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SC20B152

Assignment – 3

Aim

This assignment allows us to use BAGPIPES package to model the spectra of four galaxies from the GAMA survey using photometric observations.

Steps Involved

These are the steps that we have to follow,

1. **Data Collection and Preparation**
   Obtain two ASCII files containing photometric data for four galaxies from the GAMA survey. Ensure the availability of filter response curves for the 21 photometric bands mentioned in the assignment.

2. **Installation of BAGPIPES**
   Install the BAGPIPES package according to the provided instructions, ensuring compatibility with Python 3.10.9. This was a very hectic task.

3. **Model Definition**
   Define the model to be fitted to the photometric data using BAGPIPES. Specify parameters such as star formation rate (SFR), stellar mass, redshift, age of the stellar population, and any other relevant parameters.

4. **Model Fitting**
   Use BAGPIPES to generate synthetic spectral energy distributions (SEDs) for each of the four galaxies based on their photometric magnitudes. Fit the photometric data to the defined model and obtain posterior distributions for the model parameters.

5. **Analysis and Interpretation**
   Create figures illustrating the best-fit synthetic SEDs for each galaxy with the photometric magnitudes overlaid. List the values for SFR, stellar mass, redshift, and age derived from the posterior distributions, along with uncertainties. Provide best guess-estimates on the morphological type(s) of the galaxies based on the fitted models.

6. **Comparison of Photometry**
   Compare the results obtained from 21-band photometry with those from 5-band photometry. Comment on the relative accuracy of the results and provide reasoning for any observed differences.

SED FITTING IN 5-BAND

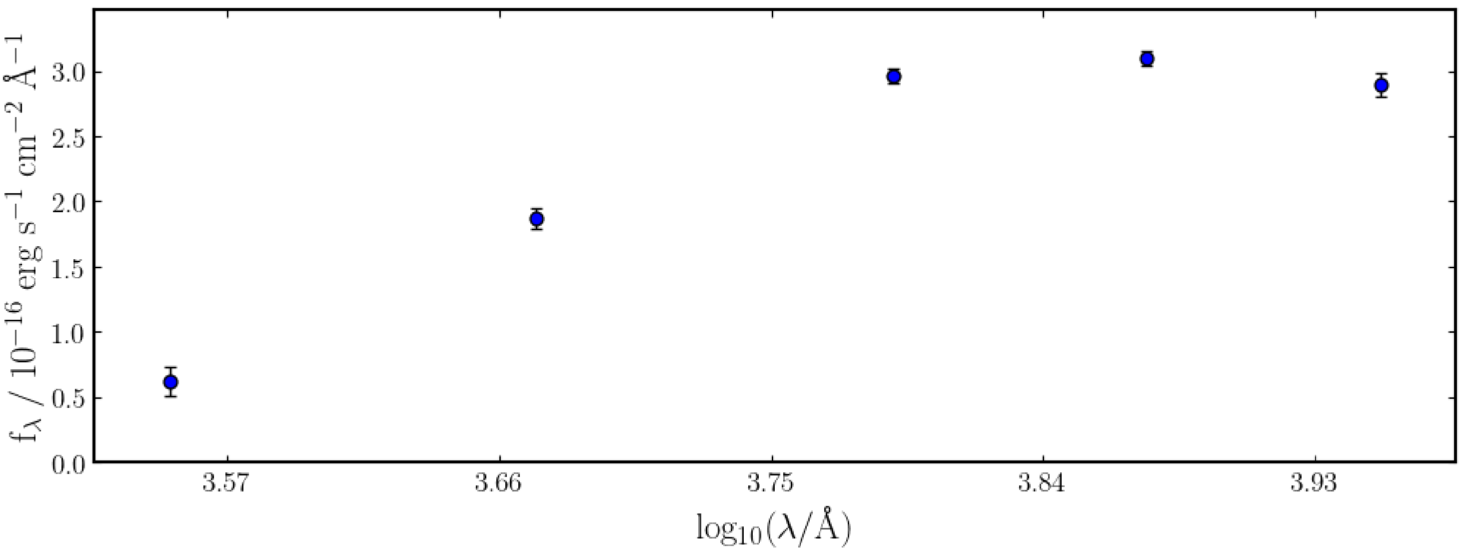
Two galaxies from the GAMA survey were characterized by their fluxes in five distinct bands or filters, specifically the SDSS (u,g,r,i,z) filters, which span a broad range of wavelengths from ultraviolet to infrared. Employing the BAGPIPES package in Python, we visualized the spectral energy distribution (SED) of these galaxies. To grasp the intricacies of the code, I referred to the mock SED fits provided on GitHub and carefully studied the accompanying code documentation.

