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Auto guiders for remotely operated, automated, or robotic telescopes

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ABSTRACT

Ground based telescopes operated from Afar need to be guided. DFM Engineering has designed and built several different Type I auto guiders and investigated Type II auto guiders. The common features and the differences between the two types are discussed. Additional features such as filter changers and instrumentation selection ports may be incorporated into the auto guider.

Keywords: Auto guiding, optical feedback, beam wander, tracking

1. INTRODUCTION

Even the best tracking telescopes need to be guided using optical feedback. A tracking of <0.25 arc seconds seems to be the agreed upon level of accuracy desired. Calculations show that dome seeing can easily bend the light coming into the telescope by ½ arc second. For example, a 1.3-m diameter beam with a path length of 3-m with a 1 C-degree temperature gradient will cause a 0.4 arc second deviation in single pass. In a Cassegrain optical system, there are 3 passes of the light headed for the focal plane:

1. The light coming into the telescope on its way to the primary mirror
2. The light from the primary mirror to the secondary mirror
3. The light from the secondary mirror to the focal plane

These beams have decreasing diameter but they all contribute to the beam deviation. If the temperature gradient changes slowly (on the time scale of a second or longer) this deviation (or beam wander) is seen as a tracking error. Depending upon the auto guider and the frequency of the beam wander, this apparent tracking error can be guided out.

2. AUTO GUIDING

The Auto Guiding function needs to be:

1. Automated and transparent to the user (produces a "perfect" tracking telescope)
2. Require very little overhead (quickly find a suitable guide star and starts guiding)
3. Keep the guide star centroid centered to <0.25 arc seconds

3. TYPE I, TYPE II, and TYPE III AUTO GUIDERS

A Type I Auto Guider uses a pick off mirror to fold light from the edge of the Field Of View (FOV) into a guide camera. The guide camera can be moved in X-Y over several fields of view of the guide camera to search for a guide star. The pick off mirror can be stationary or can move with the guide camera. The guide camera also needs a focus stage with a motion changing the spacing between the camera and the pick off mirror. This type of guide system has been made for decades. Automating the motions makes the autoguider into a "Smart Auto Guider™" (SAG™).

The Type I Smart Auto Guider™ searches for a suitable star in 3 dimensions-over several fields of view of the guide camera (X, Y) and various integration times until a star is found. If no suitable guide star is found, then an error message is generated. The guide camera focus can be slaved to the telescope focus so the guide camera stays in focus when the telescope focus is changed for different filters, for example.

The Type II Auto Guider performs the same functions as the Type I auto guider and in the same manner but the control software contains a large data base where the search for a suitable guide star takes place based upon the telescope R.A. and Declination. The Guide camera is driven to the proper offset (perhaps while the telescope is being driven to coordinates). The guide camera integration time is preset based upon the selected guide star brightness. The guide star is imaged and centroided, and if desired, any position offset due to telescope pointing errors can be corrected.

Rather than using a pick off mirror at the edge of the field, an auto guiding detector can be built into the imaging camera. CMOS detectors may be able to designate on the fly a small sub array to the auto guiding function because this sub array can be read out often while the rest of the array is integrating. This would result in a Smart Auto Guider™ with no moving parts and could be called a Type III Auto Guider. The selection of the guide star can be performed by taking a short integration or by searching a data base (Type I or Type II selection methods). Most likely, the star selection would be performed by searching a data base.

4. Advantages and Disadvantages:

Type	Advantages	Disadvantages
I	Mimics the traditional auto guider	Time consuming to find a guide star. Requires 2 or 3 motorized, encoded, and computer controlled stages so is mechanically and electronically complex
II	Mimics the well prepared observer who selects guide stars ahead of time by automatically selecting guide stars. Quickly finds guide star	Software complex Mechanically and Electronically complex
III	No moving parts. Very accurate. No differential flexure. Quickly finds guide stars. Has a very large FOV available to search for a guide star Inexpensive to duplicate	Suitable CMOS detectors are not available yet

