

QSpace: tDMRG for the 1D XY model

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We simulate the real-time evolution using the time-dependent DMRG (t-DMRG) in QSpace for the one-dimensional XY model,

$$H_{XY} = \sum_i S_i^x S_{i+1}^x + S_i^y S_{i+1}^y.$$

Following [Phys. Rev. E. 71, 036102 \(2005\)](#), we study the time evolution with an initial state $|\Psi(t=0)\rangle = |\uparrow \cdots \uparrow \downarrow \cdots \downarrow\rangle$. The domain wall at the center of the chain will delocalize over time, and the magnetization profile in the infinite chain limit ($N_{\text{site}} \rightarrow \infty$) reads,

$$\langle \Psi(t) | \hat{S}_\ell^z | \Psi(t) \rangle = \frac{-1}{2} \sum_{n=1-(\ell-N_{\text{site}}/2)}^{(\ell-N/2)-1} [J_n(t)]^2, \quad \text{for } \ell > N_{\text{site}}/2,$$

and $\langle \Psi(t) | \hat{S}_\ell^z | \Psi(t) \rangle = -\langle \Psi(t) | \hat{S}_{N-\ell}^z | \Psi(t) \rangle$, where $J_n(t)$ is the Bessel function of the first kind.

Exercise (a): t-DMRG error analysis

Complete the function `TDMRG_ex.m` which is zipped together with this tutorial material.

Here we benchmark t-DMRG with $N_{\text{site}} = 50$ upto $t = 20$. We fix the bond dimension $D = 20$ and the time step $dt = 0.05$ though out, with the Trotter decompositions from the 1st order upto the 4th order:

```
clear all;
addpath(genpath('./lib'));

%% Basic Operators
[ss, info] = getLocalSpace('Spin' , 1/2, '-A', '-v');
eid = info.E;
vac = getvac(eid, [1]);
opI = QSpace(permuteQS(QCREATE(eid, '1', vac, '1*', 'OUT'), [1,3,2]));
sz = ss(1);
sm = ss(2);
sp = ss(3);
opI_T = permute(opI, [3,2,1], 'conj');
sz_T = permute(sz, [3,2,1], 'conj');
sm_T = permute(sm, [3,2,1], 'conj');
sp_T = permute(sp, [3,2,1], 'conj');

%% tDMRG parameters
NSITE = 50;
DKEEP = 20;
TMAX = 20;
DT = 0.05;
NSTEP = ceil(TMAX/DT);
```

```

%% XY model
ham = contract(sm, [3], sp_T, [1]) + contract(sp, [3], sm_T, [1]) + ...
    realmin * contract(opI, [3], opI_T, [1]);
ham = repmat(ham, [NSITE-1,1]);

```

1-st order Trotter (D=20):

```

ORDER = 1;
[IDX, GATE] = TROTTER(ham, ORDER, DT);
%% initial state as |up>|up>...|up>|down>...|down> with a single domain wall at the center
MPS = QSpace(NSITE,1);
MPS(1) = QCREATE(vac, '1', eid, '1', 'OUT');
MPS(1) = getsub(MPS(1), 2);
for isite = 2 : ceil(NSITE/2)
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 2);
end
for isite = ceil(NSITE/2)+1 : NSITE
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 1);
end

%% run tDMRG
SZ1 = zeros(NSTEP, NSITE);
EE1 = zeros(NSTEP, 1);
for istep = 1 : NSTEP
    time = tic;
    [MPS, err] = TDMRG_ex(MPS, GATE, DKEEP, IDX);
    if ~mod(ORDER, 2)
        IDX = flip(IDX);
        GATE = flip(GATE);
    end

    % measure Sz on each site
    [mpsB, ~] = CANONICAL(MPS, [], NSITE, 0, 1E-16, -1);
    eyeL = QSpace(NSITE, 1);
    eyeL(1) = QCREATE(mpsB(1), '1', 'OUT');
    for isite = 1 : NSITE
        tmp = contract(eyeL(isite), [1], conj(mpsB(isite)), [1]);
        if (isite~=NSITE)
            eyeL(isite+1) = contract(tmp, [1,2], mpsB(isite), [1,2]);
        end
        tmp = contract(tmp, [2], sz, [1]);
        tmp = contract(tmp, [1,3,2], mpsB(isite), [1,2,3]);
        SZ1(istep, isite) = real(tmp.data{1});
    end

    % measure half chain entanglement entropy
    [~, lambda] = CANONICAL(mpsB, [], 0, NSITE/2, 1E-16, -1);
    EE1(istep) = SEntropy(contract(lambda, [2], lambda, [1]));
    fprintf('Step: %5d, Entropy= %10.3e, Error= %10.3e >>> %9.2f sec \n', ...
        istep, EE1(istep), err, toc(time));
end

```

Step:	1,	Entropy=	5.235e-03,	Error=	0.000e+00 >>>	2.70 sec
Step:	2,	Entropy=	1.746e-02,	Error=	0.000e+00 >>>	2.66 sec
Step:	3,	Entropy=	3.467e-02,	Error=	0.000e+00 >>>	2.64 sec
Step:	4,	Entropy=	5.578e-02,	Error=	2.220e-16 >>>	2.64 sec
Step:	5,	Entropy=	7.999e-02,	Error=	0.000e+00 >>>	2.63 sec
Step:	6,	Entropy=	1.067e-01,	Error=	0.000e+00 >>>	2.64 sec
Step:	7,	Entropy=	1.353e-01,	Error=	0.000e+00 >>>	2.65 sec
Step:	8,	Entropy=	1.654e-01,	Error=	0.000e+00 >>>	2.65 sec
Step:	9,	Entropy=	1.967e-01,	Error=	0.000e+00 >>>	2.63 sec
Step:	10,	Entropy=	2.286e-01,	Error=	0.000e+00 >>>	2.66 sec
Step:	11,	Entropy=	2.610e-01,	Error=	0.000e+00 >>>	2.65 sec
Step:	12,	Entropy=	2.934e-01,	Error=	0.000e+00 >>>	2.66 sec
Step:	13,	Entropy=	3.257e-01,	Error=	0.000e+00 >>>	2.67 sec
Step:	14,	Entropy=	3.576e-01,	Error=	0.000e+00 >>>	2.67 sec
Step:	15,	Entropy=	3.889e-01,	Error=	0.000e+00 >>>	2.66 sec
Step:	16,	Entropy=	4.193e-01,	Error=	0.000e+00 >>>	2.66 sec
Step:	17,	Entropy=	4.487e-01,	Error=	0.000e+00 >>>	2.68 sec
Step:	18,	Entropy=	4.770e-01,	Error=	0.000e+00 >>>	2.69 sec
Step:	19,	Entropy=	5.039e-01,	Error=	0.000e+00 >>>	2.68 sec
Step:	20,	Entropy=	5.294e-01,	Error=	0.000e+00 >>>	2.69 sec
Step:	21,	Entropy=	5.534e-01,	Error=	0.000e+00 >>>	2.70 sec
Step:	22,	Entropy=	5.758e-01,	Error=	0.000e+00 >>>	2.69 sec
Step:	23,	Entropy=	5.966e-01,	Error=	0.000e+00 >>>	2.68 sec
Step:	24,	Entropy=	6.156e-01,	Error=	0.000e+00 >>>	2.69 sec
Step:	25,	Entropy=	6.328e-01,	Error=	0.000e+00 >>>	2.69 sec
Step:	26,	Entropy=	6.483e-01,	Error=	2.220e-16 >>>	2.69 sec
Step:	27,	Entropy=	6.620e-01,	Error=	0.000e+00 >>>	2.71 sec
Step:	28,	Entropy=	6.739e-01,	Error=	0.000e+00 >>>	2.70 sec
Step:	29,	Entropy=	6.841e-01,	Error=	0.000e+00 >>>	2.71 sec
Step:	30,	Entropy=	6.926e-01,	Error=	2.220e-16 >>>	2.70 sec
Step:	31,	Entropy=	6.994e-01,	Error=	0.000e+00 >>>	2.73 sec
Step:	32,	Entropy=	7.047e-01,	Error=	0.000e+00 >>>	2.73 sec
Step:	33,	Entropy=	7.084e-01,	Error=	0.000e+00 >>>	2.74 sec
Step:	34,	Entropy=	7.107e-01,	Error=	2.220e-16 >>>	2.75 sec
Step:	35,	Entropy=	7.116e-01,	Error=	0.000e+00 >>>	2.76 sec
Step:	36,	Entropy=	7.113e-01,	Error=	0.000e+00 >>>	2.74 sec
Step:	37,	Entropy=	7.098e-01,	Error=	0.000e+00 >>>	2.74 sec
Step:	38,	Entropy=	7.073e-01,	Error=	0.000e+00 >>>	2.74 sec
Step:	39,	Entropy=	7.038e-01,	Error=	0.000e+00 >>>	2.73 sec
Step:	40,	Entropy=	6.994e-01,	Error=	2.220e-16 >>>	2.72 sec
Step:	41,	Entropy=	6.944e-01,	Error=	0.000e+00 >>>	2.71 sec
Step:	42,	Entropy=	6.888e-01,	Error=	2.220e-16 >>>	2.78 sec
Step:	43,	Entropy=	6.826e-01,	Error=	0.000e+00 >>>	2.77 sec
Step:	44,	Entropy=	6.761e-01,	Error=	0.000e+00 >>>	2.74 sec
Step:	45,	Entropy=	6.693e-01,	Error=	0.000e+00 >>>	2.72 sec
Step:	46,	Entropy=	6.624e-01,	Error=	0.000e+00 >>>	2.71 sec
Step:	47,	Entropy=	6.554e-01,	Error=	2.220e-16 >>>	2.72 sec
Step:	48,	Entropy=	6.485e-01,	Error=	0.000e+00 >>>	2.74 sec
Step:	49,	Entropy=	6.417e-01,	Error=	0.000e+00 >>>	2.81 sec
Step:	50,	Entropy=	6.352e-01,	Error=	2.220e-16 >>>	2.82 sec
Step:	51,	Entropy=	6.290e-01,	Error=	2.220e-16 >>>	2.79 sec
Step:	52,	Entropy=	6.233e-01,	Error=	0.000e+00 >>>	3.01 sec
Step:	53,	Entropy=	6.180e-01,	Error=	0.000e+00 >>>	2.91 sec
Step:	54,	Entropy=	6.132e-01,	Error=	2.220e-16 >>>	2.78 sec
Step:	55,	Entropy=	6.091e-01,	Error=	2.220e-16 >>>	2.77 sec
Step:	56,	Entropy=	6.056e-01,	Error=	2.220e-16 >>>	2.81 sec
Step:	57,	Entropy=	6.028e-01,	Error=	2.220e-16 >>>	2.77 sec
Step:	58,	Entropy=	6.007e-01,	Error=	0.000e+00 >>>	2.79 sec
Step:	59,	Entropy=	5.994e-01,	Error=	0.000e+00 >>>	3.26 sec
Step:	60,	Entropy=	5.988e-01,	Error=	0.000e+00 >>>	2.95 sec
Step:	61,	Entropy=	5.990e-01,	Error=	2.220e-16 >>>	2.82 sec
Step:	62,	Entropy=	6.000e-01,	Error=	2.220e-16 >>>	2.83 sec
Step:	63,	Entropy=	6.017e-01,	Error=	2.220e-16 >>>	2.77 sec
Step:	64,	Entropy=	6.042e-01,	Error=	2.220e-16 >>>	2.79 sec

Step:	65,	Entropy=	6.074e-01,	Error=	0.000e+00 >>>	2.83 sec
Step:	66,	Entropy=	6.113e-01,	Error=	0.000e+00 >>>	2.87 sec
Step:	67,	Entropy=	6.158e-01,	Error=	2.220e-16 >>>	2.87 sec
Step:	68,	Entropy=	6.210e-01,	Error=	2.220e-16 >>>	2.87 sec
Step:	69,	Entropy=	6.267e-01,	Error=	2.220e-16 >>>	2.80 sec
Step:	70,	Entropy=	6.330e-01,	Error=	4.441e-16 >>>	2.84 sec
Step:	71,	Entropy=	6.398e-01,	Error=	4.441e-16 >>>	2.78 sec
Step:	72,	Entropy=	6.469e-01,	Error=	6.661e-16 >>>	3.05 sec
Step:	73,	Entropy=	6.544e-01,	Error=	8.882e-16 >>>	2.86 sec
Step:	74,	Entropy=	6.622e-01,	Error=	1.332e-15 >>>	2.84 sec
Step:	75,	Entropy=	6.702e-01,	Error=	1.998e-15 >>>	2.78 sec
Step:	76,	Entropy=	6.784e-01,	Error=	2.665e-15 >>>	2.79 sec
Step:	77,	Entropy=	6.867e-01,	Error=	3.775e-15 >>>	2.79 sec
Step:	78,	Entropy=	6.950e-01,	Error=	5.329e-15 >>>	2.83 sec
Step:	79,	Entropy=	7.032e-01,	Error=	7.327e-15 >>>	2.84 sec
Step:	80,	Entropy=	7.114e-01,	Error=	1.044e-14 >>>	2.80 sec
Step:	81,	Entropy=	7.194e-01,	Error=	1.421e-14 >>>	2.79 sec
Step:	82,	Entropy=	7.272e-01,	Error=	1.976e-14 >>>	2.82 sec
Step:	83,	Entropy=	7.348e-01,	Error=	2.687e-14 >>>	2.79 sec
Step:	84,	Entropy=	7.420e-01,	Error=	3.686e-14 >>>	3.48 sec
Step:	85,	Entropy=	7.489e-01,	Error=	5.018e-14 >>>	2.88 sec
Step:	86,	Entropy=	7.554e-01,	Error=	6.772e-14 >>>	2.85 sec
Step:	87,	Entropy=	7.614e-01,	Error=	9.148e-14 >>>	2.88 sec
Step:	88,	Entropy=	7.670e-01,	Error=	1.228e-13 >>>	2.87 sec
Step:	89,	Entropy=	7.721e-01,	Error=	1.643e-13 >>>	2.92 sec
Step:	90,	Entropy=	7.766e-01,	Error=	2.192e-13 >>>	2.93 sec
Step:	91,	Entropy=	7.807e-01,	Error=	2.913e-13 >>>	2.87 sec
Step:	92,	Entropy=	7.842e-01,	Error=	3.859e-13 >>>	2.92 sec
Step:	93,	Entropy=	7.871e-01,	Error=	5.094e-13 >>>	2.85 sec
Step:	94,	Entropy=	7.895e-01,	Error=	6.701e-13 >>>	2.89 sec
Step:	95,	Entropy=	7.913e-01,	Error=	8.784e-13 >>>	2.86 sec
Step:	96,	Entropy=	7.926e-01,	Error=	1.148e-12 >>>	2.92 sec
Step:	97,	Entropy=	7.934e-01,	Error=	1.496e-12 >>>	2.88 sec
Step:	98,	Entropy=	7.936e-01,	Error=	1.943e-12 >>>	2.88 sec
Step:	99,	Entropy=	7.934e-01,	Error=	2.516e-12 >>>	2.86 sec
Step:	100,	Entropy=	7.928e-01,	Error=	3.248e-12 >>>	2.86 sec
Step:	101,	Entropy=	7.917e-01,	Error=	4.181e-12 >>>	2.85 sec
Step:	102,	Entropy=	7.903e-01,	Error=	5.366e-12 >>>	2.90 sec
Step:	103,	Entropy=	7.885e-01,	Error=	6.867e-12 >>>	2.86 sec
Step:	104,	Entropy=	7.864e-01,	Error=	8.763e-12 >>>	2.94 sec
Step:	105,	Entropy=	7.840e-01,	Error=	1.115e-11 >>>	2.86 sec
Step:	106,	Entropy=	7.814e-01,	Error=	1.415e-11 >>>	2.92 sec
Step:	107,	Entropy=	7.786e-01,	Error=	1.790e-11 >>>	2.90 sec
Step:	108,	Entropy=	7.758e-01,	Error=	2.259e-11 >>>	2.98 sec
Step:	109,	Entropy=	7.728e-01,	Error=	2.844e-11 >>>	3.04 sec
Step:	110,	Entropy=	7.698e-01,	Error=	3.569e-11 >>>	2.91 sec
Step:	111,	Entropy=	7.668e-01,	Error=	4.468e-11 >>>	3.01 sec
Step:	112,	Entropy=	7.638e-01,	Error=	5.013e-11 >>>	3.04 sec
Step:	113,	Entropy=	7.610e-01,	Error=	1.688e-11 >>>	3.06 sec
Step:	114,	Entropy=	7.583e-01,	Error=	1.928e-11 >>>	2.88 sec
Step:	115,	Entropy=	7.558e-01,	Error=	2.201e-11 >>>	2.91 sec
Step:	116,	Entropy=	7.534e-01,	Error=	2.509e-11 >>>	3.01 sec
Step:	117,	Entropy=	7.514e-01,	Error=	2.858e-11 >>>	2.91 sec
Step:	118,	Entropy=	7.496e-01,	Error=	3.251e-11 >>>	3.05 sec
Step:	119,	Entropy=	7.481e-01,	Error=	3.693e-11 >>>	2.92 sec
Step:	120,	Entropy=	7.469e-01,	Error=	4.191e-11 >>>	2.91 sec
Step:	121,	Entropy=	7.461e-01,	Error=	4.750e-11 >>>	2.95 sec
Step:	122,	Entropy=	7.457e-01,	Error=	5.378e-11 >>>	2.96 sec
Step:	123,	Entropy=	7.456e-01,	Error=	6.082e-11 >>>	3.00 sec
Step:	124,	Entropy=	7.459e-01,	Error=	6.871e-11 >>>	2.88 sec
Step:	125,	Entropy=	7.467e-01,	Error=	7.755e-11 >>>	2.90 sec
Step:	126,	Entropy=	7.477e-01,	Error=	8.746e-11 >>>	2.90 sec
Step:	127,	Entropy=	7.492e-01,	Error=	9.856e-11 >>>	2.89 sec
Step:	128,	Entropy=	7.511e-01,	Error=	1.110e-10 >>>	2.94 sec
Step:	129,	Entropy=	7.533e-01,	Error=	1.250e-10 >>>	3.03 sec

