HW 4 - ASTR503

Created with Wolfram Mathematica 11.0 on 9-30-2016

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1)

Q1)

Frame width

$$\text{FrameWidth} = \frac{\text{DetectorWidth}}{\text{FocalLength}}$$

Numerical value

```
In[2]:= sFW = FW -> UnitConvert[w/f rad //. {f → 6 m, w → 1024. 18 μm}, "ArcMinutes"]

Out[2]= FW → 10.56076'
```

Pixel scale

For n x n pixels:

$$\text{PixelScale} = \frac{\text{FrameWidth}}{n}$$

Numerical value

```
In[3]:= PS → UnitConvert[FW / n /. {sFW, n → 1024}, "ArcSeconds"]

Out[3]= PS → 0.6187944"
```

Q2)

Formula for resolution at diffraction limit

```
In[4]:= fθ[λ_, d_] := θmin → UnitConvert[1.22 λ/d rad, "ArcSeconds"]
```

Hubble space telescope

At 300nm

In[5]:=
```
fθ[300 nm, 2.4 m]
```
Out[5]= $\theta_{min} \to 0.03145538''$

At 2μm

In[6]:=
```
fθ[2 μm, 2.4 m]
```
Out[6]= $\theta_{min} \to 0.2097026''$

8m space telescope

At 2 μm

In[7]:=
```
fθ[2 μm, 8 m]
```
Out[7]= $\theta_{min} \to 0.06291077''$

Q3)

In[8]:=
```
FormulaData["FNumber"]
```
Out[8]= $N == \frac{f}{D}$

Here N is the f-number, f is the focal length and D is the aperture.

a) Refractor (f/10)

In[9]:=
```
With[{f = 10 m}, TubeLength → f]
```
Out[9]= TubeLength → 10 m

b) Schmidt (f/10)

In[10]:=
```
With[{f = 10 m}, TubeLength → 2 f]
```
Out[10]= TubeLength → 20 m

c) Schmidt (f/2.5)

In[11]:=
```
With[{f = 2.5 m}, TubeLength → 2 f]
```
Out[11]=
```
TubeLength → 5. m
```

d) Cassegrain (f/10, f/3 primary, final focus at 20cm)

Equations

In[12]:=
```
eqd = {f1 == 3 m, f == 10 m, β f1 == 0.2 m,
   m == f / f1, 1 - d / f1 == (1 + β) / (1 + m), TubeLength == d + β f1};
```

Solving

In[13]:=
```
NSolve[eqd, {TubeLength, β, f1, d, f, m}][[1, -1]]
```
Out[13]=
```
TubeLength → 2.461538 m
```

Therefore the TubeLength is 2.462 meters.

e) Cassegrain (f/10, f/2 primary, final focus at 20cm)

Equations

In[14]:=
```
eqe = {f1 == 2 m, f == 10 m, β f1 == 0.2 m,
   m == f / f1, 1 - d / f1 == (1 + β) / (1 + m), TubeLength == d + β f1};
```

Solving

In[37]:=
```
NSolve[eqe, {TubeLength, β, f1, d, f, m}][[1, -1]]
```
Out[37]=
```
TubeLength → 1.833333 m
```

Therefore the TubeLength is 1.833 meters.

Q4)

Equations

$m1 - m2 = -2.5 \,\mathrm{Log}_{10}(F1 / F2)$

$mb1 - mb2 = -2.5 \,\mathrm{Log}_{10}(b1 / b2) = -1$

$$\frac{F1}{F2} = \sqrt{\frac{b1}{b2} \frac{D2}{D1}}$$

$m1 = 26$

Solving for m2

In[16]:=
```
Solve[26 - m2 == -2.5 Log10[Sqrt@rb 6.5 / 2.4]
    /. Solve[1 == -2.5 Log10@rb, rb] [[1]], m2] [[1, 1]]
```

Out[16]= m2 → 26.58176

Q2) Observing Andromeda

Fetching values from WolframAlpha:

In[17]:=
```
Grid[Prepend[Thread@Prepend[(ev={"Rise","Transit","Set"})]@
 {lt=(ob= M31 )@EntityProperty[ob@"ObjectType",#,
  {"Location"→(ps= 40.1105° N, 88.2284° W ),"Date"→ sep 30 }]&/@
   (#<>"Time"&/@ev),st=SiderealTime[ps,#]&/@lt,st-ob@"RightAscension"},
    {ob@"Name","Local Time","Local Sidereal Time","Hour Angle"}],Frame→All]
```

Out[17]=

M31	Local Time	Local Sidereal Time	Hour Angle
Rise	Fri 30 Sep 2016 15:40 GMT–5.	$15^h\ 25^m\ 26.23772^s$	$14^h\ 42^m\ 41.93772^s$
Transit	Fri 30 Sep 2016 00:59 GMT–5.	$0^h\ 42^m\ 1.511847^s$	-42.78815^s
Set	Fri 30 Sep 2016 10:14 GMT–5.	$9^h\ 58^m\ 32.68422^s$	$9^h\ 15^m\ 48.38422^s$