1. **Galaxy 130653**
   After grasping the fundamental process of fitting spectral energy distributions (SEDs) for galaxies using the third example notebook provided in the documentation, we delved into the fourth example for more advanced fitting of the objects within our dataset.

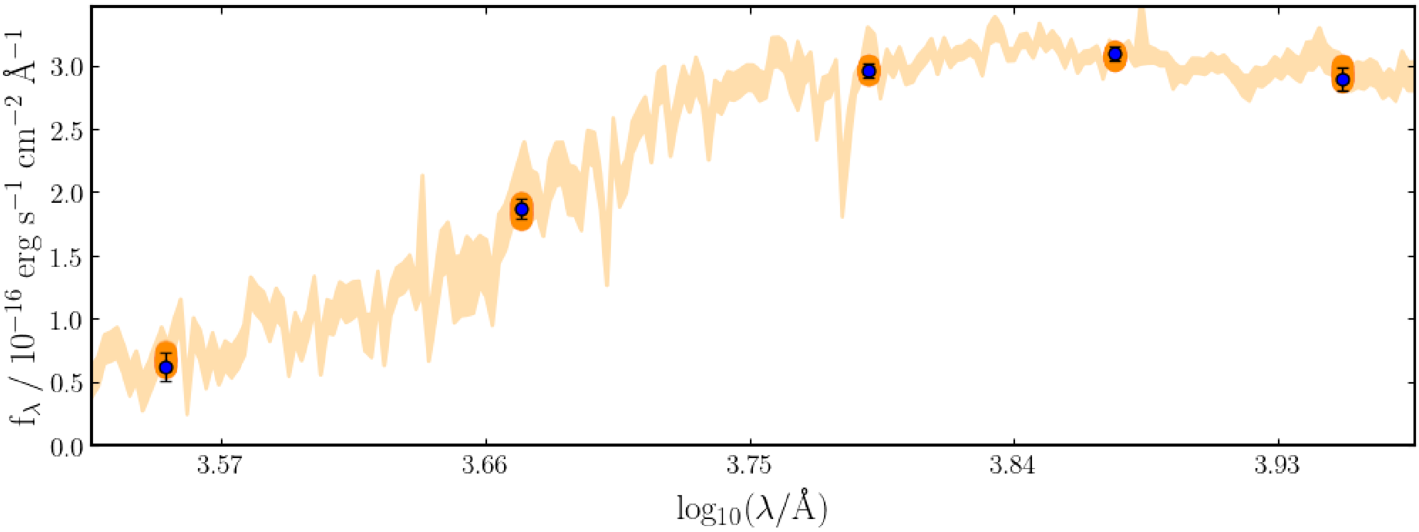
We examined various parameters and conducted fitting exercises to observe how altering these parameters affected the fit. The key parameters under consideration included the star-forming duration (represented by τ), the total stellar mass formed, and the redshift of the galaxy. These quantities were pivotal in deriving additional parameters, such as the star formation rate (SFR).

During the exploration, we discovered that certain parameters had negligible impact on the outcomes. For instance, varying the star-forming period between 0 to 15 billion years didn't notably affect the mass formed or the redshift. Similarly, imposing constraints on the mass formed didn't significantly alter the results. Upon scrutinizing the initial spectra of the galaxy, we noticed a lack of significant emission lines. Consequently, the nebular emission parameter was excluded from the analysis, resulting in minimal change in the spectra, as anticipated.

