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NIR visibility function of galaxies with GOHSS

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Abstract.
We study the visibility function of galaxy emission lines which are observable with GOHSS. Taking into account the expected noise sources and the instrument nominal efficiency we find that a flux limit of $\gtrsim 10^{-16} erg\ s^{-1}\ cm^{-2}$ for objects with velocity dispersion $\simeq 100\ km\ s^{-1}$ at $z \simeq 1$ can be observed in 4 hrs. Numerical simulations are performed in order to estimate the number of observable objects for given values of redshift and restframe luminosity.

Key words. near-IR instrumentation – high redshift emission lines galaxies

1. Introduction

GOHSS is a fiber fed multiechelle spectrograph which works in the (z, J, H) bands (Scaramella et al. 1997; Lorenzetti et al. 2002), The instrument allows a maximum multiplexing of $\simeq 23$ fibers with a degraded spectral resolution of $\simeq 4 \div 5 \times 10^3$. This spectrograph accomplishes OH night -sky suppression by mean of a software subtraction. Thanks to the high resolution only a limited fraction of pixels is lost due to atmospheric OH contamination. Moreover, for strong emission lines, like redshifted $H\alpha$, even where OH lines are strong it is still possible by a weighted fit to recover part of the flux of the line lost to the OH blanked regions.

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2. Simulated spectra

To simulate expected performances and feed the data reduction package, starting from the grating and prism equations we compute the small wavelength band falling over each pixel. Assuming a pointlike PSF for each wavelength we compute the fiber area falling over each pixel in order to take into account the degradation of the resolution due to the finite size of fibers. A given spectrum is convolved with this function in order to find the expected photon distribution on the array. As input we use a local galaxy spectrum from Kennicutt (1992) or Kinney et al. (1996) catalogues shifted at a given z and normalize it to a given magnitude mag_J. We then add the expected values for the sky and the noise sources and finally we perform the operation: (spectrum+sky+noise sources) - ⟨sky+noise sources⟩ with Poissonian statistics. Figure 1 shows a typical output of the simulation.

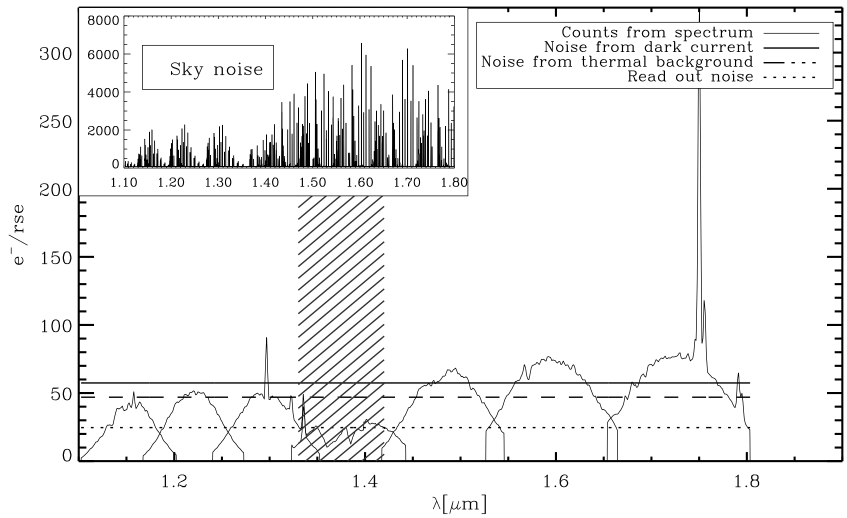

Fig. 1. Counts per bin expected for an Sc galaxy spectrum with redshift $z = 1.5$, observed at a magnitude $mag_J = 21.5$ within the fiber and with an Hα flux of $10^{-16}cgs$. Notice the "bumps" which reflect the efficiency curves due to the blaze function for different orders. The Poissonian noise from sky (small up-left window), dark current (solid line), thermal background (dashed line) and read out noise (dotted line) are also shown. The dashed region corresponds to an atmospheric transimission lower then the 70%.

