The Meade Schmidt-Cassegrain Optical System

In the Schmidt-Cassegrain design of the Meade 8", 10", 12", 14", and 16" LX200GPS models, light enters from the right, passes through a thin lens with 2-sided aspheric correction ("correcting plate"), proceeds to a spherical primary mirror, and then to a convex secondary mirror. The convex secondary mirror multiplies the effective focal length of the primary mirror and results in a focus at the focal plane, with light passing through a central perforation in the primary mirror.

The Meade 8", 10" and 12" Schmidt-Cassegrain models include an oversize primary mirror, yielding a fully illuminated field-of-view significantly wider than is possible with a standard-size primary mirror. Note that light ray (2) in the figure would be lost entirely, except for the oversize primary. It is this phenomenon which results in Meade Schmidt-Cassegrains having off-axis field illuminations about 10% greater, aperture-for-aperture, than other Schmidt-Cassegrains utilizing standard-size primary mirrors. Field stops machined into the inside-diameter surface of the primary mirror baffle tube significantly increase lunar, planetary, and deep-space image contrast. These field stops effectively block off-axis stray light rays.
LASER LIGHT and SPECKLE

GENERAL PRECAUTIONS WHEN USING LASERS: The helium-neon lasers used in class produce a total beam power of 1 milliwatt and should not be capable of doing serious damage to your eyes -- but we shall not test this hypothesis! NEVER allow the beam to enter your eye directly. You should also be careful not to look at the laser beam reflected in a mirrorlike surface. When the beam has been "expanded" by a lens, as with most activities here, or has been diffusely reflected (e.g., on paper, or a painted surface, or a matte-finished metal surface) it is quite safe because the beam energy has been spread over a large area, as with ordinary light sources.

Spatial filtering:
Dust specks and imperfections in the laser's optical system will produce diffraction fringe patterns in the beam. These are readily visible if the beam is expanded by a short-f lens (usually microscope objectives are used) and then projected on a screen. The diffraction fringes can be eliminated by passing the beam through a pinhole (usually 10--25 microns in diameter). This is called "spatial filtering".

SPECKLE:
When an expanded, spatially filtered laser beam is viewed on a diffusely reflecting surface (white paper, screen, or wall), the illuminated area has a granular appearance called "speckle". The speckle phenomenon has some remarkable properties which you should observe for yourself:

1) The speckle is not on the surface you are viewing. To prove this, hold a pencil at your near point and focus on it while gazing at the screen. The speckle pattern is still sharp! If you wear glasses, take them off: no difference. Speckle is an interference pattern in space caused by the coherent light of the laser being reflected from the rough surface.

2) Because the speckle pattern is not located on any particular plane in space, you will have trouble focussing on a laser-illuminated surface; the eye involuntarily tries to focus on the speckle grains. Try reading a printed page by laser light. Try again while moving your head.

3) The apparent "grain size" of the speckle depends upon your distance from the viewing screen and also the aperture available to your eye. For example, if you hold a variable iris in front of your eye, closing the aperture will increase the coarseness of the speckle pattern; the same thing happens if you step further away from the screen.

4) The speckle pattern is sharp regardless of your visual acuity. In fact, you can use speckle as a crude eye test: stand about 2m from the illuminated surface, and move your head slowly from side to side. If the speckle pattern appears to move in the same sense as your head motion (i.e., pattern moves left as your head moves left), you are far-sighted. If motion is in the opposite sense, you are nearsighted. If there is no motion of the pattern, you have normal, 20/20 vision. If you wear glasses, try this test with and without your glasses; if you have normal vision, simulate nearsightedness and farsightedness by holding positive and negative lenses in front of your eye.

5) Speckle is observed only for stationary surfaces. For example, your hand will not display clear speckle, nor will the surface of a glass of milk (use the milk surface, not the glass) -- milk is a colloidal suspension and the Brownian motion of the suspended particles destroys the pattern. This fact can be exploited to detect vibrational motions with amplitude as small as a quarter-wavelength (about 0.15 micron) with the unaided eye.
Physics 545
R. J. Wilkes

Lab 2: Cardinal points and aberrations of lenses

1. Nodal slide method for locating cardinal points.

**Apparatus:** Laser, screen, rotatable translator (nodal slide); lenses: camera, thick simple convex (plano and mensicus)

**Note:** download and read SPECKLE.pdf before using lasers in class.

**Setup:** Mount lens on rotatable translator carrier; align laser and lens so beam coincides with lens axis. View beam spot on screen with graph paper.

**Procedure:** Beam will be undeviated as lens is rotated about a vertical axis if rotation axis passes thru nodal point. Nodal points coincide with principal planes for lenses with same medium on both sides. Rotate lens, find position where beam is undeviated, and measure distance of rotation axis from lens vertex. Find the back focus of lens by imaging a distant source and you have the cardinal points defining the lens. Now find the Gaussian constants and system matrix for the lens.

2. Lens aberrations

**Apparatus:** lamp, condenser lens, diffusing screen and target transparencies (resolution target, radial target, grid target), assorted positive lenses (simple, cemented, photographic), screen.

**Setup:** arrange lamp and condenser to illuminate glass target holder. Mount targets on glass and image them on screen.

**Procedure:** Observe portions of resolution target that are in focus as a function of screen distance.
Physics 545

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Lab 3: Optical Instruments

1. Microscope

A lab microscope with oil-immersion objective will be provided. Set up Kohler illumination conditions:

1) adjust the lamp focus to image the lamp filament onto the plane of the substage condenser lens's diaphragm;

2) then adjust the substage condenser focus to image the lamp diaphragm in the specimen plane.

Observe the specimen, which is a photographic plate made from nuclear emulsion, showing elementary particle tracks. (The silver grains in the image are 0.25-1.0 micron in diameter, at the resolution limit of optical microscopy.)

Now alter various parameters of the illumination train and note the results. In particular, note the effects of a) closing down the diaphragm on the substage condenser; b) altering condenser focus.

2. View camera

This camera has a variety of adjustments, allowing the lens to be tilted and/or displaced relative to the normal camera axis. These adjustments are used, for example, by architectural photographers to distort the apparent perspective of an image to better match (or fool) human sensibilities; small buildings can be made to appear large and vice versa, depending on whether the photo is for viewing by the client or the prospective neighbors. The important point is that the camera lens must be able to deliver a sharp image, even at the edge of the field, despite the photographer's tilts and shifts. Note the effect of these adjustments on the image observed in the ground glass. Try to connect your observations with our discussion of aberrations and their cure.

4. Astronomy Department's 12" Meade Schmidt-Cassegrain telescope

If it isn't raining, we'll deploy the Astro Dept's telescope and look at the Space Needle (if cloudy) or the Moon or a planet (if visible).