Re: Parametric models of two and three mirror reflecting telescopes

Source: http://sci.tech−archive.net/Archive/sci.optics/2004−06/0092.html

---

From: West Coast Engineering (*westcoastengineering_at_westcoastengineering.com*)
Date: 06/12/04

Date: Sat, 12 Jun 2004 15:53:33 GMT

rupton@noao.edu (Optiker857) wrote:

>Dear Optikers,
>
>Would any of you find a paper that discusses the analytical properties
>of two and three mirror reflective telescopes useful? The analytical
>properties of the telescopes encapsulate the radii of curvature, the
>conic constants, chief and marginal ray heights, residual aberrations
>and ect in terms of normalized system constraints such as back focal
>distance and primary mirror focal length.
>
>Also, H.H. Hopkins published a text on classical aberration theory.
>Does anyone know its reference?
>
>Many Thanks

There is Reflective Optics by Korsch. He passed away a few years back but I think his book is still in print.

I'll skip two mirrors systems because the Cass, Gregorian and Mersein are just on−axis designs with zero spherical and the rest are best designed from these with ray tracing using your favorite design program.

The real trick in doing three and four mirror designs is that the design space does not act very continuous with respect to FOV, F/# or Afocal Mag and pupil characteristics and you need to get close with first and third order solutions or real ray optimization just wanders off to never−never−land and then you don't get a very good performance review at the end of the year.:−)

My former section head, Mr Lacy Cook, now at Raytheon in El Segundo, taught a class in the design of the full spread of TMAs and Reflective triplets in 1986−87. Each type, afocal or focal, on−axis in aperture or off axis (un−obscured) had it's own design approach which started with some rules of thumb for primary f/#.

The process then proceeded with an on−axis version for which the desired mirror clearances were set using one OAL constraint plus the requirement that the third order Petzval Sum be zero.

Then third order spherical, coma and astigmatism were minimized using three conic constants.

In most cases, these designs become "perfect" in first and third order which does mean that with sufficient algebra, simple calculator equations are possible. I've always been way to lazy to attempt it.

Next, the third order aberrations are replaced with a real ray merit function and solves are replaced with real ray constraints. We then tilt the whole system and proceed with optimization. If performance is not up to requirements, the secondary and tertiary can be tilted and decentered (using Tilt with an immediate return to the surfaces original coordinated system − TILT DAR in Code−V or dummy surfaces with −1 pikups). This actually helps the performace and tends to increase mirror clearances which means the design FOV off−set can be decreased which helps performance.

Aspherics can then be placed on the secondary and tertiary. Usually never beyond 10th order. Aspherics on the primary rarely do much and I have never seen anyone use them unless the aperture stop is not on the primary.

These techniques work in all the design codes (OPD, Code−V, ZEMAX, OSLO, etc.)

One important point, Petzval Sum needs to be optimized to ZERO, NOT PETZVAL RADIUS. Some codes have both available and if you use RADIUS and drive it to zero you get an infinite SUM instead of ZERO after which you can't trace real rays because the system is so meesed up.

The point to the design is to zero out the Petzval Sum because if that is not don't, it is impossible to remove third order Astigmatism and that takes the A out of Anastigmat :−)

As you can tell I like talking about this because it is one of the few things in life I have learned to do fairly well. If you need to know more, just email me.

Sincerely,

Jim Klein
West Coast Engineering