se tiene:

(12)

$$\langle p(t)\rangle = \langle \psi(t)|\hat{p}|\psi(t)\rangle = -\frac{i\hbar\beta}{\sqrt{2}}\langle \psi(t)|\hat{a}-\hat{a}^{\dagger}|\psi(t)\rangle$$

$$= -\frac{i\hbar\beta}{\sqrt{2}}\cdot\frac{1}{2}\left(\left(\langle \alpha e^{-i\Omega t}| - i\langle -\alpha e^{-i\Omega t}|\right)(\hat{a}-\hat{a}^{\dagger})\left(|\alpha e^{-i\Omega t}\rangle + i|-\alpha e^{-i\Omega t}\rangle\right)\right)$$

$$= -\frac{i\hbar\beta}{\sqrt{2}}\Big\{ \cancel{\tfrac{1}{2}(\alpha e^{-i\Omega t} - \alpha^{*}e^{i\Omega t})} - \cancel{\tfrac{1}{2}(\alpha e^{-i\Omega t} - \alpha^{*}e^{i\Omega t})}$$

$$- \frac{i}{2}(\alpha e^{-i\Omega t} + \alpha^{*}e^{i\Omega t})\langle \alpha e^{-i\Omega t}|-\alpha e^{-i\Omega t}\rangle$$

$$- \frac{i}{2}(\alpha^{*}e^{i\Omega t} + \alpha e^{-i\Omega t})\underbrace{\langle -\alpha e^{-i\Omega t}|\alpha e^{-i\Omega t}\rangle}_{= e^{-2|\alpha|^2}}\Big\}$$

$$= -\frac{\hbar\beta}{\sqrt{2}}e^{-2|\alpha|^2}\cdot(\alpha^{*}e^{i\Omega t} + \alpha e^{-i\Omega t})$$

$$= -\sqrt{2}\,\hbar\beta\, e^{-2|\alpha|^2}\cdot \mathrm{Re}(\alpha e^{-i\Omega t})$$