$$\Lambda^0_0 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^0 B_z\, \sigma_0\, B_z^\dagger\right] = \frac{1}{2}\,\mathrm{Tr}\left[\mathbb{I}\, B_z\, \mathbb{I}\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-2\alpha} & 0 \\ 0 & e^{2\alpha} \end{pmatrix}$$

$$\Rightarrow e^{-2\alpha} + e^{2\alpha} = 2\cosh(2\alpha) \Rightarrow \boxed{\Lambda^0_0 = \cosh(\eta)}$$

$$\Lambda^0_1 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^0 B_z\, \sigma_1\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & e^{\alpha} \\ e^{-\alpha} & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

$$\Rightarrow \boxed{\Lambda^0_1 = 0 = \Lambda^1_0}$$

$$\Lambda^0_2 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^0 B_z\, \sigma_2\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \Rightarrow \boxed{\Lambda^0_2 = 0 = \Lambda^2_0}$$

$$\Lambda^0_3 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^0 B_z\, \sigma_3\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & -e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-2\alpha} & 0 \\ 0 & -e^{2\alpha} \end{pmatrix}$$

$$\Rightarrow e^{-2\alpha} - e^{2\alpha} = 2\,\mathrm{senh}(2\alpha) \Rightarrow \boxed{\Lambda^0_3 = \mathrm{senh}\,\eta}$$

$$\Lambda^1_1 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^1 B_z\, \sigma_1\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \begin{pmatrix} 0 & e^{-\alpha} \\ e^{\alpha} & 0 \end{pmatrix}\begin{pmatrix} 0 & e^{-\alpha} \\ e^{\alpha} & 0 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$$\Rightarrow \boxed{\Lambda^1_1 = 1}$$

$$\Lambda^2_1 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^2 B_z\, \sigma_1\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} 0 & -ie^{\alpha} \\ ie^{-\alpha} & 0 \end{pmatrix}\begin{pmatrix} 0 & e^{\alpha} \\ e^{-\alpha} & 0 \end{pmatrix} = \begin{pmatrix} -i & 0 \\ 0 & i \end{pmatrix}$$

$$\Rightarrow \boxed{\Lambda^2_1 = \frac{1}{2}(-i+i) = 0 = \Lambda^1_2}$$

$$\Lambda^3_1 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^3 B_z\, \sigma_1\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & -e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & e^{\alpha} \\ e^{-\alpha} & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$$

$$\Rightarrow \boxed{\Lambda^3_1 = 0 = \Lambda^1_3}$$

$$\Lambda^3_2 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^3 B_z\, \sigma_2\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & -e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & -ie^{\alpha} \\ ie^{-\alpha} & 0 \end{pmatrix} = \begin{pmatrix} 0 & -i \\ -i & 0 \end{pmatrix}$$

$$\Rightarrow \boxed{\Lambda^3_2 = 0 = \Lambda^2_3}$$

$$\Lambda^3_0 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^3 B_z\, \sigma_0\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & -e^{\alpha} \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-2\alpha} & 0 \\ 0 & -e^{2\alpha} \end{pmatrix}$$

$$\Rightarrow e^{-2\alpha} - e^{2\alpha} = 2\,\mathrm{senh}(2\alpha) \Rightarrow \boxed{\Lambda^3_0 = \mathrm{senh}\,\eta}$$

$$\Lambda^2_2 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^2 B_z\, \sigma_2\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} 0 & -ie^{\alpha} \\ ie^{-\alpha} & 0 \end{pmatrix}\begin{pmatrix} 0 & -ie^{\alpha} \\ ie^{-\alpha} & 0 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$$\Rightarrow \boxed{\Lambda^2_2 = 1}$$

$$\Lambda^3_3 = \frac{1}{2}\,\mathrm{Tr}\left[\bar{\sigma}^3 B_z\, \sigma_3\, B_z^\dagger\right] \Rightarrow \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-\alpha} & 0 \\ 0 & -e^{\alpha} \end{pmatrix}\begin{pmatrix} e^{-\alpha} & 0 \\ 0 & -e^{\alpha} \end{pmatrix} = \begin{pmatrix} e^{-2\alpha} & 0 \\ 0 & e^{2\alpha} \end{pmatrix}$$

$$\Rightarrow e^{-2\alpha} + e^{2\alpha} = 2\cosh(2\alpha) \Rightarrow \boxed{\Lambda^3_3 = \cosh\eta}$$