

$$\begin{aligned}\Gamma \omega \mathbf{f} &= -\mathbf{f} \omega \Gamma \\ \Gamma J \omega \mathbf{f} J &= \Gamma \omega \mathbf{f} \\ \Gamma J \omega \mathbf{f} &= -\Gamma \omega \mathbf{f} J\end{aligned}$$

$$\Gamma (J + i) \omega \mathbf{f} = \frac{i}{2} \Gamma (1 - iJ) \omega \mathbf{f} (1 + iJ)$$

$$\begin{aligned}\Gamma (1 - iJ) \omega \mathbf{f} (1 + iJ) &= \overline{\Gamma (1 - iJ) J} \overline{\omega \mathbf{f} (1 + iJ) J} = \Gamma (J + i) \omega \mathbf{f} (J - i) \\ &= \Gamma J \omega \mathbf{f} J + i \Gamma \omega \mathbf{f} J - i \Gamma J \omega \mathbf{f} + \Gamma \omega \mathbf{f} = 2(\Gamma \omega \mathbf{f} - i \Gamma J \omega \mathbf{f}) = -2i \Gamma (J + i) \omega \mathbf{f}\end{aligned}$$

$$\begin{aligned}{}^J \mathbf{r} \mathbf{e}^{\Gamma} &= \exp \Gamma (J + i) \omega \mathbf{f} \\ {}^J \mathbf{J} &= {}^J \mathbf{r} \mathbf{e}^{\Gamma} \omega / 2 \mathbf{h} \mathbf{J} \\ {}^J \mathbf{J} \mathbf{K} \mathbf{J} &= \int {}^J \mathbf{J} \mathbf{J} \mathbf{J} = \int {}^J \mathbf{r} \mathbf{e}^{\Gamma} \omega / \mathbf{h} \mathbf{J} \mathbf{J} \\ {}^J \mathbf{J} &= \int {}^J \mathbf{K} \mathbf{J} \mathbf{J}\end{aligned}$$

$$\begin{aligned}{}^J \mathbf{K} \mathbf{J} &= {}^J \mathbf{r} \mathbf{e}^{\Gamma - \mathbf{J}} \omega / 2 \mathbf{h} \mathbf{J} - \mathbf{J} \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / 2 \mathbf{h} \\ 2 \log {}^J \mathbf{K} \mathbf{J} &= \Gamma (J + i) \frac{\omega}{\mathbf{h}} (\Gamma - \mathbf{J}) + (\mathbf{J} - \Gamma) (J + i) \frac{\omega}{\mathbf{h}}\end{aligned}$$

$${}^J \mathbf{J} = \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / \mathbf{h} \mathbf{J} + \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / \mathbf{h} \mathbf{J}$$

$$\Gamma (J + i) \omega \Gamma + \mathbf{J} (J + i) \omega \mathbf{J} - 2 \Gamma (J + i) \omega \mathbf{J} = \Gamma (J + i) \omega (\Gamma - \mathbf{J}) + (\mathbf{J} - \Gamma) (J + i) \omega \mathbf{J}$$

$$\begin{aligned}\Rightarrow {}^J \mathbf{J} &= {}^J \mathbf{r} \mathbf{e}^{\Gamma} \omega / 2 \mathbf{h} \mathbf{J} = {}^J \mathbf{r} \mathbf{e}^{\Gamma} \omega / 2 \mathbf{h} \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / \mathbf{h} \mathbf{J} + \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / \mathbf{h} \mathbf{J} = \int {}^J \mathbf{r} \mathbf{e}^{\Gamma} \omega / 2 \mathbf{h} \mathbf{J} + \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / \mathbf{h} \mathbf{J} \\ &= \int {}^J \mathbf{r} \mathbf{e}^{\Gamma} \omega / 2 \mathbf{h} \mathbf{J} + \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / 2 \mathbf{h} \mathbf{J} + \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / \mathbf{h} \mathbf{J} = \int {}^J \mathbf{r} \mathbf{e}^{\Gamma - \mathbf{J}} \omega / 2 \mathbf{h} \mathbf{J} + \int {}^J \mathbf{r} \mathbf{e}^{\mathbf{J}} \omega / 2 \mathbf{h} \mathbf{J}\end{aligned}$$

$$2 \mathcal{J} \frac{{}^J K^\dagger}{{}_r K^\dagger} / \frac{{}^J K^\dagger}{{}_r K^\dagger} = 2 \mathcal{J} \frac{{}^J \log_r K^\dagger}{\log_r K^\dagger} = (\Gamma - \dagger) \mathcal{J} \frac{\omega}{\hbar} (\Gamma - \dagger)$$

$$\mathfrak{F} \frac{{}^J \bar{K}^\dagger}{{}_r K^\dagger} / \frac{{}^J K^\dagger}{{}_r K^\dagger} = \mathfrak{F} \overline{\log_r K^\dagger} = \mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger$$

