

## The coherence of the $AlGaAs - GaAs$ phonon laser

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To study the emission properties of a  $AlGaAs - GaAs$  phonon laser we develop a formalism similar to that used to describe a laser. The device described here consist of a double barrier resonant tunneling diode tailored to generate an intense rate of primary  $LO_1$  phonons. These phonons are confined in the well and they decay into a pair of secondary  $LO_2$  and  $TA$  phonons. The  $TA$  phonons are emitted by stimulated emission and they are partially reflected in the well walls. The combination of these two processes leads, for injection rates greater than the threshold, to the selection of a single phonon mode. Finally, the  $TA$  phonons escape through the barriers forming an intense coherent phonon beam.

We start with a Hamiltonian that takes into account the electrons, the three phonon branches, the electron-phonon interaction and the phonon-phonon interaction. The last one is the responsible for the  $TA$  phonon generation. From this Hamiltonian we get a set of five coupled Heisenberg-Langevin equations that are solved making an expansion in coherent states and doing the usual adiabatic approximation. The threshold for phonon lasing is calculated.

The results show that it is not necessary to have a big pumping to get a single mode operation. This confirm our previous results obtained using rougher approximations.

The phonon laser studied here has a very short wavelength. The mean free path of  $TA$  phonon is of the order of 2 mm. Therefore it could be useful to do acoustic nanoscopy and other applications