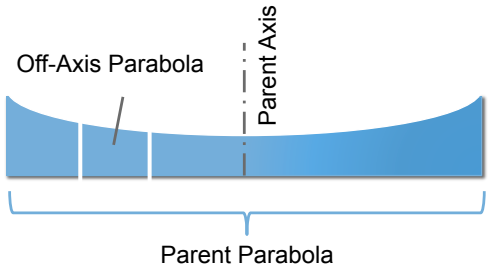
INTRODUCTION

The typical image that comes to mind when thinking about off-axis parabolas is the wedged-configuration mirror section cut out of a larger parent parabola. However, independently fabricated parallel configurations provide advantages in both cost and performance. This article explores why you should consider the parallel configuration first.

THE WEDGED-CONFIGURATION OFF-AXIS PARABOLA

The traditional wedged-shape of an off-axis parabola is a result of the way OAPs had to be made years ago. While unnecessary with today's manufacturing technology, the wedged shape remains the most requested form today. The traditional methods for making off-axis parabolas required first making a large on-axis parent, and then cutting out off-axis sections to get off-axis "child" parabolas. The techniques employed simple machines combined with the skills of master craftsmen to achieve good results with inexpensive technology. The problem with this approach is the need for a large parent. The further off-axis your sections become the bigger the parent needs to be – this ultimately limits the designs, which may be fabricated. It gets expensive also, particularly if one only needs a single mirror when the parent yields several. As the need for large diameter or large off-axis angle OAPs grow, the parent parabolas required become impractically large.



Even if your need is only for small mirrors, there are limitations on the accuracy for which OAPs can be defined. The OAP is defined by its focal length and off-axis distance – but also by the co-linearity of its own axis to the parent axis. This is, of course necessary for proper alignment. If you've never toured an OAP manufacturer's facility, you may not realize that the off-axis sections are cut out with core drills. Core drilling is not a great way to preserve axial co-linearity. Said another way, core drills can often introduce texture and cylindrical error into the diameter of the off-axis section. It also introduces stress – which can distort the optical surface. To mitigate these effects, manufacturers clean up the edges by milling or grinding after core drilling. The problem is, a loss of the absolute knowledge of its original off-axis location relative to the parent. We can recover knowledge of the off-axis section geometry through careful testing – but the process introduces the need for a tolerance between the desired design and the actual as-built result. Such tolerances lead to variation from part to part and ultimately require making allowances for a larger uncertainty budget in system design.

You might think that with today's computer controlled finishing technology we don't need to make parent parabolas anymore. Yes, this is indeed true – but the costly impact of the wedged geometry is even more profound when made individually. Parabolas are difficult enough to make

today, now image making a parabola on the face of a large prism. This is effectively what a wedged OAP is. Some other drawbacks include:

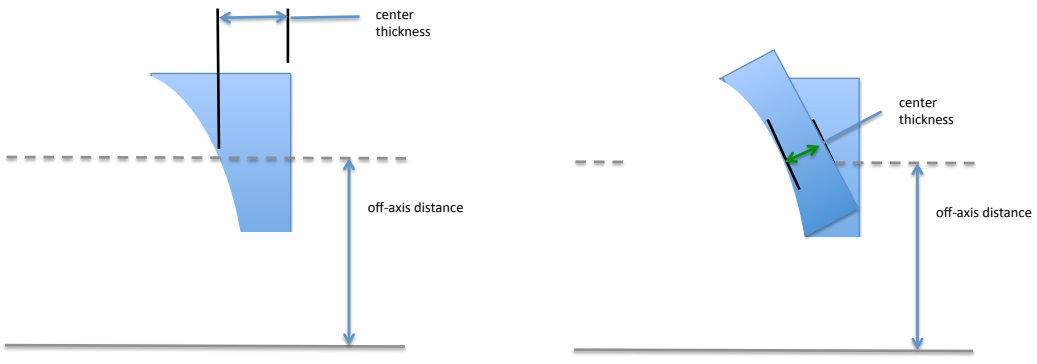
- Because the mass is non-symmetric, the mirror alignment can drift due to gravity
- Wedges must use specialized mounts, which must accommodate the wedged configuration.
- A Wedged-design requires either a large parent or a very thick starting blank. This means a lot of wasteful stock removal to get the correct shape.
- There is no continuous front face rim on an OAP like there are on spheres and flats. Wedged OAPs must be mounted by their edges and rear surface only. The wedge complicates tools and fixtures for coating and safe packaging.

So what's the advantage? Some people like to use the rear surface as a reference datum to locate the parent parabola axis. Common practice? Yes. Convenient? Perhaps – but completely unnecessary.

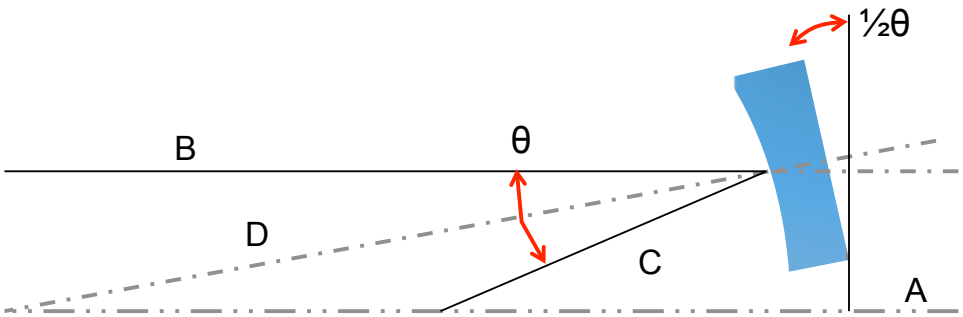
THE BETTER DESIGN ALTERNATIVE: PARALLEL CONFIGURATION OAPS

We did not invent the parallel form OAP – but we've sure made a lot of noise about its benefits since starting our company. We're happy to share these advantages with our customers and the interested community.

Parallel Configuration OAPs are not made from a parent, just a simple disk of material. Less material is required for the starting blank, and less stock removal required to arrive at the final geometry. The prescription of the OAP can be fabricated based on geometric datums such as the diameter, off-axis angle and rear surface angle relative to the parent axis. Instead of making the rear surface perpendicular to the parent axis, we make it perpendicular to the radius of curvature (the surface normal at its center of rotation). This angle is exactly one half the of the off-axis angle relative to the parent axis. Therefore the alignment of the parallel OAP can be fully defined by its physical geometry.



Wedged vs. Parallel OAPs



A. Parent Axis
B. Off-Axis Segment Axis
C. Segment Focal Length
D. Radius of Curvature (surface normal at OAP center)
Θ. Off-Axis Angle

Parallel Configuration OAP Geometry

Some of the advantages of the parallel configuration are:

- Rotational symmetry
- Can fit in standard optics mounts
- Less mass
- Accessible diameter and rear surface datums relating to OAP axis & parent axis
- Easy to mount for coating, and safe packaging
- Easier to polish (which translates to higher quality levels possible)
- Less expensive to manufacture

CONCLUSIONS

1. Although more familiar and common, the wedged OAP configuration is more difficult to make, more expensive, and more difficult to use than the parallel configuration.
2. The rear surface perpendicularity to the parent axis of the wedged configuration can be a convenient geometry for alignment purposes, but is unnecessary in most cases.
3. Customers can often save money and get superior quality with parallel configuration OAPs

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