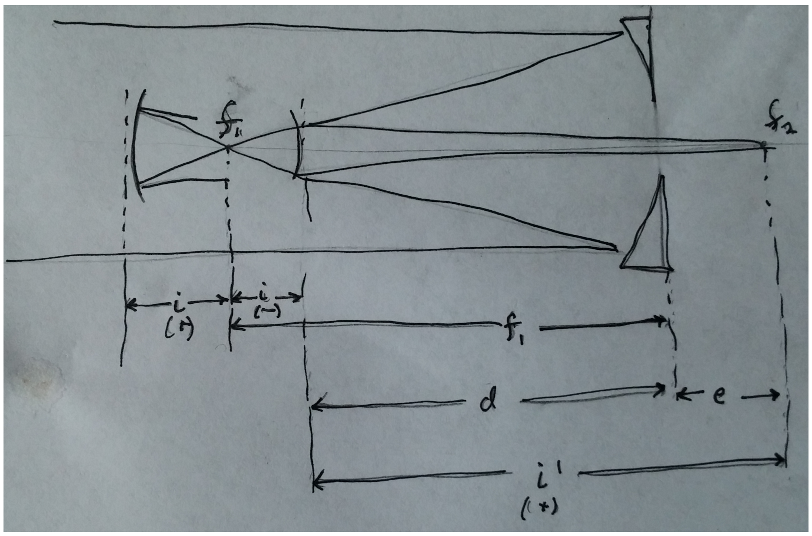
Homework3 ElijahBernstein-Cooper
Astron 500

1

This telescope is a Richey Chertian Telescope given that both mirrors are hyperbolic.

2



$e = i' - d$

$i' = \left(\frac{1}{f_2} - \frac{1}{i}\right)^{-1}$

$i = f_1 - d$

$i' = \frac{f_2\, i}{i - f_2} = \frac{(f_1 - d)\, f_2}{f_1 - d - f_2}$

$e = \frac{(f_1 - d)\, f_2}{f_1 - d - f_2} - d$

3a

$f^2 = a^2 + b^2$

where f is the focal length and a and b define the hyperbola by $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$

The curvature is $k = -e^2$ where e the eccentricity is

$$e = \sqrt{1 + \frac{b^2}{a^2}}$$

b will be the diameter of the telescope, thus we can solve for a since we know k

$$a = \sqrt{\frac{-b^2}{k+1}}$$

and substitute to find the focus

In[1229]:=

```
k = -1.285;
Diam = 2.5;
b = Diam;
```

$$a = \sqrt{\frac{-b^2}{k+1}};$$

$$f1 = \sqrt{(b)^2 - \frac{(b)^2}{k+1}};$$

```
StringForm["The focus of the primary is ``m", N[f1, 1]]
```

Out[1234]= The focus of the primary is 5.308467251608841`m

3b

In[763]:= $fratio = \frac{f1}{Diam};$

$$s = \frac{206\,265}{Diam * 1000.0 * fratio};$$

```
StringForm["s = ``arcsec/mm", s]
```

Out[765]= s = 77.71169726534045`arcsec/mm

3c

In[766]:=

```
k = -11.97;
Diam = 1.08;
b = Diam / 2;
```

$$a = \sqrt{\frac{-b^2}{k+1}}$$

$$f2 = \sqrt{\left(\frac{Diam}{2}\right)^2 - \frac{\left(\frac{Diam}{2}\right)^2}{k+1}}$$

Out[769]= 0.163039

Out[770]= 0.564076

3d

In[771]:=

```
d = -3.644;
pupildist = (f2 * d)/(f2 - d)
```

Out[772]= -0.488464

4a

In[773]:=

```
d = 11;
r = d / 2;
area = Pi * r^2;
area_obstructed = area * 0.6919;
ϵ_primary = 0.75;
ϵ_corrector = 0.80;
ϵ_glass = 0.99;
ϵ_ccd = 0.85;
ϵ_optics,salt = ϵ_primary * ϵ_corrector^4 * ϵ_glass^8 * ϵ_ccd;
area_salt,eff = area_obstructed * ϵ_optics,salt;
StringForm["Effective collecting area = ``m^2", area_salt,eff]
diam_equiv = Sqrt[area_salt,eff / Pi];
StringForm["Equivalent diameter = ``m", diam_equiv]
```

