8.13-4 Subreflector Feed Mismatch

The currents excited on the subreflector due to feed illumination radiate and couple into the feed antenna and cause a mismatch. The mismatch adds to the feed mismatch when it radiates into free space. This section discusses various methods of determining this mismatch and compares them for particular examples of Cassegrain and Gregorian dual reflectors.

The first method uses the method of stationary phase similar to section 8-9 using the subreflector geometry and a Gaussian beam feed gain in the near-field. We start with Eq. (8-30).

$$\Gamma = -j\frac{G_f(\rho_0)}{4k\rho_0}\sqrt{\frac{\rho_1\rho_2}{(\rho_1+\rho_0)(\rho_2+\rho_0)}}e^{-j2k\rho_0}$$

At the center of the subreflector the radii of curvature $\rho_1 = \rho_2 = b^2/a$. Given the distance between the feed and the subreflector, L_s, and the Gaussian beam feed near-field gain, the reflection coefficient is given as

$$\Gamma = \frac{-jG_f(L_s)\rho_1}{4kL_s(\rho_1+L_s)}e^{-j2kL_s} \quad \text{Cassegrain}$$

$$\Gamma = \frac{-jG_f(L_s)\rho_1}{4kL_s(L_s-\rho_1)}e^{-j2kL_s} \quad \text{Gregorian}$$

Physical optics can be used to compute the mismatch from coupling between the feed antenna and the currents induced on the subreflector due to the radiation of the feed using Eq. (1-55). This method can be applied to shaped subreflectors while the equations given above for the canonical Cassegrain and Gregorian reflectors only apply to those cases. Mismatch equals the coupling.

The commercial code GRASP (TICRA) has a coupling add-on that computes the radiation from the currents induced on the subreflector and couples the radiation to the feed using a method equivalent to Eq. (1-54) where the radiation by the feed is expanded in a spherical wave expansion to obtain the near-field radiation for general feeds. The Gaussian beam feed has a near-field expression and does not need to be expanded in spherical wave terms. Before computing the currents on the subreflector, define a planar grid across an equivalent aperture at the feed location which can be used as a convergence structure when determining the number of currents on the subreflector. The command list uses the feed to compute currents on the subreflector and a second command to compute the coupling between the feed and the subreflector currents. For this computation the ray output must be added to the PO structure for coupling. If the currents on the subreflector will be used to excite currents on the main reflector to compute the full pattern, a time savings is to second PO structure for the subreflector without the ray output to be used for inducing currents on the main reflector.

Figure 8-13.4.1 gives the geometry of an example for a Cassegrain dual reflector while Figure 8-13.4.2 gives a similarly sized example for a Gregorian dual reflector.

