Nonthermal Emission From Black Hole Accretion Flows

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I. *Introduction*

The objective of this project is to model the emission from an accretion flow with an electron distribution having a nonthermal (NT) component. This could model the black hole at the galactic center (Sgr A*). Current data of the galactic center suggest that there is stronger emission from the infrared range of the spectrum than previous models have accounted for. This project looks into accounting for the missing emission with a NT component in the electron distribution function.

II. *Methods and Model Parameters*

- Models simulated with code written in C.
- Ray tracing methods are used to image the synchrotron emission.
- Presented simulations used parameters to best model Sgr A*:
  - Mass of black hole: $4.5\times10^{6} M_\odot$
  - Distance to source: 8.3×10^{3} parsec
  - Ion to electron temperature: 3
  - Normalization Mass Unit: 6×10^{18} g
  - Max Lorentz Factor: 1000
  - Simulation Size: 50 GM/c^2 by 50 GM/c^2
  - Energy ratio NT to thermal: 5 to 100

III. *Old Model: Thermal Shortcomings*

- All particles are in thermal equilibrium.
- Coefficients of emission can be calculated with $j_{th} = B_\nu(T) \bullet \alpha_{th}$.
- Where j_{th} is the thermal emissivity, $B_\nu(T)$ is the spectral radiance determined by Planck's Law and α_{th} is the thermal absorptivity.
- Fails to adequately account for emission in infrared range.

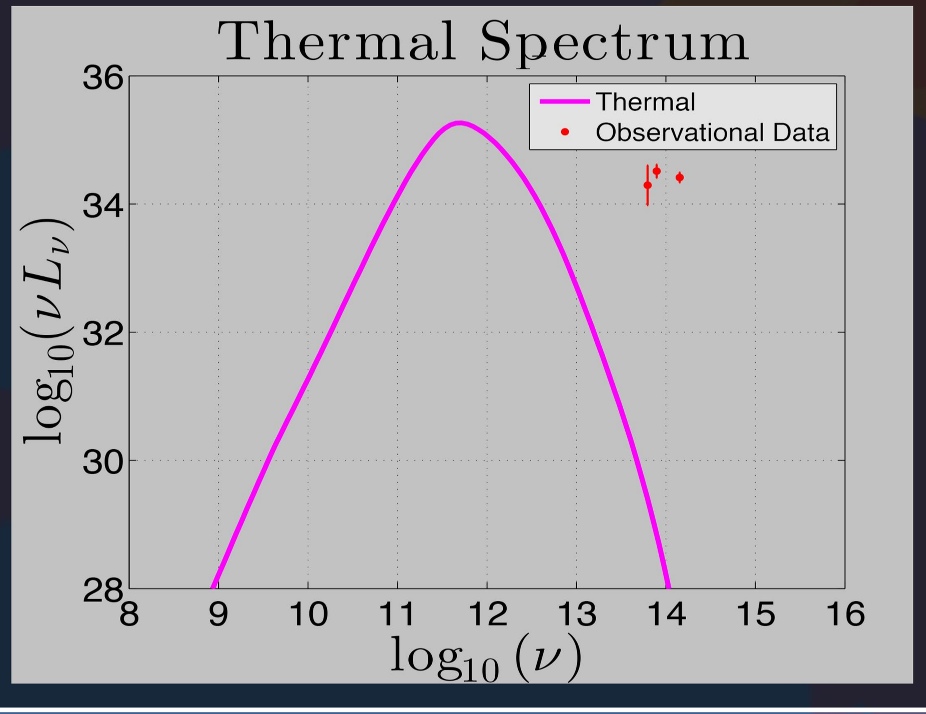


Figure 1: *Spectrum of an accretion flow in the old model with only a thermal component. Peaks around 10^{12} Hz, and lacks observed emission in the infrared range [6].*

IV. *New Model: A Nonthermal Component*

- Particles out of thermal equilibrium.
- NT component modeled with a power law.
- Power law emission will continue at higher frequencies indefinitely.

