Probing the difference between host halos for obscured and unobscured quasars

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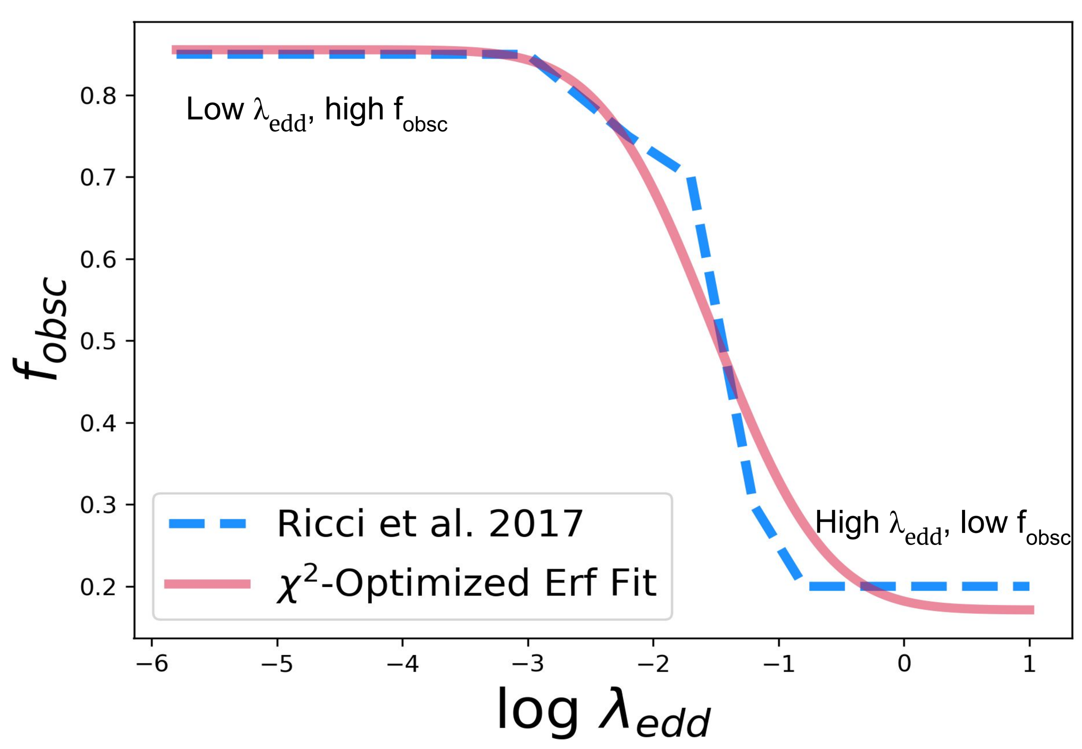
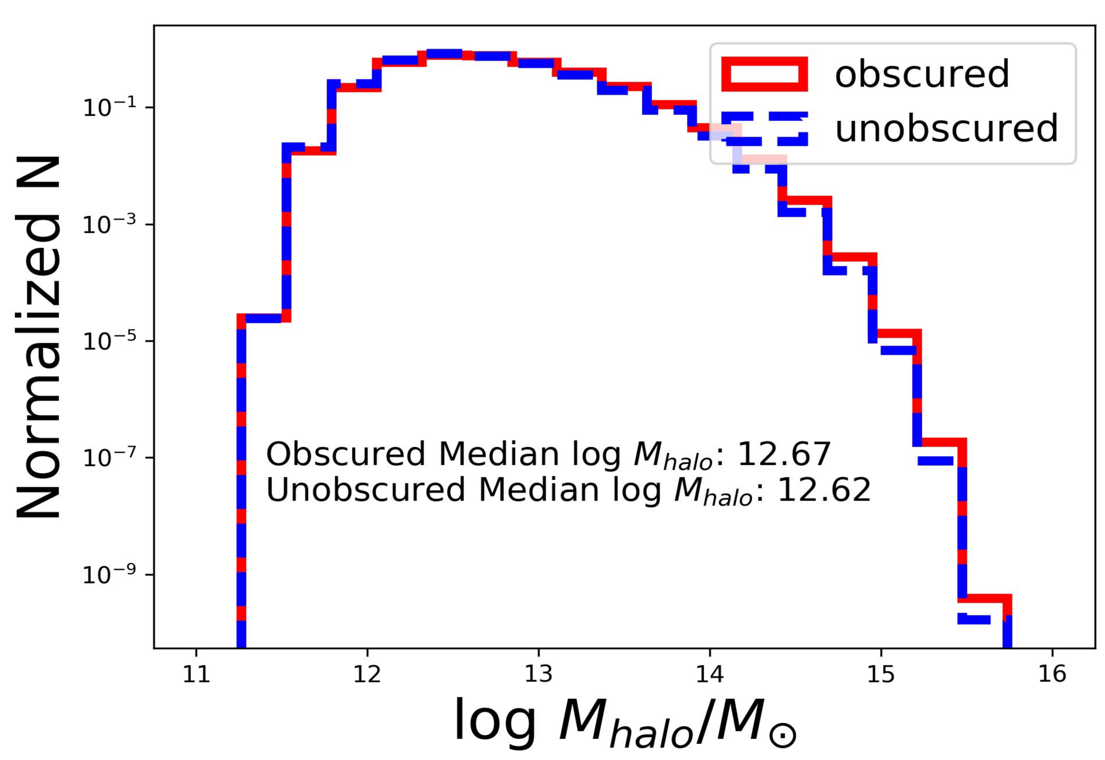
Abstract

