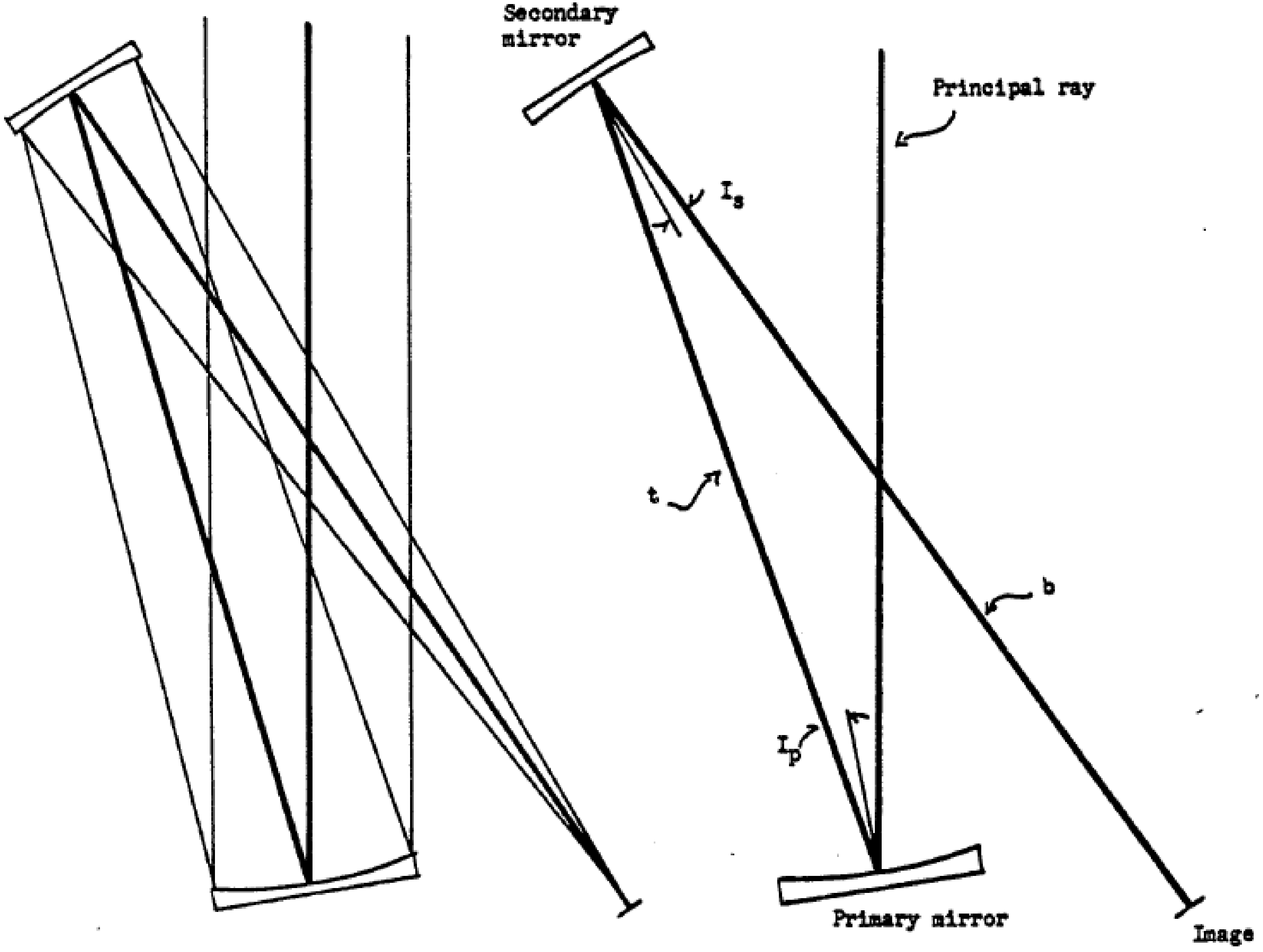

The Optical Layout and Notation Used to Describe the Yolo

Design Formulae for a Yolo

The first step in designing a Yolo scope is to decide the primary and secondary apertures Φ_p and Φ_s, and their radii of curvature R_p and R_s. Then the tilt of the primary is calculated, that is, the angle of incidence of the principal ray to have an unobscured light path. It is given by:

