## Measuring Light Echos in NG-C4051

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- Insufficient counts to separate lines and continuum on short timescales
- Measure reverberation between broad bands
- Reflected & direct mixed in different
  fractions in the bands



a Lag times increase with band separation

- Estimate cross-band power spectrum (max likelihood) -> time delay as function of source variations
- Lag spectrum given by phases of Fourier transform of the transfer function which describes spread of time delays in the signal











- Hard Lags soft by >~1000 s at 5x10<sup>-5</sup> Hz for
  all band pairs
- Negative Lags ~400 s at 2x10<sup>-4</sup> Hz
- top hat model fits simplistic but data do
  not warrant more complex model



- Iight echos from shell, tmin 2,200s -> scatt light close to los is absent -> shell with holes/clumps
- Emax 14,000s (Fe K band) light travel time
  across shell diameter
- o not a unique model

Scattered fraction
 increases with photon
 energy while max time
 delay decreases

Higher fraction of soft photons scattered from larger radii?



| We have a series of the series |                 |                 |      |
|--|-----------------|-----------------|------|
| band   | $t_{\rm min}/s$ | $t_{\rm max}/s$ | R    |
| 2-4 keV  | -               | -               | 0    |
| 5-7.5 keV  | 2200            | 14400           | 0.14 |
| 8-15 keV   | 2200            | 10600           | 0.22 |
| 15-70 keV  | 2200            | 2900            | 0.47 |



Negative lag - but
 soft band has no
 reflected
 contribution

(cf blurred ref
 model for 1H0707)



## Conclusions

- Hard band flux variations consistently lag softer
  band in NuSTAR data from NGC 4051
- Negative Lag seen but cannot be from inner disk reflection as soft band has no reflection
- Top hat model fits lags consistent with reverberation from cloud ensemble but not a unque solution
- · Reverberation likely mapping stratified clumpy wind
- @ Zones out to 7000 Ls radii, global covering ~50%