Astronomy 330 Homework 2

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Part 1: Class 4 Exercise

1. Color plot of the 6 SSPs - Log(Luminosity) as a function of wavelength.

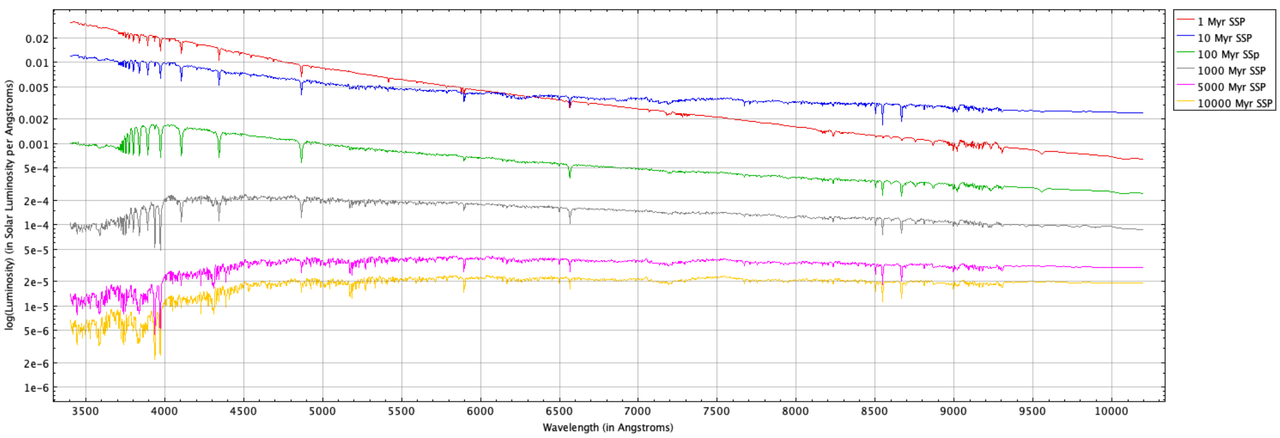
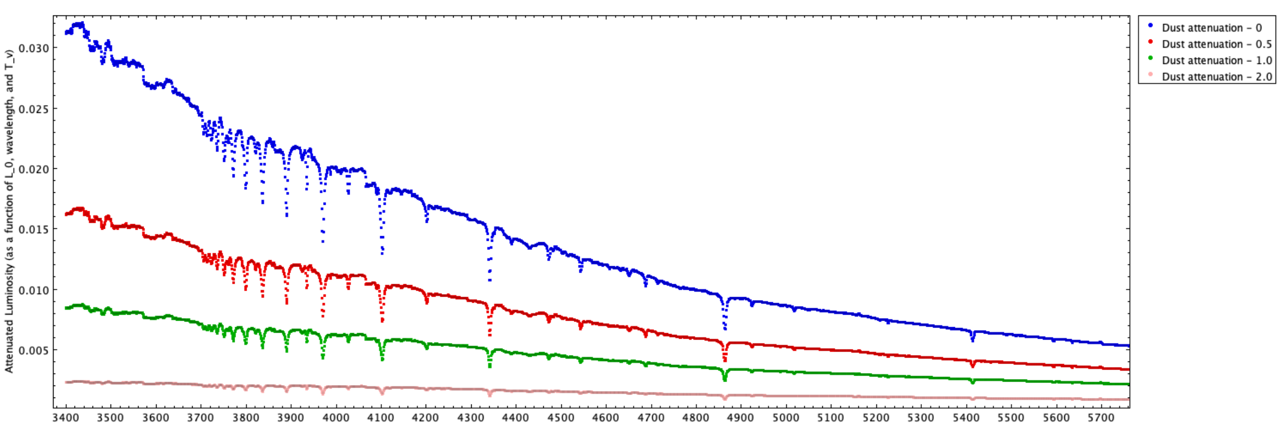
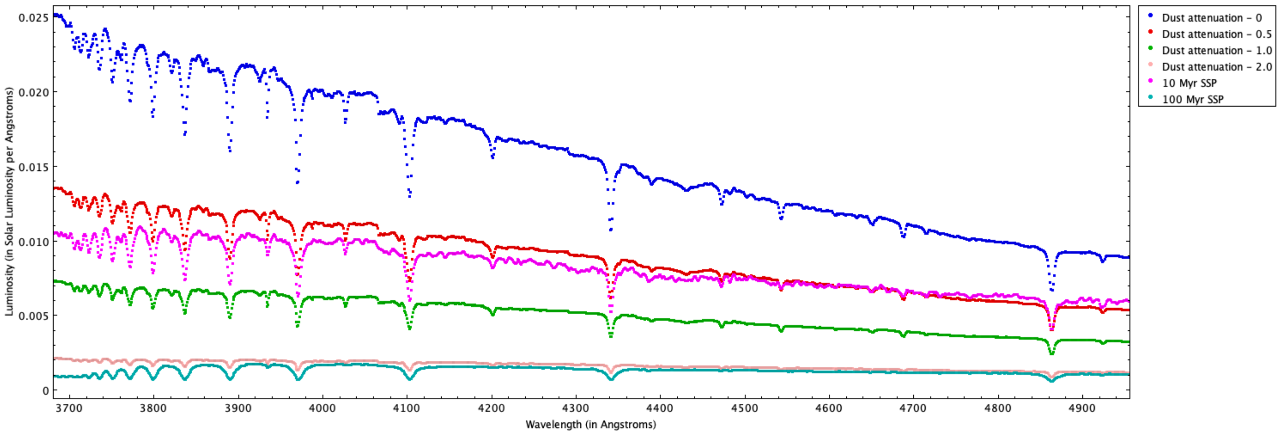


