ASTR 3510 Exam 1 Review Session Notes

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October 2, 2019

1 Coordinates and Time

1.1 Definitions

- Celestial sphere
- Meridian
- Zenith
- Horizon
- Altitude/Azimuth
- Right Ascension (RA)/Declination (Dec) (Latitude/Longitude)
- Universal Time (UT)
- (Local) Sidereal Time (LST)
- Hour Angle (HA)
- North/South Celestial Pole (NCP/SCP)
- Celestial equator
- First Point of Aries
- Julian Date (JD)
- Modified Julian Date (MJD)
- Heliocentric Julian Date (HJD)
- Precession
- Epoch
- Air Mass

1.2 Main Equations

$$\text{Angular dist } ('') = 15'' \cos(\text{dec}) \times \text{RA } (^s)$$

$$\text{Observer}'\text{s latitude} = \text{Altitude of NCP}$$

$$\text{UT} = \text{MDT} + 6/7 \text{ hours}$$

$$\text{LST} = \text{RA on the meridian/transiting}$$

$$\text{HA} = \text{LST} - \text{RA}$$

$$\sin(\text{Alt}) = \sin(\delta)\sin(L) + \cos(\delta)\cos(L)\cos(\text{HA})$$

$$\text{Airmass} = \sec(z)$$

where $z = 90^\circ - \text{Alt}$

1.3 Key Things to Remember

* RA/Dec Notation: $HH^h\ MM^m\ SS^s, DD\ MM'\ SS''$.
* Know how to convert between degrees, arcminutes, and arcseconds, and similarly hours, minutes, and seconds.
* Know some reference point for LST e.g. September 21 at midnight is $LST = 0$.
  - A month = 2 hours.
  - A week = 30 minutes.
  - Make sure to adjust for DST, if necessary.

2 CCD Properties and Data Reduction

2.1 Definitions

- Charged Coupled Device (CCD)
- Noise (readout/thermal/random)
- Resolution
- Semiconductors
- Blooming/Bleeding
- Bias level/frame
- Flat fielding/frame
- Analog-Digital Unit (ADU)
- Quantum Efficiency (QE)

- Pixels
- Nonlinearity/Saturation
- Gain
- Dark current/frame
- Charge Transfer Efficiency (CTE)
- Binning
- Subframes

2.2 Main Equations

$$\text{ADU} = \#\text{ of electrons/Gain}$$

$$\text{ADU} = \frac{(\text{Flux} \cdot \text{QE} + \text{DC})t \pm \text{noise}}{\text{Gain}} + \text{Bias}$$

$$\text{Corrected data} = \frac{\text{Data} - \text{Data Dark}}{\text{Flat} - \text{Flat Dark}}$$

$$\text{Normalized flat} = \frac{\text{Flat} - \text{Flat Dark}}{(\text{Flat} - \text{Flat Dark})_{\text{mode}}}$$

2.3 Key Things to Remember

* Know why we need bias, dark, and flat-field frames.
* Two types of saturation: full-well capacity (FWC) and digital.
* Pay close attention to units.
* Know the different types of flats.

3 Optics and Telescope

3.1 Definitions

- Law of Reflection
- Refraction
- Fermat's Principle of Least Time
- f/#
- Point Spread Function (PSF)
- Seeing

- Full-Width at Half-Maximum (FWHM)
- Adaptive Optics
- Active Optics

3.2 Main Equations

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2) \text{ (Snell's Law)}$$

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \text{ (Thin Lens Equation)}$$

$$\implies \frac{1}{s'} = \frac{1}{f} \text{ (for a telescope)}$$

$$\text{Magnification} = \frac{\text{focal length, telescope}}{\text{focal length, eyepiece}}$$

$$\theta_{\text{diff}} \text{ (rad)} = \frac{1.22\lambda}{D}$$

$$\theta_{\text{diff}} \text{ ('')} = \frac{2.5 \times 10^5 \lambda}{D}$$

3.3 Key Things to Remember

* Light gathering power $\propto D^2$.
* Angular resolution $\propto \lambda/D$.
* Magnification $\propto$ IPS $\propto f \propto f/\#$.
* Know that we see diffraction patterns (usually) due to secondary support structures.
* Ideal sampling of PSF is 2.4 pixels across FWHM.
* Know the contributions to seeing.
* Know the basics of Adaptive Optics.