Rothwarf–Taylor equations

- Rate equations describe the interaction between quasiparticles and phonons in the superconductor:

Quasiparticles: \[ \frac{dN_{QP}}{dt} = I_{QP} - RN_{QP}^2 + \frac{2}{\tau_B} N_\omega \]

Phonons: \[ \frac{dN_\omega}{dt} = I_\omega + \frac{1}{2} RN_{QP}^2 - \frac{1}{\tau_B} N_\omega - \frac{1}{\tau_{es}} (N_\omega - N_{\omega T}) \]

- \( N_{QP}, N_\omega, \) and \( N_{\omega T} \) are the number per unit volume of quasiparticles, 2\( \Delta \) phonons, and equilibrium thermal phonons, respectively.

- \( I_{QP} \) is the external generation rate (optical pulse) for the quasiparticles.

- \( I_\omega \) is the 2\( \Delta \) phonon generation rate.

- \( R \) is the recombination rate for the quasiparticles into Cooper pairs.

- \( \tau_B \) and \( \tau_{es} \) are the phonon pair breaking time and the phonon escape times, respectively.