Step:	130,	Entropy=	7.559e-01,	Error=	1.407e-10 >>>	2.94 sec
Step:	131,	Entropy=	7.588e-01,	Error=	1.584e-10 >>>	2.96 sec
Step:	132,	Entropy=	7.620e-01,	Error=	1.784e-10 >>>	3.02 sec
Step:	133,	Entropy=	7.655e-01,	Error=	2.010e-10 >>>	2.97 sec
Step:	134,	Entropy=	7.692e-01,	Error=	2.266e-10 >>>	3.14 sec
Step:	135,	Entropy=	7.732e-01,	Error=	2.558e-10 >>>	3.02 sec
Step:	136,	Entropy=	7.774e-01,	Error=	2.890e-10 >>>	3.05 sec
Step:	137,	Entropy=	7.818e-01,	Error=	3.271e-10 >>>	3.06 sec
Step:	138,	Entropy=	7.863e-01,	Error=	3.708e-10 >>>	2.99 sec
Step:	139,	Entropy=	7.909e-01,	Error=	4.212e-10 >>>	2.91 sec
Step:	140,	Entropy=	7.955e-01,	Error=	4.795e-10 >>>	3.03 sec
Step:	141,	Entropy=	8.002e-01,	Error=	5.472e-10 >>>	3.06 sec
Step:	142,	Entropy=	8.049e-01,	Error=	6.259e-10 >>>	3.04 sec
Step:	143,	Entropy=	8.095e-01,	Error=	7.178e-10 >>>	3.03 sec
Step:	144,	Entropy=	8.140e-01,	Error=	8.255e-10 >>>	3.04 sec
Step:	145,	Entropy=	8.185e-01,	Error=	9.518e-10 >>>	2.96 sec
Step:	146,	Entropy=	8.228e-01,	Error=	1.100e-09 >>>	2.95 sec
Step:	147,	Entropy=	8.269e-01,	Error=	1.275e-09 >>>	3.10 sec
Step:	148,	Entropy=	8.308e-01,	Error=	1.481e-09 >>>	3.03 sec
Step:	149,	Entropy=	8.346e-01,	Error=	1.725e-09 >>>	3.02 sec
Step:	150,	Entropy=	8.380e-01,	Error=	1.956e-09 >>>	3.01 sec
Step:	151,	Entropy=	8.412e-01,	Error=	1.389e-09 >>>	3.09 sec
Step:	152,	Entropy=	8.441e-01,	Error=	1.638e-09 >>>	2.95 sec
Step:	153,	Entropy=	8.467e-01,	Error=	1.940e-09 >>>	2.99 sec
Step:	154,	Entropy=	8.490e-01,	Error=	2.307e-09 >>>	3.07 sec
Step:	155,	Entropy=	8.510e-01,	Error=	2.685e-09 >>>	3.04 sec
Step:	156,	Entropy=	8.527e-01,	Error=	9.558e-10 >>>	3.10 sec
Step:	157,	Entropy=	8.540e-01,	Error=	1.017e-09 >>>	3.01 sec
Step:	158,	Entropy=	8.550e-01,	Error=	1.083e-09 >>>	2.99 sec
Step:	159,	Entropy=	8.557e-01,	Error=	1.152e-09 >>>	3.09 sec
Step:	160,	Entropy=	8.561e-01,	Error=	1.227e-09 >>>	3.09 sec
Step:	161,	Entropy=	8.562e-01,	Error=	1.306e-09 >>>	3.05 sec
Step:	162,	Entropy=	8.559e-01,	Error=	1.392e-09 >>>	3.08 sec
Step:	163,	Entropy=	8.555e-01,	Error=	1.483e-09 >>>	3.11 sec
Step:	164,	Entropy=	8.547e-01,	Error=	1.582e-09 >>>	3.10 sec
Step:	165,	Entropy=	8.537e-01,	Error=	1.689e-09 >>>	3.09 sec
Step:	166,	Entropy=	8.526e-01,	Error=	1.783e-09 >>>	3.12 sec
Step:	167,	Entropy=	8.512e-01,	Error=	1.031e-09 >>>	3.18 sec
Step:	168,	Entropy=	8.496e-01,	Error=	1.158e-09 >>>	3.04 sec
Step:	169,	Entropy=	8.480e-01,	Error=	1.301e-09 >>>	3.07 sec
Step:	170,	Entropy=	8.462e-01,	Error=	1.460e-09 >>>	3.00 sec
Step:	171,	Entropy=	8.443e-01,	Error=	1.639e-09 >>>	3.14 sec
Step:	172,	Entropy=	8.424e-01,	Error=	1.838e-09 >>>	3.11 sec
Step:	173,	Entropy=	8.405e-01,	Error=	2.060e-09 >>>	3.04 sec
Step:	174,	Entropy=	8.386e-01,	Error=	2.308e-09 >>>	3.07 sec
Step:	175,	Entropy=	8.367e-01,	Error=	2.585e-09 >>>	2.99 sec
Step:	176,	Entropy=	8.349e-01,	Error=	2.893e-09 >>>	3.08 sec
Step:	177,	Entropy=	8.332e-01,	Error=	2.853e-09 >>>	3.01 sec
Step:	178,	Entropy=	8.316e-01,	Error=	1.042e-09 >>>	3.13 sec
Step:	179,	Entropy=	8.301e-01,	Error=	1.193e-09 >>>	3.13 sec
Step:	180,	Entropy=	8.288e-01,	Error=	1.424e-09 >>>	3.06 sec
Step:	181,	Entropy=	8.277e-01,	Error=	1.708e-09 >>>	3.09 sec
Step:	182,	Entropy=	8.268e-01,	Error=	2.056e-09 >>>	3.11 sec
Step:	183,	Entropy=	8.261e-01,	Error=	2.482e-09 >>>	3.05 sec
Step:	184,	Entropy=	8.256e-01,	Error=	3.000e-09 >>>	3.13 sec
Step:	185,	Entropy=	8.254e-01,	Error=	3.630e-09 >>>	3.14 sec
Step:	186,	Entropy=	8.254e-01,	Error=	4.392e-09 >>>	3.07 sec
Step:	187,	Entropy=	8.257e-01,	Error=	4.940e-09 >>>	3.15 sec
Step:	188,	Entropy=	8.262e-01,	Error=	1.133e-09 >>>	3.06 sec
Step:	189,	Entropy=	8.270e-01,	Error=	1.141e-09 >>>	3.13 sec
Step:	190,	Entropy=	8.281e-01,	Error=	1.145e-09 >>>	3.06 sec
Step:	191,	Entropy=	8.294e-01,	Error=	1.176e-09 >>>	3.05 sec
Step:	192,	Entropy=	8.310e-01,	Error=	1.268e-09 >>>	3.12 sec
Step:	193,	Entropy=	8.328e-01,	Error=	1.369e-09 >>>	3.08 sec
Step:	194,	Entropy=	8.348e-01,	Error=	1.482e-09 >>>	3.03 sec

Step:	195,	Entropy=	8.370e-01,	Error=	1.606e-09 >>>	3.08 sec
Step:	196,	Entropy=	8.395e-01,	Error=	1.745e-09 >>>	3.08 sec
Step:	197,	Entropy=	8.421e-01,	Error=	1.899e-09 >>>	3.13 sec
Step:	198,	Entropy=	8.448e-01,	Error=	2.071e-09 >>>	3.21 sec
Step:	199,	Entropy=	8.477e-01,	Error=	2.261e-09 >>>	3.17 sec
Step:	200,	Entropy=	8.508e-01,	Error=	2.474e-09 >>>	3.12 sec
Step:	201,	Entropy=	8.539e-01,	Error=	2.710e-09 >>>	3.08 sec
Step:	202,	Entropy=	8.571e-01,	Error=	2.972e-09 >>>	3.20 sec
Step:	203,	Entropy=	8.603e-01,	Error=	3.264e-09 >>>	3.16 sec
Step:	204,	Entropy=	8.635e-01,	Error=	3.589e-09 >>>	3.22 sec
Step:	205,	Entropy=	8.668e-01,	Error=	3.950e-09 >>>	3.23 sec
Step:	206,	Entropy=	8.700e-01,	Error=	4.350e-09 >>>	3.21 sec
Step:	207,	Entropy=	8.731e-01,	Error=	4.795e-09 >>>	3.71 sec
Step:	208,	Entropy=	8.762e-01,	Error=	5.275e-09 >>>	3.26 sec
Step:	209,	Entropy=	8.792e-01,	Error=	2.401e-09 >>>	3.14 sec
Step:	210,	Entropy=	8.821e-01,	Error=	2.495e-09 >>>	3.13 sec
Step:	211,	Entropy=	8.848e-01,	Error=	2.606e-09 >>>	3.10 sec
Step:	212,	Entropy=	8.874e-01,	Error=	2.739e-09 >>>	3.25 sec
Step:	213,	Entropy=	8.898e-01,	Error=	3.285e-09 >>>	3.16 sec
Step:	214,	Entropy=	8.920e-01,	Error=	3.981e-09 >>>	3.12 sec
Step:	215,	Entropy=	8.940e-01,	Error=	4.826e-09 >>>	3.28 sec
Step:	216,	Entropy=	8.958e-01,	Error=	5.847e-09 >>>	3.20 sec
Step:	217,	Entropy=	8.974e-01,	Error=	7.078e-09 >>>	3.24 sec
Step:	218,	Entropy=	8.988e-01,	Error=	7.369e-09 >>>	3.26 sec
Step:	219,	Entropy=	8.999e-01,	Error=	5.852e-09 >>>	3.21 sec
Step:	220,	Entropy=	9.008e-01,	Error=	7.027e-09 >>>	3.24 sec
Step:	221,	Entropy=	9.015e-01,	Error=	8.452e-09 >>>	3.27 sec
Step:	222,	Entropy=	9.019e-01,	Error=	1.017e-08 >>>	3.15 sec
Step:	223,	Entropy=	9.022e-01,	Error=	1.224e-08 >>>	3.38 sec
Step:	224,	Entropy=	9.022e-01,	Error=	1.340e-08 >>>	3.33 sec
Step:	225,	Entropy=	9.020e-01,	Error=	2.305e-09 >>>	3.34 sec
Step:	226,	Entropy=	9.016e-01,	Error=	2.258e-09 >>>	3.22 sec
Step:	227,	Entropy=	9.010e-01,	Error=	2.210e-09 >>>	3.22 sec
Step:	228,	Entropy=	9.003e-01,	Error=	2.162e-09 >>>	3.21 sec
Step:	229,	Entropy=	8.994e-01,	Error=	2.190e-09 >>>	3.08 sec
Step:	230,	Entropy=	8.984e-01,	Error=	2.411e-09 >>>	3.14 sec
Step:	231,	Entropy=	8.973e-01,	Error=	2.662e-09 >>>	3.19 sec
Step:	232,	Entropy=	8.960e-01,	Error=	2.945e-09 >>>	3.16 sec
Step:	233,	Entropy=	8.948e-01,	Error=	3.264e-09 >>>	3.25 sec
Step:	234,	Entropy=	8.934e-01,	Error=	3.624e-09 >>>	3.20 sec
Step:	235,	Entropy=	8.920e-01,	Error=	4.028e-09 >>>	3.36 sec
Step:	236,	Entropy=	8.906e-01,	Error=	4.482e-09 >>>	3.21 sec
Step:	237,	Entropy=	8.892e-01,	Error=	4.993e-09 >>>	3.26 sec
Step:	238,	Entropy=	8.879e-01,	Error=	5.564e-09 >>>	3.17 sec
Step:	239,	Entropy=	8.866e-01,	Error=	6.003e-09 >>>	3.24 sec
Step:	240,	Entropy=	8.853e-01,	Error=	4.513e-09 >>>	3.24 sec
Step:	241,	Entropy=	8.842e-01,	Error=	5.051e-09 >>>	3.40 sec
Step:	242,	Entropy=	8.832e-01,	Error=	5.662e-09 >>>	3.30 sec
Step:	243,	Entropy=	8.823e-01,	Error=	6.356e-09 >>>	3.14 sec
Step:	244,	Entropy=	8.815e-01,	Error=	7.332e-09 >>>	3.17 sec
Step:	245,	Entropy=	8.808e-01,	Error=	8.877e-09 >>>	3.15 sec
Step:	246,	Entropy=	8.804e-01,	Error=	9.992e-09 >>>	3.27 sec
Step:	247,	Entropy=	8.801e-01,	Error=	7.536e-09 >>>	3.17 sec
Step:	248,	Entropy=	8.800e-01,	Error=	4.938e-09 >>>	3.17 sec
Step:	249,	Entropy=	8.800e-01,	Error=	5.916e-09 >>>	3.18 sec
Step:	250,	Entropy=	8.803e-01,	Error=	7.128e-09 >>>	3.30 sec
Step:	251,	Entropy=	8.808e-01,	Error=	8.622e-09 >>>	3.26 sec
Step:	252,	Entropy=	8.814e-01,	Error=	1.045e-08 >>>	3.41 sec
Step:	253,	Entropy=	8.823e-01,	Error=	1.267e-08 >>>	3.33 sec
Step:	254,	Entropy=	8.833e-01,	Error=	1.535e-08 >>>	3.31 sec
Step:	255,	Entropy=	8.845e-01,	Error=	1.615e-08 >>>	3.30 sec
Step:	256,	Entropy=	8.859e-01,	Error=	3.298e-09 >>>	3.43 sec
Step:	257,	Entropy=	8.875e-01,	Error=	2.479e-09 >>>	3.32 sec
Step:	258,	Entropy=	8.892e-01,	Error=	2.523e-09 >>>	3.29 sec
Step:	259,	Entropy=	8.911e-01,	Error=	2.782e-09 >>>	3.36 sec

Step:	260,	Entropy=	8.931e-01,	Error=	3.094e-09 >>>	3.33 sec
Step:	261,	Entropy=	8.952e-01,	Error=	3.448e-09 >>>	3.21 sec
Step:	262,	Entropy=	8.974e-01,	Error=	3.848e-09 >>>	3.31 sec
Step:	263,	Entropy=	8.997e-01,	Error=	4.301e-09 >>>	3.29 sec
Step:	264,	Entropy=	9.021e-01,	Error=	4.811e-09 >>>	3.30 sec
Step:	265,	Entropy=	9.045e-01,	Error=	5.386e-09 >>>	3.31 sec
Step:	266,	Entropy=	9.069e-01,	Error=	6.032e-09 >>>	3.36 sec
Step:	267,	Entropy=	9.094e-01,	Error=	6.756e-09 >>>	3.37 sec
Step:	268,	Entropy=	9.118e-01,	Error=	7.276e-09 >>>	3.25 sec
Step:	269,	Entropy=	9.142e-01,	Error=	4.761e-09 >>>	3.22 sec
Step:	270,	Entropy=	9.166e-01,	Error=	5.783e-09 >>>	3.29 sec
Step:	271,	Entropy=	9.189e-01,	Error=	7.019e-09 >>>	3.37 sec
Step:	272,	Entropy=	9.211e-01,	Error=	8.509e-09 >>>	3.35 sec
Step:	273,	Entropy=	9.233e-01,	Error=	1.030e-08 >>>	3.38 sec
Step:	274,	Entropy=	9.253e-01,	Error=	1.230e-08 >>>	3.36 sec
Step:	275,	Entropy=	9.272e-01,	Error=	7.771e-09 >>>	3.28 sec
Step:	276,	Entropy=	9.290e-01,	Error=	8.755e-09 >>>	3.27 sec
Step:	277,	Entropy=	9.306e-01,	Error=	9.876e-09 >>>	3.44 sec
Step:	278,	Entropy=	9.321e-01,	Error=	1.110e-08 >>>	3.27 sec
Step:	279,	Entropy=	9.334e-01,	Error=	1.167e-08 >>>	3.40 sec
Step:	280,	Entropy=	9.346e-01,	Error=	1.216e-08 >>>	3.34 sec
Step:	281,	Entropy=	9.356e-01,	Error=	8.786e-09 >>>	3.21 sec
Step:	282,	Entropy=	9.364e-01,	Error=	1.073e-08 >>>	3.46 sec
Step:	283,	Entropy=	9.370e-01,	Error=	1.310e-08 >>>	3.35 sec
Step:	284,	Entropy=	9.374e-01,	Error=	1.598e-08 >>>	3.26 sec
Step:	285,	Entropy=	9.377e-01,	Error=	1.945e-08 >>>	3.27 sec
Step:	286,	Entropy=	9.378e-01,	Error=	2.361e-08 >>>	3.36 sec
Step:	287,	Entropy=	9.377e-01,	Error=	2.857e-08 >>>	3.37 sec
Step:	288,	Entropy=	9.375e-01,	Error=	3.446e-08 >>>	3.36 sec
Step:	289,	Entropy=	9.372e-01,	Error=	3.983e-08 >>>	3.44 sec
Step:	290,	Entropy=	9.367e-01,	Error=	2.893e-08 >>>	3.49 sec
Step:	291,	Entropy=	9.360e-01,	Error=	1.603e-08 >>>	3.34 sec
Step:	292,	Entropy=	9.353e-01,	Error=	1.857e-08 >>>	3.25 sec
Step:	293,	Entropy=	9.345e-01,	Error=	5.458e-09 >>>	3.24 sec
Step:	294,	Entropy=	9.336e-01,	Error=	6.138e-09 >>>	3.45 sec
Step:	295,	Entropy=	9.326e-01,	Error=	6.902e-09 >>>	3.43 sec
Step:	296,	Entropy=	9.316e-01,	Error=	7.759e-09 >>>	3.44 sec
Step:	297,	Entropy=	9.305e-01,	Error=	7.972e-09 >>>	3.39 sec
Step:	298,	Entropy=	9.294e-01,	Error=	8.871e-09 >>>	3.39 sec
Step:	299,	Entropy=	9.283e-01,	Error=	1.074e-08 >>>	3.41 sec
Step:	300,	Entropy=	9.273e-01,	Error=	1.297e-08 >>>	3.35 sec
Step:	301,	Entropy=	9.262e-01,	Error=	1.336e-08 >>>	3.46 sec
Step:	302,	Entropy=	9.252e-01,	Error=	4.846e-09 >>>	3.41 sec
Step:	303,	Entropy=	9.243e-01,	Error=	5.678e-09 >>>	3.49 sec
Step:	304,	Entropy=	9.235e-01,	Error=	6.686e-09 >>>	3.47 sec
Step:	305,	Entropy=	9.227e-01,	Error=	7.902e-09 >>>	3.46 sec
Step:	306,	Entropy=	9.220e-01,	Error=	9.365e-09 >>>	3.40 sec
Step:	307,	Entropy=	9.215e-01,	Error=	1.112e-08 >>>	3.49 sec
Step:	308,	Entropy=	9.211e-01,	Error=	1.321e-08 >>>	3.40 sec
Step:	309,	Entropy=	9.208e-01,	Error=	1.569e-08 >>>	3.53 sec
Step:	310,	Entropy=	9.207e-01,	Error=	1.864e-08 >>>	3.47 sec
Step:	311,	Entropy=	9.207e-01,	Error=	2.154e-08 >>>	3.35 sec
Step:	312,	Entropy=	9.208e-01,	Error=	1.733e-08 >>>	3.45 sec
Step:	313,	Entropy=	9.212e-01,	Error=	1.965e-08 >>>	3.45 sec
Step:	314,	Entropy=	9.216e-01,	Error=	2.225e-08 >>>	3.45 sec
Step:	315,	Entropy=	9.223e-01,	Error=	2.677e-08 >>>	3.49 sec
Step:	316,	Entropy=	9.230e-01,	Error=	3.256e-08 >>>	3.46 sec
Step:	317,	Entropy=	9.240e-01,	Error=	3.944e-08 >>>	3.41 sec
Step:	318,	Entropy=	9.251e-01,	Error=	4.066e-08 >>>	3.26 sec
Step:	319,	Entropy=	9.263e-01,	Error=	3.792e-08 >>>	3.47 sec
Step:	320,	Entropy=	9.276e-01,	Error=	4.479e-08 >>>	3.56 sec
Step:	321,	Entropy=	9.291e-01,	Error=	5.210e-08 >>>	3.47 sec
Step:	322,	Entropy=	9.307e-01,	Error=	2.639e-08 >>>	3.40 sec
Step:	323,	Entropy=	9.324e-01,	Error=	2.891e-08 >>>	3.45 sec
Step:	324,	Entropy=	9.341e-01,	Error=	3.165e-08 >>>	3.39 sec

