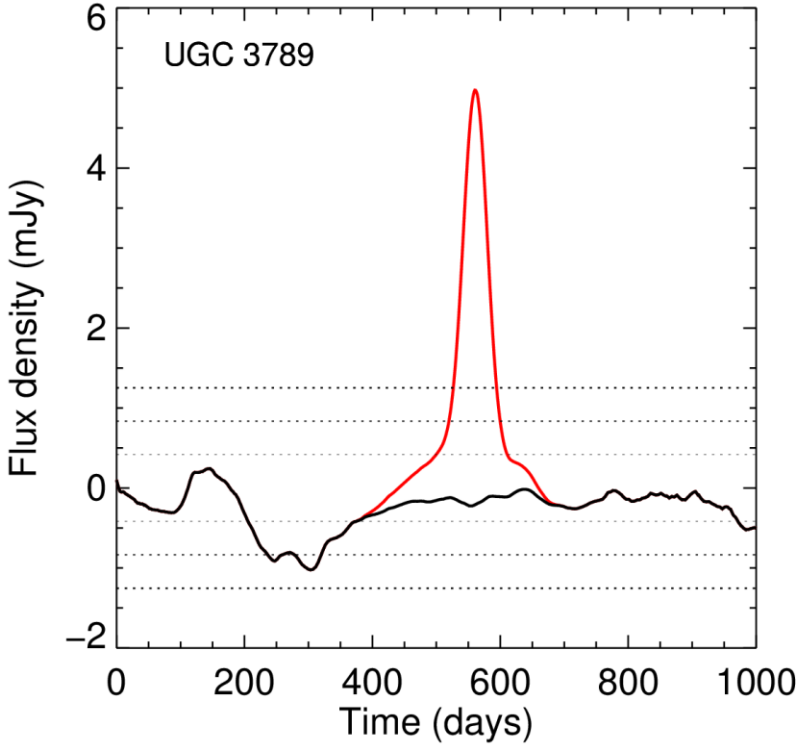
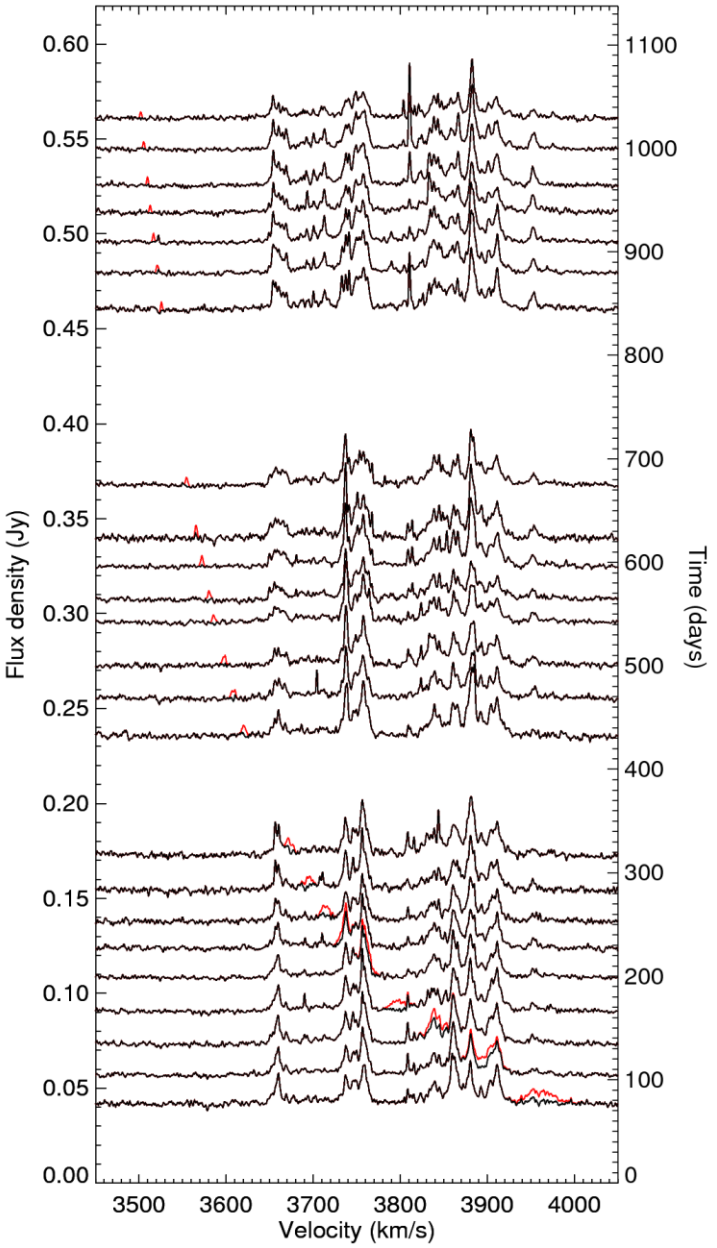
$$r = \frac{GM_{\rm BH}}{(v - v_0)^2}$$

