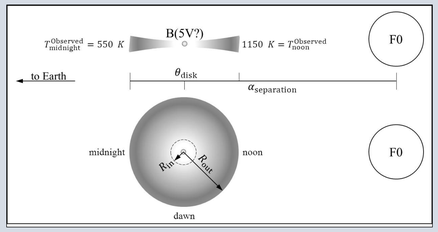
The Invisible Monster Lives In A Cage

Kian Greene

Dr. Richard Pearson

Introduction:

Epsilon Aurigae is a long-period eclipsing binary consisting of a F0Ia primary star and a dust-shrouded secondary object, likely a BV star. High uncertainty in parallax measurements of this systems has contributed to further uncertainty in the system parameters themselves. Using the Hyperion Monte-Carlo Radiative Transfer (MCRT) code, we attempt to apply constraints on the Epsilon Aurigae system using a selected distance range. Spectral Energy Distributions (SEDs) produced from this code will be also be used as an analytical tool to compare our results with existing literature.



Methods:

The VizieR library of astronomical catalogues was used to gather initial parallax measurements of the epsilon Aurigae system, which were converted to distance values. Parameters dependent on distance were determined from the following set of fundamental equations and observational constraints for the system:

$$M_2 = f(\mathrm{M})(1+q)^2/\sin^3 i$$

$$M_1 = q\,M_2$$

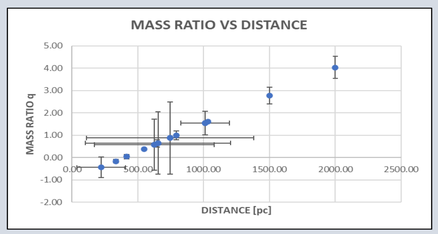
$$d[\mathrm{m}] = 1000\,(q+1)\frac{(a_1 \sin i)}{\sin i \tan\left(\frac{\alpha_T}{3600000}\right)}$$

$$r_{\text{disk}} = d\tan(R_{\text{disk}})$$

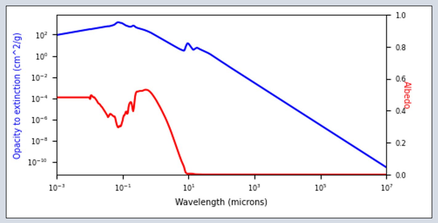
Symbol	Observed Value
f(M)	2.51 $M_\odot$
$a_1 \sin i$	1.84 Tm
i	89°
α_T	31 mas
R_{disk}	7.416 mas

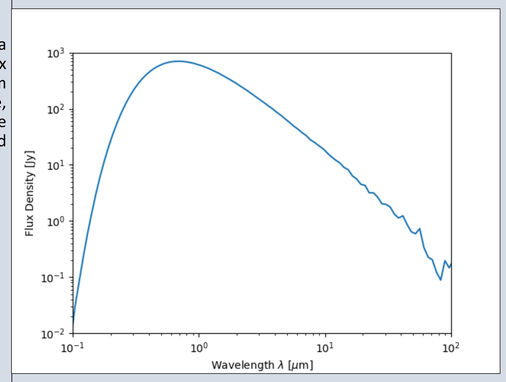
These constraints have their own uncertainty, but they were considered negligible compared to the error in the distance, which is itself excluded in the presented information.

Outputs were then plotted according to distance, like that of the plot below, which were used along with M_2 to determine a suitable range of distances the system likely falls in, assuming a BV star in the dust disk.

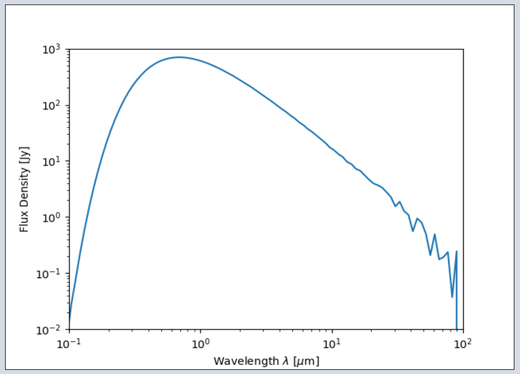


These assumptions constrain the distance of epsilon Aurigae to a range of about **415-1033 pc**. Five distances were selected and modeled from this range using the Hyperion MCRT code, with dust parameters specified by the plot below. In particular, the Hyperion code produced wavelength and flux density values according to a specified grid size and photon count for initializing and imaging the system. The wavelength and flux density were then used to plot SEDs for the five selected distances.