Figure 1: A plot of 6 different Simple Stellar Populations (SSPs) given by Log(Luminosity) as a function of the Wavelength.

2. Interstellar Dust Attenuation on Galaxy Spectra plot for different values of the V-band dust attenuation for the 1 Myr SSP.

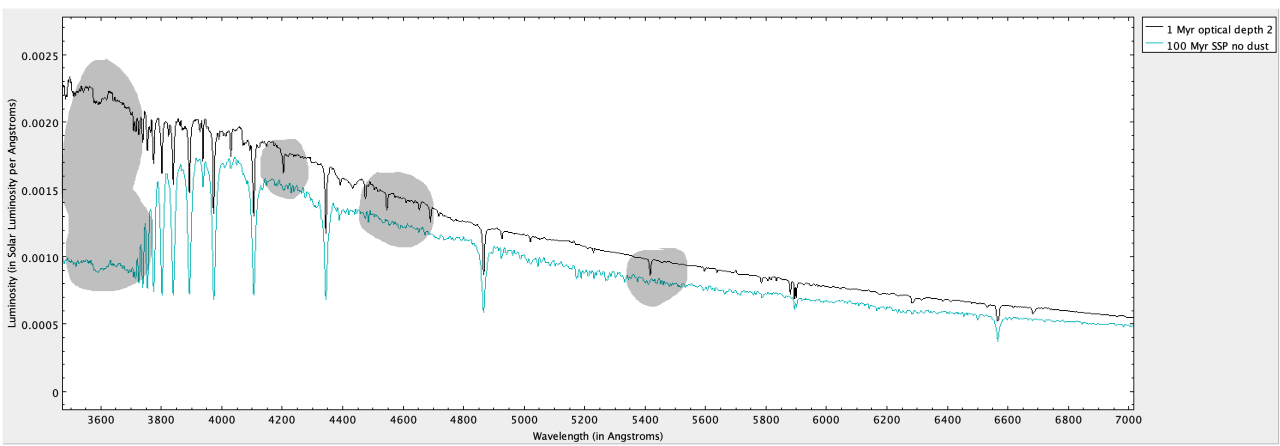


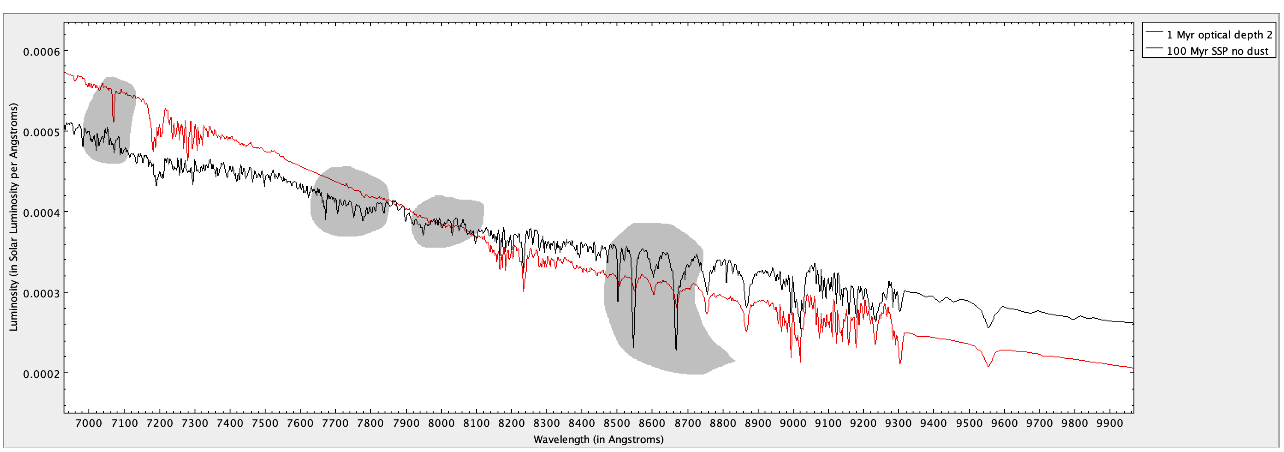
3. Plotting the 10 Myr SSP and the 100 Myr SSPs without dust attenuation along with the plot from question 2.



Upon comparison, the value of $\tau_\nu = 2.2$ would make it difficult to distinguish between a 1 