Out[783]= Effective collecting area = 15.8431 m^2

Out[785]= Equivalent diameter = 2.2456661965860807`m

In[786]:=

```
ϵ_Vband = 0.90;
```

4b

In[834]:=

```
r = 6 / 39.37 / 2;
area_df = 8 * Pi * r^2;
ϵ_optics,df = 0.48;
area_df,eff = ϵ_optics,df * area_df;
Ω_df = 2.9 * 1.9;
Ω_salt = Pi * (8. / 2 / 60)^2;
area_salt,eff * Ω_salt
area_df,eff * Ω_df
```

Out[840]= 0.221211

Out[841]= 0.385962

4c

In[795]:=
```
Diam = 11;
f1 = Diam * 4.2;
```
$$f_{ratio} = \frac{f1}{Diam};$$
$$s = \frac{206\,265}{Diam * 1000.0 * f_{ratio}};$$

```
StringForm["s = ``arcsec/mm", s]
```

Out[799]= s = 4.46461038961039`arcsec/mm

4d

In[800]:=
```
Diam = 11;
f1 = Diam * 1.9;
```
$$f_{ratio} = \frac{f1}{Diam};$$
$$s = \frac{206\,265}{Diam * 1000.0 * f_{ratio}};$$

```
StringForm["s = ``arcsec/mm", s]
```

Out[804]= s = 9.869138755980861`arcsec/mm

4e

In[946]:=
$$pix_{salt} = 15 * 10^{-6};$$
$$\theta_{pix,salt} = \left(s * 10^{3}\right) * pix_{salt};$$
$$\theta_{pix,df} = 2.8;$$
$$npix_{bin} = \frac{\theta_{pix,df}}{\theta_{pix,salt}}$$
StringForm["Number of binned salt pixels = ``", Round[$npix_{bin}$, 1]]

Out[949]= 18.9142

Out[950]= Number of binned salt pixels = 19

4f

In[951]:=
$RN = 3;$

$n_{pix,salt} = \Omega_{salt} * 3600^2 / (\theta_{pix,salt}{}^2);$

$f_{sky} = 3640 * 10^{-0.4*21.5} * \frac{15.1}{1 * 10^{-6}};$

$I_{sky} = f_{sky} * \pi * (11/2)^2 * 0.16 * \Omega_{salt} * ((3600)\wedge 2/1) / n_{pix,salt};$

$t = \frac{(3 * RN)^2}{I_{sky} * \epsilon_{optics,salt}} (*s*);$

```
StringForm["Equivalent sky-limited time for Salt = `` s", ScientificForm[t]]
```

Out[956]= Equivalent sky-limited time for Salt = 7.30716 s

4g

In[1176]:=
$\theta_{pix,df} = 2.8;$

$RN = 3;$

$n_{pix,salt,binned} = \frac{n_{pix,salt}}{npix_{bin}};$

$f_{sky} = 3640 * 10^{-0.4*21.5} * \frac{15.1}{1 * 10^{-6}};$

$I_{sky} = f_{sky} * \pi * (11/2)^2 * bandwidth * \Omega_{salt} * ((3600)\wedge 2/1) / n_{pix,salt,binned};$

$t = \frac{(3 * RN)^2}{I_{sky} * \epsilon_{optics,salt}} (*s*);$

```
output = NSolve[t == 3600, bandwidth];
StringForm["Bandwidth = ``", ScientificForm[bandwidth /. output]]
```

Out[1183]= Bandwidth = $\{1.71703 \times 10^{-5}\}$

5a

In[816]:=
$f = 4.2;$

$Diam = 11;$

$\beta_s = \frac{206\,265}{128 * (f)^3};$

$StringForm["\beta_s=``arcsec", \beta_s]$

Out[819]= β_s=21.75042263929381`arcsec

5b

In[820]:=

```
θ = 8 * 60;
```

In[821]:=

$$\beta_c = \frac{\theta}{16 * f^2};$$

$$\beta_a = \frac{(\theta)^2}{2 * f};$$

```
StringForm["βc=``arcsec", ScientificForm[βc]]
```

Out[823]= β_c=1.70068arcsec

Chromatic abberation

In[824]:=

```
StringForm["βa=``arcsec", ScientificForm[βa]]
```

Out[824]= β_a=2.74286×10^4arcsec

Astigmatism abberation

5c

In[825]:=

$$\lambda = \frac{\frac{\beta_s}{206\,265}}{1.22} * 10^{10};$$

```
StringForm["λ=``Å", λ]
```

Out[826]= λ=864335.4557539903`Å

The circle of least confusion is at a much coarser resolution than the smallest optic diffraction limit on SALT.