Zoom telescope

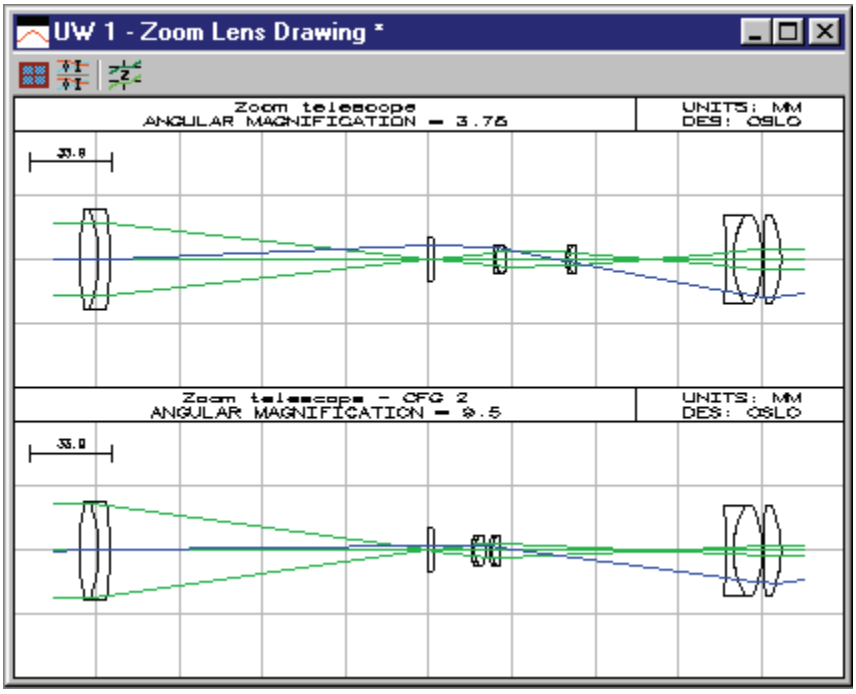
A rifle scope is an inverting telescope designed to be mounted on a rifle and used as a telescopic sight. The scope consists of four parts: an objective, an erecting system, a reticle, and an eyepiece. In use, the objective and erecting system for an image of an object at or near infinity on the reticle (or vice versa). The erector system in a real system contains tilt and decentering adjustments that provide alignment capability as well as compensation for windage and bullet drop, but the design included here does not include such adjustments. The overall system is afocal, and must be designed with generous eye relief to prevent injury when the rifle is fired.

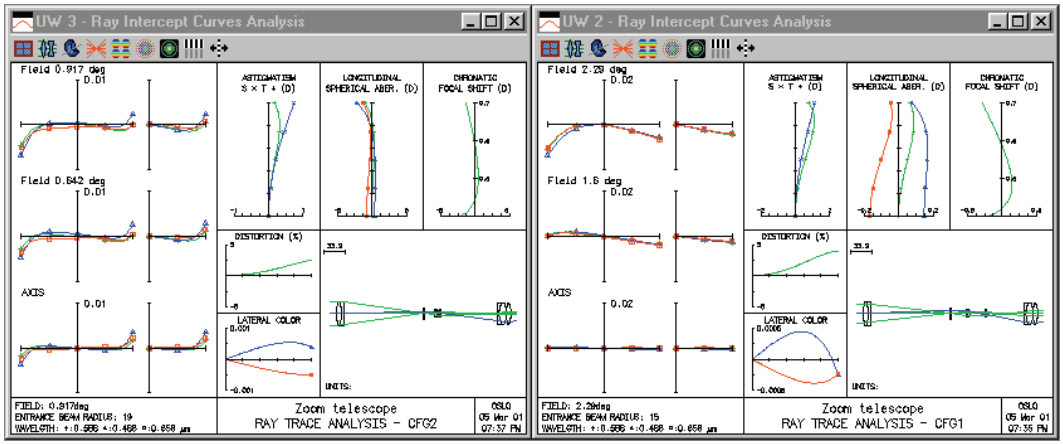
In fact, this system is one position of a zoom system. Surface 11, the last surface of the second erector doublet, is specified by a the command **pk lnm 4 11 90.7025** command, sometimes called a *zoom pickup*, because it holds the total distance between surface 4 and 12 at 90.7025mm, no matter what value is given to any intervening thicknesses. The system is zoomed by changing thicknesses 5 and 8. To design the system, you can choose some value of th[8], then optimize the image quality by varying th[5]. This will produce the proper location (or locations - there may be two) of components and the magnification. By repeating this procedure for several values of th[8], you can construct a *cam curve* that shows how the elements must track to change the magnification.