3. Emission lines visibility function

The spectral features we expect to observe better are strong emission lines. These are also an excellent scientific target in order to estimate physical parameters for target objects. We want now to study to what extent the OH contamination covers the signal and which are the limiting fluxes given by the nominal throughput of the spectrograph.

Where OH is strong it masks some restframe spectral region containing emission lines according to the different redshift of the galaxy. When the spectral line is not completely masked by the OH lines we can recover the missed part by a line profile fitting.

We then analyze the success rate in fitting the lines as function of redshift and limiting flux. We choose an $H\alpha$ line with a restframe amplitude corresponding to 100 kms^{-1} according to typical measured values (Pettini et al. 1998) (Glazebrook et al. 1999). Models are obtained by varying z in our observable range for $H\alpha$, $0.95 \lesssim z \lesssim 1.70$, and by varying the line flux in the range $5.0 \div 20 \times\ 10^{-17} erg\ s^{-1}\ cm^{-2}$. Figure 2 shows the result of this simulation. The dotted line shows the expected flux and the solid line what has been recovered. The shaded region shows the $1-\sigma$ uncertainty expected. It is interesting to note only a slight dependence of the line observability on the redshift, even though the OH emission is not uniformly distribuited with the wavelength. This happens thanks to our chosen spectral resolution which counter balances the decreasing S/N for fainter objects. With our assumptions we expect to be able to observe down to a flux of $\gtrsim 10^{-16} erg\ s^{-1}\ cm^{-2}$

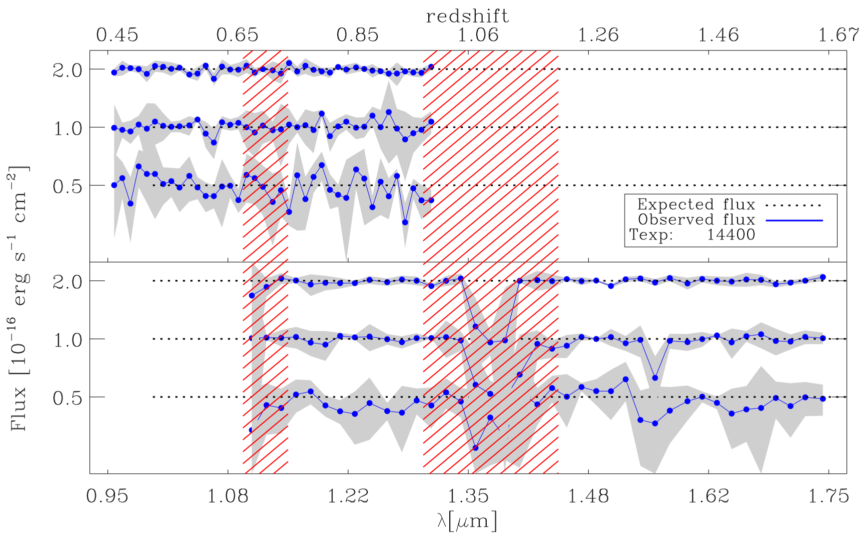

Fig. 2. Visibility function for the $H\alpha$ line of an Sc galaxy as function of the redshift and of the line flux. **Top panel** z+J band case ($R \simeq 5000$). **Bottom panel** J+H band case ($R \simeq 4000$)