$$\begin{aligned} 2 \hbar \text{ LHS} &= \mathfrak{F} \overline{\Gamma (J+i) \omega (\Gamma - \dagger) + (\dagger - \Gamma) (J+i) \omega \dagger} = \mathfrak{F} (J+i) \omega (\Gamma - \dagger) + \Gamma (J+i) \omega \mathfrak{F} - \mathfrak{F} (J+i) \omega \dagger \\ &= \mathfrak{F} J \omega \Gamma + i \mathfrak{F} \omega \Gamma - \mathfrak{F} J \omega \dagger - i \mathfrak{F} \omega \dagger + \Gamma J \omega \mathfrak{F} + i \Gamma \omega \mathfrak{F} - \mathfrak{F} J \omega \dagger - i \mathfrak{F} \omega \dagger = 2 \mathfrak{F} J \omega \Gamma - 2 \mathfrak{F} J \omega \dagger - 2i \mathfrak{F} \omega \dagger \end{aligned}$$

$$\mathfrak{F} \mathfrak{F} \frac{{}^J \bar{K}^\dagger}{{}_r K^\dagger} / \frac{{}^J K^\dagger}{{}_r K^\dagger} = \mathfrak{F} J \frac{\omega}{\hbar} \mathfrak{F} + \underbrace{\mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger}_{\mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger} \mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger$$

$$\begin{aligned} \mathfrak{F} \mathfrak{F} \frac{{}^J \bar{K}^\dagger}{{}_r K^\dagger} &= \mathfrak{F} \mathfrak{F} \overline{{}^J \bar{K}^\dagger} = \mathfrak{F} \frac{{}^J K^\dagger}{\Gamma} \mathfrak{F} \overline{J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger} \\ &= \mathfrak{F} \frac{{}^J \bar{K}^\dagger}{\Gamma} \mathfrak{F} \underbrace{J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger}_{\mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger} + \frac{{}^J K^\dagger}{\Gamma} \mathfrak{F} \overline{\mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger} \\ &= \frac{{}^J K^\dagger}{\Gamma} \mathfrak{F} \underbrace{J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger}_{\mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger} \mathfrak{F} J \frac{\omega}{\hbar} \Gamma - \mathfrak{F} (J+i) \frac{\omega}{\hbar} \dagger + \frac{{}^J K^\dagger}{\Gamma} \mathfrak{F} J \frac{\omega}{\hbar} \mathfrak{F} \end{aligned}$$

$$\mathbb{F} \mathbb{F} \int_{\Gamma}^J \bar{J} = \mathbb{F} \int_{\mathbb{H}}^J \omega \Gamma \int_{\Gamma}^J J - \int_{\Gamma}^J K^{\uparrow} \int_{\Gamma}^J J \mathbb{F} (J+i) \frac{\omega}{\mathbb{H}} \uparrow$$

$$\begin{aligned} \int_{\Gamma}^J J &= \int_{\Gamma}^J K^{\uparrow} \int_{\Gamma}^J J \Rightarrow \text{LHS} = \int_{\Gamma}^J \mathbb{F} \int_{\Gamma}^J \bar{K}^{\uparrow} \int_{\Gamma}^J J = \int_{\Gamma}^J K^{\uparrow} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega \Gamma - \mathbb{F} (J+i) \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \\ &= \mathbb{F} \int_{\mathbb{H}}^J \omega \Gamma \int_{\Gamma}^J K^{\uparrow} \int_{\Gamma}^J J - \int_{\Gamma}^J K^{\uparrow} \mathbb{F} (J+i) \frac{\omega}{\mathbb{H}} \uparrow \int_{\Gamma}^J J = \text{RHS} \end{aligned}$$

$$\begin{aligned} \mathbb{F} \mathbb{F} \int_{\Gamma}^J \bar{J} &= \int_{\Gamma}^J K^{\uparrow} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega \mathbb{F} + \mathbb{F} \int_{\mathbb{H}}^J \omega \Gamma - \mathbb{F} (J+i) \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega \Gamma - \mathbb{F} (J+i) \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \\ &= \int_{\Gamma}^J K^{\uparrow} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega \mathbb{F} + \mathbb{F} \int_{\mathbb{H}}^J \omega (\Gamma - \uparrow) - \mathbb{F} \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega (\Gamma - \uparrow) - \mathbb{F} \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \\ &= \int_{\Gamma}^J K^{\uparrow} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega \mathbb{F} + \mathbb{F} \int_{\mathbb{H}}^J \omega (\Gamma - \uparrow) - \mathbb{F} \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \underbrace{\mathbb{F} \int_{\mathbb{H}}^J \omega (\Gamma - \uparrow) - \mathbb{F} \frac{\omega}{\mathbb{H}} \uparrow}_{\int_{\Gamma}^J J} \end{aligned}$$

$$\int_{\Gamma}^J J = \int_{\Gamma}^J K^{\uparrow} \int_{\Gamma}^J J \Rightarrow \text{LHS} = \int_{\Gamma}^J \mathbb{F} \mathbb{F} \int_{\Gamma}^J \bar{K}^{\uparrow} \int_{\Gamma}^J J = \text{RHS}$$