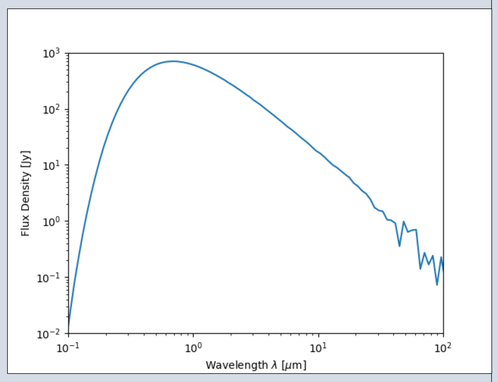




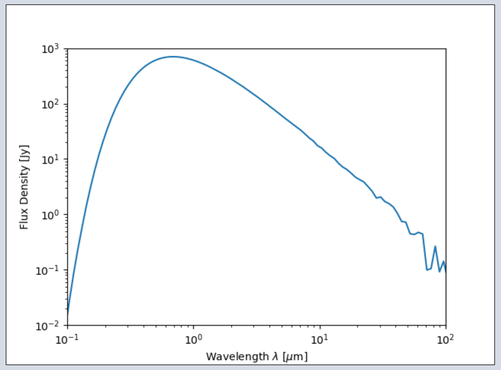
415 pc



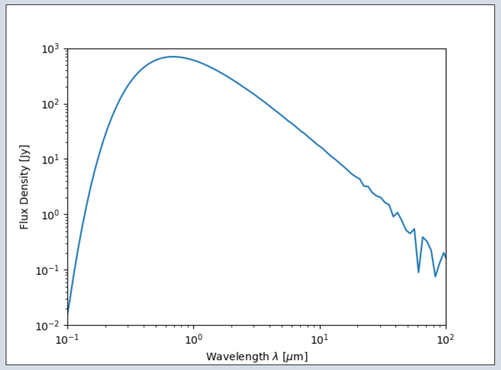
550 pc



794 pc



1012 pc



1033 pc

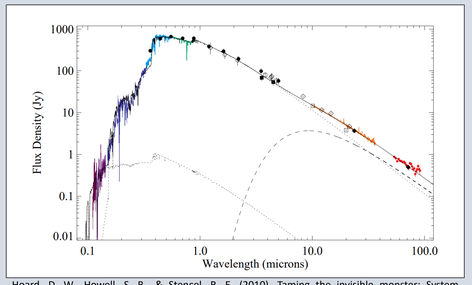
DISTANCE [pc]	MASS RATIO q ESTIMATE	MASS OF B STAR [M⊙]	MASS OF F STAR [M⊙]	TEMP OF B STAR [K]	RADIUS OF B STAR [R⊙]	RADIUS OF F STAR [R⊙]	2x SEMI-MAJOR AXIS [au]	DISK INNER RADIUS [R⊙]	DISK OUTER RADIUS [au]	MASS OF DISK [M⊕]	SCALE HEIGHT OF DISK [au]
415	0.05	2.75	0.13	10677	2.42	99.05	12.86	3.63	3.08	1.00	0.43
550	0.39	4.85	1.89	15853	3.38	131.29	17.05	5.07	4.08	1.76	0.57
794	1.00	10.04	10.04	24551	5.37	189.43	24.60	8.06	5.89	3.65	0.82
1012	1.55	16.34	25.35	31559	6.57	241.63	31.38	9.86	7.51	5.94	1.05
1033	1.61	17.12	27.54	32211	6.72	246.59	32.03	10.08	7.66	6.22	1.07

<u>NOTE:</u> The temperature of the F Star was assumed to remain constant at 7395 K.

Discussion

Though the SED plots of epsilon Aurigae were made according to different distances, and therefore different system parameters, they appear to exhibit a similar shape overall, which roughly approximates the SED from Hoard, Howell, & Stencel (2010). However, the contribution from the dust disk appears to be negligible in the resultant SEDs, despite it being a prominent part of the system.

Despite the inconsistencies with the Hoard, Howell, & Stencel SED, it can be said that the epsilon Aurigae system likely falls in a distance range of about 415-1033 pc if it is to have a single main sequence BV star hidden in its dust.



Hoard, D. W., Howell, S. B., & Stencel, R. E. (2010). Taming the invisible monster: System parameter constraints for ϵ aurigae from the far-ultraviolet to the mid-infrared. *The Astrophysical Journal, 714*(1), 549–560. https://doi.org/10.1088/0004-637X/714/1/549

Future Research

Further research performed on the modeling of epsilon Aurigae through Hyperion MCRT code should concentrate on refining the dust disk placed around the BV star. In this case, we explored a predominantly silicate composition of the disk, but other materials are more plausible. Additionally, the density of the disk could be explored, which again could be related to the composition, but could also influence the parameter of particle size, which was not explored in depth here.

Moreover, some of the literature surrounding epsilon Aurigae details the possibility that the object within the dust disk is itself a close binary of main sequence B stars, which would further influence the modeling properties and parameters of the system; in the case of this research, it was assumed that a single BV star resides in the dust.