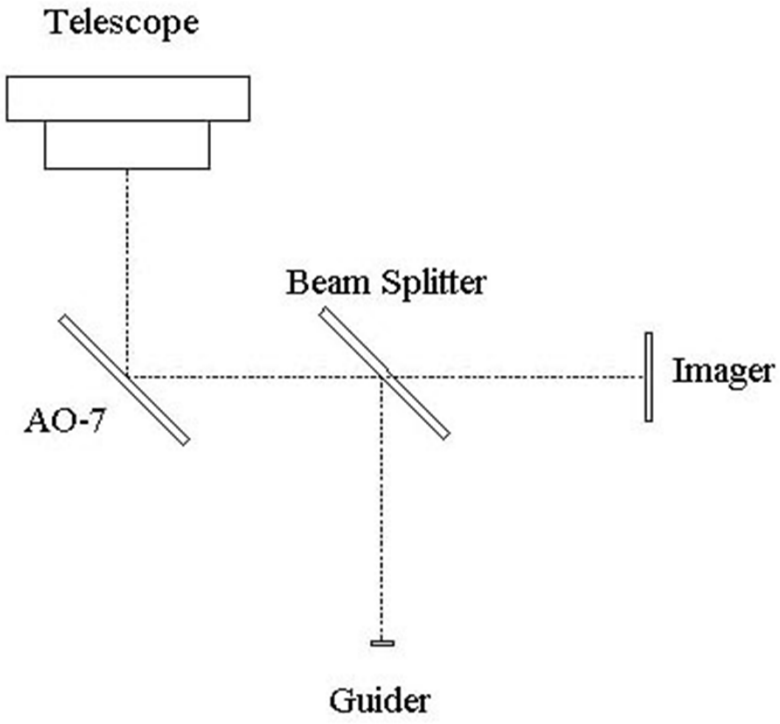
Ghost images from plane parallel plates

R.D. Crisp
03/14/2011
rdcrisp@earthlink.net
www.narrowbandimaging.com

RCOS Dichroic Beam Splitter used for imaging with narrowband filters and AO7 with a NON-SBIG Camera



