Dealing with low S/N high-redshift Integral Field Spectroscopic (IFS) Data

After this exercise you would :

Get more comfortable with IDL coding

Learn how to manipulate 3D datacube

Grasp the concept of co-adding data and characterizing the errors of the co-added datacube

Background of the data you are going to deal with:

In 2011 we reported the metallicity gradient of a gravitationally lensed high-redshift spiral galaxy. The data you are going to use is from this piece of work (Yuan et al. 2011, ApJ, 732). The data were collected from the adaptive-optics aided IFS instrument OSIRIS at KECK. Don't worry I'm not going to let you reduce the rawdata. You are mostly going to experience some of the fun processes that we have to go through in order to dig out the signal from the noise-dominated high-z data. This project will give you a good feeling of what the challenges we are facing in analyzing the low S/N high-z IFS data. It is also a good practice for your IDL coding skills.

The datacube can be downloaded from here:

http://www.mso.anu.edu.au/~yuantt/IDLcourse/highz_data/

Steps:

1. You'll be given 18 3D data-cubes of the lensed spiral galaxy that are obtained from 18 individual exposure in observations. Read in one of these cubes in IDL. Learn how to extract the spatial and wavelength information from the datacube.
2. For the original datacube, can you tell me which dimension is the wavelength, which is RA and which is Dec ? How did you come up with the answer ?
3. Now transpose each datacube such that the first dimension is RA, the 2nd dimension is Dec, and the third dimension is the wavelength
4. Please install ds9 or qfitsview if you want a more intuitive look at the IFS data. After you understand the IFS data, you should be able to generate a wavelength-collapsed(*hint-1) 2D image for any of the datacube.
5. The redshift of the galaxy is about 1.489. Can you generate a 2D Halpha image from each datacube ? Also please describe how do you generate the Halpha image.
6. Co-add the 18 datacube and generate a final co-added 3D datacube that has the best S/N in the Halpha emission line detection. (*hint-2)
7. (optional) Calculate the associated error cube from above step.

Send me your IDL codes as well as a short description of how you do each step (you can add those descriptions in your IDL codes)

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Hints:

*h1: wavelength-collapsed: take a median in the wavelength direction

*h2: the datacube is dominated by sky noise, cosmic rays, and instrument background (imperfect flat-fielding). To get the best S/N in emission lines (in our case Halpha), please fit a linear function to the continuum in the spectral direction for each spaxel, and subtract it out from each spaxel. This will help you subtract the imperfect flat-fielding on the price of losing the first order continuum of the science object (we don't care about the continuum of the science object anyway).

*h3: There may be some spatial shift among the 18 data cubes, i.e., the center of the spiral galaxy could have some offsets among the 18 datacube. If you can find a way to determine the offset, the S/N of the co-adding can be improved by correcting for the offsets.

Requirements:

It's okay if you can't finish all the steps. Finish as many as you can.