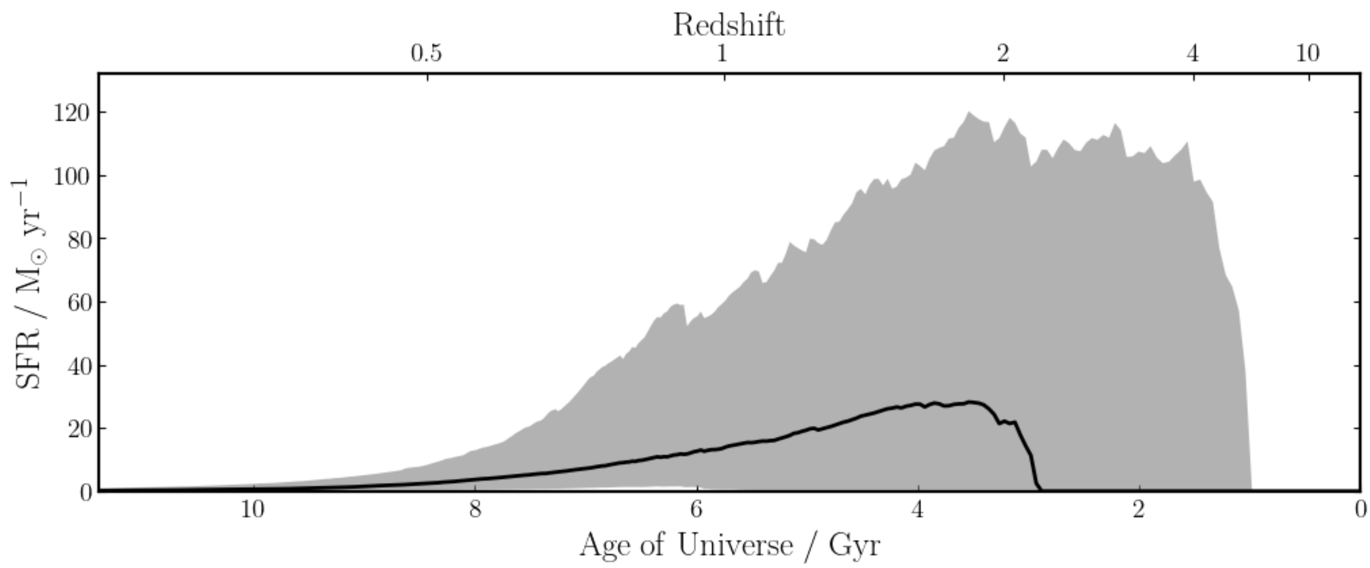
Furthermore, we set certain priors, such as specifying the fitting function as Gaussian and defining its mean and standard deviation. These parameters helped guide the fitting process and refine our understanding of the galaxies' characteristics.



The above figure depicts the flux in 5 SDSS filter.



The above figure depicts the best model for the SED of the galaxy.



The above figure depicts the star formation history of the Galaxy under discussion.

Therefore these are the plots that we have obtained for this galaxy, and now we will make note of the following values from it.

Star Formation Rate(M/yr)	17.5
Stellar Mass(M)	10^{14}
Redshift	0.0035
Age(Gyr)	9.42