Q3)

SPT

In[18]:= $\{\sigma \to 8 \times 10\text{^}-5,\ \text{SNR}_{\text{Max}} \to 8.57\}$ // Column

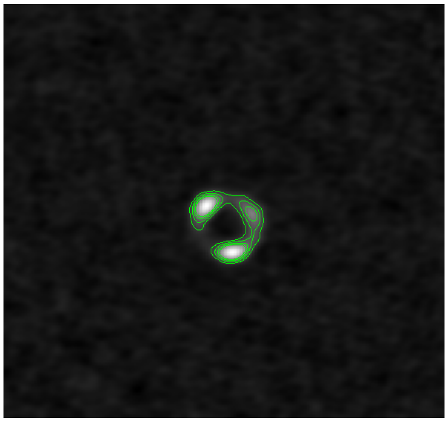
Out[18]=
$\sigma \to \frac{1}{12500}$
$\text{SNR}_{\text{Max}} \to 8.57$

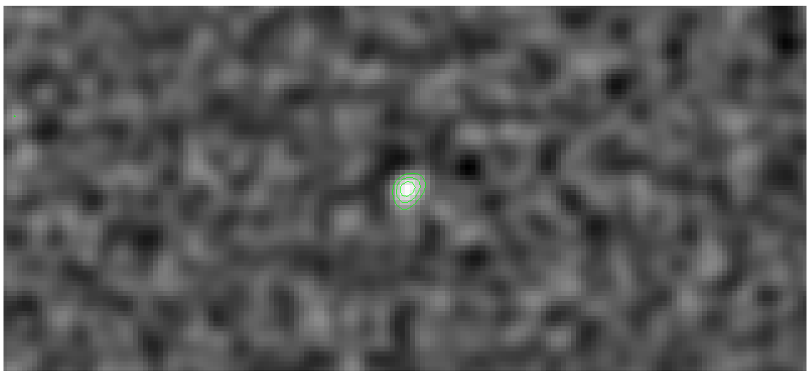
ALMA

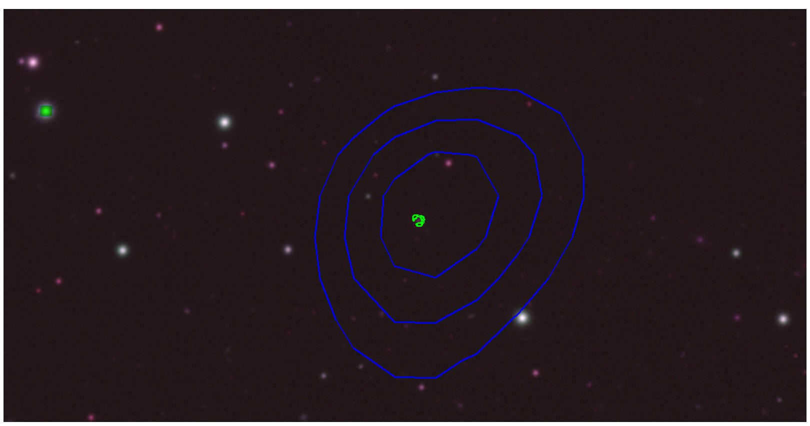
In[19]:= $\{\sigma \to 1.4 \times 10\text{^}-3,\ \text{SNR}_{\text{Max}} \to 18.99\}$ // Column

Out[19]=
$\sigma \to 0.0014$
$\text{SNR}_{\text{Max}} \to 18.99$

Images







Q4)

Selection criteria

- **SNR of either 2mm or 1.4mm > 4.5σ**
- **Does not appear in IRAC or SUMSS catalog**
- **Posterior probability P(α>1.66) > 0.5**

Importing SPT catalog

In[36]:=
```
catSPT = SemanticImport[NotebookDirectory[] <> "PointSourceSPT.dat"];
```

Selecting lensed sources

In[21]:=
```
lensed = catSPT[Select[(#["S/N_2.0mm"] > 4.5 || #["S/N_1.4mm"] > 4.5) &&
      #["P(alpha>1)"] > .5 && #["dR_SUMSS[arcsec]"] > 60 && #["dR_IRAS[arcsec]"] > 60 &]];
```

Number of lensed sources

In[22]:=
```
Length@lensed
```

Out[22]= 33

Plot

In[28]:=
```
ListLogLogPlot[Normal /@ (#[All, {"S_raw_2.0mm[mJy]", "S_raw_1.4mm[mJy]"}] & /@ {catSPT, lensed}),
 PlotMarkers → {".", "×"}, Frame → True, PlotLegends → Placed[{"All", "Lensed"}, {Left, Bottom}],
 FrameLabel → {"S_raw_2.0mm[mJy]", "S_raw_1.4mm[mJy]"}, ImageSize → 500]
```

Out[28]=