$$I_p = (\theta + \arcsin((\Phi_p + \Phi_s)/2t))/2 .$$

where θ is the desired field of view in degrees and t is the mirror separation measured along the principal ray. (See below for a relation giving t.)

The angle of tilt of the secondary mirror, that is, the angle of incidence of the principal ray to correct on-axis coma is given by:

$$I_s = \arcsin((\varepsilon^2 \sin(I_p))/(\kappa^3 (1+2\varepsilon/\kappa))).$$

where

$$\varepsilon = R_s/R_p$$

and

$$\kappa = \Phi_s/\Phi_p.$$

Note that I_p and I_s are half the principal ray angles of deviation. The ratio R_s/R_t between the short R_s and long R_t radii of curvature of the secondary mirror to correct on-axis astigmatism is given by:

$$R_s/R_t = 1 - ((\varepsilon/\kappa^2)\cdot\sin^2(I_p) + \sin^2(I_s)) .$$

The primary K-factor to correct spherical aberration is given by:

$$\text{K-factor} = -1 - (1+(2\varepsilon/\kappa))^2 \kappa^4/\varepsilon^3 .$$

The primary focal and secondary focal lengths are given by:

$$f_p = R_p/2\cos(I_p) ,$$

and

$$f_s = R_s/2\cos(I_s)$$

and the effective focal length is given by:

$$F = 1/((1/f_p)+(1/f_s)-(t/(f_p f_s))) .$$

The mirror separation is given by:

$$t = (1-\kappa)\cdot f_p .$$

The final secondary diameter, to have an unvignetted field of view, is given by:

$$\Phi_s + t \cdot \tan(\theta).$$

Note that t depends on $\cos(I_p)$ and can be approximated by:

$$t \cong ((1-\kappa) \cdot R_p)/2$$

to start the calculations. The distance b from the secondary mirror to the image plane along the principal ray is given by:

$$b = F \cdot \kappa .$$

It is worth commenting that some of the equations are not exact, but they give an excellent approximation of the necessary quantities when the angles of tilt are small, which is the case for the Yolo system.

Design Example: Albert Priselac's Yolo

After the publication of "A Practical Yolo Telescope" (*S&T*, August 1988), Albert Priselac, an amateur telescope maker from Uniontown, Pennsylvania, brought to my attention the weird size I chose for the mirrors of the aplanatic Yolo telescope. He wrote: "Sometimes motivation is governed by certain situations, I think convenience is the one that counts. . . ." I appreciated the philosophy stated in his comment, so I decided to design a Yolo for him using standard 4.25- and 6-inch Pyrex blanks.

The radii of curvature of both mirrors were chosen to be 5,150mm. Thus, $\varepsilon = 1$ and $\kappa = (101\text{ mm})/(151\text{ mm}) \cong 0.67$. The secondary is actually 108mm in diameter, which allows the system to have an unvignetted field of view of 0.5 degrees for a mirror separation of 855mm.

The primary and secondary angles of tilt are:

$$I_p = 4.5°$$

and

$$I_s = 3.8° .$$

The long radius of curvature of the secondary is 5,245mm. The primary K-factor is K = –4.2, and its effective focal length is 1,547mm. The f/ratio of the complete telescope is 10.2, and the distance from the secondary to the image plane is 1,035mm.

For the design of other Yolo systems, it is recommended to minimize the angles of tilt and verify the optical layout by making a drawing to scale. For an 8-inch aperture Yolo the minimum recommended focal ratio would be 12, and for a 12-inch aperture the mini-