Line Ratios as Diagnostics for Star Formation Histories of Galaxies using Cloudy

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Abstract:

We use Cloudy to explore the effects that star formation history (SFH) has on optical and IR line ratios. Our goal is to find good diagnostics to search for recently quenched systems and systems that recently underwent a starburst episode. We explore a quenched SFH, and different ionization parameters to simulate the effects of a recent burst.

The SFHs

Using the Bruzual and Charlot (2003) code we created the stellar SED of a galaxy with the SFH shown in Figure 1. This is a constant SF model for 1 Gyr followed by a sudden truncation. We explore the line ratios at the following times: 800 Myr (before truncation), 1 Gyr (at truncation), 1.02 Gyr (right after truncation), 1.1 Gyr, 1.3 Gyr, and 1.5 Gyr.

While exploring the effects of a burst, we realize that a sudden increase in the SFR does not change the shape of the ionizing SED, only its normalization. Therefore we have explored the effect of a recent starburst by varying the ionization parameter between log(U) = -3 – 0.

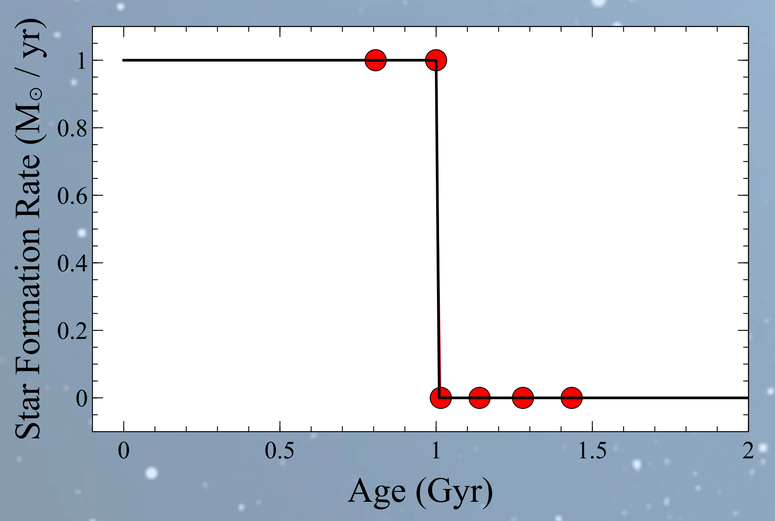
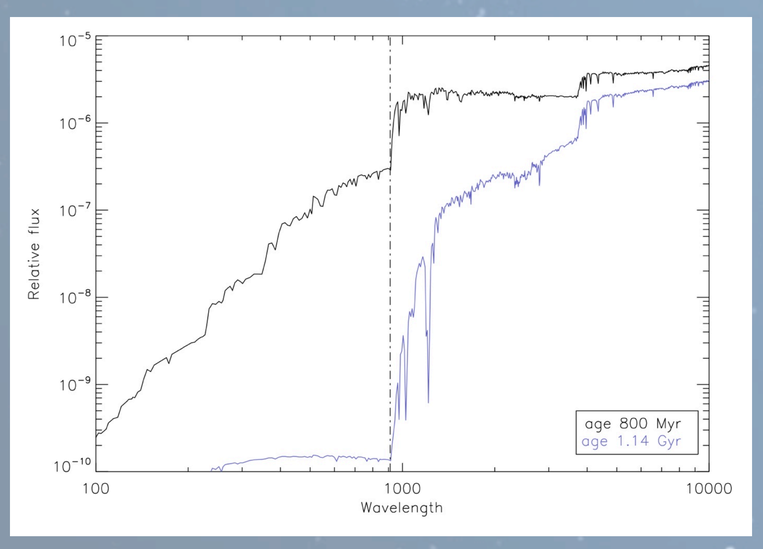


Figure 1. The SFH of our model. SFR is constant for 1Gyr and then it is truncated. The points indicate the models ages we studied.

Figure 2. The incident SED during the CSF period, and 140 Myr after star formation has ceased.



Results

In the starburst case, we have identified a couple of lines (e.g. CII 158, NII 6583) that seem insensitive to log(U) for the metallicity we explored (solar). Line ratios like OIII/CII, and especially NeIII/NII are very sensitive to log(U) (our proxy for the strength of the star burst) for a wide range of values (see Figure 3).

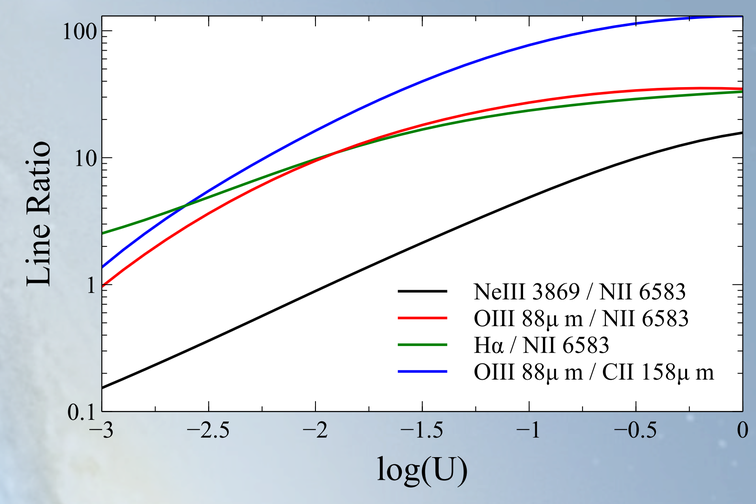
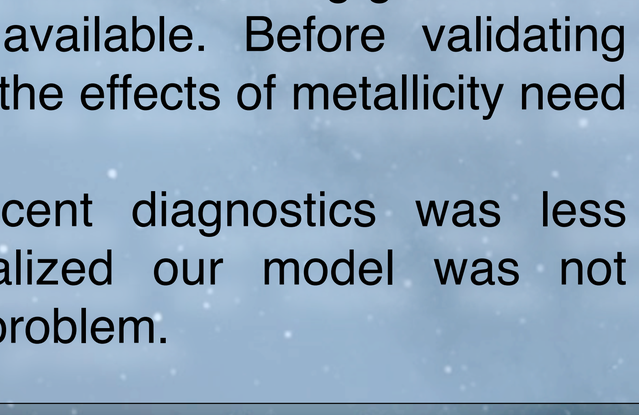


Figure 3. Line ratios that are sensitive to log(U), our proxy for the strength of the SFR.

However, our setup for quiescent galaxies was unsuccessful. Although we captured the softening of the SED as a function of age (see Figure 2), our constant log(U) setup is unphysical. As a result, lines like Hα show a behavior that is clearly affected by processes other than just recombination (line intensity increases after the shutoff of SF which can not be due to recombination processes). We will need to correct our physical setup to include a more realistic change in the incident SED.

Figure 4. Hα as a function of Age. The softening of the SED was captured but to make log(U) = -2 constant, the SED was amplified beyond a realistic value.



Conclusion:

We have identified a few line ratios that correlate well with the ionization parameter (our proxy for the strength of a recent burst), in particular OIII 88 / CII 158. The best choice to look for bursting galaxies will depend on the data available. Before validating these results, however, the effects of metallicity need to be explored further.

Our search for quiescent diagnostics was less successful as we realized our model was not suitable to explore this problem.