

# Electron-lattice coupling and the superconductivity in hydrogen-rich systems

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Recent development in the high-pressure physics provides us with a new class of the superconducting materials, namely with the hydrogen-rich materials, such as silane ( $\text{SiH}_4$ , transition temperature  $T_c=17\text{K}$  at pressure  $p=96\text{GPa}$ ), hydrogen sulphide ( $\text{H}_{2/3}\text{S}$ ,  $T_c=203\text{K}$  @  $150\text{GPa}$ ) or hydrogen lanthanide ( $\text{H}_{1-x}\text{La}$ ,  $T_c=274\text{--}286\text{K}$  @  $210\text{GPa}$ ).

We investigate the versatility of the molecular-to-atomic transitions in one-, two-, and quasi-three-dimensional hydrogen systems, using our own original approach – the Exact Diagonalization Ab-Initio (edabi) method. Starting from the extended Hubbard model, we examine an electron-correlation-driven conductivity connected with the creation of high-symmetry hydrogen molecular and atomic planes, as well as a series of both structural and electronic-in-nature quantum phase transitions.

We discuss the suppression of molecular nature in a reversed Peierls-like transition under high pressure, as well as the proper van-der-Waals-like effective interaction derived from the first principles of quantum mechanics.

Using effective electron-phonon Hamiltonian we estimate both the zero-point motion of the lattice ions, as well as the electron-lattice coupling. Next, by using the McMillan formula we estimate the superconducting transition temperature versus the effective pressure (external and/or chemical).

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