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Use & Care of 2" *INFINITY XLKP*™ Series Autocollimators

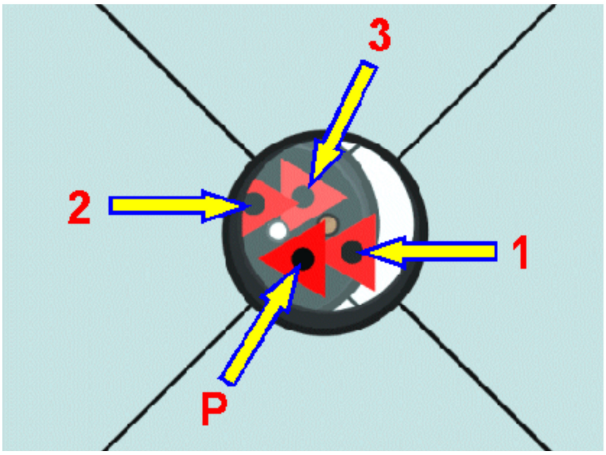
Revised 5/5/2022

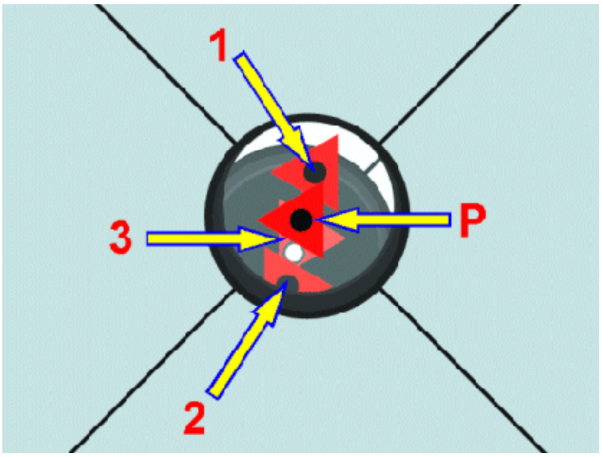
To meet the demand for the more critical alignment needed in todays' fast, big Newts, 2" *INFINITY XLKP*™ Autocollimators have been carefully engineered and hand-crafted to achieve world-class benchmark precision and visual queue resolution & clarity.

The 2" *INFINITY XLKP*™ "Ghost" Images Explanation

When "perfect" collimation is "close at hand", 4 center-spot reflections can be seen in the central pupil of the *INFINITY XLKP*™ autocollimator and are the result of multiple reflective interactions between the 3 mirror components of Primary, Secondary and Autocollimator.

In these simulations below, both Primary and Focuser optical axes alignment errors are present resulting in the reflections being spread apart from their "perfect collimation" stacked position. You might see something like this .... or this ....





- Reflection "P is the "Primary" or "first" reflection and is the direct reflected image of the spot itself via the Diagonal mirror after 1 FL pass. Reflection "P" is what is visible "without" the autocollimator whereas images (#1, #2, & #3) are reflections of "P"

- Reflection "1" is generated from reflection "P" after an additional reflection back from the A/C mirror, via the diagonal to be reflected off the Primary and back via the diagonal to the eye for a total of 3 FL passes from the original spot. It's sensitivity to Primary axis error is 4X and to Focuser axis error is 2X.

➢ Reflection "2" (inverted) is generated from the "real" image response from the (parabolic) Primary mirror at its Center of Curvature (COC at 2 FL's away) from the spot reflection it sees in the Autocollimator mirror (which is 1 FL away). The trick here is that the autocollimator reflects (or "folds") the real image back onto the Primary surface where it is then seen via diagonal reflection by the eye (just like reflection "P") - it is a total of 5 FL passes from the origin.

Reflection "2" sensitivity to both Primary and Focuser axes errors is 4X each. Total distance between reflections "1" and "2" is the vector sum of the primary mirror and focuser axial errors. When the other axial error has been removed, this distance is either 8X the primary mirror axial error or 6X the focuser axial error.

➢ Reflection "3" (inverted) is a reflection of reflection "#2" following a path like that of reflection "#1" (generated from reflection P) for a total of 7 FL passes to the eye from the original spot. When the faintest reflection (#3) is in view, the distance from "P" to "3" represents a sensitivity to focuser axis error of 2X regardless of the Primary axis error.

It is this unilateral sensitivity to the focuser axial error that allows us to use this reflection to "zero" the focuser axis with Vic Menard's "Carefully De-collimated Primary Mirror" protocol (page 3), leaving the primary mirror axial error, magnified 8X, visualized as the distance between reflections 1 and 2.

The distance and direction between reflections "#2" and "#3" is always equal to that seen between "P" and "1" and between the two A/C pupil reflections; thus, these two spot reflection "pairs" will always be arranged with their centers forming 2 separate parallel lines that are also parallel to the A/C pupil reflections.

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Many thanks to Vic Menard and Nils Olof Carlin for their insightful contributions and editing assistance.

Adjusting the Secondary Mirror with the 2" *INFINITY XLKP*™

➢ For maximum performance and collimation accuracy, I highly recommend that the Primary mirror be center-spotted with a ***CATSEYE***™ Reflective Triangle and it's tilt adjusted with the 2" ***BLACKCAT XL***™ Cheshire.

➢ For accurate and repeatable orientation of the autocollimator in the focuser, I recommend you DO NOT tighten the focuser set screws. Simply allow the ***INFINITY XLKP***™ autocollimator to turn freely in the focuser barrel with the underside of the eyepiece knurled flange pushed against the focuser barrel lip. If you must secure the autocollimator with the focuser set screws, use only one screw tightened just snug enough to hold the ***INFINITY XLKP***™ in place against one side of the focuser barrel..