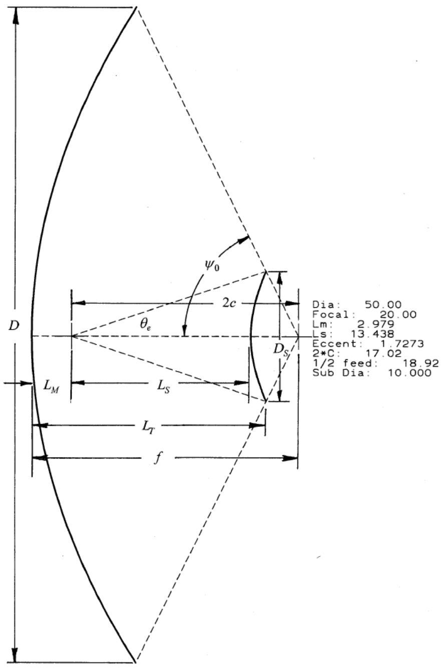

Figure 8-13.4.1 Cassegrain dual reflector example

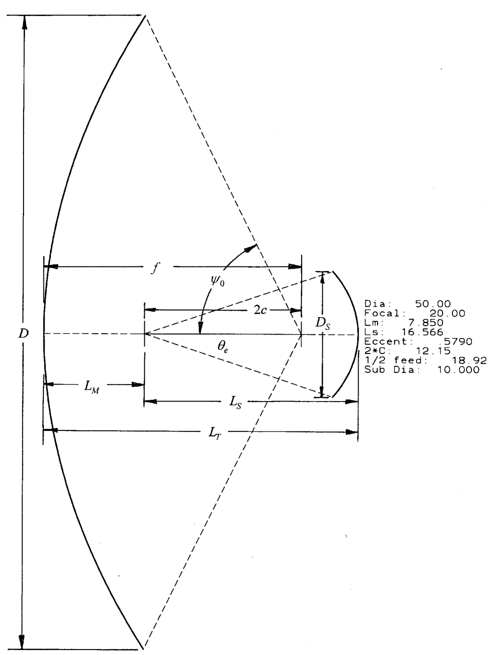

Figure 8-13.4.2 Gregorian dual reflector example

If we use dimensions in meters and 300 MHz frequency, the subreflector diameter is 10 wavelengths. The attached program SUBRRTLS (executed in a DOS window) computes geometry of the dual reflector and then the geometric optics (GO) stationary phase reflection coefficient and the PO coupling method. Table 8-13.4.1 gives the comparison between the methods for the two examples for subreflectors from 10 to 66.6 wavelengths diameter where frequency is given in GHz.

Table 8-13.4.1 Comparison of Mismatch Methods

```
Cassegrain geometry
Main reflector focal length:   20.0000
Subreflector diameter:         10.0000
Feed Half subtended angle:       18.92

  Main     Vertex     Feed to    Subrefl.  Subrefl.  Total
Diameter   to feed    Subrefl.      A       Focal    Length
 40.0000   1.6628     13.7538     4.5852    9.1686  16.2500
 45.0000   2.3746     13.5975     4.7848    8.8127  16.9618
 50.0000   2.9753     13.4412     4.9289    8.5123  17.5625
 55.0000   3.4952     13.2850     5.0326    8.2524  18.0824
 60.0000   3.9545     13.1287     5.1060    8.0228  18.5417
Main reflector diameter:   50.0000
Length units: m.
Beamwidth:    37.840 Level dB:   10.00 Gain dB:   19.31

Frequency  PO Rtn Ls GO Rtn Ls  Gain dB  GRASP   CHAMP

   0.3000     20.60     19.99    19.05   20.54   20.87 (-,+0.73)
   0.4000     21.98     22.27    19.16   22.33
   0.5000     23.51     24.10    19.21   23.22
   0.6000     26.38     25.63    19.24   26.26
   0.7000     26.57     26.94    19.26   27.11
   0.8000     27.62     28.07    19.27   27.22
   0.9000     29.85     29.08    19.28   29.61
   1.0000     29.57     29.99    19.28   30.32
   1.1000     30.43     30.80    19.29
   1.2000     32.33     31.55    19.29   31.93
   1.3000     31.78     32.24    19.29
   1.4000     32.57     32.88    19.30   32.04
   1.5000     34.25     33.48    19.30
   1.6000     33.54     34.04    19.30   34.71
   1.7000     34.30     34.56    19.30
   1.8000     35.81     35.06    19.30   35.02
   1.9000     35.00     35.53    19.30
   2.0000     35.75     35.97    19.30   35.27
```

```
Gregorian geometry
Main reflector focal length:   20.0000
Subreflector diameter:         10.0000
Feed Half subtended angle:       18.92

  Main     Vertex     Feed to    Subrefl.  Subrefl.  Total
Diameter   to feed    Subrefl.      A       Focal    Length
 40.0000   9.1628     16.2537    10.8352    5.4186  25.4166
 45.0000   8.4510     16.4100    10.6355    5.7745  24.8610
 50.0000   7.8503     16.5662    10.4914    6.0748  24.4166
 55.0000   7.3304     16.7225    10.3877    6.3348  24.0529
 60.0000   6.8711     16.8787    10.3143    6.5644  23.7499
Main reflector diameter:   50.0000
Length units: m.
Beamwidth:    37.840 Level dB:   10.00 Gain dB:   19.31

Frequency  PO Rtn Ls GO Rtn Ls  Gain dB  GRASP  CHAMP

   0.3000     16.61     16.89    19.14   16.43  17.27 (-,+0.48)
   0.4000     20.51     19.24    19.21   20.32
   0.5000     21.40     21.11    19.25   21.97
   0.6000     21.71     22.66    19.26   21.96
   0.7000     23.81     23.97    19.28   23.23
   0.8000     26.30     25.12    19.28   25.83
   0.9000     26.18     26.13    19.29   27.11
   1.0000     26.05     27.04    19.29   26.50
   1.1000     27.78     27.86    19.29
   1.2000     29.77     28.61    19.30   28.97
   1.3000     29.25     29.30    19.30
   1.4000     28.95     29.95    19.30   29.70
   1.5000     30.53     30.54    19.30
   1.6000     32.25     31.10    19.30   31.07
   1.7000     31.50     31.63    19.30
   1.8000     31.12     32.12    19.30   32.23
   1.9000     32.63     32.59    19.30
   2.0000     34.17     33.04    19.30   32.68
```