Myr SSP with dust attenuation from a dust-free 100 Myr SSP. This is because after experimenting with a bunch of τ_ν values, I found 2.2 aligns best with the 100 Myr SSP line.

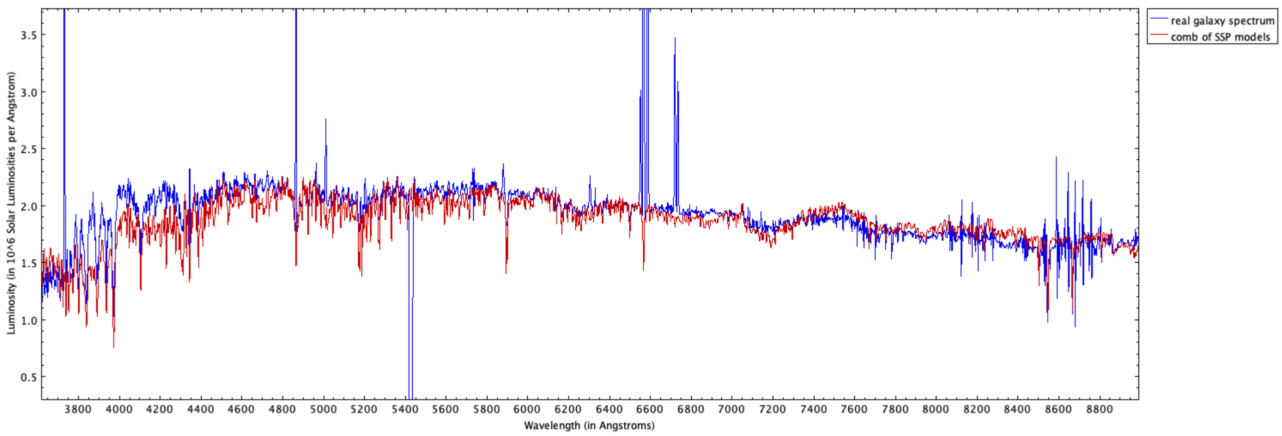
4. Annotated plots for comparing the 1 Myr SSP with $\tau_\nu = 2$ to the dust-free 100 Myr SSP. The annotations show the mismatched spectral features from both the plots. I made two plots: the first one is for all the wavelengths below 7000 $\mathring{A}$ and the second one is for all the wavelengths above 7000 $\mathring{A}$.