➢ Before the primary center spot can be used as a reference in the ***INFINITY XLKP***™ autocollimator tool, you must have alignment of the optical axes of the Focuser, Primary and Secondary sufficiently close to provide a "closed" light path. If your previous focuser and diagonal mechanical alignment efforts have been successful, you will see a "dark" or "partially dark" view upon initially looking through the autocollimator. If part or all of the view is "bright", indicating the introduction of external light and an "open" optical system, go back over the mechanical, Primary & Secondary alignments until you can achieve a "dark" view (which is the reflected view of the inside of the autocollimator).

- Once you've reached the "dark" view step, you should see at least one center-spot image which is the "direct" spot reflection image. Now, just reach around the front of the tube and grab your secondary holder. Gently and ever-so-slightly, apply pressure to twist and/or tilt the diagonal to subtly tilt the diagonal up-down, and rotate right-left. What you are "looking" for are the fleeting progressive "ghost" reflections (typically, up to 3 more in addition to the "direct" image) of the center spot. Some reflections will be "inverted". If you can see 4 images (direct & 3 "ghost), you will be viewing along a folded optical axis for a distance of 7 times the primary focal length (for my 8"f/6, that's visual adjustment resolution through a distance of 28 feet - pretty remarkable resolution!.
- When you finally succeed in seeing one or more of the "ghost" images flash by, work at it again until you can repeatedly get it (them) in view. Determine and make the diagonal holder adjustment(s) necessary to "hold" the progressive images in the autocollimator view with no pressure applied on the diagonal. Once the "ghost" images are all in view, the last step is to carefully fine tune the diagonal tilt and rotation to get them all to CONVERGE together as one.
- If the multiple images are in view but are "top & bottom" (in a line perpendicular to the tube axis), usually just a gentle "twist" of the secondary holder is sufficient to bring them together. If the images are "left & right"(in a line parallel to the tube axis), an EVER-SO-SLIGHT adjustment of one of the secondary tilt adjustment screws will bring them together. Often, I find this adjustment necessary SEVERAL times as the evening cools and the secondary adjustment screws contract with the temperature drop - IT'S THAT SENSITIVE!
- Alternate, iterative adjustment of the Primary and Secondary is sometimes required. Collimation adjustments of the Primary with the Cheshire slightly affects the view as seen with the autocollimator and vice-versa. When satisfactory, simultaneous views are obtained with **BOTH** Cheshire and the autocollimator tools, you have achieved perfect collimation.

Implementing Vic Menard's "Carefully De-collimated Primary" Protocol

(Refer to the "ghost image" explanation on Page 1)

- Start with the scope "closely" collimated -- good diagonal positioning and final Cheshire collimation.
- Carefully "de-collimate" the primary mirror only. I suggest the topmost collimation screw or whichever screw allows the primary mirror to gently "tip" forward (or backward -- direction isn't important.) The reason I suggest simple tipping motion is to minimize twisting in a sling or other edge support, which may not be as easily "undone" when the primary is re-collimated Perform this de-collimation with the autocollimator in the focuser to ensure that, as the "ghost" reflections are spread apart, they do not leave the face of the autocollimator.
- Looking in the autocollimator, you will notice that the primary mirror center spot (P) is slightly offset (because the primary mirror has been de-collimated.) On either side of the primary mirror spot (P), you will observe a bright upright reflection (1) and a slightly dimmer inverted reflection (2) flanking the primary mirror center spot (P). The separation between these 2 reflections (1 & 2), is 8X the actual primary mirror axial error (+/- any residual focuser axial error) induced when the primary mirror was de-collimated. For now, you can ignore the flanking reflections. Look carefully at the primary mirror center spot (P) and you should be able to see a second, fainter, inverted reflection (3) either behind or very close to the primary mirror center spot (P).
- Stack the faint, inverted reflection (3) under the primary mirror center spot (P) to form a "Star of David" by adjusting either the diagonal or focuser alignment ONLY. If the focuser is aligned instead of the diagonal, the impact on the primary mirror collimation will be minimized (not eliminated.) However, this is only an issue if the required correction is "significant".

- With the primary center spot (P) and the faint inverted reflection (3) precisely stacked, go back to the same primary mirror collimation screw you used to de-collimate the primary mirror and "undo" the de-collimation, watching in the autocollimator as reflections (1 & 2) slowly merge with the primary mirror center spot (P) and finally all secondary reflections (1, 2, & 3) finally disappear from view.
- Verify the primary mirror collimation with a calibrated Cheshire. If it agrees with the autocollimator -- you're done. If there is a slight primary mirror axial correction needed, make the correction and reiterate the autocollimator procedure. Now "axial" collimation is fully corrected and you can reevaluate the diagonal positioning if necessary.

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Compliments of Vic Menard

Cleaning the 2" *INFINITY XLKP*™

I recommend cleaning the mirror with 91% isopropyl (rubbing) alcohol and cotton-tipped swabs (Q-tips). First, "blow off" the mirror with a camera "lens" brush/air-puffer or a "trigger-type" can of pressurized contaminant-free "cleaning" air. Dip a Q-tip in the alcohol and dab a couple of drops gently in the center of the mirror. With a gentle circular wiping motion, work out from the center with the Q-tip; even though the reflective surface has a tough dielectric protective coating, a gentle touch and minimum cleaning strokes are still recommended. Avoid jamming the Q-tip against the barrel at the edge of the mirror. When the alcohol begins to dissipate, repeat with a fresh Q-tip with alcohol. Finish up with a dry Q-tip to remove any residual smudges or streaks.

ENJOY EASY, PRECISION COLLIMATION!