Step:	325,	Entropy=	9.360e-01,	Error=	3.462e-08 >>>	3.51 sec
Step:	326,	Entropy=	9.379e-01,	Error=	3.783e-08 >>>	3.55 sec
Step:	327,	Entropy=	9.398e-01,	Error=	4.129e-08 >>>	3.40 sec
Step:	328,	Entropy=	9.418e-01,	Error=	4.502e-08 >>>	3.50 sec
Step:	329,	Entropy=	9.438e-01,	Error=	4.903e-08 >>>	3.53 sec
Step:	330,	Entropy=	9.458e-01,	Error=	5.686e-08 >>>	3.51 sec
Step:	331,	Entropy=	9.478e-01,	Error=	6.664e-08 >>>	3.50 sec
Step:	332,	Entropy=	9.498e-01,	Error=	7.779e-08 >>>	3.47 sec
Step:	333,	Entropy=	9.517e-01,	Error=	9.045e-08 >>>	3.59 sec
Step:	334,	Entropy=	9.536e-01,	Error=	9.476e-08 >>>	3.38 sec
Step:	335,	Entropy=	9.554e-01,	Error=	1.003e-08 >>>	3.46 sec
Step:	336,	Entropy=	9.571e-01,	Error=	1.195e-08 >>>	3.59 sec
Step:	337,	Entropy=	9.587e-01,	Error=	1.425e-08 >>>	3.68 sec
Step:	338,	Entropy=	9.602e-01,	Error=	1.700e-08 >>>	3.61 sec
Step:	339,	Entropy=	9.615e-01,	Error=	2.025e-08 >>>	3.52 sec
Step:	340,	Entropy=	9.628e-01,	Error=	2.410e-08 >>>	3.46 sec
Step:	341,	Entropy=	9.639e-01,	Error=	2.864e-08 >>>	3.62 sec
Step:	342,	Entropy=	9.649e-01,	Error=	3.345e-08 >>>	3.55 sec
Step:	343,	Entropy=	9.657e-01,	Error=	1.850e-08 >>>	3.55 sec
Step:	344,	Entropy=	9.664e-01,	Error=	2.048e-08 >>>	3.59 sec
Step:	345,	Entropy=	9.670e-01,	Error=	2.263e-08 >>>	3.37 sec
Step:	346,	Entropy=	9.674e-01,	Error=	2.498e-08 >>>	3.55 sec
Step:	347,	Entropy=	9.676e-01,	Error=	2.753e-08 >>>	3.39 sec
Step:	348,	Entropy=	9.677e-01,	Error=	3.030e-08 >>>	3.36 sec
Step:	349,	Entropy=	9.677e-01,	Error=	3.032e-08 >>>	3.56 sec
Step:	350,	Entropy=	9.675e-01,	Error=	3.533e-08 >>>	3.59 sec
Step:	351,	Entropy=	9.672e-01,	Error=	4.196e-08 >>>	3.42 sec
Step:	352,	Entropy=	9.668e-01,	Error=	4.977e-08 >>>	3.48 sec
Step:	353,	Entropy=	9.663e-01,	Error=	5.896e-08 >>>	3.56 sec
Step:	354,	Entropy=	9.656e-01,	Error=	6.807e-08 >>>	3.50 sec
Step:	355,	Entropy=	9.649e-01,	Error=	3.088e-08 >>>	3.55 sec
Step:	356,	Entropy=	9.641e-01,	Error=	3.356e-08 >>>	3.65 sec
Step:	357,	Entropy=	9.632e-01,	Error=	3.646e-08 >>>	3.66 sec
Step:	358,	Entropy=	9.623e-01,	Error=	4.274e-08 >>>	3.91 sec
Step:	359,	Entropy=	9.614e-01,	Error=	5.105e-08 >>>	3.86 sec
Step:	360,	Entropy=	9.604e-01,	Error=	5.404e-08 >>>	3.65 sec
Step:	361,	Entropy=	9.595e-01,	Error=	5.038e-08 >>>	3.58 sec
Step:	362,	Entropy=	9.585e-01,	Error=	5.452e-08 >>>	3.50 sec
Step:	363,	Entropy=	9.576e-01,	Error=	5.896e-08 >>>	3.44 sec
Step:	364,	Entropy=	9.567e-01,	Error=	6.372e-08 >>>	3.60 sec
Step:	365,	Entropy=	9.558e-01,	Error=	6.408e-08 >>>	3.47 sec
Step:	366,	Entropy=	9.550e-01,	Error=	2.052e-08 >>>	3.67 sec
Step:	367,	Entropy=	9.543e-01,	Error=	2.446e-08 >>>	3.48 sec
Step:	368,	Entropy=	9.537e-01,	Error=	2.910e-08 >>>	3.55 sec
Step:	369,	Entropy=	9.532e-01,	Error=	3.456e-08 >>>	3.61 sec
Step:	370,	Entropy=	9.528e-01,	Error=	3.936e-08 >>>	3.47 sec
Step:	371,	Entropy=	9.525e-01,	Error=	1.957e-08 >>>	3.52 sec
Step:	372,	Entropy=	9.523e-01,	Error=	2.157e-08 >>>	3.55 sec
Step:	373,	Entropy=	9.523e-01,	Error=	2.377e-08 >>>	3.77 sec
Step:	374,	Entropy=	9.524e-01,	Error=	2.616e-08 >>>	3.56 sec
Step:	375,	Entropy=	9.526e-01,	Error=	2.877e-08 >>>	3.75 sec
Step:	376,	Entropy=	9.530e-01,	Error=	3.160e-08 >>>	3.60 sec
Step:	377,	Entropy=	9.535e-01,	Error=	2.935e-08 >>>	3.44 sec
Step:	378,	Entropy=	9.542e-01,	Error=	2.913e-08 >>>	3.67 sec
Step:	379,	Entropy=	9.550e-01,	Error=	3.497e-08 >>>	3.64 sec
Step:	380,	Entropy=	9.559e-01,	Error=	4.189e-08 >>>	3.65 sec
Step:	381,	Entropy=	9.570e-01,	Error=	5.007e-08 >>>	3.69 sec
Step:	382,	Entropy=	9.581e-01,	Error=	5.969e-08 >>>	3.75 sec
Step:	383,	Entropy=	9.594e-01,	Error=	7.097e-08 >>>	3.66 sec
Step:	384,	Entropy=	9.608e-01,	Error=	7.395e-08 >>>	3.79 sec
Step:	385,	Entropy=	9.623e-01,	Error=	5.375e-08 >>>	3.74 sec
Step:	386,	Entropy=	9.639e-01,	Error=	6.375e-08 >>>	3.58 sec
Step:	387,	Entropy=	9.655e-01,	Error=	7.550e-08 >>>	3.83 sec
Step:	388,	Entropy=	9.672e-01,	Error=	8.925e-08 >>>	3.83 sec
Step:	389,	Entropy=	9.689e-01,	Error=	1.013e-07 >>>	4.01 sec

Step:	390,	Entropy=	9.707e-01,	Error=	6.053e-08 >>>	3.69 sec
Step:	391,	Entropy=	9.725e-01,	Error=	5.816e-08 >>>	3.45 sec
Step:	392,	Entropy=	9.743e-01,	Error=	4.909e-08 >>>	3.68 sec
Step:	393,	Entropy=	9.760e-01,	Error=	5.281e-08 >>>	3.63 sec
Step:	394,	Entropy=	9.778e-01,	Error=	5.645e-08 >>>	3.60 sec
Step:	395,	Entropy=	9.795e-01,	Error=	3.554e-08 >>>	3.62 sec
Step:	396,	Entropy=	9.812e-01,	Error=	4.249e-08 >>>	3.57 sec
Step:	397,	Entropy=	9.828e-01,	Error=	5.082e-08 >>>	3.66 sec
Step:	398,	Entropy=	9.843e-01,	Error=	6.074e-08 >>>	3.64 sec
Step:	399,	Entropy=	9.858e-01,	Error=	5.936e-08 >>>	3.97 sec
Step:	400,	Entropy=	9.871e-01,	Error=	2.265e-08 >>>	3.81 sec

2-nd order Trotter (D=20):

```

ORDER = 2;
[IDX, GATE] = TROTTER(ham, ORDER, DT);
%% initial state as |up>|up>...|up>|down>...|down> with a single domain wall at the center
MPS = QSpace(NSITE,1);
MPS(1) = QCREATE(vac, '1', eid, '1', 'OUT');
MPS(1) = getsub(MPS(1), 2);
for isite = 2 : ceil(NSITE/2)
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 2);
end
for isite = ceil(NSITE/2)+1 : NSITE
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 1);
end

%% run tDMRG
SZ2 = zeros(NSTEP, NSITE);
EE2 = zeros(NSTEP, 1);
for istep = 1 : NSTEP
    time = tic;
    [MPS, err] = TDMRG_ex(MPS, GATE, DKEEP, IDX);
    if ~mod(ORDER, 2)
        IDX = flip(IDX);
        GATE = flip(GATE);
    end

    % measure Sz on each site
    [mpsB, ~] = CANONICAL(MPS, [], NSITE, 0, 1E-16, -1);
    eyeL = QSpace(NSITE, 1);
    eyeL(1) = QCREATE(mpsB(1), '1', 'OUT');
    for isite = 1 : NSITE
        tmp = contract(eyeL(isite), [1], conj(mpsB(isite)), [1]);
        if (isite~=NSITE)
            eyeL(isite+1) = contract(tmp, [1,2], mpsB(isite), [1,2]);
        end
        tmp = contract(tmp, [2], sz, [1]);
        tmp = contract(tmp, [1,3,2], mpsB(isite), [1,2,3]);
        SZ2(istep, isite) = real(tmp.data{1});
    end

    % measure half chain entanglement entropy
    [~, lambda] = CANONICAL(mpsB, [], 0, NSITE/2, 1E-16, -1);

```

```

EE2(istep) = SEntropy(contract(lambda, [2], lambda, [1]));
fprintf('Step: %5d, Entropy= %10.3e, Error= %10.3e >>> %9.2f sec \n',...
    istep, EE2(istep), err, toc(time));
end

```

```

Step:    1, Entropy=  5.234e-03, Error=  0.000e+00 >>>    3.59 sec
Step:    2, Entropy=  1.745e-02, Error=  0.000e+00 >>>    3.69 sec
Step:    3, Entropy=  3.466e-02, Error=  0.000e+00 >>>    3.34 sec
Step:    4, Entropy=  5.576e-02, Error=  0.000e+00 >>>    3.36 sec
Step:    5, Entropy=  7.997e-02, Error=  0.000e+00 >>>    3.34 sec
Step:    6, Entropy=  1.067e-01, Error=  0.000e+00 >>>    3.37 sec
Step:    7, Entropy=  1.353e-01, Error=  0.000e+00 >>>    3.35 sec
Step:    8, Entropy=  1.654e-01, Error=  2.220e-16 >>>    3.40 sec
Step:    9, Entropy=  1.966e-01, Error=  2.220e-16 >>>    3.36 sec
Step:   10, Entropy=  2.286e-01, Error=  0.000e+00 >>>    3.39 sec
Step:   11, Entropy=  2.609e-01, Error=  0.000e+00 >>>    3.37 sec
Step:   12, Entropy=  2.934e-01, Error=  0.000e+00 >>>    3.42 sec
Step:   13, Entropy=  3.257e-01, Error=  0.000e+00 >>>    3.39 sec
Step:   14, Entropy=  3.575e-01, Error=  0.000e+00 >>>    3.42 sec
Step:   15, Entropy=  3.888e-01, Error=  2.220e-16 >>>    3.41 sec
Step:   16, Entropy=  4.192e-01, Error=  0.000e+00 >>>    3.43 sec
Step:   17, Entropy=  4.486e-01, Error=  0.000e+00 >>>    3.38 sec
Step:   18, Entropy=  4.769e-01, Error=  0.000e+00 >>>    3.43 sec
Step:   19, Entropy=  5.038e-01, Error=  0.000e+00 >>>    3.40 sec
Step:   20, Entropy=  5.294e-01, Error=  2.220e-16 >>>    3.43 sec
Step:   21, Entropy=  5.534e-01, Error=  0.000e+00 >>>    3.39 sec
Step:   22, Entropy=  5.758e-01, Error=  2.220e-16 >>>    3.42 sec
Step:   23, Entropy=  5.965e-01, Error=  0.000e+00 >>>    3.38 sec
Step:   24, Entropy=  6.155e-01, Error=  0.000e+00 >>>    3.43 sec
Step:   25, Entropy=  6.328e-01, Error=  0.000e+00 >>>    3.39 sec
Step:   26, Entropy=  6.483e-01, Error=  2.220e-16 >>>    3.43 sec
Step:   27, Entropy=  6.620e-01, Error=  2.220e-16 >>>    3.41 sec
Step:   28, Entropy=  6.739e-01, Error=  2.220e-16 >>>    3.44 sec
Step:   29, Entropy=  6.841e-01, Error=  0.000e+00 >>>    3.42 sec
Step:   30, Entropy=  6.926e-01, Error=  2.220e-16 >>>    3.44 sec
Step:   31, Entropy=  6.995e-01, Error=  2.220e-16 >>>    3.42 sec
Step:   32, Entropy=  7.047e-01, Error=  0.000e+00 >>>    3.47 sec
Step:   33, Entropy=  7.085e-01, Error=  2.220e-16 >>>    3.44 sec
Step:   34, Entropy=  7.108e-01, Error=  0.000e+00 >>>    3.46 sec
Step:   35, Entropy=  7.117e-01, Error=  0.000e+00 >>>    3.45 sec
Step:   36, Entropy=  7.114e-01, Error=  0.000e+00 >>>    3.48 sec
Step:   37, Entropy=  7.099e-01, Error=  0.000e+00 >>>    3.46 sec
Step:   38, Entropy=  7.074e-01, Error=  0.000e+00 >>>    3.54 sec
Step:   39, Entropy=  7.039e-01, Error=  0.000e+00 >>>    3.48 sec
Step:   40, Entropy=  6.996e-01, Error=  0.000e+00 >>>    3.48 sec
Step:   41, Entropy=  6.946e-01, Error=  0.000e+00 >>>    3.47 sec
Step:   42, Entropy=  6.889e-01, Error=  0.000e+00 >>>    3.54 sec
Step:   43, Entropy=  6.828e-01, Error=  0.000e+00 >>>    3.45 sec
Step:   44, Entropy=  6.763e-01, Error=  2.220e-16 >>>    3.49 sec
Step:   45, Entropy=  6.695e-01, Error=  0.000e+00 >>>    3.45 sec
Step:   46, Entropy=  6.626e-01, Error=  2.220e-16 >>>    3.49 sec
Step:   47, Entropy=  6.557e-01, Error=  2.220e-16 >>>    3.47 sec
Step:   48, Entropy=  6.488e-01, Error=  0.000e+00 >>>    3.59 sec
Step:   49, Entropy=  6.420e-01, Error=  0.000e+00 >>>    3.47 sec
Step:   50, Entropy=  6.355e-01, Error=  0.000e+00 >>>    3.67 sec
Step:   51, Entropy=  6.293e-01, Error=  0.000e+00 >>>    3.62 sec
Step:   52, Entropy=  6.235e-01, Error=  0.000e+00 >>>    3.62 sec
Step:   53, Entropy=  6.183e-01, Error=  2.220e-16 >>>    3.59 sec
Step:   54, Entropy=  6.135e-01, Error=  2.220e-16 >>>    3.61 sec
Step:   55, Entropy=  6.094e-01, Error=  0.000e+00 >>>    3.70 sec
Step:   56, Entropy=  6.059e-01, Error=  2.220e-16 >>>    3.94 sec
Step:   57, Entropy=  6.031e-01, Error=  2.220e-16 >>>    3.89 sec
Step:   58, Entropy=  6.010e-01, Error=  2.220e-16 >>>    3.86 sec
Step:   59, Entropy=  5.997e-01, Error=  0.000e+00 >>>    3.50 sec

```

Step:	60,	Entropy=	5.991e-01,	Error=	0.000e+00 >>>	3.55 sec
Step:	61,	Entropy=	5.993e-01,	Error=	0.000e+00 >>>	3.48 sec
Step:	62,	Entropy=	6.003e-01,	Error=	0.000e+00 >>>	3.53 sec
Step:	63,	Entropy=	6.020e-01,	Error=	0.000e+00 >>>	3.50 sec
Step:	64,	Entropy=	6.045e-01,	Error=	2.220e-16 >>>	3.59 sec
Step:	65,	Entropy=	6.077e-01,	Error=	0.000e+00 >>>	3.56 sec
Step:	66,	Entropy=	6.116e-01,	Error=	2.220e-16 >>>	3.61 sec
Step:	67,	Entropy=	6.161e-01,	Error=	2.220e-16 >>>	3.55 sec
Step:	68,	Entropy=	6.213e-01,	Error=	2.220e-16 >>>	3.58 sec
Step:	69,	Entropy=	6.270e-01,	Error=	2.220e-16 >>>	3.72 sec
Step:	70,	Entropy=	6.333e-01,	Error=	2.220e-16 >>>	3.60 sec
Step:	71,	Entropy=	6.400e-01,	Error=	0.000e+00 >>>	3.52 sec
Step:	72,	Entropy=	6.472e-01,	Error=	2.220e-16 >>>	3.62 sec
Step:	73,	Entropy=	6.546e-01,	Error=	4.441e-16 >>>	3.55 sec
Step:	74,	Entropy=	6.624e-01,	Error=	4.441e-16 >>>	3.62 sec
Step:	75,	Entropy=	6.704e-01,	Error=	6.661e-16 >>>	3.59 sec
Step:	76,	Entropy=	6.786e-01,	Error=	8.882e-16 >>>	3.63 sec
Step:	77,	Entropy=	6.869e-01,	Error=	1.332e-15 >>>	3.58 sec
Step:	78,	Entropy=	6.952e-01,	Error=	1.776e-15 >>>	3.59 sec
Step:	79,	Entropy=	7.034e-01,	Error=	2.442e-15 >>>	3.60 sec
Step:	80,	Entropy=	7.116e-01,	Error=	3.331e-15 >>>	3.87 sec
Step:	81,	Entropy=	7.196e-01,	Error=	4.663e-15 >>>	3.74 sec
Step:	82,	Entropy=	7.274e-01,	Error=	6.439e-15 >>>	3.82 sec
Step:	83,	Entropy=	7.350e-01,	Error=	8.438e-15 >>>	3.78 sec
Step:	84,	Entropy=	7.422e-01,	Error=	1.155e-14 >>>	3.67 sec
Step:	85,	Entropy=	7.491e-01,	Error=	1.599e-14 >>>	3.59 sec
Step:	86,	Entropy=	7.555e-01,	Error=	2.132e-14 >>>	3.68 sec
Step:	87,	Entropy=	7.616e-01,	Error=	2.887e-14 >>>	3.74 sec
Step:	88,	Entropy=	7.671e-01,	Error=	3.864e-14 >>>	4.17 sec
Step:	89,	Entropy=	7.722e-01,	Error=	5.129e-14 >>>	4.10 sec
Step:	90,	Entropy=	7.768e-01,	Error=	6.839e-14 >>>	3.98 sec
Step:	91,	Entropy=	7.808e-01,	Error=	9.059e-14 >>>	3.81 sec
Step:	92,	Entropy=	7.843e-01,	Error=	1.197e-13 >>>	3.70 sec
Step:	93,	Entropy=	7.872e-01,	Error=	1.574e-13 >>>	3.63 sec
Step:	94,	Entropy=	7.896e-01,	Error=	2.065e-13 >>>	3.66 sec
Step:	95,	Entropy=	7.914e-01,	Error=	2.702e-13 >>>	3.62 sec
Step:	96,	Entropy=	7.927e-01,	Error=	3.519e-13 >>>	3.68 sec
Step:	97,	Entropy=	7.935e-01,	Error=	4.574e-13 >>>	3.68 sec
Step:	98,	Entropy=	7.938e-01,	Error=	5.926e-13 >>>	3.69 sec
Step:	99,	Entropy=	7.936e-01,	Error=	7.654e-13 >>>	4.09 sec
Step:	100,	Entropy=	7.930e-01,	Error=	9.857e-13 >>>	3.80 sec
Step:	101,	Entropy=	7.919e-01,	Error=	1.265e-12 >>>	3.70 sec
Step:	102,	Entropy=	7.904e-01,	Error=	1.620e-12 >>>	3.90 sec
Step:	103,	Entropy=	7.886e-01,	Error=	2.068e-12 >>>	4.09 sec
Step:	104,	Entropy=	7.865e-01,	Error=	2.633e-12 >>>	4.11 sec
Step:	105,	Entropy=	7.842e-01,	Error=	3.342e-12 >>>	4.03 sec
Step:	106,	Entropy=	7.816e-01,	Error=	4.231e-12 >>>	3.74 sec
Step:	107,	Entropy=	7.788e-01,	Error=	5.342e-12 >>>	3.71 sec
Step:	108,	Entropy=	7.760e-01,	Error=	6.726e-12 >>>	3.94 sec
Step:	109,	Entropy=	7.730e-01,	Error=	8.446e-12 >>>	3.90 sec
Step:	110,	Entropy=	7.700e-01,	Error=	1.058e-11 >>>	3.78 sec
Step:	111,	Entropy=	7.670e-01,	Error=	1.321e-11 >>>	3.76 sec
Step:	112,	Entropy=	7.641e-01,	Error=	1.647e-11 >>>	3.78 sec
Step:	113,	Entropy=	7.612e-01,	Error=	2.046e-11 >>>	3.71 sec
Step:	114,	Entropy=	7.585e-01,	Error=	2.537e-11 >>>	3.71 sec
Step:	115,	Entropy=	7.560e-01,	Error=	3.136e-11 >>>	3.79 sec
Step:	116,	Entropy=	7.537e-01,	Error=	3.868e-11 >>>	3.92 sec
Step:	117,	Entropy=	7.516e-01,	Error=	4.759e-11 >>>	3.75 sec
Step:	118,	Entropy=	7.498e-01,	Error=	5.217e-11 >>>	3.94 sec
Step:	119,	Entropy=	7.484e-01,	Error=	1.310e-11 >>>	4.05 sec
Step:	120,	Entropy=	7.472e-01,	Error=	1.465e-11 >>>	3.94 sec
Step:	121,	Entropy=	7.464e-01,	Error=	1.638e-11 >>>	3.91 sec
Step:	122,	Entropy=	7.460e-01,	Error=	1.831e-11 >>>	4.14 sec
Step:	123,	Entropy=	7.459e-01,	Error=	2.046e-11 >>>	4.04 sec
Step:	124,	Entropy=	7.462e-01,	Error=	2.284e-11 >>>	3.85 sec