$$\dot{r} = v_s = -\frac{2GM_{\rm BH}\dot{v}}{(v - v_0)^3}$$

$$M_{\rm BH} = -\frac{v_s (v - v_0)^3}{2G\dot{v}}$$

Disk reverberation





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- We searched our 6 most thoroughly-monitored systems for a reverberation signal, with no detections
  - Typical limiting (3σ) flux density of ~1-2 mJy

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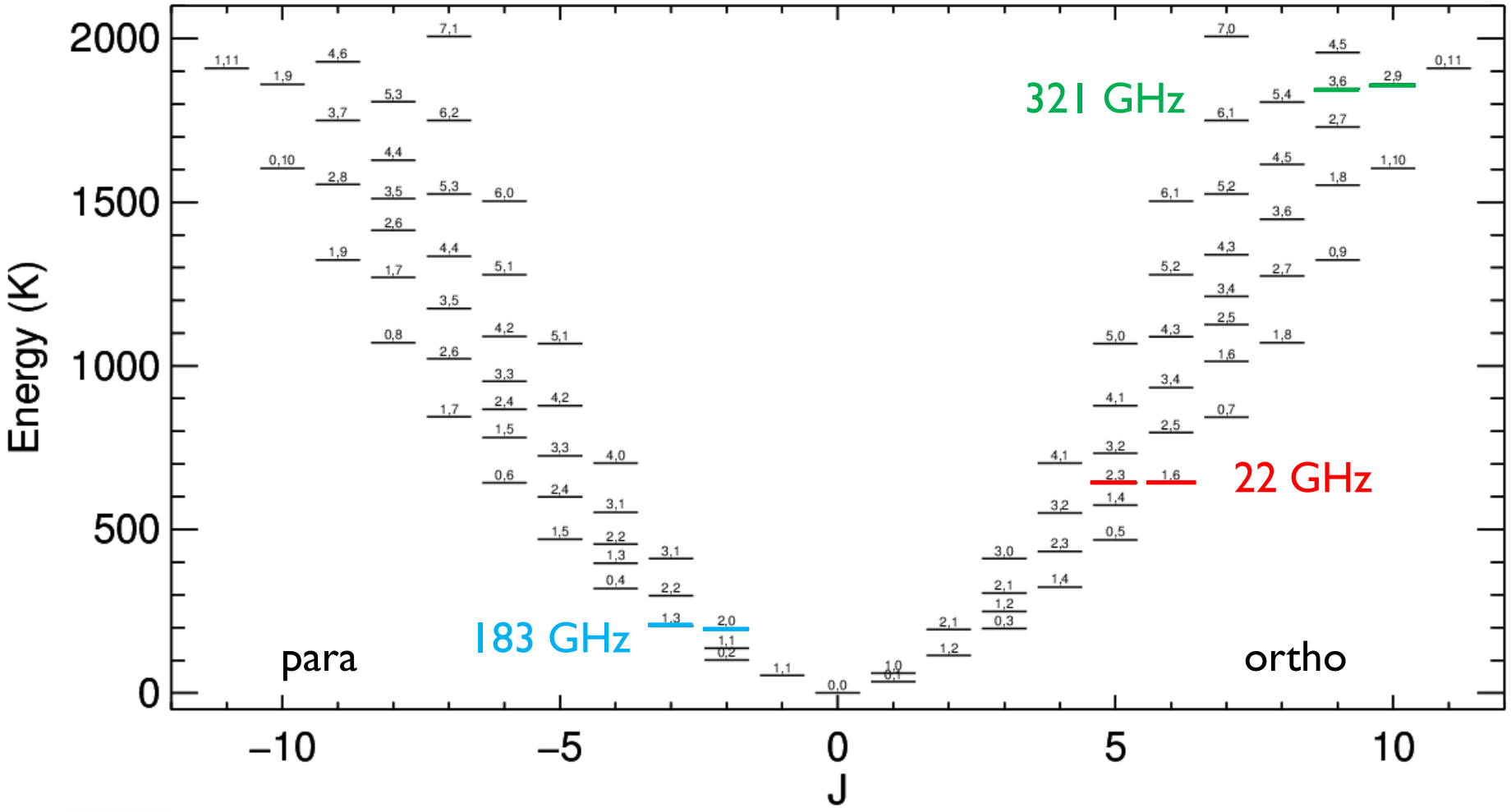
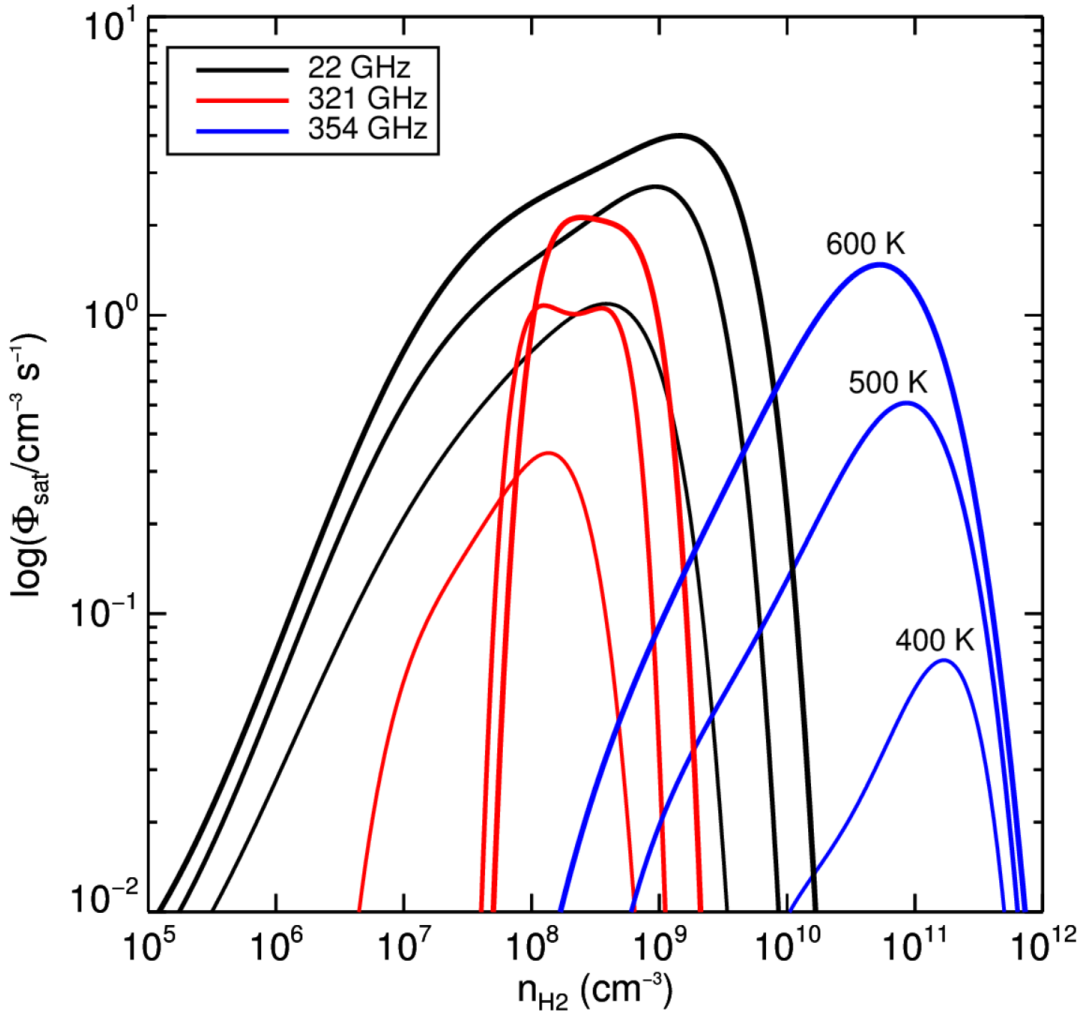
  - Typical limiting (3σ) flux density of ~1-2 mJy