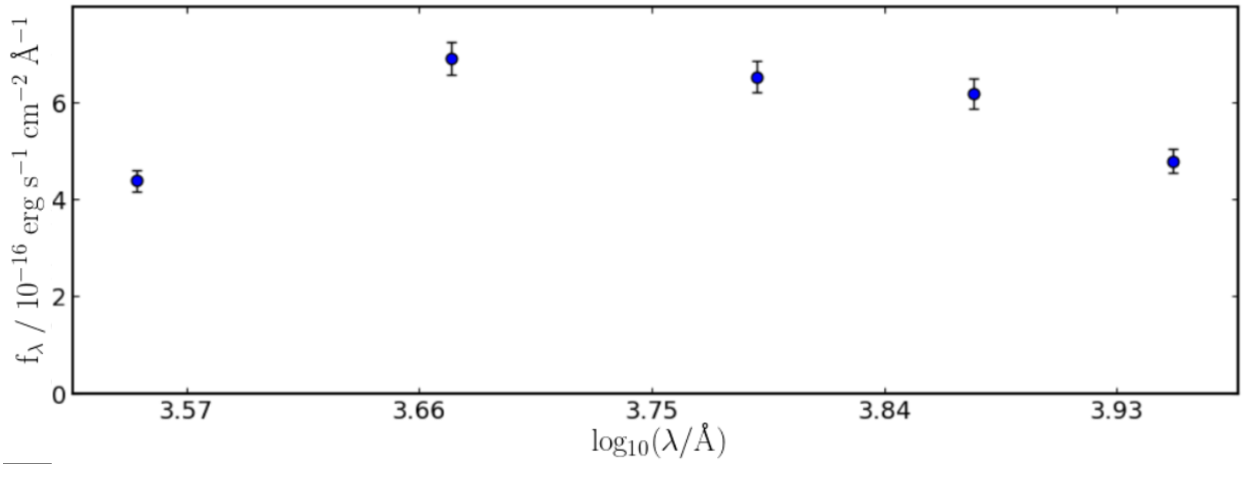
Now let us discuss about the morphology of the galaxy.

The galaxy's morphological classification as elliptical is substantiated by several key observations.

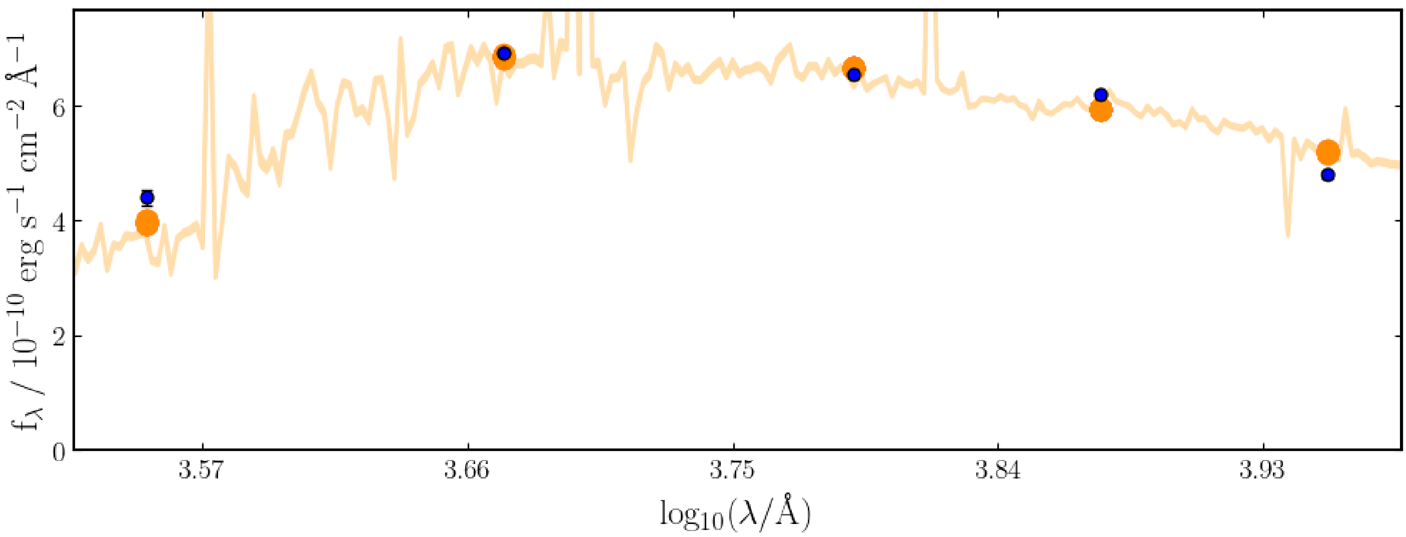
Its spectrum lacks emission lines, characteristic of regions like HII regions associated with young, massive stars, which are not prevalent in elliptical galaxies. This absence suggests that the last significant episode of star formation in the galaxy occurred over a billion years ago. Secondly, a pronounced decline in flux for wavelengths below 4000 Å indicates the dominance of older G, K, and M stars within the galaxy. These stars absorb flux through their atmospheres, contributing to the observed decrease.