5. Comparing a real galaxy spectrum with a linear combination of models with some reddening. For this plot, I

used 4 SSPs (1 Myr, 100 Myr, 1 Gyr, and 10 Gyr). This question was particularly challenging because I didn't know what the final plot is supposed to look like, but here are my results:



Part 2: The IMF and Population Synthesis

1. Complete the table that contains the values found in the previous question.

Constant	Multiples	Value
c_1	1 Myr SSP	0.01
c_2	10 Myr SSP	0.099
c_3	100 Myr SSP	0.02
c_4	1 Gyr SSP	28.0
c_5	Overall scaling constant	3000.0
τ_ν	Dust attenuation	0.1

2. Using the equation $M_* = (c_1 + c_2 + c_3 + c_4) \times c_5 \times 10^6 M_\odot$ to calculate the galaxy's stellar mass and using the constants I got from the previous question, I get $M_* = 8.4387 \times 10^{10} M_\odot$. The stellar mass of the galaxy is more than that of the Milky Way by comparison but the order of magnitude is the same.

3. Suppose that stars form in a galaxy at a constant rate of $10M_\odot$ per year for 11 Gyr.

   (a) For every 1000 low mass stars formed, there is 1 high mass star formed. With this logic, 1 set of 1000 low mass stars and 1 high mass star should take 110 years to form. So, in 11 Gyrs, 10^8 of these low and high mass pairs will be formed. This means that after 11 Gyr, $1000 \times 10^8 = 10^{11}$ low mass stars are formed and 1×10^8 high mass stars are formed.

   (b) 8.1810×10^{10} low mass stars will be on the main sequence today and 9.09×10^4 high mass stars will be on the main sequence today.

   (c) The ratio of the mass in high and low mass stars on the main sequence today is $M_{\text{hi}}/M_{\text{low}} = 1.11 \times 10^{-4}$. In other words, there is about 1 part in 10^4 as much mass in high mass stars as compared to low mass stars on the main sequence today.

4. The way we can go about this question is identifying what amount of low mass stars and high mass stars will have how much luminosity. All the low mass stars less than or approximately equal to 9 Gyrs old will have some luminosity. Similarly, all the high mass stars that go back 10 Myrs from today will have luminosity. From question 3 (b), we know that 8.1810×10^{10} low mass stars will be alive right now. Out of that, $1/9^{\text{th}}$ of the stars will be more than 8 Gyrs old and will be on the red giant branch, thus having a luminosity of $10^3 L_\odot$. The other 8/9 of the stars are younger than 8 Gyrs, so their luminosity will be $1L_\odot$. Now, for the high mass stars, 9×10^4 high mass stars are alive today and each has a luminosity of $10^6 L_\odot$. So, the ratio of the luminosity coming from the high mass stars to the low mass stars today is $L_{\text{hi}}/L_{\text{low}} = 0.0099201 \approx 0.01$.

5. The total time period for the old population of stars is 10.9 Gyrs so the total mass formed is $1.09 \times 10^{11} M_{\odot}$. Most of the high mass stars have died in the supernova and only low mass stars remain. Their contribution is of the order $10^{12} L_{\odot}$ as seen in the previous question. As for the new population, the total mass formed is $10^{11} M_{\odot}$. This is almost as much mass as in the entire old population. In addition, because the new population formed in just 100 Myr at a rate of $1000 M_{\odot}/yr$, many of its short-lived high mass stars are still alive and shining today. The fraction of these massive stars that remain on the main sequence is approximately $\frac{10Myr}{100Myr} = 0.1$. Since each high mass star emits on the order of $10^6 L_{\odot}$, their combined luminosity can easily rival (or even surpass) the $10^{12} L_{\odot}$ contribution from the older, predominantly low-mass population. As a result, the galaxy's overall light becomes much bluer and dominated by the signatures of massive, hot stars. Thus, to approximate the ratio of the luminosity coming from the low and high mass stars, I would assume it to be around 1.