System configuration schematic

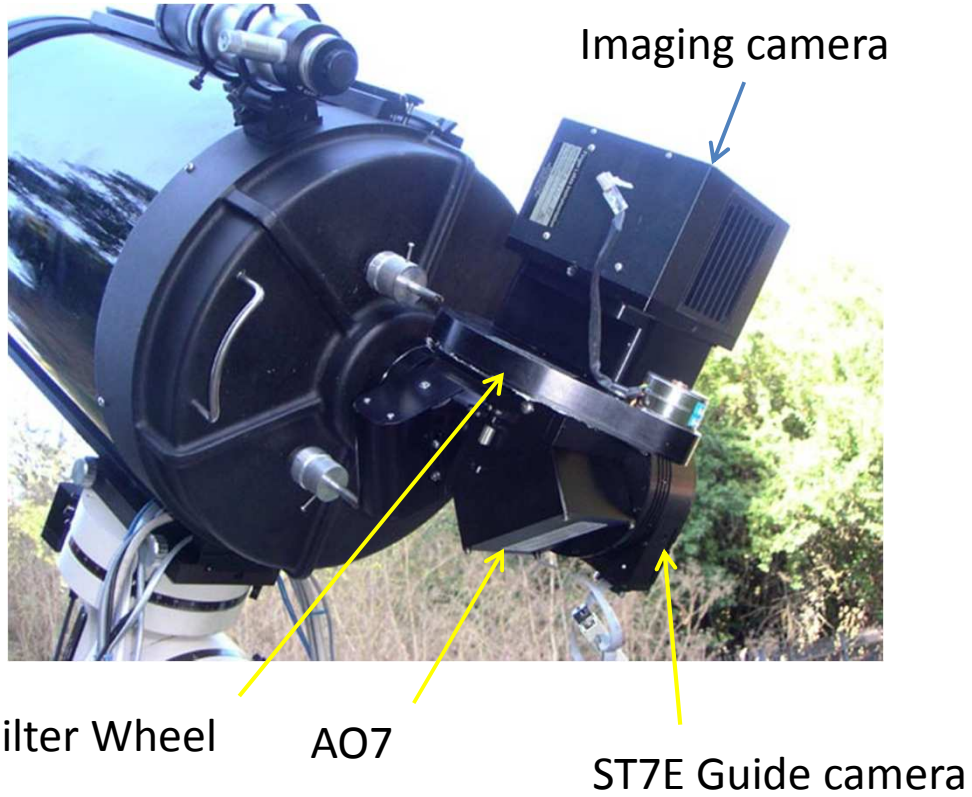


Image showing Ghost stars

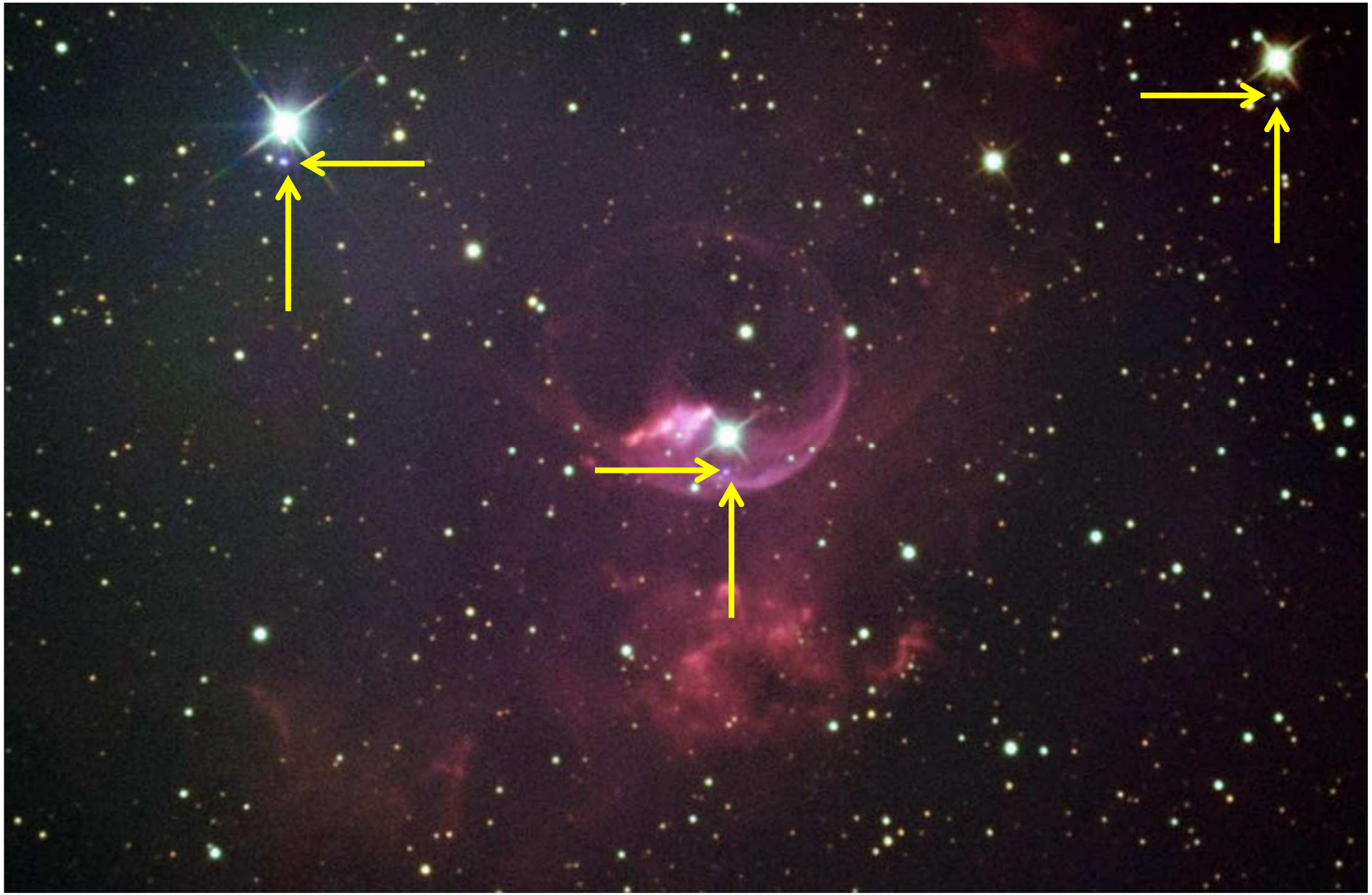


Image with no ghost stars (true starfield)