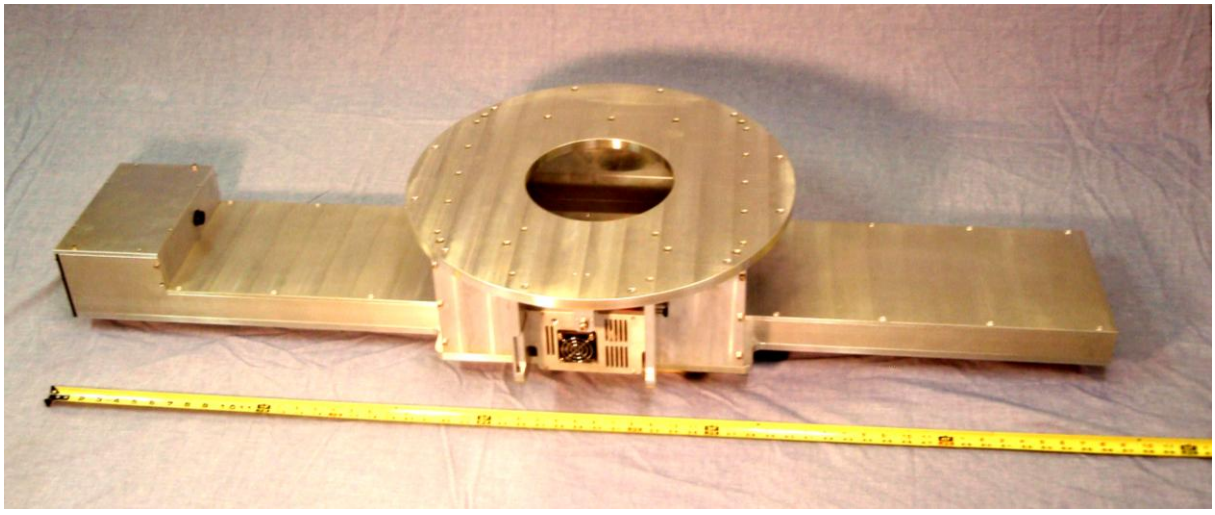

Figure 3. Type I Auto Guider with fixed pick off mirror, fixed guide camera with manual focus, and filter slide. Under construction.

