

The transformation of a DECA is given as

$$\begin{aligned} & \exp(: F_{\text{in}} :) \exp(: aL :) \exp(: H_4/2 :) \exp(: bL :) \\ & \times \exp(: V_4 :) \exp(: aL :) \exp(: H_4/2 :) \exp(: bL :) \exp(: F_{\text{out}} :) , \end{aligned} \quad (106)$$

where  $L$  and  $H_4$  are the Hamiltonians of a drift of length  $L$  and a thin decapole kick with integrated strength  $K_4$ :

$$H_4 = \frac{K_4}{5!} \Re(x - iy)^5 , \quad (107)$$

respectively. The coefficients are  $a \equiv 1/2 - 1/\sqrt{12}$  and  $b = 1/2 - a$ . Terms  $\exp(: F_{\text{in}} :)$  and  $\exp(: F_{\text{out}} :)$  are transformations for entrance and exit nonlinear fringes. The term  $\exp(: V_4 :)$  is a correction to adjust the third-order terms in  $L$ :

$$V_4 = \sum_{j=(x,y), k=(x,y)} -\frac{\beta}{2} H_{4,k}^2 + \gamma H_{4,j} H_{4,k} H_{4,j,k} , \quad (108)$$

where  $i$  represents the derivative by  $x$  or  $y$ . We have also introduced two coefficients  $\beta \equiv 1/6 - 1/\sqrt{48}$  and  $\gamma = 1/40 - 1/(24\sqrt{3})$ .