Step:	125,	Entropy=	7.469e-01,	Error=	2.550e-11 >>>	3.82 sec
Step:	126,	Entropy=	7.480e-01,	Error=	2.845e-11 >>>	3.84 sec
Step:	127,	Entropy=	7.495e-01,	Error=	3.174e-11 >>>	3.74 sec
Step:	128,	Entropy=	7.513e-01,	Error=	3.540e-11 >>>	3.83 sec
Step:	129,	Entropy=	7.536e-01,	Error=	3.949e-11 >>>	3.75 sec
Step:	130,	Entropy=	7.561e-01,	Error=	4.406e-11 >>>	3.81 sec
Step:	131,	Entropy=	7.590e-01,	Error=	4.917e-11 >>>	3.91 sec
Step:	132,	Entropy=	7.622e-01,	Error=	5.491e-11 >>>	3.81 sec
Step:	133,	Entropy=	7.657e-01,	Error=	6.138e-11 >>>	3.77 sec
Step:	134,	Entropy=	7.695e-01,	Error=	6.867e-11 >>>	3.78 sec
Step:	135,	Entropy=	7.735e-01,	Error=	7.694e-11 >>>	3.78 sec
Step:	136,	Entropy=	7.776e-01,	Error=	8.634e-11 >>>	3.81 sec
Step:	137,	Entropy=	7.820e-01,	Error=	9.706e-11 >>>	3.91 sec
Step:	138,	Entropy=	7.865e-01,	Error=	1.093e-10 >>>	3.85 sec
Step:	139,	Entropy=	7.911e-01,	Error=	1.235e-10 >>>	3.76 sec
Step:	140,	Entropy=	7.957e-01,	Error=	1.398e-10 >>>	3.87 sec
Step:	141,	Entropy=	8.004e-01,	Error=	1.586e-10 >>>	3.86 sec
Step:	142,	Entropy=	8.051e-01,	Error=	1.806e-10 >>>	3.80 sec
Step:	143,	Entropy=	8.097e-01,	Error=	2.061e-10 >>>	3.80 sec
Step:	144,	Entropy=	8.142e-01,	Error=	2.360e-10 >>>	3.99 sec
Step:	145,	Entropy=	8.187e-01,	Error=	2.711e-10 >>>	3.81 sec
Step:	146,	Entropy=	8.230e-01,	Error=	3.123e-10 >>>	4.28 sec
Step:	147,	Entropy=	8.271e-01,	Error=	3.607e-10 >>>	3.92 sec
Step:	148,	Entropy=	8.310e-01,	Error=	4.179e-10 >>>	3.91 sec
Step:	149,	Entropy=	8.347e-01,	Error=	4.853e-10 >>>	3.81 sec
Step:	150,	Entropy=	8.382e-01,	Error=	5.649e-10 >>>	3.88 sec
Step:	151,	Entropy=	8.414e-01,	Error=	6.590e-10 >>>	3.78 sec
Step:	152,	Entropy=	8.443e-01,	Error=	7.702e-10 >>>	3.94 sec
Step:	153,	Entropy=	8.469e-01,	Error=	9.016e-10 >>>	3.81 sec
Step:	154,	Entropy=	8.492e-01,	Error=	1.057e-09 >>>	3.83 sec
Step:	155,	Entropy=	8.512e-01,	Error=	1.241e-09 >>>	3.84 sec
Step:	156,	Entropy=	8.528e-01,	Error=	1.457e-09 >>>	4.00 sec
Step:	157,	Entropy=	8.542e-01,	Error=	1.713e-09 >>>	3.92 sec
Step:	158,	Entropy=	8.552e-01,	Error=	2.015e-09 >>>	4.01 sec
Step:	159,	Entropy=	8.559e-01,	Error=	2.371e-09 >>>	3.97 sec
Step:	160,	Entropy=	8.562e-01,	Error=	2.633e-09 >>>	3.94 sec
Step:	161,	Entropy=	8.563e-01,	Error=	1.645e-09 >>>	3.99 sec
Step:	162,	Entropy=	8.561e-01,	Error=	4.167e-10 >>>	4.06 sec
Step:	163,	Entropy=	8.556e-01,	Error=	4.436e-10 >>>	3.98 sec
Step:	164,	Entropy=	8.549e-01,	Error=	4.728e-10 >>>	4.12 sec
Step:	165,	Entropy=	8.539e-01,	Error=	5.045e-10 >>>	3.97 sec
Step:	166,	Entropy=	8.527e-01,	Error=	5.389e-10 >>>	4.14 sec
Step:	167,	Entropy=	8.513e-01,	Error=	5.764e-10 >>>	4.34 sec
Step:	168,	Entropy=	8.498e-01,	Error=	6.172e-10 >>>	4.19 sec
Step:	169,	Entropy=	8.481e-01,	Error=	6.619e-10 >>>	4.04 sec
Step:	170,	Entropy=	8.464e-01,	Error=	7.107e-10 >>>	4.00 sec
Step:	171,	Entropy=	8.445e-01,	Error=	7.641e-10 >>>	4.01 sec
Step:	172,	Entropy=	8.426e-01,	Error=	8.226e-10 >>>	3.98 sec
Step:	173,	Entropy=	8.407e-01,	Error=	8.869e-10 >>>	4.13 sec
Step:	174,	Entropy=	8.388e-01,	Error=	9.574e-10 >>>	4.33 sec
Step:	175,	Entropy=	8.369e-01,	Error=	1.035e-09 >>>	4.13 sec
Step:	176,	Entropy=	8.351e-01,	Error=	1.120e-09 >>>	4.13 sec
Step:	177,	Entropy=	8.333e-01,	Error=	1.214e-09 >>>	4.00 sec
Step:	178,	Entropy=	8.317e-01,	Error=	1.317e-09 >>>	4.09 sec
Step:	179,	Entropy=	8.303e-01,	Error=	1.530e-09 >>>	3.94 sec
Step:	180,	Entropy=	8.290e-01,	Error=	1.795e-09 >>>	4.04 sec
Step:	181,	Entropy=	8.279e-01,	Error=	1.600e-09 >>>	3.97 sec
Step:	182,	Entropy=	8.269e-01,	Error=	1.462e-09 >>>	3.91 sec
Step:	183,	Entropy=	8.262e-01,	Error=	1.777e-09 >>>	3.99 sec
Step:	184,	Entropy=	8.258e-01,	Error=	2.168e-09 >>>	4.41 sec
Step:	185,	Entropy=	8.255e-01,	Error=	2.654e-09 >>>	4.46 sec
Step:	186,	Entropy=	8.256e-01,	Error=	3.253e-09 >>>	4.47 sec
Step:	187,	Entropy=	8.258e-01,	Error=	3.988e-09 >>>	4.75 sec
Step:	188,	Entropy=	8.264e-01,	Error=	4.514e-09 >>>	4.17 sec
Step:	189,	Entropy=	8.272e-01,	Error=	9.803e-10 >>>	4.03 sec

Step:	190,	Entropy=	8.282e-01,	Error=	1.090e-09 >>>	4.07 sec
Step:	191,	Entropy=	8.296e-01,	Error=	1.141e-09 >>>	4.03 sec
Step:	192,	Entropy=	8.311e-01,	Error=	8.450e-10 >>>	4.09 sec
Step:	193,	Entropy=	8.329e-01,	Error=	9.036e-10 >>>	4.06 sec
Step:	194,	Entropy=	8.349e-01,	Error=	9.711e-10 >>>	4.09 sec
Step:	195,	Entropy=	8.372e-01,	Error=	1.049e-09 >>>	4.11 sec
Step:	196,	Entropy=	8.396e-01,	Error=	1.138e-09 >>>	4.19 sec
Step:	197,	Entropy=	8.422e-01,	Error=	1.241e-09 >>>	4.37 sec
Step:	198,	Entropy=	8.450e-01,	Error=	1.358e-09 >>>	4.28 sec
Step:	199,	Entropy=	8.479e-01,	Error=	1.493e-09 >>>	4.31 sec
Step:	200,	Entropy=	8.509e-01,	Error=	1.646e-09 >>>	4.04 sec
Step:	201,	Entropy=	8.540e-01,	Error=	1.821e-09 >>>	3.95 sec
Step:	202,	Entropy=	8.572e-01,	Error=	2.020e-09 >>>	4.07 sec
Step:	203,	Entropy=	8.604e-01,	Error=	2.245e-09 >>>	4.18 sec
Step:	204,	Entropy=	8.636e-01,	Error=	2.501e-09 >>>	4.17 sec
Step:	205,	Entropy=	8.668e-01,	Error=	2.789e-09 >>>	4.13 sec
Step:	206,	Entropy=	8.701e-01,	Error=	3.115e-09 >>>	4.15 sec
Step:	207,	Entropy=	8.732e-01,	Error=	3.483e-09 >>>	4.00 sec
Step:	208,	Entropy=	8.763e-01,	Error=	3.896e-09 >>>	4.12 sec
Step:	209,	Entropy=	8.793e-01,	Error=	4.324e-09 >>>	4.05 sec
Step:	210,	Entropy=	8.821e-01,	Error=	1.584e-09 >>>	4.15 sec
Step:	211,	Entropy=	8.848e-01,	Error=	1.647e-09 >>>	4.18 sec
Step:	212,	Entropy=	8.874e-01,	Error=	1.729e-09 >>>	4.25 sec
Step:	213,	Entropy=	8.898e-01,	Error=	1.832e-09 >>>	4.08 sec
Step:	214,	Entropy=	8.920e-01,	Error=	1.962e-09 >>>	4.00 sec
Step:	215,	Entropy=	8.940e-01,	Error=	2.144e-09 >>>	4.09 sec
Step:	216,	Entropy=	8.958e-01,	Error=	2.533e-09 >>>	4.04 sec
Step:	217,	Entropy=	8.974e-01,	Error=	2.927e-09 >>>	4.08 sec
Step:	218,	Entropy=	8.988e-01,	Error=	2.884e-09 >>>	4.19 sec
Step:	219,	Entropy=	8.999e-01,	Error=	3.260e-09 >>>	4.10 sec
Step:	220,	Entropy=	9.008e-01,	Error=	3.395e-09 >>>	4.18 sec
Step:	221,	Entropy=	9.015e-01,	Error=	3.514e-09 >>>	4.04 sec
Step:	222,	Entropy=	9.019e-01,	Error=	4.139e-09 >>>	4.16 sec
Step:	223,	Entropy=	9.021e-01,	Error=	4.797e-09 >>>	4.11 sec
Step:	224,	Entropy=	9.022e-01,	Error=	3.447e-09 >>>	4.32 sec
Step:	225,	Entropy=	9.020e-01,	Error=	3.343e-09 >>>	4.20 sec
Step:	226,	Entropy=	9.016e-01,	Error=	3.472e-09 >>>	4.19 sec
Step:	227,	Entropy=	9.010e-01,	Error=	3.837e-09 >>>	4.05 sec
Step:	228,	Entropy=	9.003e-01,	Error=	4.237e-09 >>>	4.22 sec
Step:	229,	Entropy=	8.994e-01,	Error=	4.676e-09 >>>	3.99 sec
Step:	230,	Entropy=	8.984e-01,	Error=	5.155e-09 >>>	4.27 sec
Step:	231,	Entropy=	8.972e-01,	Error=	5.678e-09 >>>	4.19 sec
Step:	232,	Entropy=	8.960e-01,	Error=	6.245e-09 >>>	4.25 sec
Step:	233,	Entropy=	8.947e-01,	Error=	6.857e-09 >>>	4.18 sec
Step:	234,	Entropy=	8.934e-01,	Error=	7.516e-09 >>>	4.21 sec
Step:	235,	Entropy=	8.920e-01,	Error=	8.223e-09 >>>	4.13 sec
Step:	236,	Entropy=	8.906e-01,	Error=	8.980e-09 >>>	4.04 sec
Step:	237,	Entropy=	8.892e-01,	Error=	9.694e-09 >>>	4.12 sec
Step:	238,	Entropy=	8.878e-01,	Error=	3.101e-09 >>>	4.36 sec
Step:	239,	Entropy=	8.865e-01,	Error=	2.207e-09 >>>	4.28 sec
Step:	240,	Entropy=	8.853e-01,	Error=	2.672e-09 >>>	4.24 sec
Step:	241,	Entropy=	8.841e-01,	Error=	3.246e-09 >>>	4.20 sec
Step:	242,	Entropy=	8.831e-01,	Error=	3.950e-09 >>>	4.15 sec
Step:	243,	Entropy=	8.822e-01,	Error=	4.812e-09 >>>	4.16 sec
Step:	244,	Entropy=	8.814e-01,	Error=	5.863e-09 >>>	4.38 sec
Step:	245,	Entropy=	8.808e-01,	Error=	7.140e-09 >>>	4.32 sec
Step:	246,	Entropy=	8.803e-01,	Error=	8.685e-09 >>>	4.25 sec
Step:	247,	Entropy=	8.800e-01,	Error=	1.014e-08 >>>	4.16 sec
Step:	248,	Entropy=	8.799e-01,	Error=	5.880e-09 >>>	4.19 sec
Step:	249,	Entropy=	8.800e-01,	Error=	6.977e-09 >>>	4.33 sec
Step:	250,	Entropy=	8.803e-01,	Error=	8.309e-09 >>>	4.32 sec
Step:	251,	Entropy=	8.807e-01,	Error=	9.918e-09 >>>	4.27 sec
Step:	252,	Entropy=	8.814e-01,	Error=	1.185e-08 >>>	4.23 sec
Step:	253,	Entropy=	8.822e-01,	Error=	1.418e-08 >>>	4.11 sec
Step:	254,	Entropy=	8.833e-01,	Error=	1.574e-08 >>>	4.21 sec

Step:	255,	Entropy=	8.845e-01,	Error=	8.572e-09 >>>	4.28 sec
Step:	256,	Entropy=	8.859e-01,	Error=	9.521e-09 >>>	4.19 sec
Step:	257,	Entropy=	8.875e-01,	Error=	1.058e-08 >>>	4.21 sec
Step:	258,	Entropy=	8.892e-01,	Error=	1.176e-08 >>>	4.24 sec
Step:	259,	Entropy=	8.910e-01,	Error=	1.307e-08 >>>	4.22 sec
Step:	260,	Entropy=	8.930e-01,	Error=	1.453e-08 >>>	4.27 sec
Step:	261,	Entropy=	8.952e-01,	Error=	1.613e-08 >>>	4.31 sec
Step:	262,	Entropy=	8.974e-01,	Error=	1.790e-08 >>>	4.14 sec
Step:	263,	Entropy=	8.997e-01,	Error=	1.985e-08 >>>	4.30 sec
Step:	264,	Entropy=	9.020e-01,	Error=	2.124e-08 >>>	4.22 sec
Step:	265,	Entropy=	9.044e-01,	Error=	6.382e-09 >>>	4.14 sec
Step:	266,	Entropy=	9.069e-01,	Error=	4.641e-09 >>>	4.38 sec
Step:	267,	Entropy=	9.093e-01,	Error=	5.245e-09 >>>	4.16 sec
Step:	268,	Entropy=	9.118e-01,	Error=	5.927e-09 >>>	4.29 sec
Step:	269,	Entropy=	9.142e-01,	Error=	6.586e-09 >>>	4.44 sec
Step:	270,	Entropy=	9.166e-01,	Error=	2.594e-09 >>>	4.26 sec
Step:	271,	Entropy=	9.189e-01,	Error=	3.062e-09 >>>	4.19 sec
Step:	272,	Entropy=	9.211e-01,	Error=	3.613e-09 >>>	4.30 sec
Step:	273,	Entropy=	9.232e-01,	Error=	4.145e-09 >>>	4.13 sec
Step:	274,	Entropy=	9.253e-01,	Error=	4.044e-09 >>>	4.33 sec
Step:	275,	Entropy=	9.272e-01,	Error=	4.630e-09 >>>	4.14 sec
Step:	276,	Entropy=	9.289e-01,	Error=	5.315e-09 >>>	4.14 sec
Step:	277,	Entropy=	9.306e-01,	Error=	6.111e-09 >>>	4.34 sec
Step:	278,	Entropy=	9.320e-01,	Error=	7.030e-09 >>>	4.20 sec
Step:	279,	Entropy=	9.333e-01,	Error=	8.088e-09 >>>	4.36 sec
Step:	280,	Entropy=	9.345e-01,	Error=	9.298e-09 >>>	4.28 sec
Step:	281,	Entropy=	9.354e-01,	Error=	1.068e-08 >>>	4.17 sec
Step:	282,	Entropy=	9.362e-01,	Error=	1.225e-08 >>>	4.32 sec
Step:	283,	Entropy=	9.368e-01,	Error=	1.402e-08 >>>	4.32 sec
Step:	284,	Entropy=	9.372e-01,	Error=	1.602e-08 >>>	4.31 sec
Step:	285,	Entropy=	9.375e-01,	Error=	1.828e-08 >>>	4.22 sec
Step:	286,	Entropy=	9.376e-01,	Error=	2.042e-08 >>>	4.41 sec
Step:	287,	Entropy=	9.375e-01,	Error=	1.018e-08 >>>	4.22 sec
Step:	288,	Entropy=	9.373e-01,	Error=	1.198e-08 >>>	4.48 sec
Step:	289,	Entropy=	9.369e-01,	Error=	1.408e-08 >>>	4.33 sec
Step:	290,	Entropy=	9.364e-01,	Error=	1.652e-08 >>>	4.34 sec
Step:	291,	Entropy=	9.357e-01,	Error=	1.854e-08 >>>	4.34 sec
Step:	292,	Entropy=	9.350e-01,	Error=	1.161e-08 >>>	4.41 sec
Step:	293,	Entropy=	9.341e-01,	Error=	1.383e-08 >>>	4.31 sec
Step:	294,	Entropy=	9.332e-01,	Error=	1.649e-08 >>>	4.35 sec
Step:	295,	Entropy=	9.322e-01,	Error=	1.966e-08 >>>	4.31 sec
Step:	296,	Entropy=	9.312e-01,	Error=	2.344e-08 >>>	4.29 sec
Step:	297,	Entropy=	9.301e-01,	Error=	2.788e-08 >>>	4.40 sec
Step:	298,	Entropy=	9.290e-01,	Error=	3.311e-08 >>>	4.32 sec
Step:	299,	Entropy=	9.279e-01,	Error=	3.919e-08 >>>	4.21 sec
Step:	300,	Entropy=	9.268e-01,	Error=	4.625e-08 >>>	4.38 sec
Step:	301,	Entropy=	9.257e-01,	Error=	5.439e-08 >>>	4.33 sec
Step:	302,	Entropy=	9.247e-01,	Error=	6.374e-08 >>>	4.43 sec
Step:	303,	Entropy=	9.238e-01,	Error=	7.302e-08 >>>	4.27 sec
Step:	304,	Entropy=	9.229e-01,	Error=	1.538e-08 >>>	4.39 sec
Step:	305,	Entropy=	9.221e-01,	Error=	1.658e-08 >>>	4.34 sec
Step:	306,	Entropy=	9.215e-01,	Error=	1.788e-08 >>>	4.50 sec
Step:	307,	Entropy=	9.209e-01,	Error=	1.926e-08 >>>	4.40 sec
Step:	308,	Entropy=	9.205e-01,	Error=	2.074e-08 >>>	4.41 sec
Step:	309,	Entropy=	9.202e-01,	Error=	2.016e-08 >>>	4.28 sec
Step:	310,	Entropy=	9.201e-01,	Error=	1.058e-08 >>>	4.43 sec
Step:	311,	Entropy=	9.201e-01,	Error=	1.286e-08 >>>	4.42 sec
Step:	312,	Entropy=	9.203e-01,	Error=	1.562e-08 >>>	4.49 sec
Step:	313,	Entropy=	9.206e-01,	Error=	1.893e-08 >>>	4.28 sec
Step:	314,	Entropy=	9.211e-01,	Error=	2.290e-08 >>>	4.37 sec
Step:	315,	Entropy=	9.217e-01,	Error=	2.763e-08 >>>	4.31 sec
Step:	316,	Entropy=	9.225e-01,	Error=	3.325e-08 >>>	4.46 sec
Step:	317,	Entropy=	9.235e-01,	Error=	3.989e-08 >>>	4.27 sec
Step:	318,	Entropy=	9.246e-01,	Error=	4.771e-08 >>>	4.29 sec
Step:	319,	Entropy=	9.259e-01,	Error=	5.229e-08 >>>	4.34 sec