From Warren Smith's "Modern Optical Engineering"

4.14 Rhombolds and Beam Splitters

The rhomboid prism is a simple means of displacing the line of sight without affecting the orientation of the image or deviating the line of sight. The rhomboid prism and its mirror system equivalent are shown in Fig. 4.30.

A beamsplitter is frequently useful for the purpose of combining two beams (or images) into one, or for separating one beam into two. A thin plate of glass with one surface coated with a semireflecting coating, as shown in Fig. 4.31a, can be used for this purpose, but it suffers from two drawbacks. First, if used in a convergent or divergent beam, it would introduce astigmatism, and second, the reflection from the second surface, although faint, would produce a ghost image displaced from the primary image. (Note that in parallel light neither of these objections is valid, provided the surfaces of the plate are accurately parallel.) The beamsplitter cube (Fig. 4.31b) avoids these difficulties. It is composed of two right-angle prisms cemented together. The hypotenuse of one prism is coated with a semireflecting coating before cementing.

Where the weight or absorption of the cube cannot be tolerated, a *pellicle* is often used as a semireflector. A pellicle is a thin (2- to 10-μm) membrane (usually a plastic such as nitrocellulose) stretched over a frame; by virtue of its extreme thinness, both the astigmatism and ghost displacement are reduced to acceptable values.

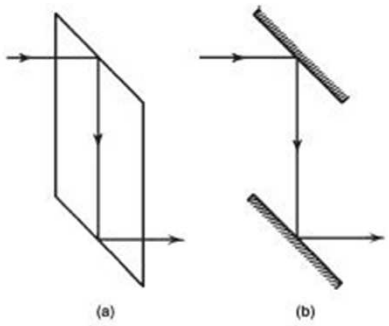


Figure 4.30 (a) Rhomboid prism. (b) An equivalent mirror system. Both systems displace the optical axis without deviation or reorientation of the image.

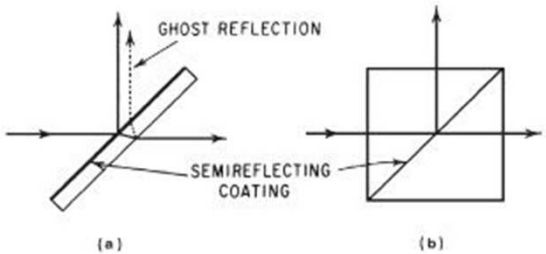


Figure 4.31 Beamsplitters. (a) A thin parallel plate is convenient but may be objectionable because of ghosting and astigmatism, unless used in parallel light. (b) Beamsplitting cube has a semireflecting coating supplied to one of the diagonal faces before cementing.

Obviously, the shape of the pellicle surface is determined by the shape of the frame over which it is stretched, and an accurately plane support is necessary. There are two less obvious features of the pellicle which may be disadvantageous: (1) Interference between light reflected from the two surfaces of the extremely thin pellicle can result in a transmission that varies in a rippled way as a function of wavelength, and (2) the pellicle can act as if it were the diaphragm of a microphone, and any atmospheric vibrations can change the shape of the reflecting surface, introducing significant changes in the imagery of the system. This is the basis for one "talk-on-a-beam-of-light" toy.

Figure 4.32 shows a prism which is often used in microscope eyepieces to change the direction of the line of sight from vertical to a more-convenient-to-use 45°. As shown, the prism can be used as a beamsplitter either to provide for coaxial illumination or to allow a second eyepiece; without the beamsplitting feature, it simply redirects the line of sight.

Discussion

- Ghost stars arise due to the internal reflection of the beam splitter
- The stars are in focus, indicating no significant difference in path length
- This is fundamentally different than haloes surrounding bright stars originating from multiple reflections from the sensor surface, camera windows, filters etc: those ***lengthen*** the optical path causing the star to be out of focus