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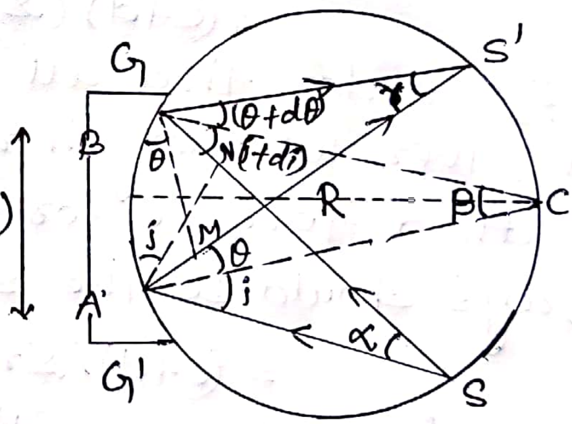
B.Sc (Part-II) Hons
Paper -(III)

Theory of Concave Grating and its Eagle Mounting.

Theory of Concave Grating :- A Concave Grating consists of a polished spherical concave surface of metal like speculum. The surface is ruled with fine parallel lines equally-spaced along the chord of the arc joining the extreme ruling. When light is incident on such a grating, It is diffracted and automatically focussed without the use of lenses.

Let GG' be the trace of the Concave grating and C its centre of Curvature. Let A and B be two ~~Crosses~~ corresponding point of the grating



So that $AB = (e+d)$ is the grating element. Let S be a narrow vertical slit illuminated with monochromatic light of wave length λ. Let SA and SB be two rays incident on the grating at angle i and $(i+di)$ respectively. AS' and BS' are the corresponding diffracted rays, the angles of diffraction being θ and $(\theta+d\theta)$ respectively.

Let AN and BM be two arcs drawn with S and S' as centres, and SA and S'B as radii respectively. These arcs will be almost straight lines. The path difference between the rays SAS' and SBS'

$$= (SB + BS') - (SA + AS')$$

$$= (SB - SA) - (AS' - BS')$$

$$= BN - AM$$

$$= AB \sin i - AB \sin \theta$$

$$= AB(\sin i - \sin \theta)$$

$$= (e+d)(\sin i - \sin \theta)$$

The rays will reinforce each other and produce a maximum at S' if

$$= (e+d)(\sin i - \sin \theta) = n\lambda \quad \text{——— (1)}$$

In order that all the diffracted rays of a given wavelength may be focussed at S', the path difference for any such pair of corresponding rays should be the same i.e.

$$= (e+d)(\sin i - \sin \theta) = \text{Constant}$$

Differentiating this, we get

$$= \cos i \, di - \cos \theta . d\theta = 0 \quad \text{——— (2)}$$

Let α, β, γ be the angles as shown in the figure. Then from figure we have

$$\alpha + i = \beta + i + di$$

$$\text{and } \beta + \theta = \gamma + \theta + d\theta$$

These two equations give respectively

$$di = \alpha - \beta \quad \text{and} \quad d\theta = \beta - \gamma$$

putting these values of di and do in eqn ② we get

$$\cos i(\alpha-\beta) - \cos(\beta-\gamma) = 0 \quad \text{—— (3)}$$

Let $SA = r$ and $AS' = r'$ and R the radius of curvature of the gratting

Then

$$r\alpha = AN = (e+d)\cos i$$

$$R\beta = AB = (e+d)$$

$$r'\gamma = BM = (e+d)\cos\theta$$

$$\therefore \alpha = \frac{(e+d)\cos i}{r}, \quad \beta = \frac{(e+d)}{R}$$

$$\text{and} \quad \gamma = \frac{(e+d)\cos\theta}{r'}$$

putting these values of α, β and γ in eqn(3) and simplifying, we get

$$\cos i\left(\frac{\cos i}{r} - \frac{1}{R}\right) - \cos\left(\frac{1}{R} - \frac{\cos\theta}{r'}\right) = 0 \quad \text{—— (4)}$$

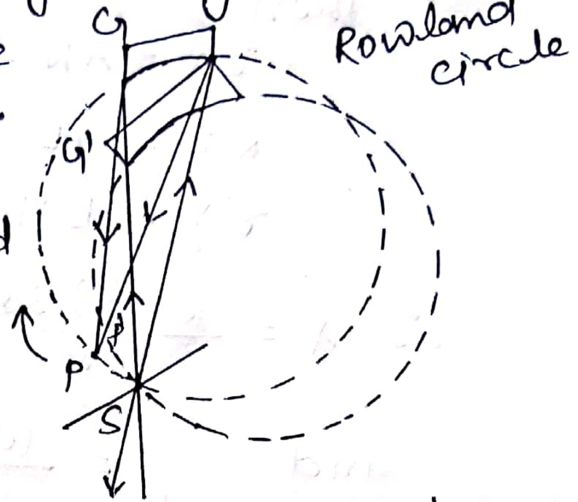
This is the general equation for the position of S'. It shows that if

$$r = R\cos i$$

$$\text{then} \quad r' = R\cos\theta$$

i.e. If S lies on a circle of radius R then S' also lies on the same circle. Thus we conclude that if the slit and the concave grating are placed at the circumference of a circle whose diameter is equal to the radius of curvature of the grating, then the spectra are focussed on the circumference of the same circle. This is known as 'Rowland Circle'.

Eagle Mounting:— In this mounting, the slit and the photographic plate P are mounted very close together at one end of a rigid bar, on the other end of which is mounted the Concave grating G.



All the three lie on the Rowland Circle. Thus only that part of the spectrum is obtained on the plate which is diffracted back nearly along the same path as of the incident beam.

To pass from one spectral region to another the Grating G is moved along the rigid bar and also rotated about a vertical axis to have a new position G' such that the Rowland Circle still passes throug S. The plate P is also tilted to P', so that its surface lies along the new Raland Circle.

Merits:—(i) This mounting is most compact and requires much less space than other mounting. Hence it is widely used in vacum spectrographs for the study of extreme ultravialet region. (ii) Temprature control is easier. (iii) High orders spectra can be attained (iv) The astigmatism is much smaller than in other mountings.

Demerits:— (i) The spectrum is not normal. (ii) The instruments is not simultaneously in focus for all spectral regions. (iii) It involves both translation and rotation of the grating, together with rotation of the plate.