2. Galaxy 220995

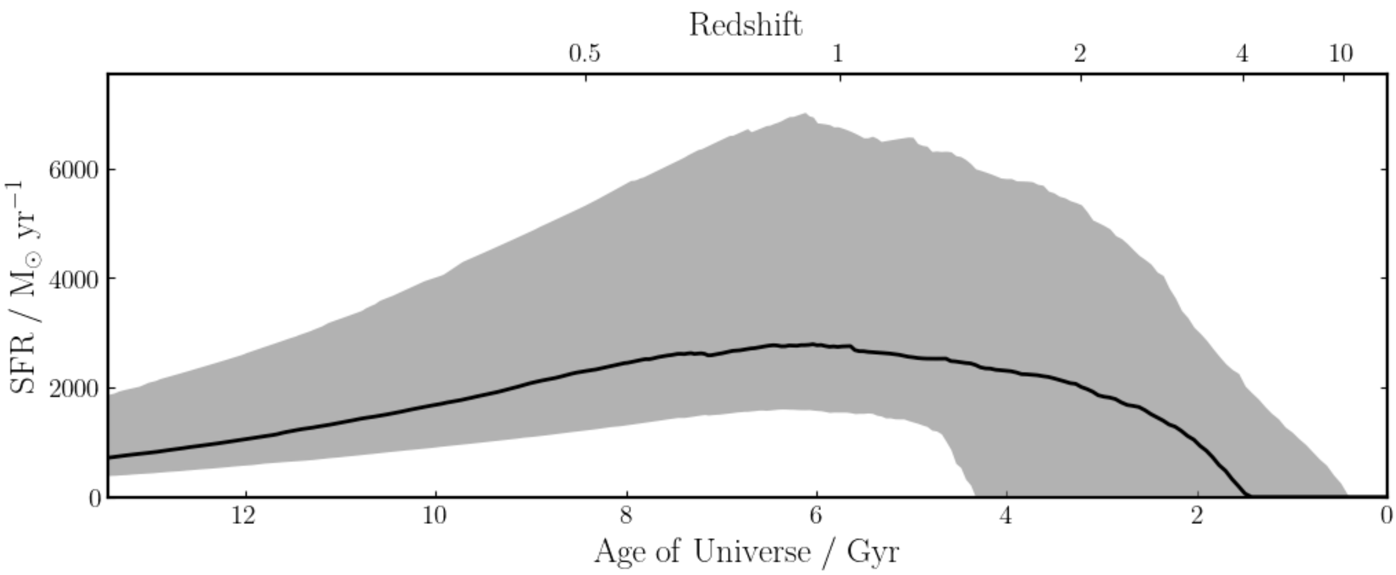
We used a similar approach to analyze this galaxy's SED. We adjusted parameters like how long stars were forming and how much mass was created to suit this galaxy. We kept the nebular emission parameter because the initial spectra showed some emission lines, indicating the possible presence of emission nebulae, which could affect the galaxy's spectrum. We also set priors, like the fitting function, to help with this analysis.



The above figure represents the flux from galaxy in 5 SDSS filters.



This figure represents the SED Spectra.



The above diagram depicts the star formation history.

Star Formation Rate(M/yr)	705.2
Stellar Mass(M)	10^{13}
Redshift	0.0015
Age(Gyr)	7.842

The galaxy's morphology is inferred to be spiral based on several pieces of evidence.

Its spectrum displays numerous emission lines, which are indicative of the presence of emission nebulae typically associated with young, massive O and B stars.

