$\omega = 0$			
$\alpha = 0$	$\alpha = 0.4$	$\alpha = 0.6$	$\alpha = 0.7$
$\gamma = 0.247 \pm 0.003$	$\gamma = 0.248 \pm 0.003$	$\gamma = 0.248 \pm 0.001$	$\gamma = 0.245 \pm 0.003$
$\alpha = 1/2$			
$\omega = 0.2$	$\omega = 0.5$	$\omega = 1/\sqrt{2}$	$\omega = 1$
$\gamma = 0.255 \pm 0.006$	$\gamma = 0.259 \pm 0.003$	$\gamma = 0.264 \pm 0.008$	$\gamma = 0.284 \pm 0.001$

TABLE II: Finite size scaling exponents γ for the cases depicted in Fig. 7

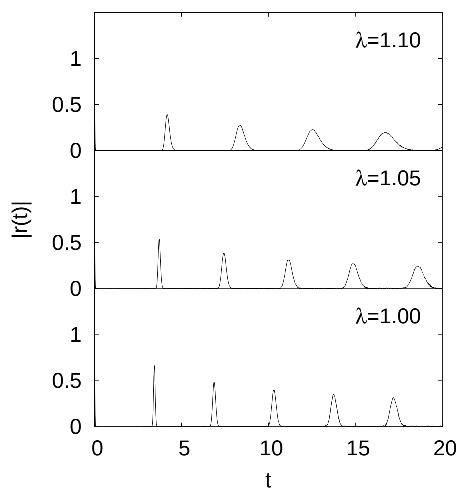

FIG. 8: $|r(t)|$ for $\alpha = 1/2$, $\omega = 1/\sqrt{2}$ and three different values of λ. In all cases $N = 10000$.

However, the numerical estimates seem to increase for larger values of ω; in particular, for the case $\omega = 1$, the result for exponent γ is significatively larger than $\gamma = 1/4$.

B. Decoherence factor for the first order ESQPT

For the case $\omega \neq 0$, the Hamiltonian considered produce, in addition to the continuous ESQPT studied in the preceding subsection, a first order ESQPT at energy $E_c^{(1)}$. This critical energy can be estimated calculating the local minima in the energy surface $\mathcal{H}(\phi, \xi)$, as it is shown in Fig. 4. Inserting this value in Eq. (17) a critical coupling $\lambda_c^{(1)}$ is obtained. For the case $\alpha = 1/2$ and $\omega = 1/\sqrt{2}$ the first order EQSPT is obtained at $\lambda_c^{(1)} \approx 1.05$.

In Fig. 8 we show the exact result for the decoherence factor $|r(t)|$ for $\alpha = 1/2$, $\omega = 1/\sqrt{2}$, and three different values of λ around $\lambda = \lambda_c^{(1)} \approx 1.05$. The most significative result is that