Step:	320,	Entropy=	9.272e-01,	Error=	2.581e-08 >>>	4.51 sec
Step:	321,	Entropy=	9.287e-01,	Error=	3.102e-08 >>>	4.33 sec
Step:	322,	Entropy=	9.304e-01,	Error=	3.723e-08 >>>	4.38 sec
Step:	323,	Entropy=	9.321e-01,	Error=	4.462e-08 >>>	4.40 sec
Step:	324,	Entropy=	9.339e-01,	Error=	4.548e-08 >>>	4.46 sec
Step:	325,	Entropy=	9.358e-01,	Error=	2.158e-08 >>>	4.37 sec
Step:	326,	Entropy=	9.377e-01,	Error=	2.346e-08 >>>	4.54 sec
Step:	327,	Entropy=	9.397e-01,	Error=	2.549e-08 >>>	4.47 sec
Step:	328,	Entropy=	9.417e-01,	Error=	2.771e-08 >>>	4.39 sec
Step:	329,	Entropy=	9.438e-01,	Error=	3.010e-08 >>>	4.40 sec
Step:	330,	Entropy=	9.458e-01,	Error=	3.269e-08 >>>	4.55 sec
Step:	331,	Entropy=	9.478e-01,	Error=	3.548e-08 >>>	4.42 sec
Step:	332,	Entropy=	9.498e-01,	Error=	3.848e-08 >>>	4.52 sec
Step:	333,	Entropy=	9.517e-01,	Error=	4.172e-08 >>>	4.52 sec
Step:	334,	Entropy=	9.535e-01,	Error=	4.519e-08 >>>	4.40 sec
Step:	335,	Entropy=	9.553e-01,	Error=	4.892e-08 >>>	4.54 sec
Step:	336,	Entropy=	9.570e-01,	Error=	5.292e-08 >>>	4.59 sec
Step:	337,	Entropy=	9.585e-01,	Error=	5.721e-08 >>>	4.49 sec
Step:	338,	Entropy=	9.600e-01,	Error=	6.181e-08 >>>	4.39 sec
Step:	339,	Entropy=	9.613e-01,	Error=	6.669e-08 >>>	4.24 sec
Step:	340,	Entropy=	9.625e-01,	Error=	7.124e-08 >>>	4.69 sec
Step:	341,	Entropy=	9.635e-01,	Error=	5.853e-08 >>>	4.43 sec
Step:	342,	Entropy=	9.644e-01,	Error=	6.696e-08 >>>	4.25 sec
Step:	343,	Entropy=	9.651e-01,	Error=	7.278e-08 >>>	4.47 sec
Step:	344,	Entropy=	9.657e-01,	Error=	1.050e-08 >>>	4.61 sec
Step:	345,	Entropy=	9.661e-01,	Error=	1.245e-08 >>>	4.41 sec
Step:	346,	Entropy=	9.664e-01,	Error=	1.473e-08 >>>	4.50 sec
Step:	347,	Entropy=	9.665e-01,	Error=	1.739e-08 >>>	4.51 sec
Step:	348,	Entropy=	9.665e-01,	Error=	2.049e-08 >>>	4.34 sec
Step:	349,	Entropy=	9.663e-01,	Error=	2.408e-08 >>>	4.55 sec
Step:	350,	Entropy=	9.660e-01,	Error=	2.824e-08 >>>	4.64 sec
Step:	351,	Entropy=	9.655e-01,	Error=	2.973e-08 >>>	4.52 sec
Step:	352,	Entropy=	9.650e-01,	Error=	1.101e-08 >>>	4.57 sec
Step:	353,	Entropy=	9.643e-01,	Error=	1.268e-08 >>>	4.39 sec
Step:	354,	Entropy=	9.635e-01,	Error=	1.500e-08 >>>	4.52 sec
Step:	355,	Entropy=	9.626e-01,	Error=	1.774e-08 >>>	4.45 sec
Step:	356,	Entropy=	9.616e-01,	Error=	2.095e-08 >>>	4.48 sec
Step:	357,	Entropy=	9.605e-01,	Error=	2.471e-08 >>>	4.49 sec
Step:	358,	Entropy=	9.595e-01,	Error=	2.910e-08 >>>	4.57 sec
Step:	359,	Entropy=	9.583e-01,	Error=	3.420e-08 >>>	4.31 sec
Step:	360,	Entropy=	9.572e-01,	Error=	4.013e-08 >>>	4.61 sec
Step:	361,	Entropy=	9.560e-01,	Error=	4.699e-08 >>>	4.57 sec
Step:	362,	Entropy=	9.549e-01,	Error=	5.491e-08 >>>	4.55 sec
Step:	363,	Entropy=	9.537e-01,	Error=	5.905e-08 >>>	4.35 sec
Step:	364,	Entropy=	9.526e-01,	Error=	6.472e-08 >>>	4.59 sec
Step:	365,	Entropy=	9.516e-01,	Error=	7.765e-08 >>>	4.55 sec
Step:	366,	Entropy=	9.506e-01,	Error=	9.262e-08 >>>	4.51 sec
Step:	367,	Entropy=	9.497e-01,	Error=	1.099e-07 >>>	4.56 sec
Step:	368,	Entropy=	9.489e-01,	Error=	1.180e-07 >>>	4.58 sec
Step:	369,	Entropy=	9.482e-01,	Error=	4.058e-08 >>>	4.50 sec
Step:	370,	Entropy=	9.477e-01,	Error=	5.017e-08 >>>	4.69 sec
Step:	371,	Entropy=	9.473e-01,	Error=	6.168e-08 >>>	4.45 sec
Step:	372,	Entropy=	9.470e-01,	Error=	7.539e-08 >>>	4.54 sec
Step:	373,	Entropy=	9.469e-01,	Error=	9.158e-08 >>>	4.32 sec
Step:	374,	Entropy=	9.469e-01,	Error=	1.067e-07 >>>	4.61 sec
Step:	375,	Entropy=	9.470e-01,	Error=	5.134e-08 >>>	4.52 sec
Step:	376,	Entropy=	9.474e-01,	Error=	3.582e-08 >>>	4.91 sec
Step:	377,	Entropy=	9.479e-01,	Error=	3.782e-08 >>>	4.54 sec
Step:	378,	Entropy=	9.485e-01,	Error=	3.995e-08 >>>	4.79 sec
Step:	379,	Entropy=	9.493e-01,	Error=	4.223e-08 >>>	4.57 sec
Step:	380,	Entropy=	9.503e-01,	Error=	4.467e-08 >>>	4.66 sec
Step:	381,	Entropy=	9.514e-01,	Error=	4.727e-08 >>>	4.60 sec
Step:	382,	Entropy=	9.527e-01,	Error=	5.005e-08 >>>	4.62 sec
Step:	383,	Entropy=	9.541e-01,	Error=	5.300e-08 >>>	4.54 sec
Step:	384,	Entropy=	9.556e-01,	Error=	5.615e-08 >>>	4.50 sec

Step:	385,	Entropy=	9.572e-01,	Error=	5.950e-08	>>>	4.37 sec
Step:	386,	Entropy=	9.590e-01,	Error=	6.147e-08	>>>	4.71 sec
Step:	387,	Entropy=	9.608e-01,	Error=	7.447e-08	>>>	4.61 sec
Step:	388,	Entropy=	9.627e-01,	Error=	8.991e-08	>>>	4.63 sec
Step:	389,	Entropy=	9.647e-01,	Error=	1.081e-07	>>>	4.54 sec
Step:	390,	Entropy=	9.667e-01,	Error=	1.296e-07	>>>	4.62 sec
Step:	391,	Entropy=	9.687e-01,	Error=	1.343e-07	>>>	4.61 sec
Step:	392,	Entropy=	9.708e-01,	Error=	7.911e-08	>>>	4.45 sec
Step:	393,	Entropy=	9.729e-01,	Error=	9.467e-08	>>>	4.54 sec
Step:	394,	Entropy=	9.750e-01,	Error=	4.752e-08	>>>	4.66 sec
Step:	395,	Entropy=	9.770e-01,	Error=	5.059e-08	>>>	4.48 sec
Step:	396,	Entropy=	9.791e-01,	Error=	5.382e-08	>>>	4.64 sec
Step:	397,	Entropy=	9.810e-01,	Error=	5.723e-08	>>>	4.51 sec
Step:	398,	Entropy=	9.829e-01,	Error=	6.082e-08	>>>	4.70 sec
Step:	399,	Entropy=	9.847e-01,	Error=	6.449e-08	>>>	4.64 sec
Step:	400,	Entropy=	9.864e-01,	Error=	6.691e-08	>>>	4.61 sec

3-rd order Trotter (D=20):

```

ORDER = 3;
[IDX, GATE] = TROTTER(ham, ORDER, DT);
%% initial state as |up>|up>...|up>|down>...|down> with a single domain wall at the center
MPS = QSpace(NSITE,1);
MPS(1) = QCREATE(vac, '1', eid, '1', 'OUT');
MPS(1) = getsub(MPS(1), 2);
for isite = 2 : ceil(NSITE/2)
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 2);
end
for isite = ceil(NSITE/2)+1 : NSITE
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 1);
end

%% run tDMRG
SZ3 = zeros(NSTEP,NSITE);
EE3 = zeros(NSTEP,1);
for istep = 1 : NSTEP
    time = tic;
    [MPS, err] = TDMRG_ex(MPS, GATE, DKEEP, IDX);
    if ~mod(ORDER,2)
        IDX = flip(IDX);
        GATE = flip(GATE);
    end

    % measure Sz on each site
    [mpsB, ~] = CANONICAL(MPS, [], NSITE, 0, 1E-16, -1);
    eyeL = QSpace(NSITE,1);
    eyeL(1) = QCREATE(mpsB(1), '1', 'OUT');
    for isite = 1 : NSITE
        tmp = contract(eyeL(isite), [1], conj(mpsB(isite)), [1]);
        if (isite~=NSITE)
            eyeL(isite+1) = contract(tmp, [1,2], mpsB(isite), [1,2]);
        end
        tmp = contract(tmp, [2], sz, [1]);
        tmp = contract(tmp, [1,3,2], mpsB(isite), [1,2,3]);
        SZ3(istep, isite) = real(tmp.data{1});
    end
end

```

```

end

% measure half chain entanglement entropy
[~, lambda] = CANONICAL(mpsB, [], 0, NSITE/2, 1E-16, -1);
EE3(istep) = SEntropy(contract(lambda, [2], lambda, [1]));
fprintf('Step: %5d, Entropy= %10.3e, Error= %10.3e >>> %9.2f sec \n',...
        istep, EE3(istep), err, toc(time));
end

