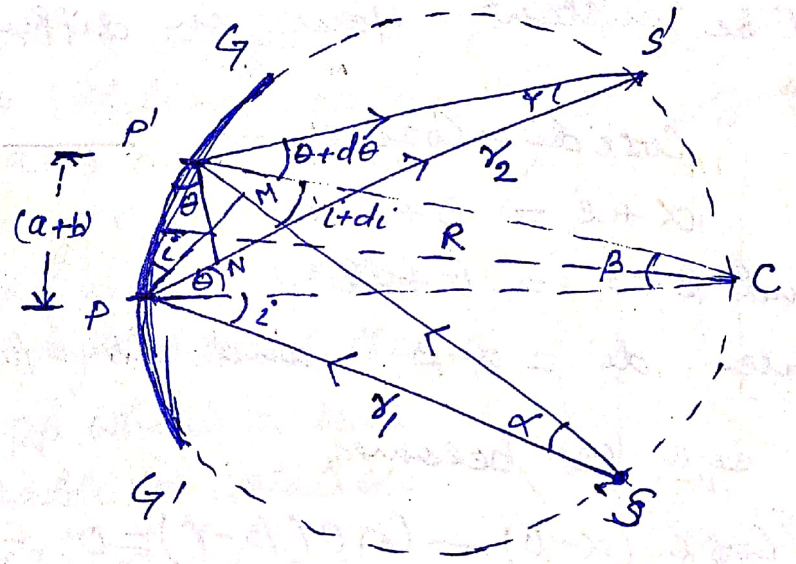
Theory of Concave grating & Eagle's Mounting

Concave grating – If a polished spherical surface of metal, like speculum, is ruled with parallel lines equally spaced along the chord of its arc, it diffracts light and brings the diffracted rays to focus without any converging lens. Such an arrangement is known as concave grating.

Theory of Concave grating



Let GG' be the surface of a concave grating with C as the centre of curvature and R be the radius of curvature. P and P' be the two consecutive points such that PP' = (a+b) is the grating element. S is a linear source of light on the circumference of the dotted circle sending light of wavelength λ. Let SP and SP' be the incident wave and PS' and P'S' the corresponding diffracted waves. Let angle of incidence be

i and $i + di$ respectively and corresponding angle of diffraction θ & $\theta + d\theta$ respectively.

The path difference between rays SPS' and $SP'S'$

$$= (SP' + P'S') - (SP + PS')$$
$$= (SP' - SP) - (PS' - P'S')$$
$$= P'M - PN = PP'\sin i - PP'\sin\theta$$
$$= PP'(\sin i - \sin\theta) = (a+b)(\sin i - \sin\theta)$$

For the rays to produce maximum at S', we should have

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

In order that all diffracted rays of a given wavelength may come to focus at s', the path difference $(a+b)(\sin i - \sin\theta)$ should be constant. Hence on differentiating eqn (1), we get

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

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

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

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

Hence eqn. (2) becomes

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

If $PS = r_1$, $PS' = r_2$ and R = radius of curvature

then $r_1 \cdot \alpha = PM = (a+b)\cos i$

$R \cdot \beta = PP' = (a+b)$

$r_2 \cdot \gamma = P'N = (a+b)\cos\theta$

$$\therefore \alpha = \frac{(a+b)\cos i}{r_1}, \quad \beta = \frac{a+b}{R}, \quad \gamma = \frac{(a+b)\cos\theta}{r_2}$$

Putting these values of α, β and γ in eq. (3), and dropping the common factor $(a+b)$, we get

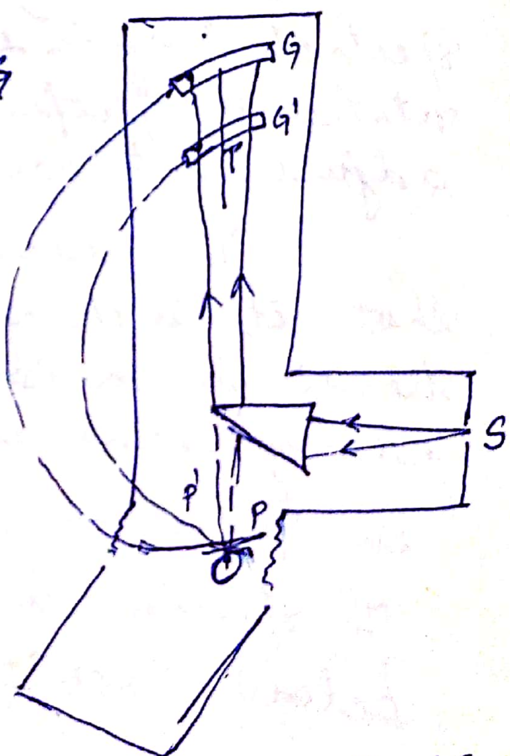
$$\cos i\left[\frac{\cos i}{r_1}-\frac{1}{R}\right]-\cos\theta\left[\frac{1}{R}-\frac{\cos\theta}{r_2}\right]=0$$

If this equation is to be satisfied for all values of i & θ, then the bracketed term should be zero. It is possible if

$$r_1 = R\cos i \quad \text{and} \quad r_2 = R\cos\theta$$

This concludes that S & S' lie on the circumference of the circle whose diameter is R and this circle is called Rowland's circle.

Eagle's Mounting:



In this mounting the grating G is capable of rotating about a vertical axis and can be moved along a track T. The whole thing is enclosed in a light tight box at the other end of which a plate holder capable of rotation about a vertical axis is mounted. The slit S lies on the side of the box at such a position that its virtual image formed by reflection at the totally reflecting prism at O (which also lies at Rowland circle) just below the centre of the photographic plate P. The light after passing through the prism falls on the grating.

To form sharply focussed spectra the grating is moved along the track T and also rotated about the vertical axis until the Rowland circle passes through O. The plate holder whose axis passes through O is then so rotated that the surface of the plate also lies on the Rowland circle. The slit S and the totally reflecting prism lie below the central horizontal plane through the grating and the plate P lies above it, hence the diffracted light from the grating is not obstructed by the prism. To pass from one spectral region to another the grating G is rotated by proper amount and the above adjustments are repeated.

The advantages of this mounting are that it is cheap and quite compact and hence the ~~various~~ variations in temp. can be easily controlled. This is commonly used in vacuum spectrography for the study of spectra in the ultra violet region below 2000 Å.

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