Yes, the formula which you posted is the most common mathematics representation for computing PSF.

Normally, I use this to do computing.

$$\mathbf{E}(r_P,\theta_P,\varphi_P) = -\frac{ik}{2\pi}\iint \cos^{\frac{1}{2}}\theta \cdot \mathbf{P}(\theta,\varphi)\cdot \sin\theta\, e^{ikr_P(\cos\theta\cos\theta_P+\sin\theta\sin\theta_P\cos(\varphi-\varphi_P)}\, d\theta d\varphi, \text{ --------- } (1)$$

Where: $\mathbf{P}(\theta,\varphi)$ is conversion matrix for polarization state from initial state (incident light polarization) to focal region.

$$\mathbf{P}(\theta,\varphi) = R^{-1}CR\mathbf{P}_0 = \begin{bmatrix}\vec{p}_x\\ \vec{p}_y\\ \vec{p}_z\end{bmatrix}\begin{bmatrix}1+(\cos\theta-1)\cos^2\varphi & (\cos\theta-1)\cos\varphi\sin\varphi & -\sin\theta\cos\varphi\\ (\cos\theta-1)\cos\varphi\sin\varphi & 1+(\cos\theta-1)\sin^2\varphi & -\sin\theta\sin\varphi\\ \sin\theta\cos\varphi & -\sin\theta\sin\varphi & \cos\theta\end{bmatrix} \text{ ----(2)}$$

I didn't use the conversion formula:

$$\int_0^{2\pi}\cos(n\varphi)\, e^{ik\rho_p sin\theta cos\varphi}\, d\varphi = 2\pi i_n j_n(k\rho_p sin\theta) \text{ -----(3)}$$

To simplify the original formula (1) to the one which you've given in your post. Because sometimes I use vortex mask or other phase modulation. The formula (3) is only suitable for the case of axial symmetric case.

Ok, back to the previous post:

What I talked about is that :

for computing, the formula (1) has to be converted into discrete form:

$$\mathbf{E}(r_P,\theta_P,\varphi_P) = \textit{sum of } [-\frac{ik}{2\pi}\cos^{\frac{1}{2}}\theta \cdot \mathbf{P}(\theta,\varphi)\cdot \sin\theta\, e^{ikr_P(\cos\theta\cos\theta_P+\sin\theta\sin\theta_P\cos(\varphi-\varphi_P)}\, \Delta\theta\Delta\varphi],$$

Where $0 \le \theta \le \alpha, \Delta\theta = \frac{\alpha}{N}, N \text{ is } 1 \text{ to } 100(\text{or even larger for more accuracy result}),$

Finally the formula is become:

$$\mathbf{E}(r_P,\theta_P,\varphi_P) = E_{\theta=0} + \cdots E_{\theta=i} + \cdots E_{\theta=\alpha}$$

$$I_{total} = [\mathbf{E}(r_P,\theta_P,\varphi_P)]^2 = [E_{\theta=0} + \cdots E_{\theta=i} + \cdots E_{\theta=\alpha}]^2 \text{ -------(4)}$$

Notice: same for the variant φ, for each step of θ_i, φ is from 0 to 2π.

In the last post, what I wanna express is that in the case of incoherent incident light, is it possible to change the formula into :

$I_{total} = [E_{\theta=0}]^2 + \cdots + [E_{\theta=i}]^2 + \cdots + [E_{\theta=\alpha}]^2$ Instead of formula (4). I think because of incoherent, there should be no interaction between the light rays. Only the sum of intensity of each way, but it seems that the simulation result is not correct. I got uniform distribution everywhere , there is no shape like PSF formed, what I think is that the only difference is that compared with coherent light there is no side loop emerge. I am so confused. Do you have any idea for this ? thank you very much