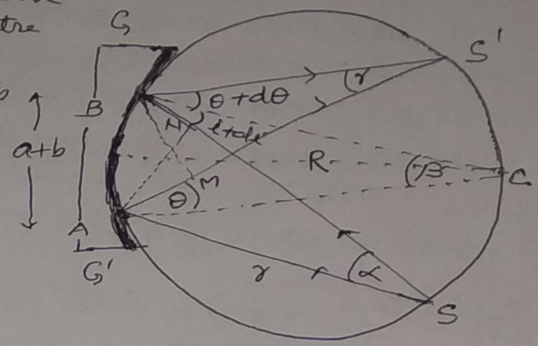
{ B.Sc Part II (PHYSICS HONS)
Dr Satyadeo Narayan Singh
S.B. College, Ara } ①

Question:- Explain the theory of formation of spectra by a concave grating and ~~show how you would use it to find~~ Describe Rowland mounting and Eagle mounting.?

Answer:- **Concave-grating:→**

It is a polished spherical concave surface ruled with fine parallel lines equidistance along the chord of the arc joining the extreme rulings. It diffracts light which is automatically focussed without any lens.

THEORY:→



GG' → The trace of concave grating with C as centre of curvature.

AB → Two corresponding points of the grating

AB → (a+b) → The grating element

S → A narrow vertical slit illuminated with monochromatic light of wavelength λ

SA → ray incident at an angle i

SB → ray incident at an angle $i+di$

AS' → ray diffracted at an angle θ

BS' → ray diffracted at an angle $\theta+d\theta$

AN → arc drawn with S centre and radius SA

BM → arc drawn with S' as centre and $S'B$ as radius

The path difference between the rays SAS' & SBS'

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

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

$= BN - AM$

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

$= AB(\sin i - \sin\theta) \quad = (a+b)(\sin i - \sin\theta) \quad \text{---} ①$

the grating for light of wavelength λ.

For all the diffracted rays of a given wavelength to be focussed at S', the path difference for any such pair of corresponding rays should be equal. That is $(a+b)(\sin i - \sin\theta) = \text{constant}$

Differentiating this,

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

Let $\angle ASB = \alpha$, $\angle ACB = \beta$, $\angle AS'B = \gamma$

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

and $\beta + \theta = \gamma + \theta + d\theta$

$\therefore di = \alpha - \beta$ and $d\theta = \beta - \gamma$

from (2) we get

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

Let $SA = r$, $S'A = r'$ and R = Radius of curvature of grating

$r\alpha = AN = (a+b)\cos i$

$R\beta = AB = (a+b)$

$r'\gamma = BM = (a+b)\cos\theta$

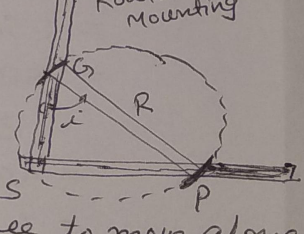
$\therefore \alpha = \dfrac{(a+b)\cos i}{r}$, $\beta = \dfrac{a+b}{R}$, $\gamma = \dfrac{(a+b)\cos\theta}{r'}$

from eq^n (iii), we get

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

If $r = R\cos i$ then $r' = R\cos\theta$. If S lies on the circle of radius R then S' also lies on the same circle. Hence if the slit and the concave grating are placed at the circumference of a circle of diameter equal to the radius of curvature of the grating, the spectra are focussed on the circumference of the same circle. This circle is known as Rowland circle.

(i) ROWLAND MOUNTING :→



The grating G and plateholder P are fixed to opposite ends of a rigid beam of length R. The two ends of this beam rest on swivel trucks which are free to move along two tracks ⊥ to each other. The slit S is mounted just above the intersection of the two tracks. with which arrangement, the position of the spectrum reaching the plates may be varied by sliding the beam. This effectively moves S around on the Rowland circle. ③

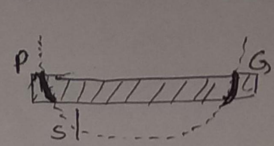
The merit of Rowland mounting is that the spectrum is normal and hence the track SP can be graduated to read wavelength directly.

This mounting is now rarely used as its demerits are many. It needs large space, expensive. It involves a considerable amount of mechanism. Its adjustment is disturbed when the spectral region is changed.

(ii) **EAGLE - MOUNTING:→**

The slit S is placed at one end of the photoholder, the latter being pivoted like a ~~glass~~ gate at S.

S = Slit
G = Grating
P - plate



To observe different position of the spectrum, the grating is turned about an axis ⊥ to the figure. It must then be moved along horizontal ways, and the plate holder turned until P and S again lies on the Rowland circle. Here the part of the spectrum is observed which is diffracted back at angles nearly equal to the angle of incident.

Because of its compactness and flexibility, It is widely used. Temp. control is easier. High order spectra can be attained. The astigmatism is also small.

The demerit is that the spectrum is not normal. The instrument is not simultaneously in focus for all spectral region. It involves both translation and rotation of the grating, together with the rotation of this plate.