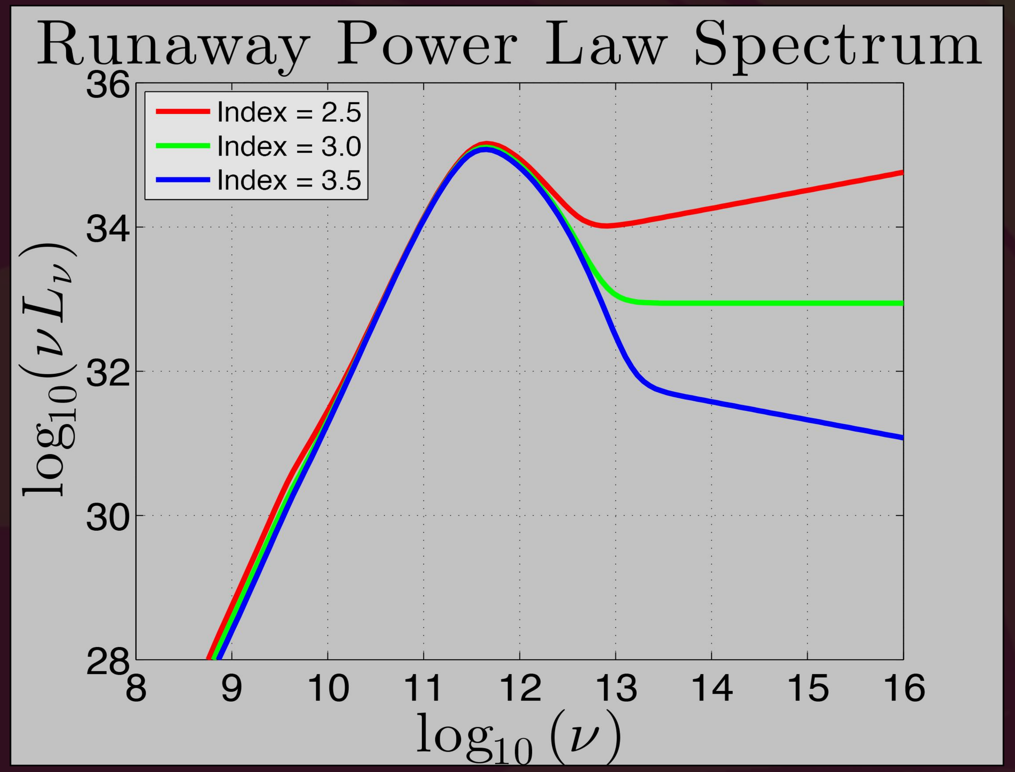


Figure 2: *The power law model for the electron distribution allows for a parameter to account for observed infrared emission. However, the power law spectrum for an electron distribution with a NT component will continue indefinitely.*

- Unphysical for emission to continue indefinitely.
- Power law emission needed an exponential cutoff.
- Looking to match power law to quasi-analytic simulated coefficients.
- An approximate fitting formula for the cutoff is: $\exp(-\nu/(Y\, \nu_c \sin(\theta)\, \gamma^2))$.
- Where ν_c is the cyclotron frequency and θ the angle between the field lines and the wave vector.
- The coefficient Y needed to be determined, and was found to be 1.5

