w7

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Contents

1 Week 7 - Adaptive Optics

```
# astrophysics .sagews prologue
%auto
typeset_mode(true)
Npi = pi.n()
```

```
# Star is at distance D from Earth and has luminosity L
# flux at earth is
%var F_s,L,D
eq_flux = F_s == L / (4 * pi * D^2)
eq_flux
```

$$F_s = \frac{L}{4\,\pi D^2}$$

```
# Planet has radius r_p and orbit r_o. If 100% of light from the star is \
   reflected, what is flux at Earth?
%var F_p,r_p,r_o,L_p

# first compute lumninosity of the planet, which is the flux from the \
   star hitting the area of the planet
eq_lp = L_p == (L/(4 * pi * r_o^2)) * (pi * r_p^2)
eq_lp

# then compute the flux from the planet at Earth
eq_fp = eq_flux.subs_expr(F_s == F_p,L == L_p)
eq_fp
eq_fp2 = eq_fp.subs(eq_lp)
eq_fp2

# how much brighter is the star than the planet?
eq_sp = eq_flux/eq_fp2
```

```
eq_sp
```

$$L_p = \frac{Lr_p^2}{4\,r_o^2}$$

$$F_p = \frac{L_p}{4\,\pi D^2}$$

$$F_p = \frac{Lr_p^2}{16\,\pi D^2 r_o^2}$$

$$\frac{F_s}{F_p} = \frac{4\,r_o^2}{r_p^2}$$

1.1 LQ7.5 Diffraction limit

```
%var theta,D
lam = var("lam",latex_name="\lambda")
eqdl = theta == lam / D
eqdl
```

$$\theta = \frac{\lambda}{D}$$

```
# theta_SS (resolution in radians) for Siding Spring Observatory
%var theta_SS
lam_SS = (0.5 * units.length.meter * units.si_prefixes.micro).convert()
D_SS = 2.3 * units.length.meter
theta_SS == (eqdl.subs(lam = lam_SS,D = D_SS)).rhs()
```

$$\theta_{SS} = \left(2.17391304347826 \times 10^{-7}\right)$$

```
# theta_PR (resolution in radians) for Parkes Radio Telescope
%var theta_PR
lam_PR = (21.0 * units.length.centimeter).convert()
D_PR = 64.0 * units.length.meter
theta_PR == (eqdl.subs(lam = lam_PR,D = D_PR)).rhs()
```

$$\theta_{PR} = 0.00328125000000000$$

1.2 Practice Questions

```
# PQ7.1 Angular separation
%var theta_rad,r_orbit,D
eq_as = theta_rad == r_orbit / D
eq_as
```

$$\theta_{rad} = \frac{r_{orbit}}{D}$$

```
%var as_rad
# r71 = planet orbit radius form 7.1
r71 = 1.5e11 * units.length.meter
D71 = 4.1e16 * units.length.meter
```

```
as_arcsec = (eq_as.subs(r_orbit = r71,D = D71).rhs()) * (units.angles.\
   radian.convert(units.angles.arc_second))
as_arcsec.simplify()*pi/Npi
print("angular separation is {0}".format(as_arcsec.simplify()*pi/Npi))
as_rad = eq_as.subs(r_orbit = r71,D = D71).rhs()
print("angular separation in radians is {0}".format(as_rad))
```

$$0.754627339928\, arc_{second}$$

```
angular separation is 0.754627339928*arc_second
angular separation in radians is 3.65853658536585e-6
```

```
# PQ7.2 Brightness ratio
# rp71 = planet radius from 7.1
rp71 = 6400 * units.length.kilometer.convert()
rp71
star_over_planet_flux = eq_sp.subs(r_o = r71,r_p = rp71)
star_over_planet_flux
print(star_over_planet_flux)
```

$$6400000\, meter$$

$$\frac{F_s}{F_p} = \left(2.19726562500000 \times 10^9\right)$$

```
F_s/F_p == 2.19726562500000e9
```

```
# PQ7.3
eqdl
lam73 = 0.5 * units.length.meter * units.si_prefixes.micro.convert()
eq73a = eqdl.subs(theta = as_rad,lam=lam73)
eq73b = (eq73a*D).solve(D)[0]
eq73b
md = float(eq73b.rhs().coeffs()[0][0].n())
print("Mirror diameter is {:.3f} meters".format(md))
```

$$\theta = \frac{\lambda}{D}$$

$$D = \frac{41}{300}\, meter$$

```
Mirror diameter is 0.137 meters
```

```
### The End
```