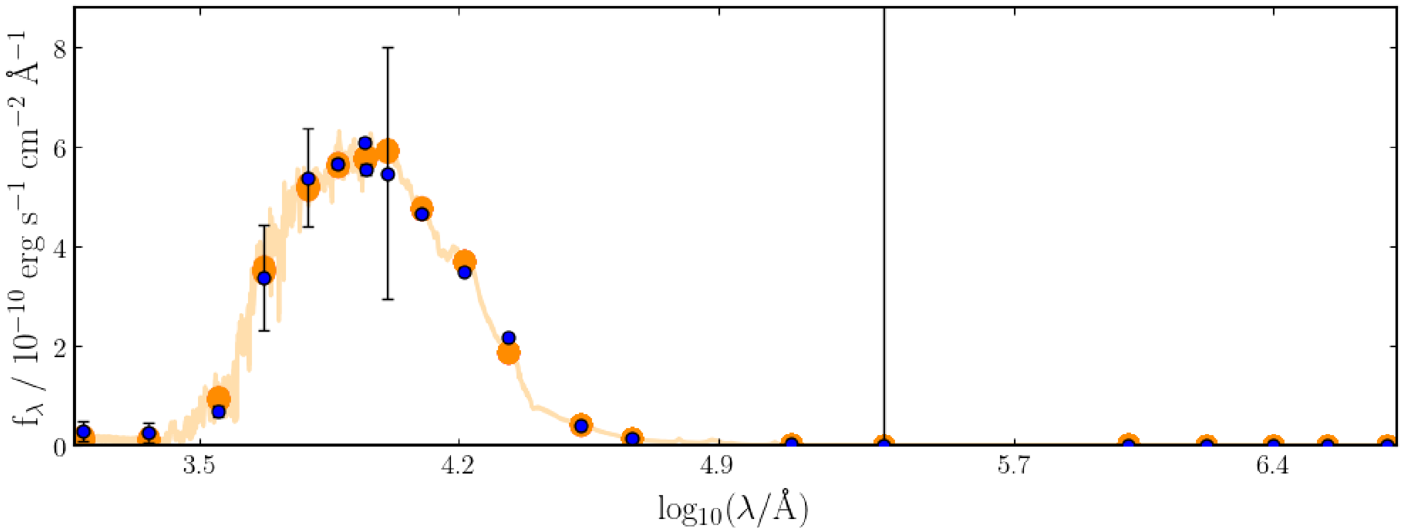
The analysis of the galaxy's star formation history also reveals ongoing star formation activity, a trait more commonly observed in spiral galaxies rather than ellipticals. Taken together, these observations strongly support the classification of the galaxy as spiral, characterized by its active star formation and spectral features.

SED FITTING IN 21-BAND

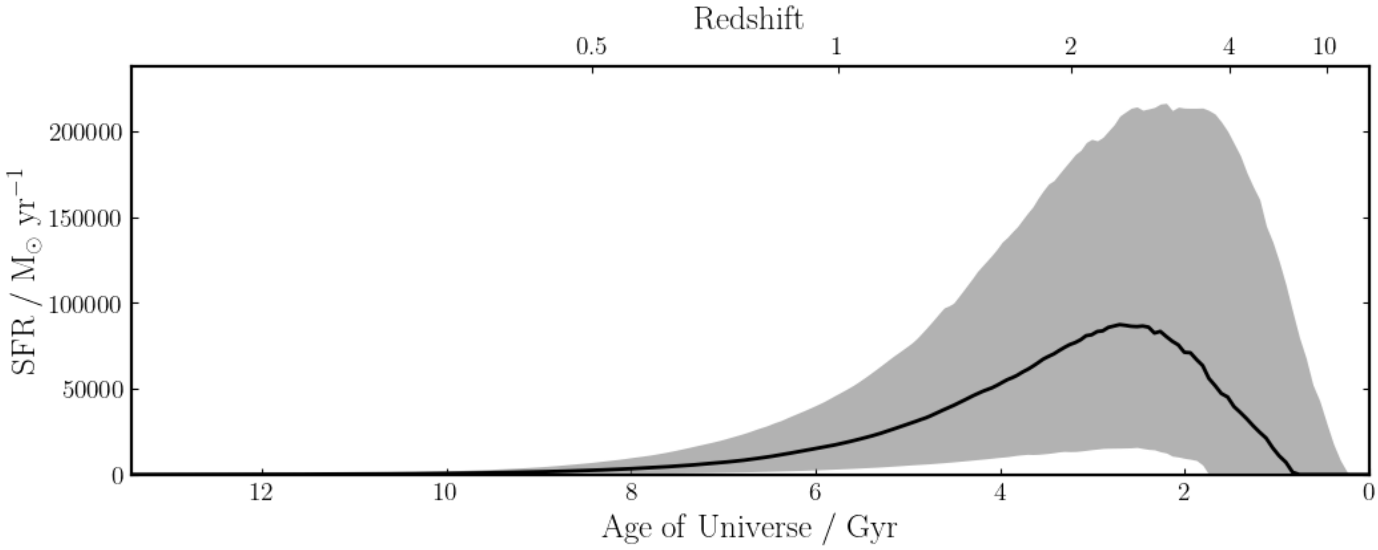
We had taken flux in 21 filter bands for a galaxy. We have done this namely for 2 galaxies.

