Lyα emission from high redshift galaxies

Lyα emission is produced when hydrogen recombines. Lyα emission is therefore a sign of the presence of hydrogen ionising sources in a gas-rich galaxy. These ionising sources are mainly hot, short-lived and massive O and B stars. In other words Lyα emitting galaxies are in a state of active star formation. Galaxy formation must include an early phase where the young galaxy is gas-rich and actively star forming. For these reasons Lyα emission was already in the late 60ies suggested as a way to locate and study newly formed galaxies in the early universe.

However, for many years nobody succeeded in detecting these Lyα emitting galaxies at high redshifts. The reason was thought to be the following. Lyα photons have a very high cross-section for absorption by hydrogen atoms. Before they can escape from galaxies they therefore experience a huge number of absorptions and re-emissions (so called resonant scattering) effectively making their optical path through the galaxies very long. This also means that Lyα photons face a larger probability to be absorbed by dust particles. The fact that all the early surveys for high redshift Lyα emitters produced only null-results was interpreted as being due to the presence of dust. Today this is a view still hold by many, but it is only part of the truth. The main reason for the early failures was that todays massive ellipticals were thought to have formed in a single collapse of a gas cloud embedded in a single dark matter halo. Today we have strong reasons to believe that structure formation follows a hierarchical scenario where todays galaxies have formed from merging of many smaller units. Therefore, the flux limits believed to be sufficient in the early surveys were too shallow.

During the last ten years the search for galaxies at high redshifts has undergone a revolution. One of the several now successful survey techniques is Lyα narrow band imaging.

This project : Spectroscopy of a candidate Lyα emitter

The purpose of this project is to perform confirming long-slit spectroscopy of a candidate z=2.04 Lyα emitter found during a narrow band imaging survey at the NOT in May 2001 (Fynbo et al., 2002, A&A, 388, 425). The brightest candidate in this survey, named S926_2, is bright enough to allow a firm detection during one night of observations. The advantage of this project for teaching purposes is that is forces the students to think about several important considerations for sky-limited observations (the importance of read-out noise vs. sky noise, binning, wavelength calibration, spectroscopic flatfielding, etc.). Furthermore, it is a extragalactic project that is feasible in the limited time available. Important scientific results resulting from this project are : the precise redshift, the importance of AGN (via the presence or lack of CIV emission), and the Lyα line shape. The project can be supplemented with existing narrow band and broad band URIJH imaging from Alfosc and NOTCam.

Signal-to-noise calculation

We wish to detect a Lyα emission line with a flux of 2.6×10^{-16} erg s^{-1} cm^{-2} at $>$30 sigma integrated over the line. We plan to use grism 6 and a 1.3 arcsec wide slit providing a resolution of 10Å (fwhm). This corresponds to 800km/s at z=2, hence the line will most likely not be resolved unless the source is an AGN. In the following we assume a linewidth of 800km/s (unresolved). We assume a total efficiency (above atmosphere-to-detector) of 10% at λ=3700Å.

Noise: For the background we assume a dark time skyglow of U=21.5 mag/arcsec^2 typical of dark time at Roque de los Muchachos. This corresponds to $0.10\times10^{-0.4\times21.5}\times4.2\times10^{-9}$ erg s^{-1} cm^{-2} Å^{-1} = 1.0×10^{-18} erg s^{-1} cm^{-2} Å^{-1} arcsec^{-2}. The total noise from the sky background corresponds to the following counts : 1.0×10^{-18} erg s^{-1} cm^{-2} Å^{-1} arcsec^{-1} $\times$ $\pi128^2$ cm^2 $\times$ 3700^{-8}cm / (6.63×10^{-27} erg s $\times$ 3×10^{10}cm/s) = 0.010 e$^-$ s^{-1} Å^{-1} arcsec^{-2} or 0.010 e$^-$ s^{-1} Å^{-1} arcsec^{-2} $\times$10Å$\times$ 1.3 arcsec $\times$ 0.189 arcsec = 0.024 e$^-$ s^{-1} per 10Å resolution bin with the 1.3 arcsec slit and 0.189 arcsec pixels. We plan to bin the detector 2$\times$2. The ReadOut Noise (RON) per resolution bin is then $\sqrt{1.3/(2*0.189)}\times 6.0\mathrm{e}^- = 11\mathrm{e}^-$. For individual exposures of 1500 sec we will therefore not be dominated by RON.

Signal: The count rate for the assumed flux is 2.7×10^{-16} erg s^{-1} cm^{-2} $\times$ 0.10 $\times$ $\pi128^2$ cm^2 $\times$ 3700^{-8}cm / (6.63×10^{-27} erg s $\times$ 3×10^{10}cm/s) = 0.26 e$^-$ s^{-1}.

Signal-to-noise: We assume that the total signal is distributed over 800km/s corresponding to 10Å or 3.0 binned pixels). The signal-to-Noise (SN) ratio as a function of total exposure time T and the number of readouts N is then :

$$SN = \frac{0.26\times T}{\sqrt{N*3*6^2+(0.26+0.024*3)\times T}}$$

Hence, we need 5$\times$1500sec or 2.1 hours.