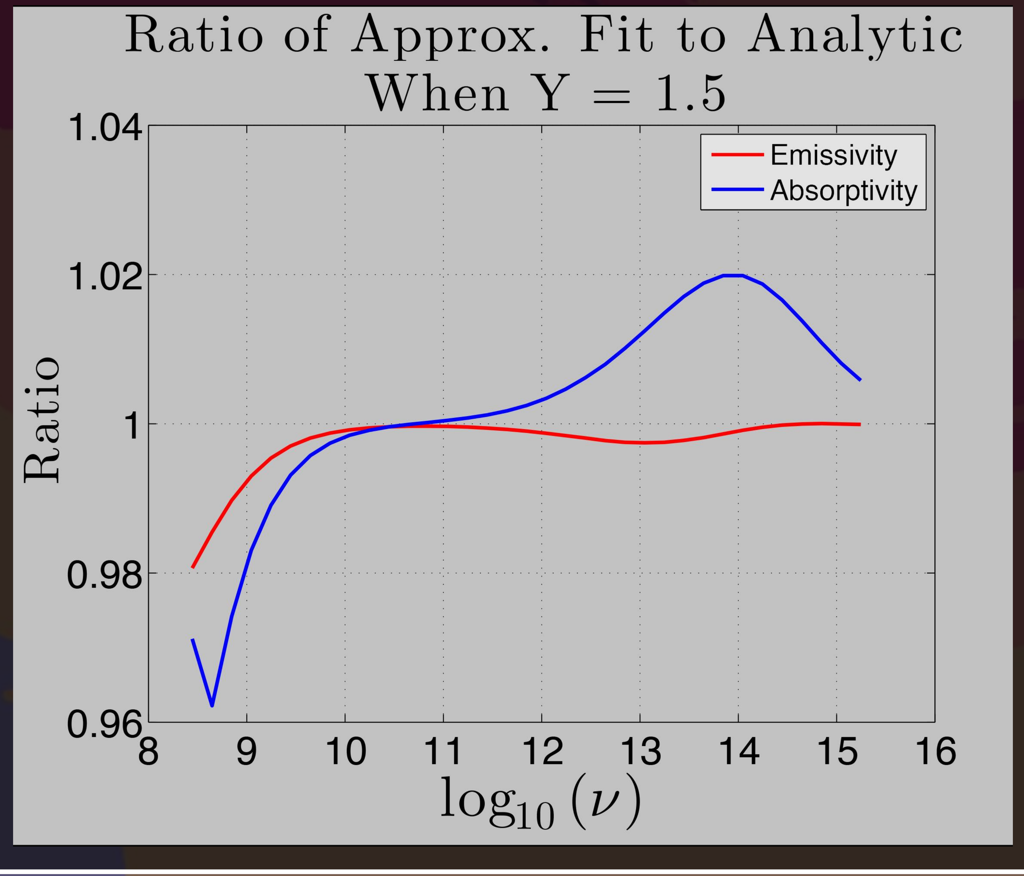
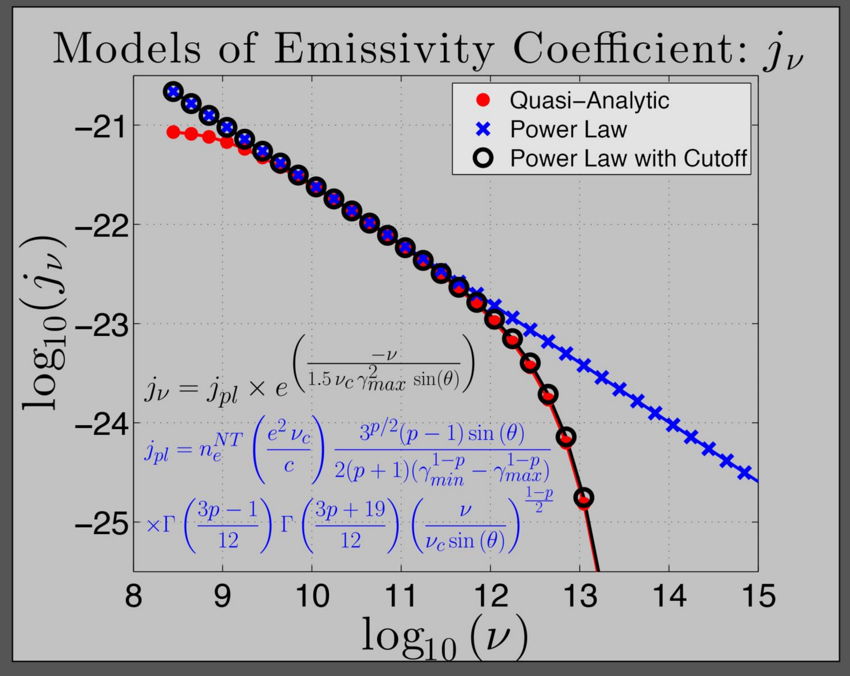
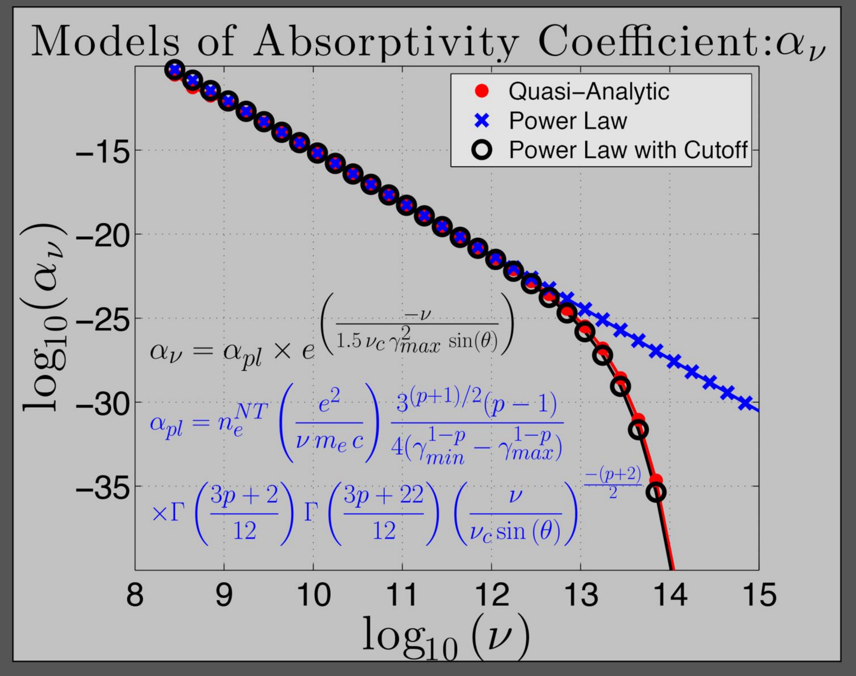


