

(11)

$$= \begin{pmatrix} \cos \gamma t + (1 - \cos \gamma t) \sin^2 \theta \cos^2 \phi \\ (1 - \cos \gamma t) \sin \theta \cos \phi \sin \phi + \sin \gamma t \cos \theta \\ \sin \gamma t \sin \theta \sin \phi + (1 - \cos \gamma t) \sin \theta \cos \theta \cos \phi \end{pmatrix}$$

$$R_z \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ \cos \gamma t \\ 0 \end{pmatrix} + (1 - \cos \gamma t) \sin \theta \sin \phi \begin{pmatrix} \sin \theta \cos \phi \\ \sin \theta \sin \phi \\ \cos \theta \end{pmatrix}$$

$$+ \sin \gamma t \begin{pmatrix} \sin \theta \cos \phi \\ \sin \theta \sin \phi \\ \cos \theta \end{pmatrix} \times \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

$$= \begin{pmatrix} (1 - \cos \gamma t) \sin^2 \theta \sin \phi \cos \phi \\ \cos \gamma t + (1 - \cos \gamma t) \sin^2 \theta \sin^2 \phi \\ (1 - \cos \gamma t) \sin \theta \sin \phi \cos \theta \\ \sin \gamma t \cos \theta \\ 0 \\ -\sin \gamma t \sin \theta \cos \phi \end{pmatrix}$$

$$= \begin{pmatrix} (1 - \cos \gamma t) \sin^2 \theta \sin \phi \cos \phi - \sin \gamma t \cos \theta \\ \cos \gamma t + (1 - \cos \gamma t) \sin^2 \theta \sin^2 \phi \\ (1 - \cos \gamma t) \sin \theta \sin \phi \cos \theta + \sin \gamma t \sin \theta \cos \phi \end{pmatrix}$$

$$R_z \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \cos \gamma t \end{pmatrix} + (1 - \cos \gamma t) \cos \theta \begin{pmatrix} \sin \theta \cos \phi \\ \sin \theta \sin \phi \\ \cos \theta \end{pmatrix}$$

$$+ \sin \gamma t \begin{pmatrix} \sin \theta \cos \phi \\ \sin \theta \sin \phi \\ \cos \theta \end{pmatrix} \times \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

$$= \begin{pmatrix} (1 - \cos \gamma t) \cos \theta \sin \theta \cos \phi \\ (1 - \cos \gamma t) \cos \theta \sin \theta \sin \phi \\ \cos \gamma t + (1 - \cos \gamma t) \cos^2 \theta \end{pmatrix} +$$

$$+ \sin \gamma t \begin{pmatrix} \sin \theta \sin \phi \\ -\sin \theta \cos \phi \\ 0 \end{pmatrix}$$

$$= \begin{pmatrix} (1 - \cos \gamma t) \cos \theta \sin \theta \cos \phi + \sin \gamma t \sin \theta \sin \phi \\ (1 - \cos \gamma t) \cos \theta \sin \theta \sin \phi - \sin \gamma t \sin \theta \cos \phi \\ \cos \gamma t + (1 - \cos \gamma t) \cos^2 \theta \end{pmatrix}$$