Given the theoretical parameters

$$x_{12} \equiv \frac{2|M_{12}|}{\Gamma} \qquad y_{12} \equiv \frac{|\Gamma_{12}|}{\Gamma} \qquad \phi_{12} \equiv \mathrm{Arg}\left(\frac{M_{12}}{\Gamma_{12}}\right),$$

we express the experimental parameters $(x, y, |q/p|, \phi)$ in terms of $(x_{12}, y_{12}, \phi_{12})$ as follows. Solving the eigenvalue problem gives [see Eqs. (10)(11) of Kagan and Sokoloff, PRD 80, 076008 (2009)]:

$$(x - iy)^2 \;=\; {x_{12}}^2 - {y_{12}}^2 - i\,2x_{12}y_{12}\cos\phi_{12} \tag{1}$$

$$\frac{q}{p} \;=\; -\frac{\Gamma(x - iy)}{2(M_{12} - i\Gamma_{12}/2)} \;=\; -\frac{x - iy}{e^{i\phi_{\Gamma_{12}}}(x_{12}\,e^{i\phi_{12}} - iy_{12})}\,. \tag{2}$$

Squaring Eq. (2) and using Eq. (1) gives

$$\begin{aligned}
\left(\frac{q}{p}\right)^2 &= \frac{(x - iy)^2}{e^{i2\phi_{\Gamma_{12}}}(x_{12}\,e^{i\phi_{12}} - iy_{12})^2} = \frac{{x_{12}}^2 - {y_{12}}^2 - i\,2x_{12}y_{12}\cos\phi_{12}}{e^{i2\phi_{\Gamma_{12}}}({x_{12}}^2\,e^{i2\phi_{12}} - {y_{12}}^2 - i\,2x_{12}y_{12}\,e^{i\phi_{12}})} \\
\Rightarrow \qquad \left|\frac{q}{p}\right|^4 &= \frac{({x_{12}}^2 - {y_{12}}^2)^2 + 4{x_{12}}^2{y_{12}}^2\cos^2\phi_{12}}{|\,{x_{12}}^2\cos 2\phi_{12} - {y_{12}}^2 + 2x_{12}y_{12}\sin\phi_{12} \;+\; i({x_{12}}^2\sin 2\phi_{12} - 2x_{12}y_{12}\cos\phi_{12})\,|^2} \\
&= \frac{{x_{12}}^4 + {y_{12}}^4 - 2{x_{12}}^2{y_{12}}^2(1 - 2\cos^2\phi_{12})}{({x_{12}}^2\cos 2\phi_{12} - {y_{12}}^2 + 2x_{12}y_{12}\sin\phi_{12})^2 \;+\; ({x_{12}}^2\sin 2\phi_{12} - 2x_{12}y_{12}\cos\phi_{12})^2} \\
&= \frac{{x_{12}}^4 + {y_{12}}^4 + 2{x_{12}}^2{y_{12}}^2\cos 2\phi_{12}}{({x_{12}}^2 + {y_{12}}^2)^2 \;+\; 4x_{12}y_{12}\,(x_{12}y_{12}\sin^2\phi_{12} - {x_{12}}^2\sin\phi_{12} - {y_{12}}^2\sin\phi_{12})}
\end{aligned}$$

Taking the modulus squared of Eq. (2) gives

$$\left|\frac{q}{p}\right|^2 \;=\; \frac{x^2 + y^2}{{x_{12}}^2 + {y_{12}}^2 + i\,x_{12}y_{12}(e^{i\phi_{12}} - e^{-i\phi_{12}})}$$

$$\Rightarrow \qquad x^2 + y^2 \;=\; \left|\frac{q}{p}\right|^2({x_{12}}^2 + {y_{12}}^2 - 2x_{12}y_{12}\sin\phi_{12}) \tag{3}$$

But matching the real and imaginary parts of Eq. (1) implies

$$x^2 - y^2 \;=\; {x_{12}}^2 - {y_{12}}^2\,, \tag{4}$$

so combining Eqs. (3) and (4) gives

$$x^2 \;=\; \frac{1}{2}\left[{x_{12}}^2\left(\left|\frac{q}{p}\right|^2 + 1\right) \;+\; {y_{12}}^2\left(\left|\frac{q}{p}\right|^2 - 1\right) \;-\; 2\,x_{12}\,y_{12}\left|\frac{q}{p}\right|^2\sin\phi_{12}\right] \tag{5}$$

$$y^2 \;=\; \frac{1}{2}\left[{x_{12}}^2\left(\left|\frac{q}{p}\right|^2 - 1\right) \;+\; {y_{12}}^2\left(\left|\frac{q}{p}\right|^2 + 1\right) \;-\; 2\,x_{12}\,y_{12}\left|\frac{q}{p}\right|^2\sin\phi_{12}\right]. \tag{6}$$

Assuming Γ_{12} is real, squaring Eq. (2) gives

$$\left(\frac{q}{p}\right)^2 = \frac{(x-iy)^2}{(x_{12}\,e^{i\phi_{12}} - iy_{12})^2} = \frac{{x_{12}}^2 - {y_{12}}^2 - i\,2x_{12}y_{12}\cos\phi_{12}}{{x_{12}}^2\,e^{i2\phi_{12}} - {y_{12}}^2 - i\,2x_{12}y_{12}\,e^{i\phi_{12}}}$$

$$= \frac{{x_{12}}^2 - {y_{12}}^2 - i\,2x_{12}y_{12}\cos\phi_{12}}{{x_{12}}^2\cos 2\phi_{12} - {y_{12}}^2 + 2x_{12}y_{12}\sin\phi_{12} \ + \ i({x_{12}}^2\sin 2\phi_{12} - 2x_{12}y_{12}\cos\phi_{12})}\,.$$

This equation has the form

$$\left(\frac{q}{p}\right)^2 = \frac{a \ + \ ib}{c \ + \ id} = \frac{(ac+bd) \ + \ i(bc-ad)}{c^2+d^2}\,,$$

and thus

$$\phi = \mathrm{Arg}\left[\frac{q}{p}\right] = \left(\frac{1}{2}\right)\mathrm{Arg}\left[\left(\frac{q}{p}\right)^2\right]$$

$$= \left(\frac{1}{2}\right)\tan^{-1}\left(\frac{bc-ad}{ac+bd}\right)\,.$$

To calculate ϕ we make the substitutions

$$a = {x_{12}}^2 - {y_{12}}^2$$

$$b = -2x_{12}y_{12}\cos\phi_{12}$$

$$c = {x_{12}}^2\cos 2\phi_{12} - {y_{12}}^2 + 2x_{12}y_{12}\sin\phi_{12}$$

$$d = {x_{12}}^2\sin 2\phi_{12} - 2x_{12}y_{12}\cos\phi_{12}\,.$$