Figure 3: *Plotted is the log of the approximate fitting formula coefficients divided by the log of the quasi-analytic coefficients. When Y is taken to be 1.5 the approximate fitting formula is good, especially at higher frequencies.*

V. *Results*

- Computationally cheap and accurate emissivity and absorptivity coefficients.
- Infrared emission better matches observational data.
- Improved model with additional degrees of freedoms will allow for better observation matching.





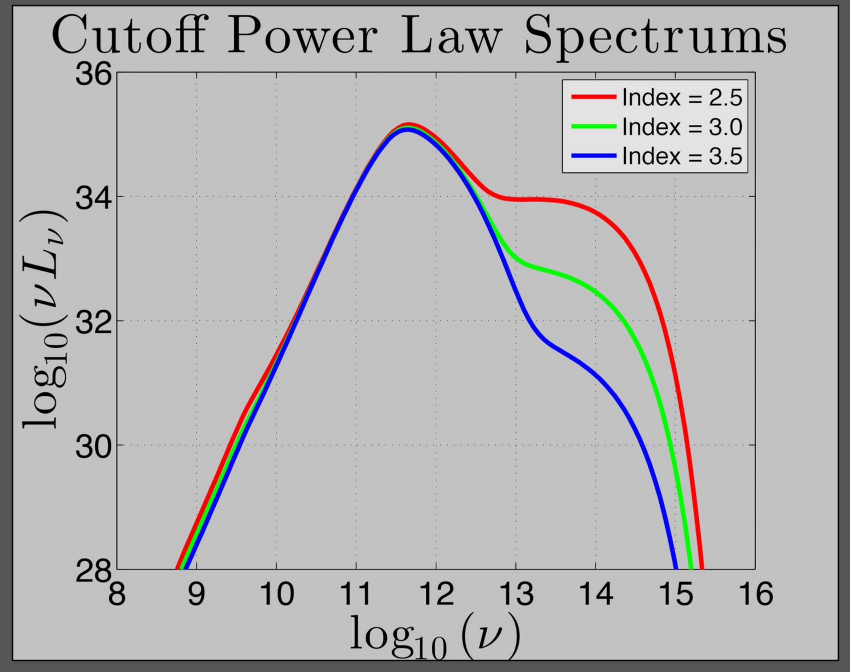


Figure 4: Upper Left and Right: *Quasi-Analytic is computationally expensive, while other two are much cheaper. Yet, the power law cutoff has good agreement to QA.* ***Bottom Left:*** *Spectrums with the cutoff implementation, resolves infrared emission.*

VI. *Acknowledgments*

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VII. *References*

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