1. **Galaxy 382576**

This is the plot I obtained for the SED.



The below plot will talk about the star formation history of the source.

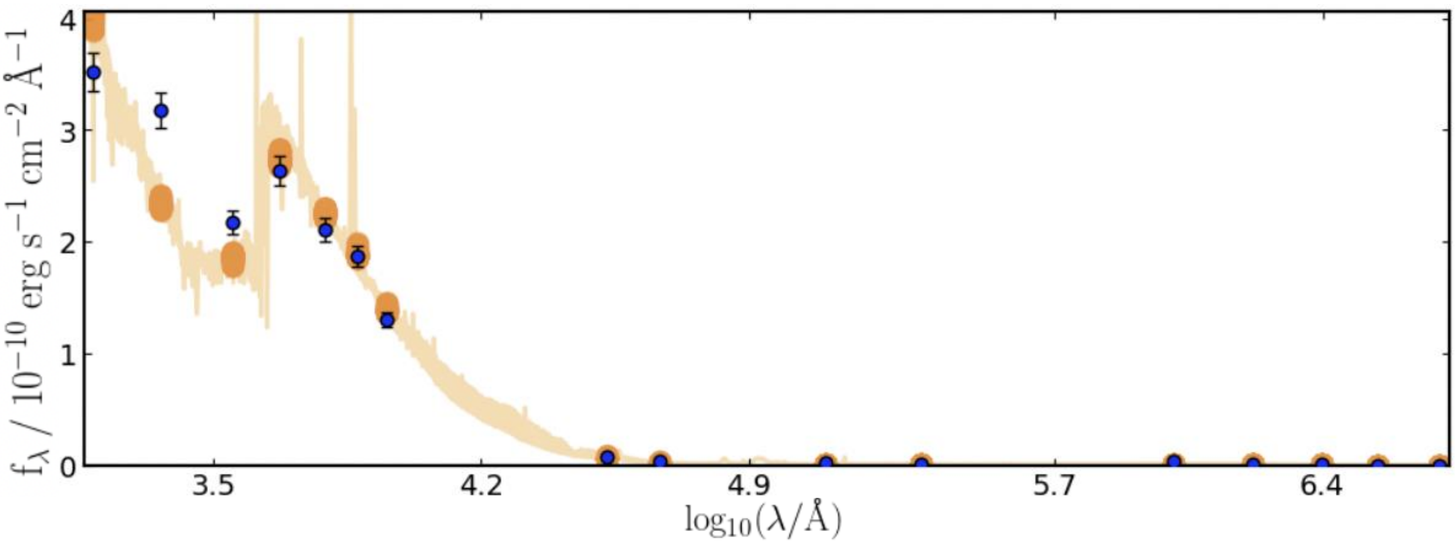


Star Formation Rate(M/yr)	2.8
Stellar Mass(M)	10^{11}
Redshift	0.155
Age(Gyr)	7.85