The fifth column lists the comparison of the mismatch computation using the coupling add-on to GRASP (TICRA). Two cases are given for a similar computation using CHAMP (TICRA) using a corrugated horn for the feed with the same beamwidth as the Gaussian beam feed. Figure 8-13.4.3 illustrates the geometry of the CHAMP model for the Gregorian subreflector. An initial design was analyzed without the subreflector to determine the mismatch of the horn (Return Loss = 42.5 dB). A BOR-MoM analysis of the subreflector interacting with the modal expansion in the corrugated horn produced a second mismatch a combination of the initial mismatch and the subreflector mismatch. Because the subreflector mismatch cannot be separated from the initial horn mismatch. The difference between the two levels gives us a multipath signal. The tolerance is determined by Scale 1-8.

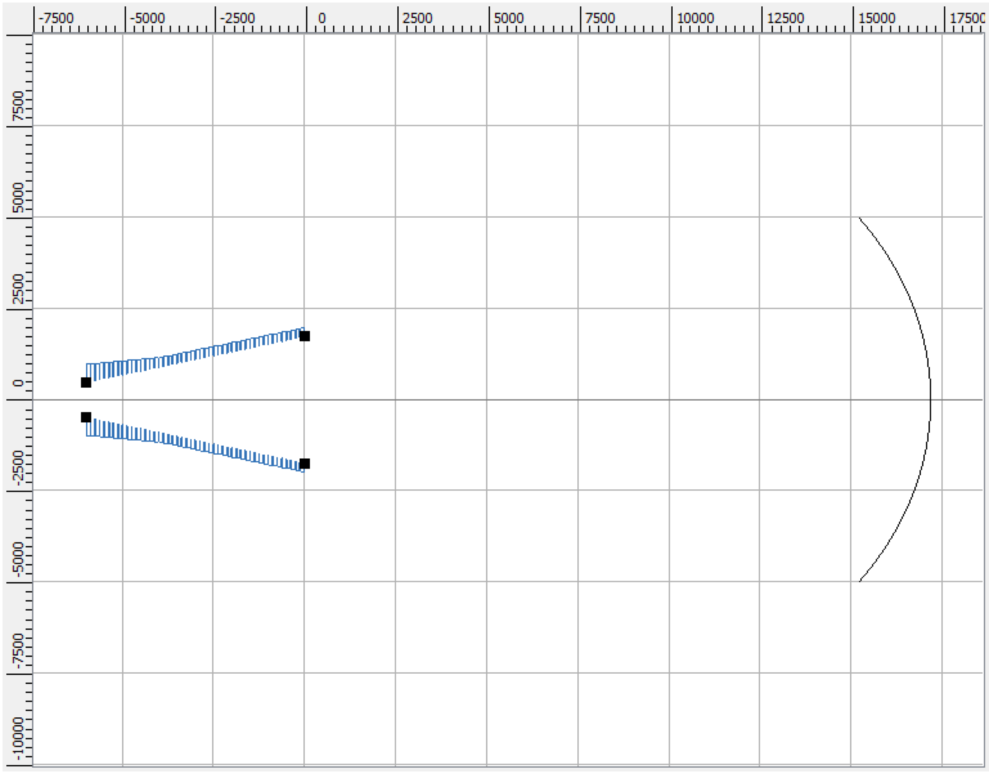

Figure 8-13.4.3 CHAMP geometry for corrugated horn feeding Gregorian subreflector