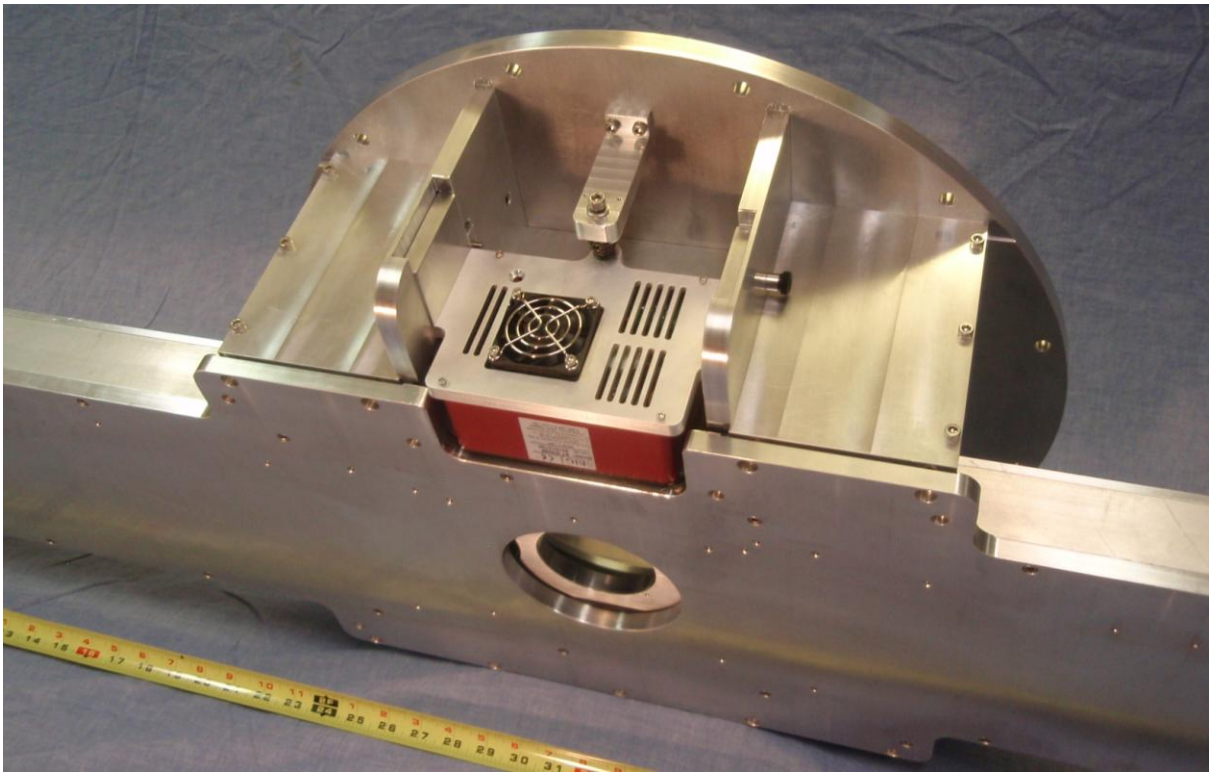

Figure 4. Bottom oblique view showing camera attach surface, guide camera, and filter slide.

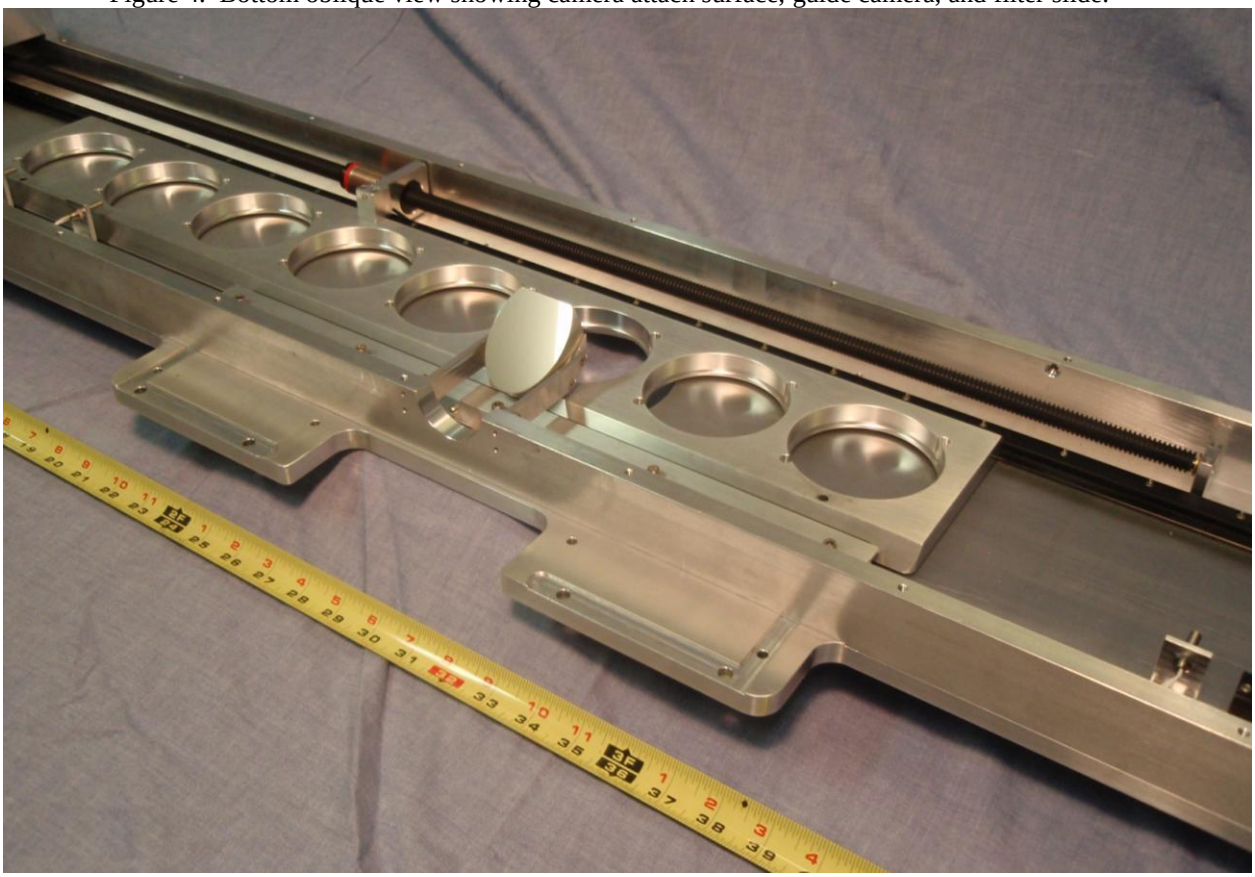

Figure 5. Pick off mirror and filter slide details.

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