Wide-field infrared surveys have allowed us to better understand obscured quasars. Recent cross-correlation and clustering measurements of obscured and unobscured quasars have shown us that obscured quasars preferentially inhabit more massive parent dark matter halos than their unobscured counterparts, in direct opposition to simple unified ("torus") models of quasar structure (DiPompeo et al. 2017). However, there are also evolutionary models that show that obscuration could be a phase in the course of a quasar's lifetime, which would allow for a discrepancy in dark matter halo masses (DiPompeo et al. 2017). Another possibility, raised by recent observations of local AGN, is that the covering factor of AGN tori depends strongly on Eddington ratio (Ricci et al. 2017). Here, **we construct a simple model using known halo mass and Eddington ratio distributions as well as empirical relationships between obscuring fraction and Eddington ratio to predict the halo masses of obscured and unobscured quasars**. We find that these effects could produce the observed quasar clustering results, but only for a relatively narrow set of relationships between AGN obscuration and Eddington ratio.

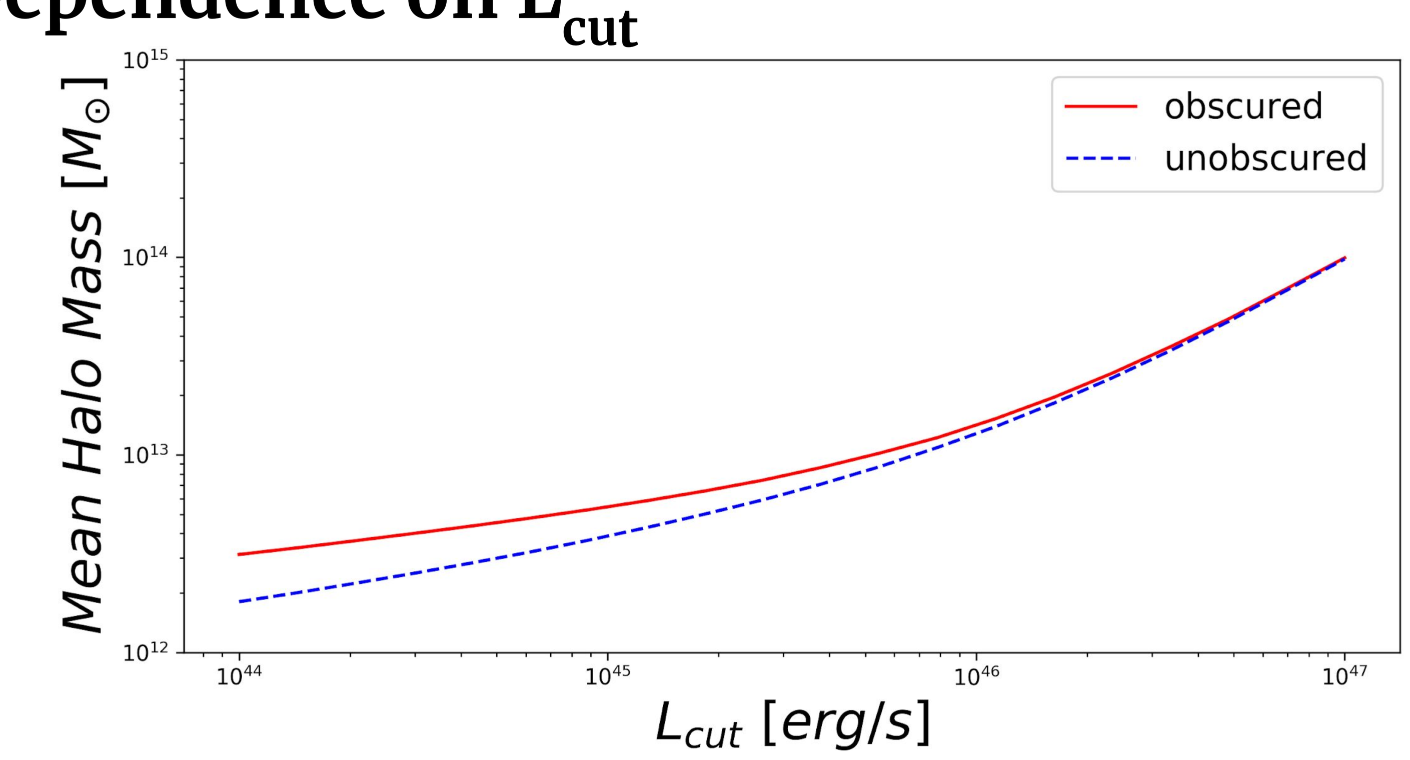
The Model

- Sample contains 10^7 dark matter halos
  - uniformly distributed in a mass range of $10 < \log M_{halo}/M_{\odot} < 16$
  - Quasars can be accreting at Eddington ratios between $-4 < \log \lambda_{edd} < 1$.
- Quasars assigned a weight
  - Weight = HMF×Schechter λ_{edd} Function. (Tinker et al. 2010, Jones et al. 2016)
- **Quasars classified as obscured or unobscured as a function of Eddington ratio** (top panel) (Ricci et al. 2017)
- Calculated the median DM halo mass for each population (bottom panel)
- For a luminosity cut of $10^{45.8}$ erg s^{-1}, **there is no discernable difference between these populations**





