**FULL TITLE**
ASP Conference Series, Vol. **VOLUME**, **YEAR OF PUBLICATION**
**NAMES OF EDITORS**

# The Impact of Nebular Emission on the Broadband Fluxes of High-Redshift Galaxies

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**Abstract.** A substantial fraction of the light emitted by young or star-forming galaxies at ultraviolet to near-infrared wavelengths comes from the ionized interstellar medium in the form of emission lines and nebular continuum. At high redshifts, star formation rates are on average higher and stellar populations younger than in the local Universe. Both of these effects act to boost the impact of nebular emission on the overall spectrum of galaxies. Even so, the broadband fluxes and colours of high-redshift galaxies are routinely analyzed assuming that the light observed originates directly from stars. Here, we assess the reliability of this approach, by deriving the ratio of nebular-to-stellar light for three different broadband filters ($R$, $H$ and the Spitzer/IRAC 5.8 micron filter) and redshifts up to $z = 15$.

## 1. Nebular Emission in High-Redshift Galaxies

In young galaxies, or galaxies with active star formation, massive stars photoionize the surrounding interstellar medium, thereby adding emission lines and nebular continuum to the integrated spectral energy distribution (SED). Since this nebular component can make up a substantial fraction of the overall light observed at rest-frame ultraviolet to near-infrared wavelengths, modellers have for a long time stressed the importance of considering the contribution from ionized gas to the SED when attempting to interpret the broadband fluxes and colours of such galaxies. This contribution is expected to grow with the redshift of the galaxies studied, since stellar populations are on average younger and the star formation activity higher at high redshifts than in the local Universe. Even so, observers often attempt to derive ages or masses of high-redshift objects based on optical to near-infrared broadband photometry using spectral evolutionary models that only predict the SED of the stars themselves.

Here, we assess the reliability of this approach by considering three types of galaxies observed at redshifts in the range $z_{\rm obs}$ = 0-15: A starburst galaxy with fixed age 50 Myr and constant prior SFR($t$); a disk galaxy with SFR($t$) $\propto$ $\exp(-t/\tau)$ and $\tau = 6$ Gyr, which started to form stars at $z_{\rm form} = 20$; and an elliptical galaxy with SFR($t$) $\propto \exp(-t/\tau)$ and $\tau = 0.5$ Gyr, which started to form stars at $z_{\rm form} = 20$. The ratios of nebular-to-stellar flux, $f_{\rm neb}/f_{\rm stars}$ are predicted for $R$, $H$ and the Spitzer/IRAC 5.8 micron filter, using the Zackrisson

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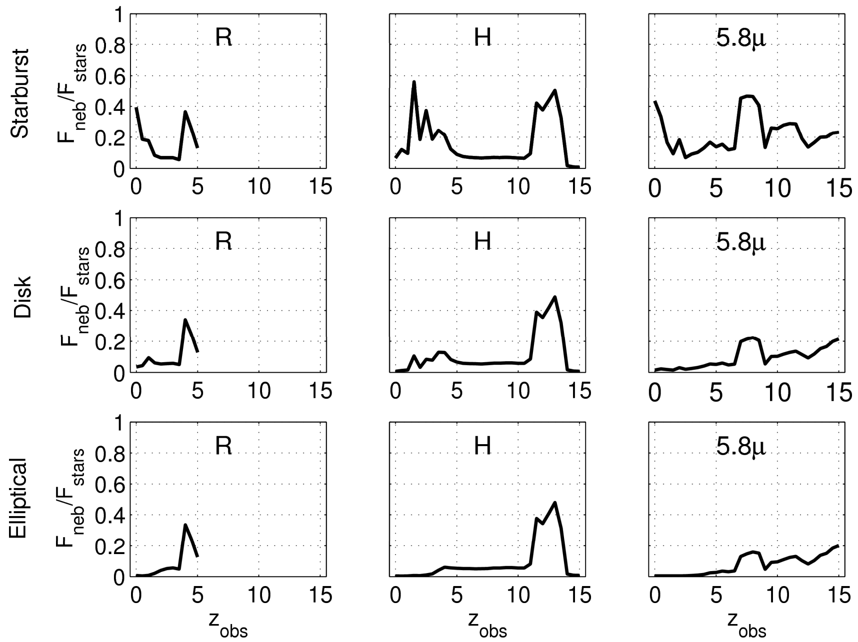


Figure 1. The predicted ratios of nebular-to-stellar flux in the $R$, $H$ and Spitzer/IRAC 5.8 micron filters for starburst (top row), disk (middle row) and elliptical (bottom row) galaxies observed at different redshifts. For the $R$ band, predictions are only plotted up to $z_{\rm obs} = 5$, after which the redshifted Lyman limit makes these galaxies effectively unobservable in this filter.

et al. (2001) spectral evolutionary model. Owing to the likely breakdown of the closed-box approximation at high redshifts, we adopt a fixed metallicity of $Z = 0.020$ for our model galaxies. This ensures that the resulting ratios $f_{\rm neb}/f_{\rm stars}$ are conservative, since lowering the metallicity to more realistic levels will only act to boost this ratio. The resulting $f_{\rm neb}/f_{\rm stars}$ ratios are presented in Fig. 1.

As seen in Fig. 1, nebular emission can correspond to up to 50% of the stellar flux at certain redshifts. The ratio of nebular-to-stellar flux also differs substantially from filter to filter, indicating that nebular emission will cause substantial colour shifts (e.g. in $R - H$). This makes the practice of deriving ages and stellar population masses for high-redshift galaxies using models that neglect nebular emission a very hazardous exercise. Predictions for $f_{\rm neb}/f_{\rm stars}$ in other filters than the ones used here will be presented in a forthcoming paper (Zackrisson, Bergvall & Leitet, in preparation).

**Acknowledgments.** EZ acknowledges research grants from the Swedish Research Council, the Academy of Finland and the Swedish Royal Academy of Sciences.

## References

Zackrisson, E., Bergvall, N., Olofsson, K., & Siebert, A. 2001, A&A, 375, 814