The RTE has the form

$$\frac{d\boldsymbol{I}}{ds} = \boldsymbol{\epsilon} - \boldsymbol{K}\boldsymbol{I}\,. \tag{1}$$

Let's rotate the field of view around the ray direction by angle α. (see Fig. 1.10 at page 25 in LL04). While I and V are not affected (they are invatiant undre rotation), the Q and U are affected. Let $\boldsymbol{A}_\alpha$ be a 4×4 matrix corresponding to the rotation by alpha. The Stokes parameters in the new frame are then $\boldsymbol{I}' = \boldsymbol{A}_\alpha \boldsymbol{I}$, where (see Eq. 1.45)

$$\boldsymbol{A}_\alpha = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & Q\cos 2\alpha & U\sin 2\alpha & 0 \\ 0 & -Q\sin 2\alpha & U\cos 2\alpha & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\,. \tag{2}$$

We want to express our Eq. 1 in the new reference frame in order to solve it there. We can multiply (from the left) Eq. 1 to get

$$\boldsymbol{A}\frac{d\boldsymbol{I}}{ds} = \frac{d\boldsymbol{I}'}{ds} = \boldsymbol{A}\boldsymbol{\epsilon} - \boldsymbol{A}\boldsymbol{K}\boldsymbol{I}\,. \tag{3}$$

The left hand side is now OK and it is clear that $\boldsymbol{A}\boldsymbol{\epsilon} = \boldsymbol{\epsilon}'$ because the emission vector transoform in the same way as the Stokes parameters. The problematic term $\boldsymbol{A}\boldsymbol{K}\boldsymbol{I}$ can be rewritten as

$$\boldsymbol{A}\boldsymbol{K}\boldsymbol{I} = \boldsymbol{A}\boldsymbol{K}\boldsymbol{A}^{-1}\boldsymbol{A}\boldsymbol{I} \tag{4}$$

and we are done because $\boldsymbol{A}\boldsymbol{I} = \boldsymbol{I}'$ and we see that

$$\boldsymbol{K}' = \boldsymbol{A}\boldsymbol{K}\boldsymbol{A}^{-1}\,. \tag{5}$$

The RTE in the rotated reference frame has now the correct form

$$\frac{d\boldsymbol{I}'}{ds} = \boldsymbol{\epsilon}' - \boldsymbol{K}'\boldsymbol{I}'\,. \tag{6}$$