- Since we see variability at the ~tens of mJy level, but any radially-propagating signal must contribute less than ~10% of this variability, we know that the maser variability in the disk is not associated with energetic events from the AGN

Submillimeter water masers

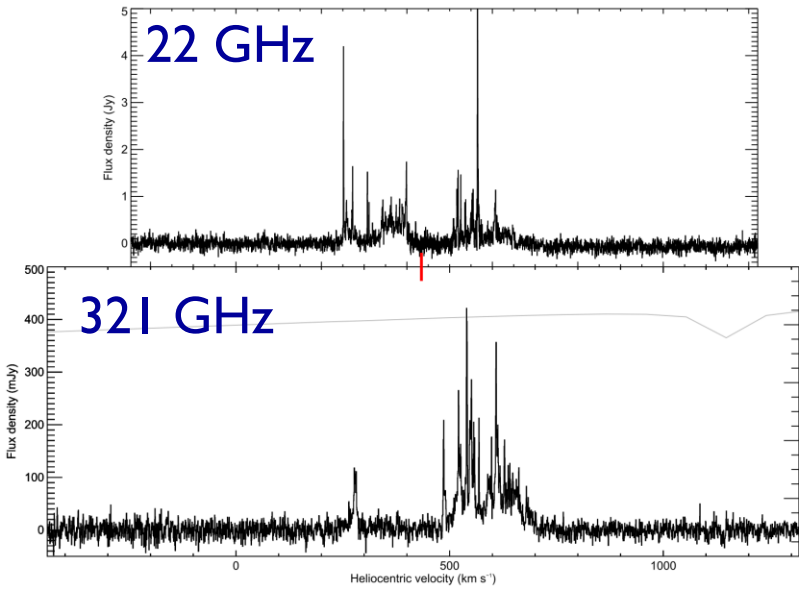


Submillimeter water masers

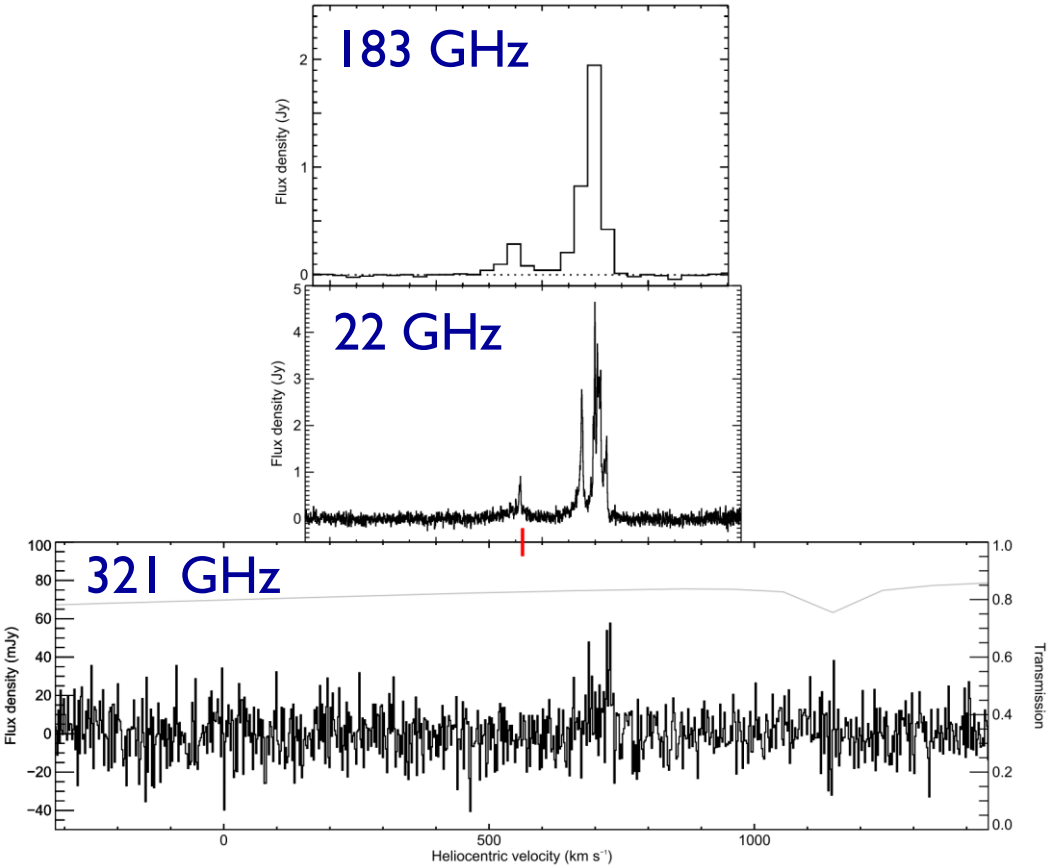


Submillimeter water masers

Circinus



NGC 4945



Pesce et al. (2016); Humphreys et al. (2016)

Summary

- The Maoz & McKee (1998) spiral shock model for maser excitation in AGN accretion disks makes some testable predictions
  - We examined all known disk maser systems and found no significant evidence for the predicted flux asymmetry or velocity drifts
- We examined well-monitored disk systems from the MCP for radially-propagating reverberation signals
  - Any such signal must be contributing less than ~10% of the total variability
- ALMA has now opened up the possibility of studying sub-mm megamasers
  - Observations of multiple masing transitions will constrain the physical conditions in the accretion disk
  - Several galaxies have already been observed to host sub-mm megamasers
  - Upcoming work will focus on spatially resolving the sub-mm maser distribution