$$x = \frac{a}{2}\sin(\theta)$$

$$\text{zeroes} \qquad x = \frac{1}{2}\lambda = \frac{a}{2}\sin(\theta)$$

$$\sin(\theta) = \frac{\lambda}{a}$$

$$\sin(\theta) \simeq \frac{y}{L} \qquad \Rightarrow \qquad y = 1\ \frac{L\lambda}{a}$$

$$x = \frac{a}{4}\sin(\theta)$$

$$\sin(\theta) = \frac{2\lambda}{a}$$

$$\sin(\theta) \simeq \frac{y}{L} \qquad \Rightarrow \qquad y = 2\ \frac{L\lambda}{a}$$

$$y = M\ \frac{L\lambda}{a} \quad , \qquad M = 1, 2, 3, ...$$

$$x = dz\sin(\theta)$$

$$\frac{x}{\lambda} = \frac{dz}{\lambda}\ \sin(\theta)$$

$$\frac{2\pi x}{\lambda} = \frac{2\pi dz}{\lambda}\ \sin(\theta)$$

$$\text{phase offset} = \frac{2\pi z}{\lambda}\ \sin(\theta)$$

$$A_m = \frac{A}{a/dz} = A\left(\frac{dz}{a}\right)$$

$$y_1 = A_m\ \frac{1}{r_1}\sin(kr_1 - \omega t)$$

$$y_2 = A_m\ \frac{1}{r_2}\sin(kr_2 - \omega t)$$

$$y_1 = \frac{A_m}{r_{\text{avg}}}\sin(kr_1 - \omega t)$$

$$y_2 \quad = \quad \frac{A_m}{r_{\text{avg}}} \sin(kr_2 - \omega t)$$

$$\text{phase offset} \quad = \quad \frac{2\pi \sin(\theta)}{\lambda}\, dz$$

$$y_1 \quad = \quad \frac{A_m}{r_{\text{avg}}} \sin\left(0 - \ \omega t\right)$$

$$y_2 \quad = \quad \frac{A_m}{r_{\text{avg}}} \sin\left(\frac{2\pi \sin(\theta)}{\lambda} z \ - \ \omega t\right)$$

$$\text{sum of all waves} \quad = \quad \int_{z=0}^{z=a} \frac{A_m}{r_{\text{avg}}} \sin\left(\frac{2\pi \sin(\theta)}{\lambda} z \ - \ \omega t\right)$$

$$\text{sum of all waves} \quad = \quad \int_{z=0}^{z=a} \left(\frac{A\, dz}{a}\right) \frac{1}{r_{\text{avg}}} \sin\left(\frac{2\pi \sin(\theta)}{\lambda} z \ - \ \omega t\right)$$

$$\text{sum of all waves} \quad = \quad \frac{A}{r_{\text{avg}}} \int_{z=0}^{z=a} \frac{1}{a} \sin\left(\frac{2\pi \sin(\theta)}{\lambda} z \ - \ \omega t\right) dz$$

$$\text{sum} \quad = \quad \frac{A}{r_{\text{avg}}} \left\{ -\frac{1}{a} \frac{\lambda}{2\pi \sin(\theta)} \cos\left(\frac{2\pi \sin(\theta)}{\lambda} a \ - \ \omega t\right) \ + \ \frac{1}{a} \frac{\lambda}{2\pi \sin(\theta)} \cos\left(0 \ - \ \omega t\right) \right\}$$

$$\beta \quad = \quad \frac{2\pi \sin(\theta) a}{\lambda}$$

$$\text{sum} \quad = \quad \frac{A}{r_{\text{avg}}} \left\{ -\frac{1}{\beta} \cos\left(\beta \ - \ \omega t\right) \ + \ \frac{1}{\beta} \cos\left(0 \ - \ \omega t\right) \right\}$$

$$\cos(P) \ - \ \cos(Q) \quad = \quad -2 \sin\left(\frac{P+Q}{2}\right) \sin\left(\frac{P-Q}{2}\right)$$

$$\text{sum} \quad = \quad \frac{A}{r_{\text{avg}}} \left\{ \frac{2}{\beta} \sin\left(\frac{\beta \ - \ 2\omega t}{2}\right) \sin\left(\frac{\beta}{2}\right) \right\}$$

$$\text{intensity} \quad = \quad \text{amplitude}^2 \quad = \quad \frac{A^2}{r_{\text{avg}}^2} \left\{ \left[\sin\left(\frac{\beta \ - \ 2\omega t}{2}\right) \right]^2 \left(\frac{\sin(\frac{\beta}{2})}{\frac{\beta}{2}} \right)^2 \right\}$$

$$\text{time} - \text{averaged intensity} \quad = \quad \frac{1}{2} \frac{A^2}{r_{\text{avg}}^2} \left(\frac{\sin(\frac{\beta}{2})}{\frac{\beta}{2}} \right)^2$$

$$\sin(\theta) \simeq \frac{y}{L}$$

$$\beta = \frac{2\pi a}{\lambda}\frac{y}{L}$$

$$\beta = \frac{2\pi a}{\lambda}\sin(\theta)$$

bright spots ?? $\quad x = 1\,\lambda = \frac{a}{2}\sin(\theta)$ warning! not correct!

$$\sin(\theta) = \frac{2\lambda}{a}$$

for $x << 1$, $\quad \sin(x) \simeq x - \frac{x^3}{3!} + \frac{x^5}{5!} - ...$

if $(\beta/2) \to 0$, $\quad \frac{\sin(\beta/2)}{\beta/2} \to \frac{(\beta/2) - \frac{(\beta/2)^3}{3!} + \frac{(\beta/2)^5}{5!} - ...}{\beta/2} \to \frac{\beta/2}{\beta/2} = 1$

$$\text{time} - \text{averaged intensity} = \frac{1}{2}\frac{A^2}{r_{\text{avg}}^2}$$

$$\sin(\beta/2) = 0$$

$$\frac{\beta}{2} = 0,\ \pi,\ 2\pi,\ 3\pi,\ ...,\ N\pi \quad \Rightarrow \quad \beta = 2\pi,\ 4\pi,\ 6\pi,\ ...$$

$$\frac{2\pi\ \sin(\theta)\, a}{\lambda} = 2\pi,\ 4\pi,\ 6\pi,\ ... \quad \Rightarrow \quad \sin(\theta) = \frac{\lambda}{a},\ \frac{2\lambda}{a},\ \frac{3\lambda}{a},\ ...$$

$$\text{dark spots}: \quad \sin(\theta) = \frac{\lambda}{a},\ 2\frac{\lambda}{a},\ 3\frac{\lambda}{a},\ ...$$

bright spots : $\quad \sin(\theta) \stackrel{?}{=} 1.5\frac{\lambda}{a},\ 2.5\frac{\lambda}{a},\ 3.5\frac{\lambda}{a},\ ...$ warning! not correct!