ASTR 3510 Exam 2 Review Session Notes

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1 More About Telescopes

1.1 Aberrations

- Coma: off-axis light for parabolic mirrors
- Spherical Aberration: spherical nature of mirrors
- Astigmatism: non-symmetric mirrors/lens
- Chromatic Aberration: for lenses
  - achromat: concave lens
- Field Curvature: flat detector

1.2 Telescope Designs

- Refractor (Galilean)
- Reflector (Newtonian): parabolic mirror + flat pickoff
- Cassegrain: parabolic primary + hyperbolic secondary
- Others

1.3 Types of Mounts

- Equatorial vs. Alt-Az

2 Statistics

2.1 Fundamental Ideas

- Precision vs. Accuracy
  - random uncertainty vs. systematic uncertainty
- Parents vs. Samples
- Know how to go back and forth between probability and confidence

2.2 Probability Distributions

2.2.1 Binomial Distribution

- discrete probability distribution
- $\mu = np$; $\sigma = \sqrt{np(1-p)}$
- $P(x; n, p) = \binom{n}{x} p^x (1-p)^{n-x}$

2.2.2 Poisson Distribution

- continuous probability distribution
- binomial limit when $p << 1$ and $n >> 1$
  - $\mu = np$; $\sigma = \sqrt{np}$
- $P(x; \mu) = e^{-\mu} \frac{\mu^x}{x!}$

2.2.3 Gaussian Distribution

- continuous probability distribution
- Poisson limit when $P(x = 0) << 1$
- $P(x; \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$

Things to Keep in Mind:

- Dimensional analysis doesn't work for the standard deviation!
- $z = \frac{x-\mu}{\sigma}$ only works for area under the curve

2.3 Error Propagation

If $y = f(u, v, w, ...)$, then:

$$\sigma_y = \sqrt{\left(\frac{\partial f}{\partial u}\right)^2 \sigma_u^2 + \left(\frac{\partial f}{\partial v}\right)^2 \sigma_v^2 + \left(\frac{\partial f}{\partial w}\right)^2 \sigma_w^2 + \cdots}$$

- Standard Deviation of the Mean: $\sigma_{\bar{x}} = \sigma/\sqrt{n}$

3 Photometry & Calibrations

3.1 Fundamentals

- $m_1 - m_2 = -2.5 \log\left(\frac{f_1}{f_2}\right)$

- Rules of thumb:

$$\Delta 1 \text{ mag} \approx 2.5\times$$
$$\Delta 2.5 \text{ mag} = 10\times$$
$$\Delta 5 \text{ mag} = 100\times$$

- $M - m = -5\log(d/10pc)$ (distance modulus)
- Surface Brightness: Total magnitude $= SB - 2.5\log(\text{Area})$

3.2 Filters & Colors

- broad-band vs. narrow-band
- Johnson/Bessel UBVRI
- Calibration based on Vega
- Color indices: B-V, U-B, V-R, R-I
- Spectral Class: OBAFGKM e.g. B-V:
  - O5 ≈ -0.33
  - B0 ≈ -0.30
  - A0 ≈ -0.02
  - F0 ≈ 0.30
  - G0 ≈ 0.58
  - K0 ≈ 0.81
  - M0 ≈ 1.40

3.3 Photometry In Practice

- Basic vocabularly: apperture, buffer, annulus
- FLUX $= (\sum_{\text{app}} ADU) - (\overline{\text{Sky}} \times \text{Area(app)})$
- Instrumental magnitude $= -2.5\log\left(\frac{\text{FLUX}}{\text{exposure time}}\right)$
- $\sigma_{\text{photon}} = \sqrt{\text{Signal}} = \sqrt{\frac{ADU}{\text{Gain}}}$
- $\sigma_{\text{SkySub}} = \sqrt{\frac{ADU_{\text{sky}}}{\text{Gain}}} \times \frac{\text{Area}_{\text{app}}}{\text{Area}_{\text{Sky}}}$
- $\sigma_{\text{ReadNoise}} = \sqrt{N_{\text{app}}} \times \overline{RN}$
- Add these in quadrature!