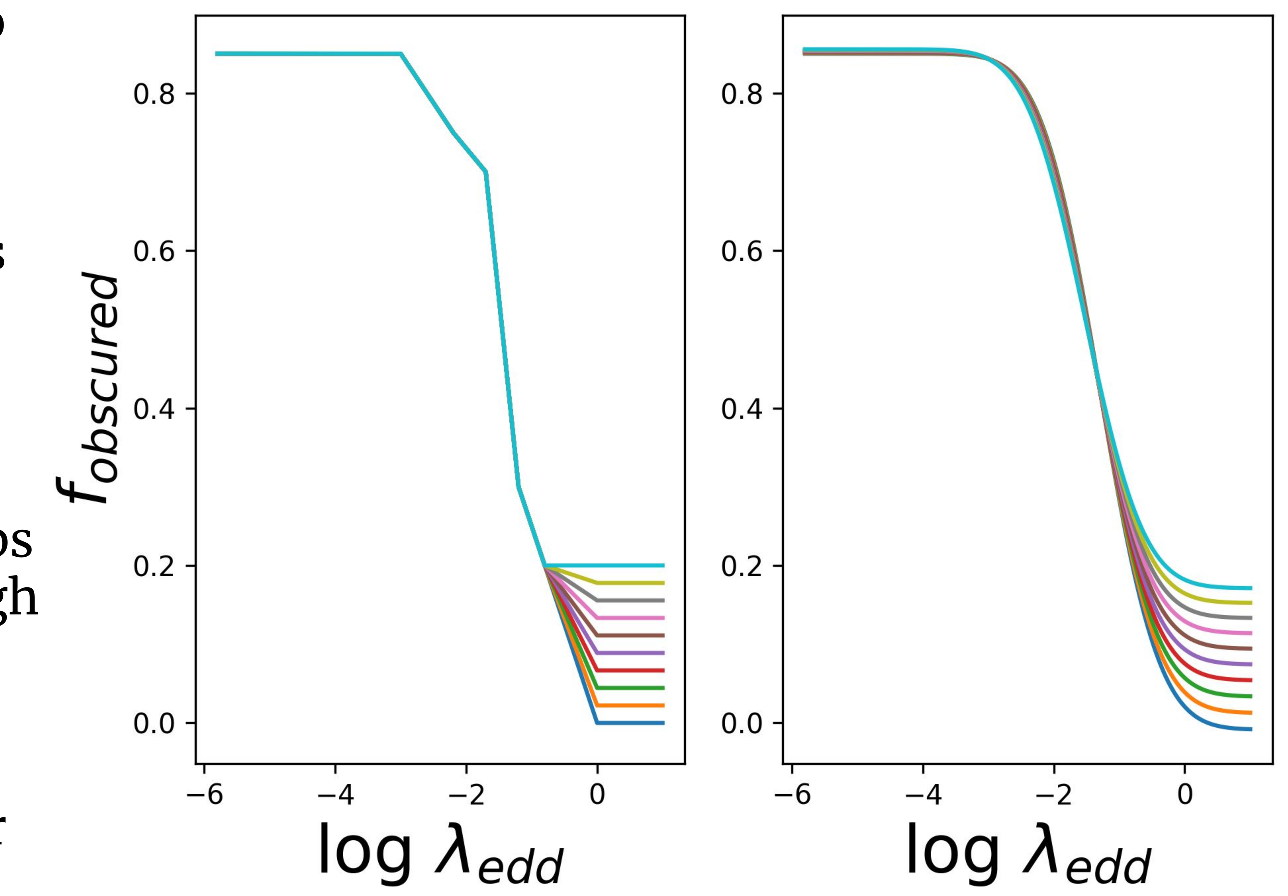
A Dependence on L_{cut}

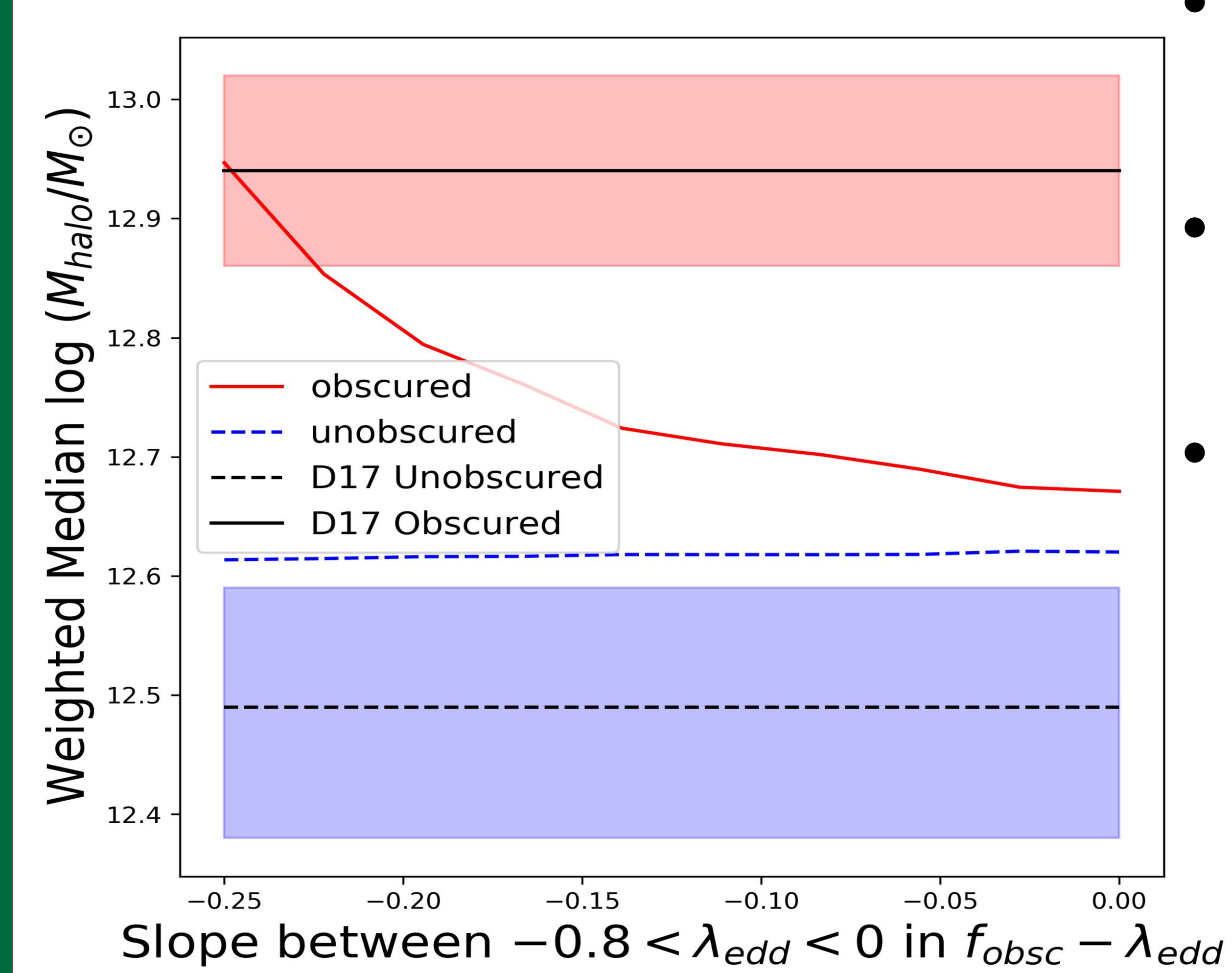


- The $10^{45.8}$ erg s^{-1} luminosity cut (DiPompeo et al. 2016) corresponds to the typical bolometric luminosity of a mid-IR selected quasar
- Quasars with lower luminosities have been observed
  - Important to determine if luminosity cut affects modeled quasar populations
- **As L_{cut} increases, we lose our lower mass quasars. This effectively makes our unobscured and obscured populations identical**

The Shape of the $f_{obsc}-\lambda_{edd}$ Relationship

- The shape of the $f_{obsc}-\lambda_{edd}$ relationship is determined by the optical depth of the obscuring material.
- Different tori models could change our modeled quasar populations
- Left Panel: various $f_{obsc}-\lambda_{edd}$ relationships
  - Flatter slope at high λ_{edd} means more optically thick torus
- Right Panel: An error function fit to the piecewise $f_{obsc}-\lambda_{edd}$ relationship

