

Due **3:04pm Thursday 2008 May 15th (in class)**

- Work on the final project for 8.982 will extend over six weeks. Roughly 40 hours of effort (equivalent to perhaps 4 problem sets) is expected. There is no requirement on the length of the final report. However the effort that went into the project will be *inferred* from what is reported. Seven possible topics are listed below. This list is *not* intended to be exhaustive. I hope to have a second list for you shortly. I would be delighted to have you propose projects of your own devising (but they will need my prior approval). As will be obvious, it has easier for me to dream up optical projects than radio or X-ray projects. I would like to avoid having too many people work on one project. I would therefore be grateful if you would send me (by Monday April 7th) your first and second choices *with* a few sentences explaining why this project is a particularly good match to your interests and talents. If a project looks as though it will take something more like 80 hours of effort I will be happy to consider proposals from teams of two people. A successful project will be one that tells the instructor something he didn't know.
- (1) Anastigmatic Chandra: In a 1971 paper van Speybroeck and Marsh argued that a Wolter-Schwarzschild design (in essence a Ritchey-Chretien, although they didn't call it that) offered no advantage over the Wolter type I design that was ultimately used on the Chandra satellite. Ritchey-Chretiens have a hyperbolic primary and a hyperbolic secondary tuned to exactly cancel out the off-axis coma. Might one, instead, have chosen a hyperbolic (or perhaps elliptical) primary and hyperbolic secondary that would instead have cancelled out (to lowest order) the off-axis astigmatism? How would its performance have compared with the Wolter-Schwarzschild and Wolter type I designs?
  - (2) Alignment of the f/5 secondaries on the MMT and Magellan: At the Magellan f/11 focii we use two Shack-Hartmann probes to align the secondary and tertiary mirrors. At the MMT there is only one on-axis wavefront sensor. A similar f/5 secondary and guider unit is being installed at Magellan. In anticipation of this, out of focus images were taken at the MMT with Megacam, a direct imager with a roughly 30 arcminute diameter field. These data have been reduced to image diameters and ellipticities. The final step is to use these (and the results of problem two on problem set #2) to determine how much to tilt the secondary. This will involve some kind of fitting. I would hope that in addition to deriving a tilt correction you would also derive an uncertainty in the tilt correction. You will want to read (but not follow slavishly) the 1996 paper by Brian McLeod on the alignment of the FLWO 1.2 meter telescope.

- (3) Interpreting out of focus images: As described in project #2, out of focus images can be used to align a telescope. The first step is to analyze the direct images and extract the defocus, coma and astigmatism for each image. The raw data obtained at the MMT are available. The idea here would be to re-reduce those data, extracting these three aberrations and comparing the values with those obtained at CfA.
- (4) Bolometers versus HEMTs: The ACBAR and CBI experiments both measure small scale fluctuations in the cosmic microwave background, with similar collecting area and a similar number of independent detectors. But the former uses bolometers while the latter uses coherent radio techniques based on high electron mobility transistors (HEMTs). ACBAR would appear to have outclassed CBI. Explain quantitatively how this came about.
- (5) As described in astro-ph/0207250, the bending mode of the primary mirrors of the Magellan telescopes that has the same “quantum numbers” as the defocus Zernike polynomial is more nearly cone-like than paraboloidal. Either analytically or numerically (and if you know how to do an FEA you are welcome to do so) show how the transition between the two shapes depends upon the size of the central hole. You may assume that the mirror is a thin, uniform disk.
- (6) Orthogonal crypto-Zernikes: This project grows directly out of the 4th problem on the second pset, and has two parts. The first would be to search the literature to see if anyone has calculated the crypto-Zernike polynomials whose *gradients* are orthogonal. My suspicion is not (or I’d have seen them used), but I would ask you to put 3-4 hours into looking through the literature. The second piece would be to actually generate these crypto-Zernikes through order 36.
- (7) Spurious coma signal at Magellan: despite the success of the Magellan active optics system (astro-ph/0207250), we believe that the Shack-Hartmann (S-H) sensor is producing a small but statistically significant systematic coma error. The tell-tale symptom is a change in the coma correction (which is applied to the secondary) as the instrument rotator (containing the S-H unit) is rotated. The S-H unit calls for small displacements of the secondary even though the secondary and telescope haven’t been moved. The project would be to analyze some fragmentary data and explore possible explanations.