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**Computational Role of Collective Tunneling in a Quantum Annealer** HARTMUT NEVEN, Google, VADIM SMELYANSKIY, NASA, SERGIO BOIXO, ALIREZA SHABANI, SERGEI ISAKOV, Google, MARK DYKMAN, Michigan State University, VASIL DENCHEV, Google, MOHAMMAD AMIN, ANATOLY SMIRNOV, D-Wave, MASOUD MOHSENI, Google — We show that quantum resources in the D-Wave Two processor enhance the probability to reach the global minimum of an optimization problem. We implemented a series of structural primitives on the device governed by non-convex optimization landscapes consisting of just one global and one false local minima. The quantum adiabatic evolution path over product states connects the initial global minimum with the final false minimum. The final global minimum can only be reached by traversing an energy barrier. Experimentally we found that the D-Wave Two quantum annealer returns the solution that minimizes the energy with consistently higher probability than physically plausible models of the hardware that only employ product states and thermal activation over the barrier and do not allow for multiqubit tunneling transitions. On the contrary open system quantum mechanical models are in very close correspondence with the hardware data without using any fitting parameters. We additionally performed a series of experiments in which we varied the temperature of the chip. We find that the observed correlation between the temperature and success probability is consistent only with quantum models. We also demonstrate that the success probabilities of path integral Monte Carlo are consistently lo

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