

# Supplementary Information for Lossy compression of statistical data using quantum annealer

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## 1 Performance of Simulated Annealing Sampler

In this section, we evaluate the quality of the D-Wave's simulated annealing sampler. Consider a problem finding  $N_q$  binary coefficients  $\mathbf{a} \in \{0, 1\}^{N_q}$  of the positive powers of  $r^{-1} < 1$  that precisely reconstruct a uniform random number  $z \in [0, 1)$  by minimizing the following reconstruction error

$$E = \left| z - \frac{1}{R} \sum_{n=1}^{N_q} a_n r^{-n} \right| \quad \text{where } R \equiv \sum_{n=1}^{\infty} r^{-n}. \quad (1)$$

The optimization problem can be converted into QUBO form of the main text Eq. (3) by the taking the transformation given in the main Eq. (4) after replacing  $\phi$  and  $\mathbf{X}$  with the vector of  $\{r^{-n}/R\}$  and  $z$ , respectively,

$$\phi \rightarrow \begin{bmatrix} r^{-1}/R \\ r^{-2}/R \\ r^{-3}/R \\ \vdots \\ r^{-N_q}/R \end{bmatrix}, \quad \mathbf{X} \rightarrow z.$$

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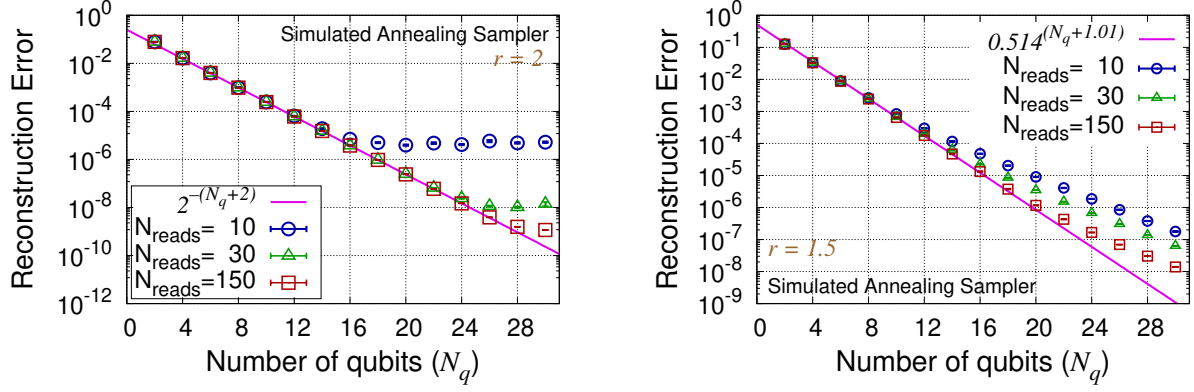


Figure S1: Average reconstruction error defined in the main text Eq. (17) for different number of reads (10, 30, and 150) of the simulated annealing sampler for  $r = 2$  (left) and  $r = 1.5$  (right). The expected average reconstruction error of the ideal QUBO solver is plotted as a magenta line.

We solve the QUBO problem using D-Wave's simulated annealing sampler on a classical computer by taking the minimum energy solution from the three different choices of  $num\_reads = 10, 30$ , and  $150$ , keeping other sampler parameters set to default, for  $10^5$  random numbers of  $r$  and calculate the average value of the reconstruction error  $E$ . The study is done at two different values of  $r = 2$  and  $1.5$ . When  $r = 2$ , it becomes a simple decimal to binary conversion problem, whose optimal solution is known. The expected value of the average reconstruction error for an ideal QUBO solver for  $N_q \gg 1$  is  $2^{-(N_q+2)}$ . For  $r = 1.5$ , we calculate the empirical average reconstruction error of an ideal QUBO solver by fitting the average values of the reconstruction errors obtained using the exact solver implemented in the D-Wave Ocean library, which finds the minimum energy solution by comparing the energies of all possible solutions. The two free parameters of the fitting functional form  $a^{N_q+b}$  are determined to be  $a = 0.514(2)$  and  $b = 1.01(6)$  from the 7 data points at  $N_q = 8, 10, 12, \dots, 20$  with the  $\chi^2/\text{dof} = 1.26$ .

Figure S1 shows that a larger number of reads makes the reconstruction error smaller, the problems with the larger number of qubits require the larger number of reads to make the solution close to the exact solution. Results show that the simulated annealing sampler with  $num\_reads=150$  gives the solution close to the ground-energy up to  $N_q \approx 20$ , but it may depend on the problem, as demonstrated by the difference between the  $r = 1.5$  and  $r = 2$  cases.