GLANCING INCIDENCE TELESCOPES FOR SPACE ASTRONOMY

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In the past two years, I have reported on our efforts to develop glancing incidence telescopes for space astronomy applications. The geometries of these telescopes are shown in Figure1. The Type I telescope, or X-ray telescope, is used in the spectral region below 100 Å. The Type II telescope is employed in the spectral region from 100 Å to approximately 900 Å. Above 900 Å, telescope configurations such as the Cassegrain telescope (Figure 1) are used to collect spatial and spectral information.

In 1968, I reported a technique to be used in optimizing the image quality of Type I telescopes, and in 1969, I reported a technique for use in the design and optimization of image quality of the Type II telescope. At that time, I also reported that two problems were to be intensively investigated in 1970:

(1) Increasing the collecting area of glancing incidence telescopes.

(2) Imaging anomalies noted in the testing of Type II telescopes.

This year, I will report on the first of these problems, which deals with the essential features of two techniques which permit the design of glancing telescopes of increased collecting area (optical throughput) and which simultaneously preserve optimized image quality. The paper by Mrs. Innes will treat the problem of imaging anomalies by glancing incidence telescopes.

Before I proceed, note that in Figure 1, the focal length of glancing telescopes is determined by the intersections of the incoming rays with those rays projected back from the focus of the telescope. The locus of points generated by these intersections is called the principal surface, and as such, determines the effective focal length of the telescope.

Figure 2 illustrates nested geometries for X-ray and extreme ultraviolet (EUV) telescopes. Note that it is imperative that each telescope in the nested array generate a singular principal surface. If this were not the case, then the telescopes would behave as if they possessed several different focal lengths. In the case of the X-ray telescope, a candidate configuration was investigated, and it was discovered that this telescope did not exhibit a singular effective focal length. The design parameters were perturbed so that the nested array generated a singular principal surface. Unfortunately, once this condition is met, the curvature of field of each telescope is significantly different. Classical field curvature is determined by the eccentricities of the image surfaces and therefore does not lend itself to modifications once the geometry has been selected. However, it was discovered that if the field curvature of the outer telescope is selected as a standard, the focus of each of the inner telescopes could be made coplanar by a slight decrease in the collecting area (diameter) of each of the inner telescopes.

The nested EUV telescope exhibited essentially the same problem, namely, that once the nested telescopes are forced to generate a singular surface, the field curvatures exhibited by each of these telescopes do not match. However, in the case of the EUV telescope, one may slightly perturb the maximum glancing angle without a severe loss in reflectance. In the case studied, it also was found that by a change in the maximum slope angle of the inner telescope of one degree, the field curvatures can be made to coincide. The image quality of each of the two candidate telescopes studied is shown in Figure 3. In Figure 3(a), the image quality is formed by five concentric X-ray telescopes with a collecting area of approximately 900 cm^2. In Figure 3(b), the image quality is shown for a nested EUV telescope which consists of two concentric telescopes. The effective focal length of the telescope is one meter, and the collecting area is 45 cm^2.

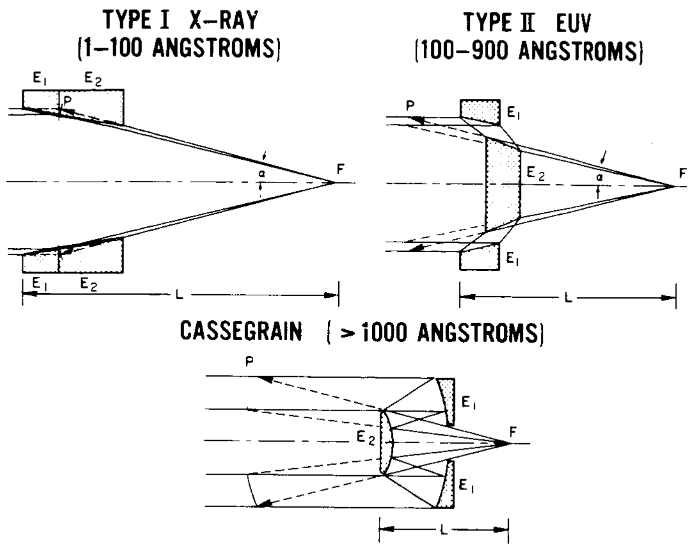

Figure 1–Types of glancing incidence telescopes for space astronomy applications.

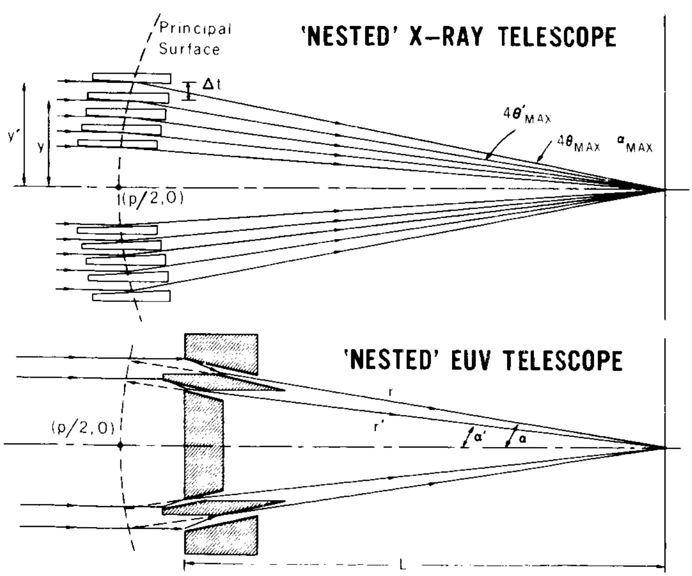

Figure 2–Telescope geometries.

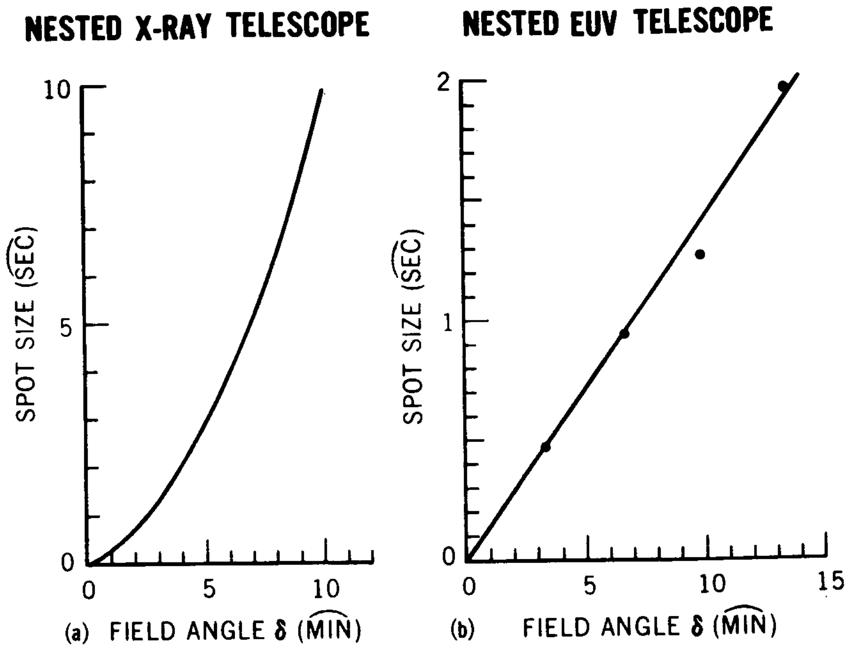

Figure 3—Image quality.