```

```

Step:    1, Entropy=  5.234e-03, Error=  0.000e+00 >>>    4.02 sec
Step:    2, Entropy=  1.746e-02, Error=  0.000e+00 >>>    4.03 sec
Step:    3, Entropy=  3.467e-02, Error=  0.000e+00 >>>    4.05 sec
Step:    4, Entropy=  5.577e-02, Error=  0.000e+00 >>>    4.05 sec
Step:    5, Entropy=  7.998e-02, Error=  0.000e+00 >>>    4.05 sec
Step:    6, Entropy=  1.067e-01, Error=  0.000e+00 >>>    4.07 sec
Step:    7, Entropy=  1.353e-01, Error=  0.000e+00 >>>    4.07 sec
Step:    8, Entropy=  1.654e-01, Error=  0.000e+00 >>>    4.07 sec
Step:    9, Entropy=  1.966e-01, Error=  0.000e+00 >>>    4.16 sec
Step:   10, Entropy=  2.286e-01, Error=  0.000e+00 >>>    4.21 sec
Step:   11, Entropy=  2.609e-01, Error=  0.000e+00 >>>    4.12 sec
Step:   12, Entropy=  2.934e-01, Error=  0.000e+00 >>>    4.09 sec
Step:   13, Entropy=  3.257e-01, Error=  0.000e+00 >>>    4.11 sec
Step:   14, Entropy=  3.576e-01, Error=  0.000e+00 >>>    4.10 sec
Step:   15, Entropy=  3.888e-01, Error=  0.000e+00 >>>    4.10 sec
Step:   16, Entropy=  4.192e-01, Error=  0.000e+00 >>>    4.12 sec
Step:   17, Entropy=  4.487e-01, Error=  0.000e+00 >>>    4.12 sec
Step:   18, Entropy=  4.769e-01, Error=  0.000e+00 >>>    4.11 sec
Step:   19, Entropy=  5.039e-01, Error=  0.000e+00 >>>    4.12 sec
Step:   20, Entropy=  5.294e-01, Error=  0.000e+00 >>>    4.13 sec
Step:   21, Entropy=  5.534e-01, Error=  0.000e+00 >>>    4.12 sec
Step:   22, Entropy=  5.758e-01, Error=  0.000e+00 >>>    4.14 sec
Step:   23, Entropy=  5.965e-01, Error=  0.000e+00 >>>    4.15 sec
Step:   24, Entropy=  6.155e-01, Error=  0.000e+00 >>>    4.13 sec
Step:   25, Entropy=  6.328e-01, Error=  0.000e+00 >>>    4.12 sec
Step:   26, Entropy=  6.483e-01, Error=  0.000e+00 >>>    4.15 sec
Step:   27, Entropy=  6.620e-01, Error=  0.000e+00 >>>    4.13 sec
Step:   28, Entropy=  6.739e-01, Error=  0.000e+00 >>>    4.17 sec
Step:   29, Entropy=  6.841e-01, Error=  0.000e+00 >>>    4.15 sec
Step:   30, Entropy=  6.926e-01, Error=  0.000e+00 >>>    4.15 sec
Step:   31, Entropy=  6.995e-01, Error=  2.220e-16 >>>    4.31 sec
Step:   32, Entropy=  7.047e-01, Error=  0.000e+00 >>>    4.15 sec
Step:   33, Entropy=  7.085e-01, Error=  0.000e+00 >>>    4.18 sec
Step:   34, Entropy=  7.107e-01, Error=  0.000e+00 >>>    4.16 sec
Step:   35, Entropy=  7.117e-01, Error=  2.220e-16 >>>    4.22 sec
Step:   36, Entropy=  7.114e-01, Error=  0.000e+00 >>>    4.19 sec
Step:   37, Entropy=  7.099e-01, Error=  0.000e+00 >>>    4.17 sec
Step:   38, Entropy=  7.073e-01, Error=  0.000e+00 >>>    4.19 sec
Step:   39, Entropy=  7.038e-01, Error=  0.000e+00 >>>    4.20 sec
Step:   40, Entropy=  6.995e-01, Error=  0.000e+00 >>>    4.19 sec
Step:   41, Entropy=  6.945e-01, Error=  0.000e+00 >>>    4.19 sec
Step:   42, Entropy=  6.888e-01, Error=  0.000e+00 >>>    4.19 sec
Step:   43, Entropy=  6.827e-01, Error=  0.000e+00 >>>    4.17 sec
Step:   44, Entropy=  6.762e-01, Error=  2.220e-16 >>>    4.17 sec
Step:   45, Entropy=  6.694e-01, Error=  2.220e-16 >>>    4.24 sec
Step:   46, Entropy=  6.625e-01, Error=  2.220e-16 >>>    4.38 sec
Step:   47, Entropy=  6.555e-01, Error=  0.000e+00 >>>    4.32 sec
Step:   48, Entropy=  6.486e-01, Error=  0.000e+00 >>>    4.23 sec
Step:   49, Entropy=  6.419e-01, Error=  0.000e+00 >>>    4.26 sec
Step:   50, Entropy=  6.354e-01, Error=  0.000e+00 >>>    4.31 sec
Step:   51, Entropy=  6.292e-01, Error=  0.000e+00 >>>    4.24 sec
Step:   52, Entropy=  6.234e-01, Error=  2.220e-16 >>>    4.21 sec
Step:   53, Entropy=  6.181e-01, Error=  0.000e+00 >>>    4.25 sec
Step:   54, Entropy=  6.134e-01, Error=  0.000e+00 >>>    4.25 sec

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Step:	55,	Entropy=	6.092e-01,	Error=	0.000e+00 >>>	4.31 sec
Step:	56,	Entropy=	6.057e-01,	Error=	2.220e-16 >>>	4.28 sec
Step:	57,	Entropy=	6.029e-01,	Error=	0.000e+00 >>>	4.30 sec
Step:	58,	Entropy=	6.008e-01,	Error=	0.000e+00 >>>	4.33 sec
Step:	59,	Entropy=	5.995e-01,	Error=	0.000e+00 >>>	4.28 sec
Step:	60,	Entropy=	5.989e-01,	Error=	2.220e-16 >>>	4.23 sec
Step:	61,	Entropy=	5.991e-01,	Error=	2.220e-16 >>>	4.23 sec
Step:	62,	Entropy=	6.001e-01,	Error=	0.000e+00 >>>	4.23 sec
Step:	63,	Entropy=	6.018e-01,	Error=	2.220e-16 >>>	4.25 sec
Step:	64,	Entropy=	6.043e-01,	Error=	0.000e+00 >>>	4.29 sec
Step:	65,	Entropy=	6.075e-01,	Error=	2.220e-16 >>>	4.31 sec
Step:	66,	Entropy=	6.114e-01,	Error=	0.000e+00 >>>	4.34 sec
Step:	67,	Entropy=	6.160e-01,	Error=	0.000e+00 >>>	4.31 sec
Step:	68,	Entropy=	6.211e-01,	Error=	2.220e-16 >>>	4.68 sec
Step:	69,	Entropy=	6.269e-01,	Error=	2.220e-16 >>>	5.39 sec
Step:	70,	Entropy=	6.331e-01,	Error=	2.220e-16 >>>	4.84 sec
Step:	71,	Entropy=	6.399e-01,	Error=	2.220e-16 >>>	4.47 sec
Step:	72,	Entropy=	6.470e-01,	Error=	4.441e-16 >>>	4.81 sec
Step:	73,	Entropy=	6.545e-01,	Error=	4.441e-16 >>>	4.96 sec
Step:	74,	Entropy=	6.623e-01,	Error=	6.661e-16 >>>	5.04 sec
Step:	75,	Entropy=	6.703e-01,	Error=	8.882e-16 >>>	4.69 sec
Step:	76,	Entropy=	6.785e-01,	Error=	1.332e-15 >>>	4.33 sec
Step:	77,	Entropy=	6.868e-01,	Error=	1.998e-15 >>>	4.56 sec
Step:	78,	Entropy=	6.951e-01,	Error=	2.442e-15 >>>	4.38 sec
Step:	79,	Entropy=	7.033e-01,	Error=	3.553e-15 >>>	5.02 sec
Step:	80,	Entropy=	7.115e-01,	Error=	5.107e-15 >>>	5.06 sec
Step:	81,	Entropy=	7.195e-01,	Error=	7.105e-15 >>>	5.17 sec
Step:	82,	Entropy=	7.273e-01,	Error=	9.548e-15 >>>	4.82 sec
Step:	83,	Entropy=	7.349e-01,	Error=	1.332e-14 >>>	4.55 sec
Step:	84,	Entropy=	7.421e-01,	Error=	1.821e-14 >>>	4.35 sec
Step:	85,	Entropy=	7.490e-01,	Error=	2.465e-14 >>>	4.38 sec
Step:	86,	Entropy=	7.555e-01,	Error=	3.331e-14 >>>	4.54 sec
Step:	87,	Entropy=	7.615e-01,	Error=	4.485e-14 >>>	4.49 sec
Step:	88,	Entropy=	7.671e-01,	Error=	6.040e-14 >>>	4.42 sec
Step:	89,	Entropy=	7.722e-01,	Error=	8.060e-14 >>>	4.80 sec
Step:	90,	Entropy=	7.767e-01,	Error=	1.075e-13 >>>	5.01 sec
Step:	91,	Entropy=	7.807e-01,	Error=	1.428e-13 >>>	4.54 sec
Step:	92,	Entropy=	7.842e-01,	Error=	1.887e-13 >>>	4.47 sec
Step:	93,	Entropy=	7.872e-01,	Error=	2.491e-13 >>>	4.48 sec
Step:	94,	Entropy=	7.895e-01,	Error=	3.273e-13 >>>	4.43 sec
Step:	95,	Entropy=	7.914e-01,	Error=	4.285e-13 >>>	4.40 sec
Step:	96,	Entropy=	7.927e-01,	Error=	5.598e-13 >>>	4.40 sec
Step:	97,	Entropy=	7.934e-01,	Error=	7.285e-13 >>>	4.40 sec
Step:	98,	Entropy=	7.937e-01,	Error=	9.452e-13 >>>	4.51 sec
Step:	99,	Entropy=	7.935e-01,	Error=	1.223e-12 >>>	4.48 sec
Step:	100,	Entropy=	7.929e-01,	Error=	1.577e-12 >>>	4.46 sec
Step:	101,	Entropy=	7.918e-01,	Error=	2.027e-12 >>>	4.47 sec
Step:	102,	Entropy=	7.904e-01,	Error=	2.599e-12 >>>	4.51 sec
Step:	103,	Entropy=	7.886e-01,	Error=	3.323e-12 >>>	4.53 sec
Step:	104,	Entropy=	7.865e-01,	Error=	4.236e-12 >>>	4.55 sec
Step:	105,	Entropy=	7.841e-01,	Error=	5.385e-12 >>>	4.50 sec
Step:	106,	Entropy=	7.815e-01,	Error=	6.826e-12 >>>	4.55 sec
Step:	107,	Entropy=	7.787e-01,	Error=	8.629e-12 >>>	4.74 sec
Step:	108,	Entropy=	7.759e-01,	Error=	1.088e-11 >>>	4.51 sec
Step:	109,	Entropy=	7.729e-01,	Error=	1.368e-11 >>>	4.48 sec
Step:	110,	Entropy=	7.699e-01,	Error=	1.715e-11 >>>	4.46 sec
Step:	111,	Entropy=	7.669e-01,	Error=	2.145e-11 >>>	4.52 sec
Step:	112,	Entropy=	7.640e-01,	Error=	2.676e-11 >>>	4.94 sec
Step:	113,	Entropy=	7.611e-01,	Error=	3.330e-11 >>>	4.49 sec
Step:	114,	Entropy=	7.584e-01,	Error=	4.133e-11 >>>	4.83 sec
Step:	115,	Entropy=	7.559e-01,	Error=	5.002e-11 >>>	4.61 sec
Step:	116,	Entropy=	7.536e-01,	Error=	1.334e-11 >>>	4.84 sec
Step:	117,	Entropy=	7.515e-01,	Error=	1.506e-11 >>>	4.76 sec
Step:	118,	Entropy=	7.497e-01,	Error=	1.700e-11 >>>	4.58 sec
Step:	119,	Entropy=	7.482e-01,	Error=	1.917e-11 >>>	4.91 sec

Step:	120,	Entropy=	7.471e-01,	Error=	2.161e-11 >>>	4.74 sec
Step:	121,	Entropy=	7.463e-01,	Error=	2.433e-11 >>>	4.84 sec
Step:	122,	Entropy=	7.458e-01,	Error=	2.737e-11 >>>	4.74 sec
Step:	123,	Entropy=	7.458e-01,	Error=	3.077e-11 >>>	4.62 sec
Step:	124,	Entropy=	7.461e-01,	Error=	3.457e-11 >>>	4.57 sec
Step:	125,	Entropy=	7.468e-01,	Error=	3.881e-11 >>>	4.59 sec
Step:	126,	Entropy=	7.479e-01,	Error=	4.355e-11 >>>	4.53 sec
Step:	127,	Entropy=	7.494e-01,	Error=	4.884e-11 >>>	4.55 sec
Step:	128,	Entropy=	7.512e-01,	Error=	5.475e-11 >>>	4.58 sec
Step:	129,	Entropy=	7.534e-01,	Error=	6.138e-11 >>>	4.70 sec
Step:	130,	Entropy=	7.560e-01,	Error=	6.881e-11 >>>	4.60 sec
Step:	131,	Entropy=	7.589e-01,	Error=	7.716e-11 >>>	4.65 sec
Step:	132,	Entropy=	7.621e-01,	Error=	8.657e-11 >>>	4.61 sec
Step:	133,	Entropy=	7.656e-01,	Error=	9.719e-11 >>>	4.60 sec
Step:	134,	Entropy=	7.694e-01,	Error=	1.092e-10 >>>	4.65 sec
Step:	135,	Entropy=	7.733e-01,	Error=	1.229e-10 >>>	4.62 sec
Step:	136,	Entropy=	7.775e-01,	Error=	1.384e-10 >>>	4.64 sec
Step:	137,	Entropy=	7.819e-01,	Error=	1.562e-10 >>>	4.65 sec
Step:	138,	Entropy=	7.864e-01,	Error=	1.767e-10 >>>	4.65 sec
Step:	139,	Entropy=	7.910e-01,	Error=	2.002e-10 >>>	4.69 sec
Step:	140,	Entropy=	7.956e-01,	Error=	2.274e-10 >>>	4.75 sec
Step:	141,	Entropy=	8.003e-01,	Error=	2.590e-10 >>>	4.80 sec
Step:	142,	Entropy=	8.050e-01,	Error=	2.958e-10 >>>	4.68 sec
Step:	143,	Entropy=	8.096e-01,	Error=	3.386e-10 >>>	4.96 sec
Step:	144,	Entropy=	8.141e-01,	Error=	3.888e-10 >>>	5.16 sec
Step:	145,	Entropy=	8.186e-01,	Error=	4.478e-10 >>>	4.64 sec
Step:	146,	Entropy=	8.229e-01,	Error=	5.171e-10 >>>	4.71 sec
Step:	147,	Entropy=	8.270e-01,	Error=	5.987e-10 >>>	5.01 sec
Step:	148,	Entropy=	8.309e-01,	Error=	6.950e-10 >>>	5.29 sec
Step:	149,	Entropy=	8.346e-01,	Error=	8.087e-10 >>>	4.80 sec
Step:	150,	Entropy=	8.381e-01,	Error=	9.431e-10 >>>	4.64 sec
Step:	151,	Entropy=	8.413e-01,	Error=	1.102e-09 >>>	5.31 sec
Step:	152,	Entropy=	8.442e-01,	Error=	1.290e-09 >>>	4.76 sec
Step:	153,	Entropy=	8.468e-01,	Error=	1.512e-09 >>>	4.61 sec
Step:	154,	Entropy=	8.491e-01,	Error=	1.775e-09 >>>	4.61 sec
Step:	155,	Entropy=	8.511e-01,	Error=	2.086e-09 >>>	4.85 sec
Step:	156,	Entropy=	8.528e-01,	Error=	2.453e-09 >>>	4.79 sec
Step:	157,	Entropy=	8.541e-01,	Error=	2.791e-09 >>>	4.70 sec
Step:	158,	Entropy=	8.551e-01,	Error=	1.955e-09 >>>	4.81 sec
Step:	159,	Entropy=	8.558e-01,	Error=	5.549e-10 >>>	4.81 sec
Step:	160,	Entropy=	8.562e-01,	Error=	5.899e-10 >>>	4.69 sec
Step:	161,	Entropy=	8.562e-01,	Error=	6.275e-10 >>>	4.84 sec
Step:	162,	Entropy=	8.560e-01,	Error=	6.680e-10 >>>	4.90 sec
Step:	163,	Entropy=	8.555e-01,	Error=	7.116e-10 >>>	4.74 sec
Step:	164,	Entropy=	8.548e-01,	Error=	7.588e-10 >>>	4.91 sec
Step:	165,	Entropy=	8.538e-01,	Error=	8.098e-10 >>>	4.80 sec
Step:	166,	Entropy=	8.526e-01,	Error=	8.651e-10 >>>	4.76 sec
Step:	167,	Entropy=	8.513e-01,	Error=	9.253e-10 >>>	4.72 sec
Step:	168,	Entropy=	8.497e-01,	Error=	9.907e-10 >>>	4.84 sec
Step:	169,	Entropy=	8.481e-01,	Error=	1.062e-09 >>>	4.84 sec
Step:	170,	Entropy=	8.463e-01,	Error=	1.140e-09 >>>	4.78 sec
Step:	171,	Entropy=	8.444e-01,	Error=	1.225e-09 >>>	4.87 sec
Step:	172,	Entropy=	8.425e-01,	Error=	1.238e-09 >>>	4.79 sec
Step:	173,	Entropy=	8.406e-01,	Error=	7.762e-10 >>>	4.82 sec
Step:	174,	Entropy=	8.387e-01,	Error=	7.897e-10 >>>	4.86 sec
Step:	175,	Entropy=	8.368e-01,	Error=	8.035e-10 >>>	4.89 sec
Step:	176,	Entropy=	8.350e-01,	Error=	8.181e-10 >>>	4.79 sec
Step:	177,	Entropy=	8.333e-01,	Error=	8.339e-10 >>>	4.89 sec
Step:	178,	Entropy=	8.317e-01,	Error=	8.518e-10 >>>	4.88 sec
Step:	179,	Entropy=	8.302e-01,	Error=	9.410e-10 >>>	4.84 sec
Step:	180,	Entropy=	8.289e-01,	Error=	1.086e-09 >>>	4.75 sec
Step:	181,	Entropy=	8.278e-01,	Error=	9.282e-10 >>>	4.76 sec
Step:	182,	Entropy=	8.269e-01,	Error=	9.667e-10 >>>	4.97 sec
Step:	183,	Entropy=	8.262e-01,	Error=	1.064e-09 >>>	4.79 sec
Step:	184,	Entropy=	8.257e-01,	Error=	1.295e-09 >>>	4.84 sec

Step:	185,	Entropy=	8.255e-01,	Error=	1.579e-09 >>>	4.83 sec
Step:	186,	Entropy=	8.255e-01,	Error=	1.926e-09 >>>	4.78 sec
Step:	187,	Entropy=	8.258e-01,	Error=	2.350e-09 >>>	4.89 sec
Step:	188,	Entropy=	8.263e-01,	Error=	2.866e-09 >>>	4.85 sec
Step:	189,	Entropy=	8.271e-01,	Error=	3.491e-09 >>>	5.07 sec
Step:	190,	Entropy=	8.282e-01,	Error=	3.706e-09 >>>	4.99 sec
Step:	191,	Entropy=	8.295e-01,	Error=	6.790e-10 >>>	5.02 sec
Step:	192,	Entropy=	8.311e-01,	Error=	6.796e-10 >>>	4.95 sec
Step:	193,	Entropy=	8.329e-01,	Error=	6.701e-10 >>>	5.03 sec
Step:	194,	Entropy=	8.349e-01,	Error=	6.992e-10 >>>	4.95 sec
Step:	195,	Entropy=	8.371e-01,	Error=	7.573e-10 >>>	4.96 sec
Step:	196,	Entropy=	8.396e-01,	Error=	8.229e-10 >>>	5.08 sec
Step:	197,	Entropy=	8.422e-01,	Error=	8.966e-10 >>>	4.99 sec
Step:	198,	Entropy=	8.449e-01,	Error=	9.796e-10 >>>	4.91 sec
Step:	199,	Entropy=	8.479e-01,	Error=	1.073e-09 >>>	4.94 sec
Step:	200,	Entropy=	8.509e-01,	Error=	1.177e-09 >>>	4.90 sec
Step:	201,	Entropy=	8.540e-01,	Error=	1.295e-09 >>>	4.97 sec
Step:	202,	Entropy=	8.572e-01,	Error=	1.426e-09 >>>	4.91 sec
Step:	203,	Entropy=	8.604e-01,	Error=	1.573e-09 >>>	5.04 sec
Step:	204,	Entropy=	8.636e-01,	Error=	1.738e-09 >>>	5.22 sec
Step:	205,	Entropy=	8.669e-01,	Error=	1.922e-09 >>>	4.91 sec
Step:	206,	Entropy=	8.701e-01,	Error=	2.127e-09 >>>	5.03 sec
Step:	207,	Entropy=	8.733e-01,	Error=	2.355e-09 >>>	4.99 sec
Step:	208,	Entropy=	8.763e-01,	Error=	2.610e-09 >>>	4.93 sec
Step:	209,	Entropy=	8.793e-01,	Error=	2.894e-09 >>>	4.90 sec
Step:	210,	Entropy=	8.822e-01,	Error=	3.209e-09 >>>	5.00 sec
Step:	211,	Entropy=	8.849e-01,	Error=	2.900e-09 >>>	4.79 sec
Step:	212,	Entropy=	8.875e-01,	Error=	2.143e-09 >>>	4.91 sec
Step:	213,	Entropy=	8.899e-01,	Error=	2.349e-09 >>>	5.04 sec
Step:	214,	Entropy=	8.921e-01,	Error=	1.573e-09 >>>	4.94 sec
Step:	215,	Entropy=	8.942e-01,	Error=	1.924e-09 >>>	5.05 sec
Step:	216,	Entropy=	8.960e-01,	Error=	2.355e-09 >>>	5.01 sec
Step:	217,	Entropy=	8.976e-01,	Error=	2.879e-09 >>>	4.97 sec
Step:	218,	Entropy=	8.989e-01,	Error=	3.514e-09 >>>	4.97 sec
Step:	219,	Entropy=	9.001e-01,	Error=	4.281e-09 >>>	5.01 sec
Step:	220,	Entropy=	9.010e-01,	Error=	5.202e-09 >>>	5.36 sec
Step:	221,	Entropy=	9.017e-01,	Error=	5.351e-09 >>>	5.11 sec
Step:	222,	Entropy=	9.021e-01,	Error=	4.531e-09 >>>	5.13 sec
Step:	223,	Entropy=	9.023e-01,	Error=	5.456e-09 >>>	4.90 sec
Step:	224,	Entropy=	9.024e-01,	Error=	6.567e-09 >>>	4.95 sec
Step:	225,	Entropy=	9.022e-01,	Error=	7.897e-09 >>>	4.92 sec
Step:	226,	Entropy=	9.018e-01,	Error=	9.482e-09 >>>	5.08 sec
Step:	227,	Entropy=	9.012e-01,	Error=	1.136e-08 >>>	5.09 sec
Step:	228,	Entropy=	9.005e-01,	Error=	1.172e-08 >>>	4.99 sec
Step:	229,	Entropy=	8.996e-01,	Error=	1.068e-09 >>>	5.15 sec
Step:	230,	Entropy=	8.986e-01,	Error=	1.077e-09 >>>	5.12 sec
Step:	231,	Entropy=	8.975e-01,	Error=	1.167e-09 >>>	5.03 sec
Step:	232,	Entropy=	8.963e-01,	Error=	1.293e-09 >>>	5.01 sec
Step:	233,	Entropy=	8.950e-01,	Error=	1.435e-09 >>>	5.16 sec
Step:	234,	Entropy=	8.936e-01,	Error=	1.596e-09 >>>	5.11 sec
Step:	235,	Entropy=	8.922e-01,	Error=	1.777e-09 >>>	5.23 sec
Step:	236,	Entropy=	8.908e-01,	Error=	1.981e-09 >>>	5.05 sec
Step:	237,	Entropy=	8.894e-01,	Error=	2.211e-09 >>>	4.96 sec
Step:	238,	Entropy=	8.881e-01,	Error=	2.468e-09 >>>	5.07 sec
Step:	239,	Entropy=	8.868e-01,	Error=	2.757e-09 >>>	5.14 sec
Step:	240,	Entropy=	8.856e-01,	Error=	3.079e-09 >>>	5.19 sec
Step:	241,	Entropy=	8.844e-01,	Error=	3.440e-09 >>>	5.05 sec
Step:	242,	Entropy=	8.834e-01,	Error=	3.339e-09 >>>	5.10 sec
Step:	243,	Entropy=	8.825e-01,	Error=	2.928e-09 >>>	5.11 sec
Step:	244,	Entropy=	8.817e-01,	Error=	3.267e-09 >>>	5.15 sec
Step:	245,	Entropy=	8.810e-01,	Error=	3.708e-09 >>>	5.16 sec
Step:	246,	Entropy=	8.806e-01,	Error=	4.539e-09 >>>	5.05 sec
Step:	247,	Entropy=	8.803e-01,	Error=	5.544e-09 >>>	5.00 sec
Step:	248,	Entropy=	8.802e-01,	Error=	6.753e-09 >>>	5.14 sec
Step:	249,	Entropy=	8.802e-01,	Error=	8.149e-09 >>>	5.02 sec

Step:	250,	Entropy=	8.805e-01,	Error=	6.449e-09 >>>	5.20 sec
Step:	251,	Entropy=	8.809e-01,	Error=	7.223e-09 >>>	5.07 sec
Step:	252,	Entropy=	8.816e-01,	Error=	8.086e-09 >>>	5.28 sec
Step:	253,	Entropy=	8.824e-01,	Error=	9.408e-09 >>>	4.99 sec
Step:	254,	Entropy=	8.835e-01,	Error=	1.111e-08 >>>	5.04 sec
Step:	255,	Entropy=	8.847e-01,	Error=	1.312e-08 >>>	5.15 sec
Step:	256,	Entropy=	8.861e-01,	Error=	1.509e-08 >>>	5.33 sec
Step:	257,	Entropy=	8.876e-01,	Error=	8.540e-09 >>>	5.06 sec
Step:	258,	Entropy=	8.893e-01,	Error=	9.416e-09 >>>	5.19 sec
Step:	259,	Entropy=	8.912e-01,	Error=	1.038e-08 >>>	5.23 sec
Step:	260,	Entropy=	8.932e-01,	Error=	1.143e-08 >>>	5.33 sec
Step:	261,	Entropy=	8.953e-01,	Error=	1.257e-08 >>>	5.07 sec
Step:	262,	Entropy=	8.975e-01,	Error=	1.382e-08 >>>	5.27 sec
Step:	263,	Entropy=	8.997e-01,	Error=	1.518e-08 >>>	5.26 sec
Step:	264,	Entropy=	9.021e-01,	Error=	1.664e-08 >>>	5.09 sec
Step:	265,	Entropy=	9.045e-01,	Error=	1.390e-08 >>>	5.15 sec
Step:	266,	Entropy=	9.069e-01,	Error=	2.702e-09 >>>	5.11 sec
Step:	267,	Entropy=	9.093e-01,	Error=	3.044e-09 >>>	5.25 sec
Step:	268,	Entropy=	9.118e-01,	Error=	3.430e-09 >>>	5.07 sec
Step:	269,	Entropy=	9.142e-01,	Error=	3.863e-09 >>>	5.31 sec
Step:	270,	Entropy=	9.165e-01,	Error=	4.349e-09 >>>	5.19 sec
Step:	271,	Entropy=	9.188e-01,	Error=	4.460e-09 >>>	5.01 sec
Step:	272,	Entropy=	9.210e-01,	Error=	3.309e-09 >>>	5.08 sec
Step:	273,	Entropy=	9.232e-01,	Error=	4.048e-09 >>>	5.08 sec
Step:	274,	Entropy=	9.252e-01,	Error=	4.940e-09 >>>	5.16 sec
Step:	275,	Entropy=	9.271e-01,	Error=	6.012e-09 >>>	5.23 sec
Step:	276,	Entropy=	9.288e-01,	Error=	7.295e-09 >>>	5.25 sec
Step:	277,	Entropy=	9.304e-01,	Error=	8.823e-09 >>>	5.09 sec
Step:	278,	Entropy=	9.319e-01,	Error=	8.472e-09 >>>	5.25 sec
Step:	279,	Entropy=	9.332e-01,	Error=	5.081e-09 >>>	5.28 sec
Step:	280,	Entropy=	9.343e-01,	Error=	5.792e-09 >>>	5.13 sec
Step:	281,	Entropy=	9.353e-01,	Error=	6.597e-09 >>>	5.22 sec
Step:	282,	Entropy=	9.360e-01,	Error=	7.507e-09 >>>	5.29 sec
Step:	283,	Entropy=	9.366e-01,	Error=	8.532e-09 >>>	5.07 sec
Step:	284,	Entropy=	9.371e-01,	Error=	1.006e-08 >>>	5.20 sec
Step:	285,	Entropy=	9.373e-01,	Error=	1.195e-08 >>>	5.38 sec
Step:	286,	Entropy=	9.374e-01,	Error=	1.418e-08 >>>	5.35 sec
Step:	287,	Entropy=	9.373e-01,	Error=	1.681e-08 >>>	5.26 sec
Step:	288,	Entropy=	9.371e-01,	Error=	1.989e-08 >>>	5.28 sec
Step:	289,	Entropy=	9.367e-01,	Error=	2.339e-08 >>>	5.39 sec
Step:	290,	Entropy=	9.362e-01,	Error=	2.004e-08 >>>	5.23 sec
Step:	291,	Entropy=	9.355e-01,	Error=	2.249e-08 >>>	5.22 sec
Step:	292,	Entropy=	9.348e-01,	Error=	2.521e-08 >>>	5.14 sec
Step:	293,	Entropy=	9.339e-01,	Error=	2.823e-08 >>>	5.42 sec
Step:	294,	Entropy=	9.330e-01,	Error=	2.951e-08 >>>	5.41 sec
Step:	295,	Entropy=	9.320e-01,	Error=	1.403e-08 >>>	5.34 sec
Step:	296,	Entropy=	9.310e-01,	Error=	1.380e-08 >>>	5.35 sec
Step:	297,	Entropy=	9.299e-01,	Error=	1.497e-08 >>>	5.30 sec
Step:	298,	Entropy=	9.288e-01,	Error=	1.624e-08 >>>	5.15 sec
Step:	299,	Entropy=	9.277e-01,	Error=	1.842e-08 >>>	5.33 sec
Step:	300,	Entropy=	9.267e-01,	Error=	2.197e-08 >>>	5.21 sec
Step:	301,	Entropy=	9.256e-01,	Error=	2.610e-08 >>>	5.25 sec
Step:	302,	Entropy=	9.246e-01,	Error=	3.089e-08 >>>	5.30 sec
Step:	303,	Entropy=	9.237e-01,	Error=	3.641e-08 >>>	5.41 sec
Step:	304,	Entropy=	9.229e-01,	Error=	4.275e-08 >>>	5.33 sec
Step:	305,	Entropy=	9.221e-01,	Error=	4.998e-08 >>>	5.52 sec
Step:	306,	Entropy=	9.215e-01,	Error=	5.820e-08 >>>	5.30 sec
Step:	307,	Entropy=	9.210e-01,	Error=	6.750e-08 >>>	5.21 sec
Step:	308,	Entropy=	9.206e-01,	Error=	7.798e-08 >>>	5.35 sec
Step:	309,	Entropy=	9.203e-01,	Error=	8.226e-08 >>>	5.55 sec
Step:	310,	Entropy=	9.202e-01,	Error=	6.724e-09 >>>	5.25 sec
Step:	311,	Entropy=	9.203e-01,	Error=	8.107e-09 >>>	5.31 sec
Step:	312,	Entropy=	9.205e-01,	Error=	9.766e-09 >>>	5.36 sec
Step:	313,	Entropy=	9.209e-01,	Error=	1.175e-08 >>>	5.25 sec
Step:	314,	Entropy=	9.214e-01,	Error=	1.411e-08 >>>	5.41 sec

Step:	315,	Entropy=	9.221e-01,	Error=	1.691e-08 >>>	5.54 sec
Step:	316,	Entropy=	9.229e-01,	Error=	2.022e-08 >>>	5.36 sec
Step:	317,	Entropy=	9.239e-01,	Error=	2.411e-08 >>>	5.32 sec
Step:	318,	Entropy=	9.251e-01,	Error=	2.867e-08 >>>	5.31 sec
Step:	319,	Entropy=	9.264e-01,	Error=	3.401e-08 >>>	5.37 sec
Step:	320,	Entropy=	9.278e-01,	Error=	3.848e-08 >>>	5.30 sec
Step:	321,	Entropy=	9.293e-01,	Error=	1.857e-08 >>>	5.40 sec
Step:	322,	Entropy=	9.310e-01,	Error=	2.206e-08 >>>	5.53 sec
Step:	323,	Entropy=	9.327e-01,	Error=	2.620e-08 >>>	5.27 sec
Step:	324,	Entropy=	9.346e-01,	Error=	3.110e-08 >>>	5.39 sec
Step:	325,	Entropy=	9.365e-01,	Error=	3.686e-08 >>>	5.43 sec
Step:	326,	Entropy=	9.385e-01,	Error=	4.362e-08 >>>	5.48 sec
Step:	327,	Entropy=	9.405e-01,	Error=	5.152e-08 >>>	5.30 sec
Step:	328,	Entropy=	9.425e-01,	Error=	5.907e-08 >>>	5.38 sec
Step:	329,	Entropy=	9.446e-01,	Error=	2.271e-08 >>>	5.48 sec
Step:	330,	Entropy=	9.466e-01,	Error=	2.435e-08 >>>	5.36 sec
Step:	331,	Entropy=	9.486e-01,	Error=	2.611e-08 >>>	5.42 sec
Step:	332,	Entropy=	9.506e-01,	Error=	2.800e-08 >>>	5.38 sec
Step:	333,	Entropy=	9.525e-01,	Error=	3.001e-08 >>>	5.49 sec
Step:	334,	Entropy=	9.544e-01,	Error=	3.283e-08 >>>	5.46 sec
Step:	335,	Entropy=	9.562e-01,	Error=	3.882e-08 >>>	5.45 sec
Step:	336,	Entropy=	9.579e-01,	Error=	4.568e-08 >>>	5.31 sec
Step:	337,	Entropy=	9.595e-01,	Error=	5.350e-08 >>>	5.39 sec
Step:	338,	Entropy=	9.609e-01,	Error=	6.236e-08 >>>	5.47 sec
Step:	339,	Entropy=	9.623e-01,	Error=	6.474e-08 >>>	5.45 sec
Step:	340,	Entropy=	9.635e-01,	Error=	8.227e-09 >>>	5.31 sec
Step:	341,	Entropy=	9.645e-01,	Error=	9.907e-09 >>>	5.41 sec
Step:	342,	Entropy=	9.654e-01,	Error=	1.191e-08 >>>	5.47 sec
Step:	343,	Entropy=	9.662e-01,	Error=	1.428e-08 >>>	5.33 sec
Step:	344,	Entropy=	9.668e-01,	Error=	1.709e-08 >>>	5.39 sec
Step:	345,	Entropy=	9.672e-01,	Error=	2.040e-08 >>>	5.53 sec
Step:	346,	Entropy=	9.675e-01,	Error=	2.428e-08 >>>	5.32 sec
Step:	347,	Entropy=	9.676e-01,	Error=	2.882e-08 >>>	5.34 sec
Step:	348,	Entropy=	9.675e-01,	Error=	3.412e-08 >>>	5.37 sec
Step:	349,	Entropy=	9.673e-01,	Error=	4.027e-08 >>>	5.48 sec
Step:	350,	Entropy=	9.669e-01,	Error=	4.092e-08 >>>	5.53 sec
Step:	351,	Entropy=	9.665e-01,	Error=	1.670e-08 >>>	5.41 sec
Step:	352,	Entropy=	9.658e-01,	Error=	1.813e-08 >>>	5.41 sec
Step:	353,	Entropy=	9.651e-01,	Error=	1.996e-08 >>>	5.54 sec
Step:	354,	Entropy=	9.642e-01,	Error=	2.394e-08 >>>	5.35 sec
Step:	355,	Entropy=	9.633e-01,	Error=	2.865e-08 >>>	5.39 sec
Step:	356,	Entropy=	9.623e-01,	Error=	3.419e-08 >>>	5.58 sec
Step:	357,	Entropy=	9.612e-01,	Error=	4.070e-08 >>>	5.60 sec
Step:	358,	Entropy=	9.600e-01,	Error=	4.831e-08 >>>	5.67 sec
Step:	359,	Entropy=	9.588e-01,	Error=	5.718e-08 >>>	5.46 sec
Step:	360,	Entropy=	9.576e-01,	Error=	6.750e-08 >>>	5.50 sec
Step:	361,	Entropy=	9.564e-01,	Error=	6.518e-08 >>>	5.56 sec
Step:	362,	Entropy=	9.551e-01,	Error=	3.344e-08 >>>	5.81 sec
Step:	363,	Entropy=	9.539e-01,	Error=	3.825e-08 >>>	5.53 sec
Step:	364,	Entropy=	9.528e-01,	Error=	4.136e-08 >>>	5.35 sec
Step:	365,	Entropy=	9.517e-01,	Error=	4.917e-08 >>>	5.49 sec
Step:	366,	Entropy=	9.507e-01,	Error=	5.816e-08 >>>	5.41 sec
Step:	367,	Entropy=	9.497e-01,	Error=	6.844e-08 >>>	5.65 sec
Step:	368,	Entropy=	9.489e-01,	Error=	8.015e-08 >>>	5.44 sec
Step:	369,	Entropy=	9.482e-01,	Error=	8.331e-08 >>>	5.56 sec
Step:	370,	Entropy=	9.475e-01,	Error=	4.294e-08 >>>	5.53 sec
Step:	371,	Entropy=	9.471e-01,	Error=	4.569e-08 >>>	5.46 sec
Step:	372,	Entropy=	9.467e-01,	Error=	5.247e-08 >>>	5.55 sec
Step:	373,	Entropy=	9.465e-01,	Error=	6.281e-08 >>>	5.40 sec
Step:	374,	Entropy=	9.465e-01,	Error=	7.457e-08 >>>	5.36 sec
Step:	375,	Entropy=	9.466e-01,	Error=	3.538e-08 >>>	5.27 sec
Step:	376,	Entropy=	9.469e-01,	Error=	4.211e-08 >>>	5.56 sec
Step:	377,	Entropy=	9.474e-01,	Error=	4.833e-08 >>>	5.35 sec
Step:	378,	Entropy=	9.480e-01,	Error=	1.812e-08 >>>	5.57 sec
Step:	379,	Entropy=	9.487e-01,	Error=	1.977e-08 >>>	5.56 sec

Step:	380,	Entropy=	9.497e-01,	Error=	2.156e-08 >>>	5.63 sec
Step:	381,	Entropy=	9.508e-01,	Error=	2.348e-08 >>>	5.50 sec
Step:	382,	Entropy=	9.520e-01,	Error=	2.046e-08 >>>	5.72 sec
Step:	383,	Entropy=	9.534e-01,	Error=	2.261e-08 >>>	5.52 sec
Step:	384,	Entropy=	9.548e-01,	Error=	2.745e-08 >>>	5.34 sec
Step:	385,	Entropy=	9.565e-01,	Error=	3.322e-08 >>>	5.52 sec
Step:	386,	Entropy=	9.582e-01,	Error=	4.005e-08 >>>	5.53 sec
Step:	387,	Entropy=	9.600e-01,	Error=	4.813e-08 >>>	5.58 sec
Step:	388,	Entropy=	9.619e-01,	Error=	5.764e-08 >>>	5.76 sec
Step:	389,	Entropy=	9.639e-01,	Error=	6.878e-08 >>>	5.46 sec
Step:	390,	Entropy=	9.659e-01,	Error=	8.179e-08 >>>	5.55 sec
Step:	391,	Entropy=	9.679e-01,	Error=	9.694e-08 >>>	5.49 sec
Step:	392,	Entropy=	9.700e-01,	Error=	1.145e-07 >>>	5.49 sec
Step:	393,	Entropy=	9.721e-01,	Error=	1.156e-07 >>>	5.43 sec
Step:	394,	Entropy=	9.741e-01,	Error=	8.333e-08 >>>	5.53 sec
Step:	395,	Entropy=	9.762e-01,	Error=	9.538e-08 >>>	5.66 sec
Step:	396,	Entropy=	9.782e-01,	Error=	5.951e-08 >>>	5.74 sec
Step:	397,	Entropy=	9.801e-01,	Error=	6.982e-08 >>>	5.64 sec
Step:	398,	Entropy=	9.820e-01,	Error=	8.151e-08 >>>	5.64 sec
Step:	399,	Entropy=	9.837e-01,	Error=	9.284e-08 >>>	5.61 sec
Step:	400,	Entropy=	9.854e-01,	Error=	6.888e-08 >>>	5.73 sec

4-th order Trotter (D=20):