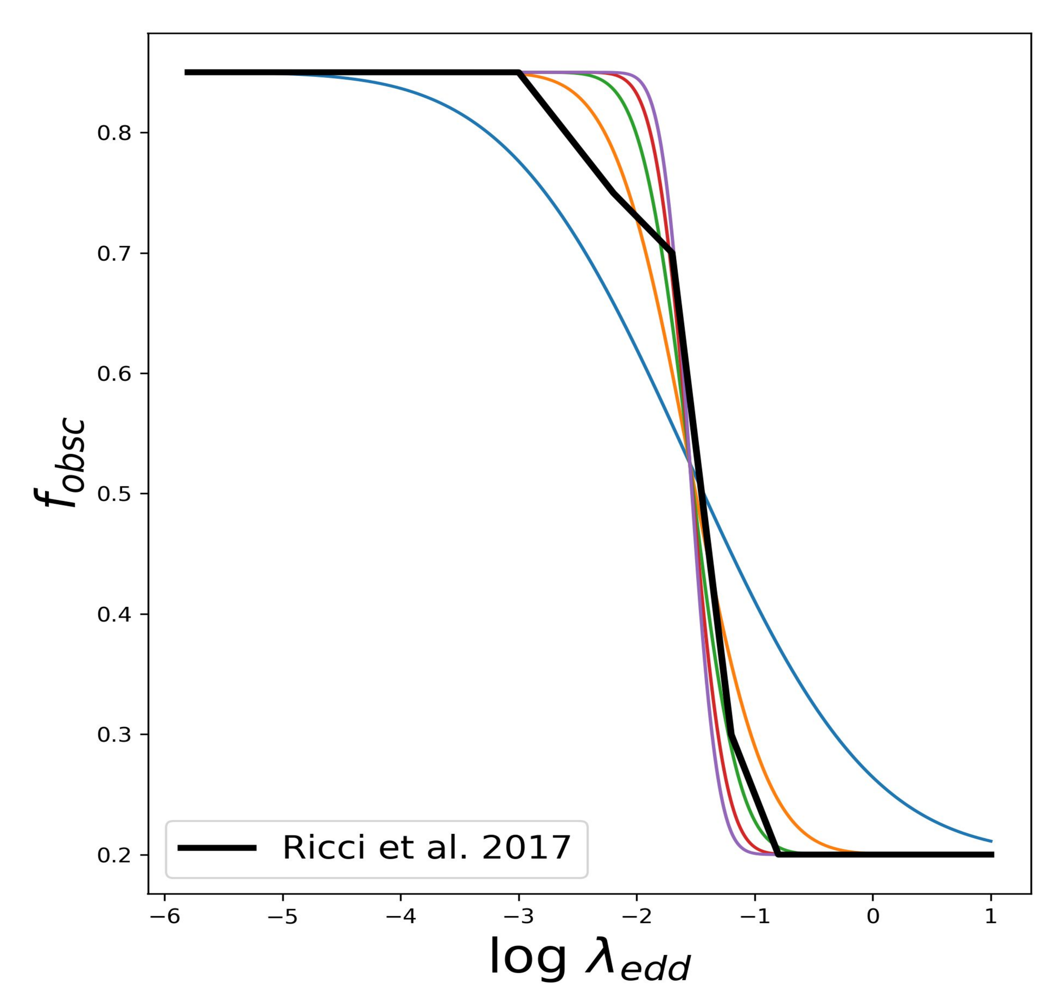




- Calculated the median DM halo mass for populations generated using above $f_{obsc}-\lambda_{edd}$ relationships
- Observations from DiPompeo et al. (2017) shown in the red and blue shaded regions
- **As the slope at high Eddington ratios steepens, the median obscured quasar halo mass diverges from that of the unobscured population**
  - This makes sense since more low mass/high Eddington quasars would be unobscured

Summary and Future Work

- Preliminary results show that **for certain luminosity cuts and $f_{obsc}-\lambda_{edd}$ relationships, there is a clear difference in DM halo mass for our populations of quasars**
- We plan on examining what happens when we alter the width of our modeled error function (right)



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