

# AST 598 – Astronomical Instrumentation and Data Analysis Homework Set #3

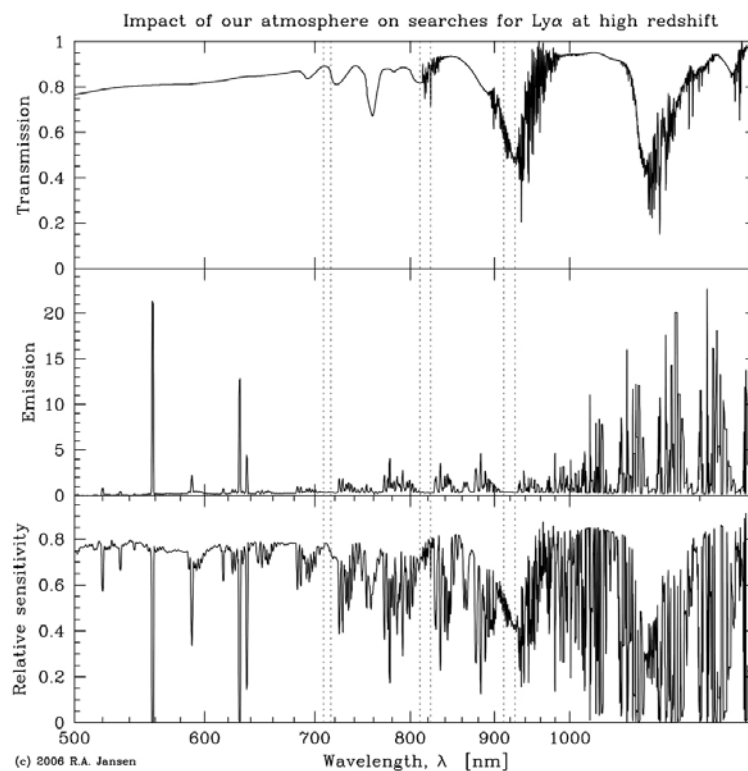
Due 5pm, Wed Nov 15<sup>th</sup>, 2006

Please leave in the Instructor's mailbox on the F-wing 6<sup>th</sup> floor

Questions should be addressed to the Instructor via email to [paul.scowen@asu.edu](mailto:paul.scowen@asu.edu) or during Office Hours (see website for these)

(1) Why is it OK to omit subtracting the MASTERBIAS frame (containing any systematic structure and offsets from the overscan level) from the dome- and twilight sky flat frames as long as one does subtract the overscan level itself?

(2) Why is it OK to also omit correcting flat frames for dark current?



(3) Searches for high-redshift Ly-alpha emitting objects using deep images taken through narrow-band filters have uncovered objects with redshifts clustered around  $z \sim 4.86$ ,  $z \sim 5.72$  and  $z \sim 6.56$ . Given what you have learned about the effects of the Earth's atmosphere on observations (see also the figure above), discuss

(a) why there are so few objects found with redshifts intermediate between the ones listed above,

(b) what would be the next two (even higher) redshifts around which objects are likely to be found if they exist (motivate your answer!),

And, (c [bonus]) what would be the age of the universe at those two redshifts?

(A table with the data plotted in the bottom panel may be downloaded from [http://www.public.asu.edu/~rjansen/ast598/atm\\_abstran\\_sens.dat](http://www.public.asu.edu/~rjansen/ast598/atm_abstran_sens.dat))

(4) The purpose of this homework problem is:

(i) To reinforce the Fourier Transform aspect of optics by treating two apertures as a convolution of a single aperture and two delta functions.

(ii) To carry out calculations using the FFT and see that they reproduce the results of the analytical calculation.

(iii) To use these tools to play with configurations of an idealized optical interferometer.

Consider a telescope consisting of a circular aperture with diameter 3 meters.

(a) Based on prior notes, what is the functional form of the PSF formed by this aperture? For a wavelength of 0.5 microns, what is the resolution (Rayleigh criterion) for this telescope?

(b) Suppose that you are using a 2048 X 2048 array to calculate an FFT representing this telescope. If you want a pixel size of 0".01 in the calculated PSF, what is the step size in meters in the aperture array? What is the radius in pixels of the aperture?

(c) Use an FFT to calculate the PSF from this telescope. (IDL is my preferred environment for this kind of work.) Check your results by plotting a line through the PSF and showing that it obeys the resolution relation,  $\text{res} = 1.22 * \lambda/D$ . Turn in a plot showing the calculated PSF.

Here's some IDL code to get you started:

```
psf=shift(fft(aper,-1),1024,1024)
psf=abs(psf)^2
psf=psf/max(psf)
```

(d) Now consider a pair of such telescopes separated center to center by a distance of 1 meter. Imagine that the beams from these two telescopes are combined to form an interferometry. Use the convolution theorem for Fourier Transforms to sketch what the overall PSF of the interferometer would look like.

(e) Replace the aperture function in your code from (c) with two apertures separated by a meter, then calculate the PSF of the combined system. How does this compare with your answer to (d)? What is the effective resolution of this system parallel to the interometer baseline? Perpendicular to the baseline?

(f) Use your code to do several more cases including:  
- A linear array of 7 such telescopes, each separated from its neighbor by 1 meter  
- A + shaped cross of 13 such telescopes, again with 1 meter spacings  
- A Y shaped array of 13 such telescopes with 1 m spacings.

(g) Looking at your results, what of interest have you learned?