```

ORDER = 4;
[IDX, GATE] = TROTTER(ham, ORDER, DT);
%% initial state as |up>|up>...|up>|down>...|down> with a single domain wall at the center
MPS = QSpace(NSITE,1);
MPS(1) = QCREATE(vac, '1', eid, '1', 'OUT');
MPS(1) = getsub(MPS(1), 2);
for isite = 2 : ceil(NSITE/2)
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 2);
end
for isite = ceil(NSITE/2)+1 : NSITE
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 1);
end

%% run tDMRG
SZ4 = zeros(NSTEP,NSITE);
EE4 = zeros(NSTEP,1);
for istep = 1 : NSTEP
    time = tic;
    [MPS, err] = TDMRG_ex(MPS, GATE, DKEEP, IDX);
    if ~mod(ORDER,2)
        IDX = flip(IDX);
        GATE = flip(GATE);
    end

    % measure Sz on each site
    [mpsB, ~] = CANONICAL(MPS, [], NSITE, 0, 1E-16, -1);
    eyeL = QSpace(NSITE,1);
    eyeL(1) = QCREATE(mpsB(1), '1', 'OUT');
    for isite = 1 : NSITE
        tmp = contract(eyeL(isite), [1], conj(mpsB(isite)), [1]);
        if (isite~=NSITE)
            eyeL(isite+1) = contract(tmp, [1,2], mpsB(isite), [1,2]);
        end
    end
end

```

```

end
tmp = contract(tmp, [2], sz, [1]);
tmp = contract(tmp, [1,3,2], mpsB(isite), [1,2,3]);
SZ4(istep, isite) = real(tmp.data{1});
end

% measure half chain entanglement entropy
[~, lambda] = CANONICAL(mpsB, [], 0, NSITE/2, 1E-16, -1);
EE4(istep) = SEntropy(contract(lambda, [2], lambda, [1]));
fprintf('Step: %5d, Entropy= %10.3e, Error= %10.3e >>> %9.2f sec \n',...
        istep, EE4(istep), err, toc(time));
end

```

