HOLOGRAPHICALLY MADE ZONE PLATES FOR USE IN X-RAY-TELESCOPES

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As it is well known one can obtain images of the Sun in the soft X-ray region and far UV region by use of zone plates. The main advantage of such imaging systems is the good resolution over a large field. There are however some disadvantages by using zone plates as imaging systems. These disadvantages are the wavelength dependence of the focal length and the zero order halo which diminishes the contrast of the image.

By combination of a zone plate and a grating one can separate a small wavelength region to obtain a sufficient good image in the desired wavelength (Bräuninger, 1969). The influence of the zero order halo can be diminished or eliminated by two methods. For a point source we have $I/I_{\text{halo}} \sim N^2$ (Feitzinger, 1968), that means the influence of the halo decreases with increasing zone number N. When imaging point sources therefore it is important to use zone plates with very high zone numbers.

For extended sources, e.g. the Sun, it is better to suppress the halo by using only the outer parts of the zone plate and to image the source in the shadow region of the inner part of the zone plate. As an example let us assume a zone plate with a diameter of 26 mm and a focal length of 1000 mm for the wavelength of 30 Å. With such a zone plate we get an image of the Sun with a diameter of about 10 mm and if we want to suppress the zero order halo entirely we have to mask the inner part with 20 mm in diameter. The resulting zone plate is a ring zone plate with a ring width of 3 mm. The total zone number N of the zone plate in this example is about 5×10^4. That means: If one wants to work with such ring zone plates – known as a special sort of apodized zone plates – one needs zone plates with a very high zone number.

Since 1967 we are developing zone plates with high zone numbers at the Observatory of Göttingen by holographic methods (Schmahl and Rudolph, 1969). The interference figure which one obtains by superposing a spherical wave with a planar wave or by superposing two spherical waves has the structure of a zone plate. By using such an interference figure, made with an Argon laser, one can make in the first step a zone plate in photoresist on a glass backing. The next step is to prepare the zone plate in metal on glass and than in metal on a thin layer which is sufficient transparent to soft X rays. Such zone plates can be used as X-ray lenses.

Up to now zone plates with 1200 zones, a diameter of 2 mm and a focal length of 200 mm for 45 Å were made in metal on a layer transparent for this wavelength. One of these zone plates was tested at the Tübingen Observatory with the CKα-line at 45 Å and the Al Kα-line at 8 Å with the result that this kind of preparation has prooved to be good for these X-ray regions.

In recent experiments we succeeded in making zone plates with about 10^4 zones and a diameter of 26 mm in photoresist. After preparation they will have a focal

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length for the He II line at 304 Å of about 800 mm. To make these zone plates we used an optical system with $f/2$. By using optics with a better focal ratio – e.g. $f/0.5$ – the zone number can be further increased. Another method to increase the zone number is to use a shorter laser wavelength for producing the zone plates.

With the holographic method it is also possible to make spectroscopic diffraction gratings with laserlight and photoresist (Rudolph and Schmahl, 1970). This method allows not only to make gratings for the visible and UV region but also for the soft X-ray region. Especially the holographic method allows to make combined systems of gratings and zone plates for the above mentioned applications.

References

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