Tutorial problems for ACT filtering. Due Wednesday October 19th.

We are going to work out matched filtering to search for galaxy clusters in the SZ effect. I have snipped a much larger piece out of an ACT map than the small patch we worked with in class. You can find it at advact_tt_patch.fits, and some possibly useful utility routines are in act_mf_tools.py. There is helpfully a big cluster (Abell 2813) at the exact center of the patch.

Part 1: Fit a Gaussian to the cluster in the map center assuming the map noise is uniform and uncorrelated between map pixels. What is are your best-fit positions, sigma, and amplitude?

Part 2: Write a routine called *estimate_ps* to take the 2D power spectrum of the map. You'll do this by smoothing the absolute value squared of the 2D FFT of the map. Rather than using the slow way of smoothing I demonstrated in class, you can convolve the squared FFT with a Gaussian (feel free to use get_gauss_kernel with norm=True here). Make a plot of the log of your 2D power spectrum.

Part 3: Write a routine to apply N^{-1} to a map, using the output of your *estimate_ps* routine. Please call this routine *filter_map*, and have it accept a non-padded map and the power spectrum, and return a non-padded map. Plot the noise-filtered map, centered in a region around the center (where there ought to be a cluster).

Part 4: Make sure your noise filtering is properly normalized. In particular, show that if you start with a map of white noise, run *estimate_ps* on that, and the call *filter_map* on your white-noise map, that the variance of the filtered map agrees with what you expect.

Part 5: Make a *properly normalized* matched-filter map of the ACT data, using the width for the cluster you found from part 1. What does your matched filter say the amplitude of the cluster is in μK (the units the map are in)? What does your matched filter say the uncertainty on the amplitude is? Looking at the standard deviation of the matched filter output in a region around the cluster, do you buy this error bar?

Part 6: Find some other galaxy clusters in the ACT map, using your matched filter output. Can you match any of them up with known clusters, using the NASA Extragalactic Database (NED), and the fact that the map pixels are 30 arcseconds and that the cluster is centerd on A2813? There's a cluster roughly 200 pixels to the right and a bit up from A2813, which I was able to find in NED. As a reminder, RA *decreases* to the right in standard astronomical maps.