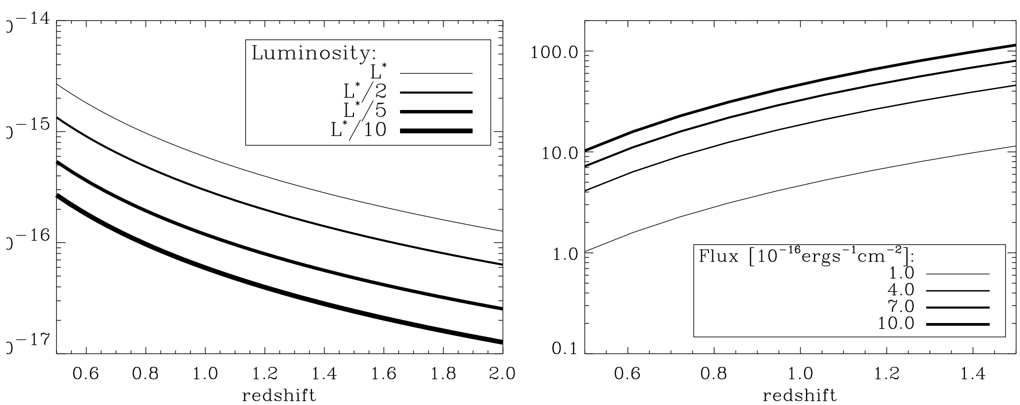

Fig. 3. **Left panel** Apparent flux [$erg\ s^{-1}\ cm^{-2}$] for different redshift and intrinsic line luminosity; **Right panel** SFR [$M_{\odot}/yr$] vs flux for different redshift values without correcting for dust absorption (dust correction can be computed by $L(H\alpha) \times 1.6$ for galaxies at $z \simeq 1$ (Glazebrook et al. 1999))

4. Relevance for emission lines studies

The limiting flux we expect for emission lines observations with GOHSS is comparable with typical flux values recentely reported in the literature for galaxies with $0.5 < z < 2$. For example Glazebrook et al. (1999) selecting between CFRS (Le Fevre et al. 1994) objects with strong O[II] and with a $H\alpha$ in free OH windows, measured fluxes in the interval: $2 \div 10 \times 10^{-16}$ $erg\ s^{-1}\ cm^{-2}$. Rigopoulou et al. (2000) select galaxies from HDF-S finding 12 objects with fluxes: $0.7 \div 7 \times 10^{-16}$ $erg\ s^{-1}\ cm^{-2}$. Finally by mean of NICMOS on HST, two groups have construct $H\alpha$ surveys for galaxies with $0.8 < z < 1.8$: McCarthy et al. (1999) obtaining 33 detection on a volume of $64 arcmin^2$ with a limiting flux of $4 \times 10^{-17}\ erg\ s^{-1}\ cm^{-2}$ and Hopkins et al. (2000) 37 objects in a much smaller area ($\simeq 4.4 arcmin^2$) with a limiting flux of $0.7 \times 10^{-16}\ erg\ s^{-1}\ cm^{-2}$. With these data the authors compute also an $H\alpha$ luminosity function. They obtain, in the redshift range $1 < z < 2$, the following Schechter parameters: $\phi^* = 1.7 \times 10^{-3} Mpc^{-3}$; $L^*_{H\alpha} = 7 \times 10^{42} erg\ s^{-1}$ and $\alpha = -1.35$. assuming $H_0 = 50 Km\ s^{-1}\ Mpc^{-1}$ and $q_0 = 0.5$.

In the previous section we shown how with GOHSS we expect to reach, with a reasonable exposure time, a flux limit of $10^{-16} erg\ cm^{-2}\ s^{-1}$. In the figure 3 we show that this limiting flux correspond to an $L^*_{H\alpha}$ galaxy with $z \simeq 2$.

We can convert the integrated $H\alpha$ luminosity density to a star formation rate (SFR) using the relation of Kennicutt (1998): $SFR(M_0\ yr^{-1}) = 7.9 \times 10^{-42} L\,(H\alpha)\,(ergs^{-1})$

The contribution of the extinction can affect the result of this equation in a systematic way. Values currently used in literature are $A(H\alpha) = 0.8 \div 1.1 mag$. Figure 3 shows also the SFR measurable as function of the limiting flux.

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