The lenses themselves can be designed with the system set at some particular magnification, or possibly at two different magnifications, to see how the optimum changes vs. magnification. Finally, you select one or the other (or some compromise) and make a final cam curve to complete the design. It is not necessary to use actual zoom optimization for a simple system such as this.

Ray displacements in afocal mode are actually direction tangents, not angles in radians, but are ordinarily so small that there is negligible difference.

The ray analyses shown on the next page show the performance of the scope at its normal magnification (3.75X), and also at a higher power (9.5X), which is achieved by changing th[5] to 15.208348, th[8] to 1.596579, the entrance beam radius to 18, and the field angle to .9 degrees. Note that the system has the afocal general operating condition set, so the ray displacements automatically are shown in radians.





OSLO has a number of routines to simplify working with zoom systems. The aberrations toolbar in the text output window contains several buttons dedicated to zoom systems, permitting analysis of a system in several positions with single commands, for example:

```
*GROUP THICKNESSES AND AIR SPACES FOR ZOOMING SYSTEMS

Group 1 consists of surf  2 to  6   Thickness =  144.810000
Group 2 consists of surf  7 to  9   Thickness =    5.480000
Group 3 consists of surf 10 to 12   Thickness =    4.250000
Group 4 consists of surf 13 to 17   Thickness =   22.610000

CFG  OBJ<->GRP1  GRP1<->GRP2  GRP2<->GRP3  GRP3<->GRP4   GRP4<->IMS
1     1.000e+20      23.7700      24.2900      60.6288     120.5415
2     1.000e+20      15.2083       1.5966      91.8839     120.5415

*ZOOM LENS DATA
MAGNIFICATION      CFG1       CFG2
        GRP1 -1.381e-18 -1.381e-18
        GRP2   -13.1573     4.0236
        GRP3     0.0936    -0.7755
        GRP4 -2.375e+05 -3.235e+04

          POWER        EFL        FNP        SNP         FF         BF
GRP1     0.0072   138.0769   243.1908  -139.9642   105.1138    -1.8872
GRP2     0.0379    26.3813     2.7291    -0.9525   -23.6522    25.4288
GRP3     0.0278    35.9617     0.0191    -2.6531   -35.9427    33.3087
GRP4     0.0220    45.3525    14.6663     1.2961   -30.6862    46.6486

                  IMAGE  EFFECTIVE   INFINITY      IMAGE      FIELD
CFG      EFL   DISTANCE        f/#        f/#      ANGLE      ANGLE        MAG
1  4.039e+07   120.5415  1.346e+06  1.346e+06     2.4137     2.2906     3.7496
2  1.394e+07   120.5415  3.668e+05  3.668e+05     5.0959     0.9167     9.5000

*VARIATION OF THE 3rd ORDER SEIDEL COEFFICIENTS BY ZOOMING
                  SA3        CMA3        AST3        PTZ3        DIS3
CFG1
    GRP 1   -0.000494    0.000194   -0.000269   -0.000597   -0.000454
    GRP 2   -0.000272    0.000406   -0.002056   -0.001250    0.009511
    GRP 3   -0.000210    0.000187   -0.001053   -0.000863   -0.000986
    GRP 4   -0.000013   -0.000234    0.001114   -0.000682    0.001474
    SUM     -0.000989    0.000553   -0.002263   -0.003391    0.009545
CFG2
    GRP 1   -0.002543    0.000315   -0.000138   -0.000306   -0.000074
    GRP 2   -0.000501   -0.000363    0.000086   -0.000642    0.001106
    GRP 3   -0.000645   -0.000003   -0.000359   -0.000443    0.001075
    GRP 4   -0.000002   -0.000061    0.000412   -0.000350    0.003030
    SUM     -0.003691   -0.000113    0.000002   -0.001741    0.005137
```