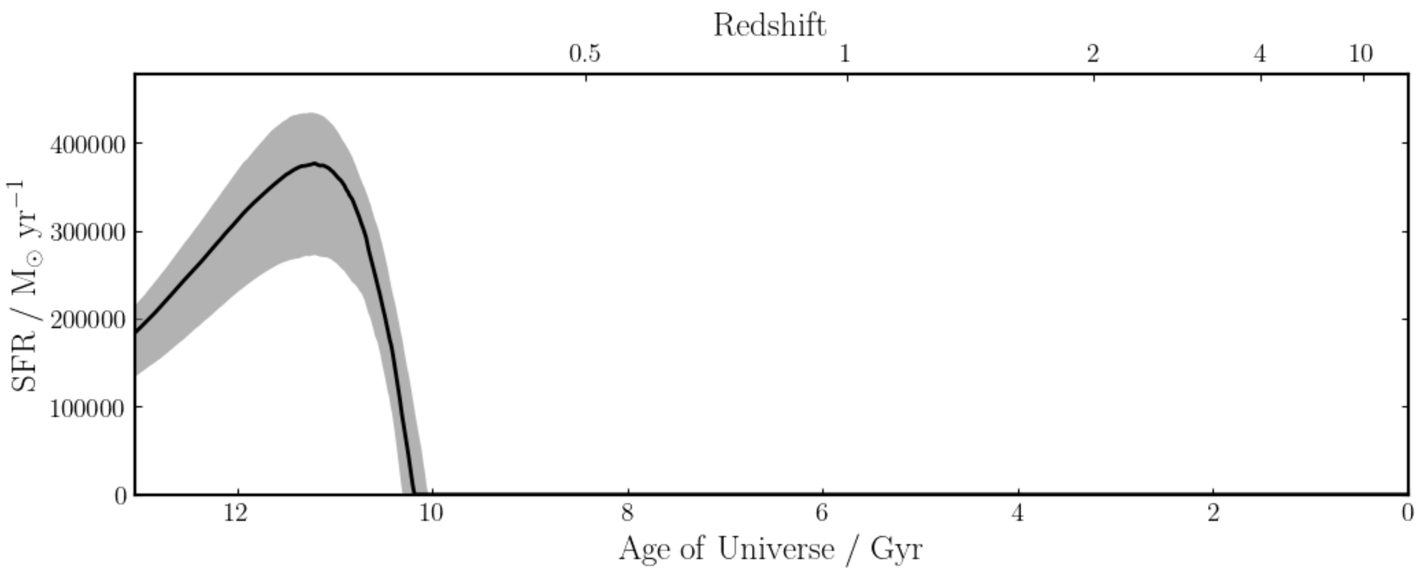
The morphology of the galaxy in this case is hard to determine since neither absorption nor emission lines can be seen in the galaxy spectra.

2. Galaxy 229206

Below is the figure that shows the best fit synthetic SED.



The below plot will talk about the star formation history of the source.



Star Formation Rate(M/yr)	15.81
Stellar Mass(M)	10^{10}
Redshift	0.350
Age(Gyr)	1.5

Prescence of emission lines in the galaxy spectra concludes that this galaxy is most likely a spiral galaxy.

Comparison between 5-Band and 21-Band fitting

21-band photometry provides more precise results compared to 5-band photometry due to several factors:

1. **Increased Data Points**
   With 21 bands, there are significantly more data points across the spectrum, which imposes more constraints on the models. This reduction in degeneracies helps to refine the fitting process and produce more accurate results.

2. **Detection of Features**
   The broader range of wavelengths covered by 21 bands increases the likelihood of capturing specific features such as emission or absorption lines. These features may only be detectable within narrow wavelength ranges, and having more bands enhances the chances of capturing them accurately.

3. **Improved Redshift and Extinction Correction**
   A broader wavelength coverage facilitates more accurate determination and correction of photometric redshifts and extinction effects. The shape of the spectral energy distribution (SED) across a wider wavelength range provides better matching to templates or models, enhancing the precision of redshift estimates and extinction corrections.

By incorporating these factors, 21-band photometry enhances the accuracy of synthetic model fitting in photometric studies of galaxies, making it a preferable choice over 5-band photometry.

I would like to thank Anand Sir for this assignment as it gave us a lot of insight and was very thought provoking.