```

Step:    1, Entropy=  5.234e-03, Error=  0.000e+00 >>>    4.75 sec
Step:    2, Entropy=  1.746e-02, Error=  0.000e+00 >>>    4.81 sec
Step:    3, Entropy=  3.467e-02, Error=  0.000e+00 >>>    4.78 sec
Step:    4, Entropy=  5.577e-02, Error=  2.220e-16 >>>    4.80 sec
Step:    5, Entropy=  7.998e-02, Error=  0.000e+00 >>>    4.83 sec
Step:    6, Entropy=  1.067e-01, Error=  0.000e+00 >>>    4.86 sec
Step:    7, Entropy=  1.353e-01, Error=  0.000e+00 >>>    4.85 sec
Step:    8, Entropy=  1.654e-01, Error=  0.000e+00 >>>    4.88 sec
Step:    9, Entropy=  1.967e-01, Error=  0.000e+00 >>>    4.84 sec
Step:   10, Entropy=  2.286e-01, Error=  2.220e-16 >>>    4.89 sec
Step:   11, Entropy=  2.609e-01, Error=  0.000e+00 >>>    4.86 sec
Step:   12, Entropy=  2.934e-01, Error=  0.000e+00 >>>    4.91 sec
Step:   13, Entropy=  3.257e-01, Error=  0.000e+00 >>>    4.91 sec
Step:   14, Entropy=  3.576e-01, Error=  0.000e+00 >>>    4.93 sec
Step:   15, Entropy=  3.888e-01, Error=  0.000e+00 >>>    4.86 sec
Step:   16, Entropy=  4.193e-01, Error=  0.000e+00 >>>    4.89 sec
Step:   17, Entropy=  4.487e-01, Error=  0.000e+00 >>>    4.87 sec
Step:   18, Entropy=  4.769e-01, Error=  0.000e+00 >>>    4.87 sec
Step:   19, Entropy=  5.039e-01, Error=  2.220e-16 >>>    4.84 sec
Step:   20, Entropy=  5.294e-01, Error=  0.000e+00 >>>    4.87 sec
Step:   21, Entropy=  5.534e-01, Error=  0.000e+00 >>>    4.87 sec
Step:   22, Entropy=  5.758e-01, Error=  0.000e+00 >>>    4.88 sec
Step:   23, Entropy=  5.965e-01, Error=  0.000e+00 >>>    4.85 sec
Step:   24, Entropy=  6.155e-01, Error=  2.220e-16 >>>    4.88 sec
Step:   25, Entropy=  6.328e-01, Error=  0.000e+00 >>>    4.86 sec
Step:   26, Entropy=  6.483e-01, Error=  0.000e+00 >>>    4.90 sec
Step:   27, Entropy=  6.620e-01, Error=  2.220e-16 >>>    4.87 sec
Step:   28, Entropy=  6.739e-01, Error=  2.220e-16 >>>    4.91 sec
Step:   29, Entropy=  6.841e-01, Error=  2.220e-16 >>>    4.88 sec
Step:   30, Entropy=  6.926e-01, Error=  2.220e-16 >>>    4.93 sec
Step:   31, Entropy=  6.995e-01, Error=  2.220e-16 >>>    4.94 sec
Step:   32, Entropy=  7.047e-01, Error=  0.000e+00 >>>    5.03 sec
Step:   33, Entropy=  7.084e-01, Error=  2.220e-16 >>>    4.97 sec
Step:   34, Entropy=  7.107e-01, Error=  2.220e-16 >>>    5.01 sec
Step:   35, Entropy=  7.117e-01, Error=  2.220e-16 >>>    4.94 sec
Step:   36, Entropy=  7.113e-01, Error=  2.220e-16 >>>    4.95 sec
Step:   37, Entropy=  7.099e-01, Error=  0.000e+00 >>>    5.00 sec
Step:   38, Entropy=  7.073e-01, Error=  0.000e+00 >>>    5.13 sec
Step:   39, Entropy=  7.038e-01, Error=  0.000e+00 >>>    5.00 sec
Step:   40, Entropy=  6.995e-01, Error=  0.000e+00 >>>    5.02 sec
Step:   41, Entropy=  6.945e-01, Error=  2.220e-16 >>>    5.01 sec
Step:   42, Entropy=  6.888e-01, Error=  2.220e-16 >>>    5.03 sec
Step:   43, Entropy=  6.827e-01, Error=  0.000e+00 >>>    4.99 sec
Step:   44, Entropy=  6.762e-01, Error=  2.220e-16 >>>    5.01 sec
Step:   45, Entropy=  6.694e-01, Error=  2.220e-16 >>>    4.97 sec
Step:   46, Entropy=  6.625e-01, Error=  0.000e+00 >>>    5.02 sec
Step:   47, Entropy=  6.555e-01, Error=  0.000e+00 >>>    4.99 sec
Step:   48, Entropy=  6.486e-01, Error=  0.000e+00 >>>    5.02 sec
Step:   49, Entropy=  6.418e-01, Error=  0.000e+00 >>>    5.01 sec

```

Step:	50,	Entropy=	6.353e-01,	Error=	0.000e+00 >>>	5.07 sec
Step:	51,	Entropy=	6.291e-01,	Error=	0.000e+00 >>>	5.03 sec
Step:	52,	Entropy=	6.234e-01,	Error=	2.220e-16 >>>	5.07 sec
Step:	53,	Entropy=	6.181e-01,	Error=	2.220e-16 >>>	5.09 sec
Step:	54,	Entropy=	6.133e-01,	Error=	0.000e+00 >>>	5.07 sec
Step:	55,	Entropy=	6.092e-01,	Error=	0.000e+00 >>>	5.02 sec
Step:	56,	Entropy=	6.057e-01,	Error=	0.000e+00 >>>	5.06 sec
Step:	57,	Entropy=	6.029e-01,	Error=	0.000e+00 >>>	5.14 sec
Step:	58,	Entropy=	6.008e-01,	Error=	0.000e+00 >>>	5.27 sec
Step:	59,	Entropy=	5.995e-01,	Error=	0.000e+00 >>>	6.20 sec
Step:	60,	Entropy=	5.989e-01,	Error=	0.000e+00 >>>	6.00 sec
Step:	61,	Entropy=	5.991e-01,	Error=	2.220e-16 >>>	5.99 sec
Step:	62,	Entropy=	6.001e-01,	Error=	2.220e-16 >>>	5.03 sec
Step:	63,	Entropy=	6.018e-01,	Error=	2.220e-16 >>>	5.67 sec
Step:	64,	Entropy=	6.043e-01,	Error=	0.000e+00 >>>	6.29 sec
Step:	65,	Entropy=	6.075e-01,	Error=	2.220e-16 >>>	6.05 sec
Step:	66,	Entropy=	6.114e-01,	Error=	2.220e-16 >>>	6.31 sec
Step:	67,	Entropy=	6.159e-01,	Error=	2.220e-16 >>>	5.18 sec
Step:	68,	Entropy=	6.211e-01,	Error=	0.000e+00 >>>	5.56 sec
Step:	69,	Entropy=	6.268e-01,	Error=	0.000e+00 >>>	5.15 sec
Step:	70,	Entropy=	6.331e-01,	Error=	2.220e-16 >>>	5.27 sec
Step:	71,	Entropy=	6.398e-01,	Error=	2.220e-16 >>>	6.14 sec
Step:	72,	Entropy=	6.470e-01,	Error=	2.220e-16 >>>	6.13 sec
Step:	73,	Entropy=	6.545e-01,	Error=	2.220e-16 >>>	6.47 sec
Step:	74,	Entropy=	6.623e-01,	Error=	6.661e-16 >>>	5.42 sec
Step:	75,	Entropy=	6.703e-01,	Error=	6.661e-16 >>>	5.17 sec
Step:	76,	Entropy=	6.785e-01,	Error=	1.110e-15 >>>	5.99 sec
Step:	77,	Entropy=	6.867e-01,	Error=	1.776e-15 >>>	5.40 sec
Step:	78,	Entropy=	6.950e-01,	Error=	2.442e-15 >>>	5.67 sec
Step:	79,	Entropy=	7.033e-01,	Error=	3.109e-15 >>>	5.23 sec
Step:	80,	Entropy=	7.115e-01,	Error=	4.441e-15 >>>	5.55 sec
Step:	81,	Entropy=	7.195e-01,	Error=	6.217e-15 >>>	6.06 sec
Step:	82,	Entropy=	7.273e-01,	Error=	8.660e-15 >>>	5.30 sec
Step:	83,	Entropy=	7.348e-01,	Error=	1.177e-14 >>>	5.22 sec
Step:	84,	Entropy=	7.421e-01,	Error=	1.621e-14 >>>	5.18 sec
Step:	85,	Entropy=	7.490e-01,	Error=	2.220e-14 >>>	5.20 sec
Step:	86,	Entropy=	7.554e-01,	Error=	2.998e-14 >>>	5.33 sec
Step:	87,	Entropy=	7.615e-01,	Error=	4.063e-14 >>>	5.28 sec
Step:	88,	Entropy=	7.671e-01,	Error=	5.440e-14 >>>	5.30 sec
Step:	89,	Entropy=	7.721e-01,	Error=	7.305e-14 >>>	5.29 sec
Step:	90,	Entropy=	7.767e-01,	Error=	9.726e-14 >>>	5.46 sec
Step:	91,	Entropy=	7.807e-01,	Error=	1.295e-13 >>>	5.26 sec
Step:	92,	Entropy=	7.842e-01,	Error=	1.719e-13 >>>	5.23 sec
Step:	93,	Entropy=	7.871e-01,	Error=	2.269e-13 >>>	5.33 sec
Step:	94,	Entropy=	7.895e-01,	Error=	2.984e-13 >>>	5.33 sec
Step:	95,	Entropy=	7.913e-01,	Error=	3.915e-13 >>>	5.23 sec
Step:	96,	Entropy=	7.926e-01,	Error=	5.120e-13 >>>	5.36 sec
Step:	97,	Entropy=	7.934e-01,	Error=	6.672e-13 >>>	5.19 sec
Step:	98,	Entropy=	7.937e-01,	Error=	8.666e-13 >>>	5.58 sec
Step:	99,	Entropy=	7.935e-01,	Error=	1.122e-12 >>>	5.82 sec
Step:	100,	Entropy=	7.928e-01,	Error=	1.450e-12 >>>	5.37 sec
Step:	101,	Entropy=	7.918e-01,	Error=	1.866e-12 >>>	5.26 sec
Step:	102,	Entropy=	7.903e-01,	Error=	2.395e-12 >>>	5.20 sec
Step:	103,	Entropy=	7.885e-01,	Error=	3.065e-12 >>>	5.19 sec
Step:	104,	Entropy=	7.864e-01,	Error=	3.912e-12 >>>	5.28 sec
Step:	105,	Entropy=	7.841e-01,	Error=	4.978e-12 >>>	5.48 sec
Step:	106,	Entropy=	7.815e-01,	Error=	6.317e-12 >>>	5.28 sec
Step:	107,	Entropy=	7.787e-01,	Error=	7.994e-12 >>>	5.31 sec
Step:	108,	Entropy=	7.758e-01,	Error=	1.009e-11 >>>	5.35 sec
Step:	109,	Entropy=	7.729e-01,	Error=	1.270e-11 >>>	5.33 sec
Step:	110,	Entropy=	7.698e-01,	Error=	1.594e-11 >>>	5.33 sec
Step:	111,	Entropy=	7.669e-01,	Error=	1.995e-11 >>>	5.48 sec
Step:	112,	Entropy=	7.639e-01,	Error=	2.491e-11 >>>	5.58 sec
Step:	113,	Entropy=	7.611e-01,	Error=	3.103e-11 >>>	5.31 sec
Step:	114,	Entropy=	7.584e-01,	Error=	3.854e-11 >>>	5.52 sec

Step:	115,	Entropy=	7.558e-01,	Error=	4.775e-11 >>>	5.37 sec
Step:	116,	Entropy=	7.535e-01,	Error=	5.172e-11 >>>	5.41 sec
Step:	117,	Entropy=	7.515e-01,	Error=	1.473e-11 >>>	5.66 sec
Step:	118,	Entropy=	7.497e-01,	Error=	1.658e-11 >>>	5.52 sec
Step:	119,	Entropy=	7.482e-01,	Error=	1.866e-11 >>>	5.28 sec
Step:	120,	Entropy=	7.470e-01,	Error=	2.098e-11 >>>	5.42 sec
Step:	121,	Entropy=	7.462e-01,	Error=	2.358e-11 >>>	5.33 sec
Step:	122,	Entropy=	7.458e-01,	Error=	2.648e-11 >>>	5.68 sec
Step:	123,	Entropy=	7.457e-01,	Error=	2.972e-11 >>>	5.42 sec
Step:	124,	Entropy=	7.460e-01,	Error=	3.333e-11 >>>	5.57 sec
Step:	125,	Entropy=	7.467e-01,	Error=	3.736e-11 >>>	5.41 sec
Step:	126,	Entropy=	7.478e-01,	Error=	4.186e-11 >>>	5.47 sec
Step:	127,	Entropy=	7.493e-01,	Error=	4.688e-11 >>>	5.36 sec
Step:	128,	Entropy=	7.512e-01,	Error=	5.249e-11 >>>	5.41 sec
Step:	129,	Entropy=	7.534e-01,	Error=	5.877e-11 >>>	5.42 sec
Step:	130,	Entropy=	7.560e-01,	Error=	6.580e-11 >>>	5.38 sec
Step:	131,	Entropy=	7.589e-01,	Error=	7.370e-11 >>>	5.47 sec
Step:	132,	Entropy=	7.621e-01,	Error=	8.259e-11 >>>	5.42 sec
Step:	133,	Entropy=	7.656e-01,	Error=	9.263e-11 >>>	5.49 sec
Step:	134,	Entropy=	7.693e-01,	Error=	1.040e-10 >>>	5.43 sec
Step:	135,	Entropy=	7.733e-01,	Error=	1.169e-10 >>>	5.42 sec
Step:	136,	Entropy=	7.775e-01,	Error=	1.316e-10 >>>	5.50 sec
Step:	137,	Entropy=	7.819e-01,	Error=	1.484e-10 >>>	5.44 sec
Step:	138,	Entropy=	7.863e-01,	Error=	1.677e-10 >>>	5.58 sec
Step:	139,	Entropy=	7.909e-01,	Error=	1.899e-10 >>>	5.42 sec
Step:	140,	Entropy=	7.956e-01,	Error=	2.155e-10 >>>	5.49 sec
Step:	141,	Entropy=	8.003e-01,	Error=	2.453e-10 >>>	5.43 sec
Step:	142,	Entropy=	8.049e-01,	Error=	2.800e-10 >>>	5.49 sec
Step:	143,	Entropy=	8.095e-01,	Error=	3.205e-10 >>>	5.49 sec
Step:	144,	Entropy=	8.141e-01,	Error=	3.679e-10 >>>	5.48 sec
Step:	145,	Entropy=	8.185e-01,	Error=	4.235e-10 >>>	5.53 sec
Step:	146,	Entropy=	8.228e-01,	Error=	4.890e-10 >>>	5.47 sec
Step:	147,	Entropy=	8.270e-01,	Error=	5.662e-10 >>>	5.56 sec
Step:	148,	Entropy=	8.309e-01,	Error=	6.573e-10 >>>	5.50 sec
Step:	149,	Entropy=	8.346e-01,	Error=	7.650e-10 >>>	5.58 sec
Step:	150,	Entropy=	8.381e-01,	Error=	8.925e-10 >>>	5.58 sec
Step:	151,	Entropy=	8.413e-01,	Error=	1.043e-09 >>>	5.64 sec
Step:	152,	Entropy=	8.442e-01,	Error=	1.222e-09 >>>	5.61 sec
Step:	153,	Entropy=	8.468e-01,	Error=	1.433e-09 >>>	5.97 sec
Step:	154,	Entropy=	8.491e-01,	Error=	1.683e-09 >>>	5.59 sec
Step:	155,	Entropy=	8.511e-01,	Error=	1.979e-09 >>>	5.57 sec
Step:	156,	Entropy=	8.527e-01,	Error=	2.329e-09 >>>	5.51 sec
Step:	157,	Entropy=	8.541e-01,	Error=	2.704e-09 >>>	5.52 sec
Step:	158,	Entropy=	8.551e-01,	Error=	1.912e-09 >>>	5.55 sec
Step:	159,	Entropy=	8.558e-01,	Error=	1.828e-09 >>>	5.53 sec
Step:	160,	Entropy=	8.561e-01,	Error=	5.612e-10 >>>	5.49 sec
Step:	161,	Entropy=	8.562e-01,	Error=	5.967e-10 >>>	5.50 sec
Step:	162,	Entropy=	8.560e-01,	Error=	6.349e-10 >>>	5.73 sec
Step:	163,	Entropy=	8.555e-01,	Error=	6.761e-10 >>>	5.66 sec
Step:	164,	Entropy=	8.548e-01,	Error=	7.206e-10 >>>	5.58 sec
Step:	165,	Entropy=	8.538e-01,	Error=	7.689e-10 >>>	5.57 sec
Step:	166,	Entropy=	8.526e-01,	Error=	8.212e-10 >>>	5.74 sec
Step:	167,	Entropy=	8.512e-01,	Error=	8.780e-10 >>>	5.59 sec
Step:	168,	Entropy=	8.497e-01,	Error=	9.400e-10 >>>	5.67 sec
Step:	169,	Entropy=	8.480e-01,	Error=	1.008e-09 >>>	5.63 sec
Step:	170,	Entropy=	8.462e-01,	Error=	1.081e-09 >>>	6.17 sec
Step:	171,	Entropy=	8.444e-01,	Error=	1.162e-09 >>>	6.00 sec
Step:	172,	Entropy=	8.425e-01,	Error=	1.226e-09 >>>	5.80 sec
Step:	173,	Entropy=	8.406e-01,	Error=	7.462e-10 >>>	5.61 sec
Step:	174,	Entropy=	8.386e-01,	Error=	7.591e-10 >>>	5.70 sec
Step:	175,	Entropy=	8.368e-01,	Error=	7.723e-10 >>>	5.63 sec
Step:	176,	Entropy=	8.349e-01,	Error=	7.862e-10 >>>	5.74 sec
Step:	177,	Entropy=	8.332e-01,	Error=	8.013e-10 >>>	5.64 sec
Step:	178,	Entropy=	8.316e-01,	Error=	8.181e-10 >>>	5.77 sec
Step:	179,	Entropy=	8.301e-01,	Error=	8.377e-10 >>>	5.60 sec

Step:	180,	Entropy=	8.288e-01,	Error=	8.611e-10 >>>	5.71 sec
Step:	181,	Entropy=	8.277e-01,	Error=	8.896e-10 >>>	5.77 sec
Step:	182,	Entropy=	8.268e-01,	Error=	9.250e-10 >>>	5.70 sec
Step:	183,	Entropy=	8.261e-01,	Error=	9.696e-10 >>>	5.61 sec
Step:	184,	Entropy=	8.257e-01,	Error=	1.026e-09 >>>	5.70 sec
Step:	185,	Entropy=	8.254e-01,	Error=	1.097e-09 >>>	5.77 sec
Step:	186,	Entropy=	8.255e-01,	Error=	1.151e-09 >>>	5.69 sec
Step:	187,	Entropy=	8.257e-01,	Error=	1.101e-09 >>>	5.87 sec
Step:	188,	Entropy=	8.263e-01,	Error=	1.347e-09 >>>	5.79 sec
Step:	189,	Entropy=	8.271e-01,	Error=	1.644e-09 >>>	5.64 sec
Step:	190,	Entropy=	8.281e-01,	Error=	2.004e-09 >>>	5.78 sec
Step:	191,	Entropy=	8.295e-01,	Error=	2.438e-09 >>>	5.70 sec
Step:	192,	Entropy=	8.310e-01,	Error=	2.745e-09 >>>	5.71 sec
Step:	193,	Entropy=	8.328e-01,	Error=	6.558e-10 >>>	5.68 sec
Step:	194,	Entropy=	8.349e-01,	Error=	6.189e-10 >>>	5.74 sec
Step:	195,	Entropy=	8.371e-01,	Error=	3.755e-10 >>>	5.91 sec
Step:	196,	Entropy=	8.395e-01,	Error=	4.077e-10 >>>	5.81 sec
Step:	197,	Entropy=	8.421e-01,	Error=	4.440e-10 >>>	5.85 sec
Step:	198,	Entropy=	8.449e-01,	Error=	4.847e-10 >>>	5.88 sec
Step:	199,	Entropy=	8.478e-01,	Error=	5.304e-10 >>>	5.76 sec
Step:	200,	Entropy=	8.508e-01,	Error=	5.817e-10 >>>	5.81 sec
Step:	201,	Entropy=	8.540e-01,	Error=	6.392e-10 >>>	5.74 sec
Step:	202,	Entropy=	8.571e-01,	Error=	7.035e-10 >>>	5.88 sec
Step:	203,	Entropy=	8.604e-01,	Error=	7.754e-10 >>>	5.71 sec
Step:	204,	Entropy=	8.636e-01,	Error=	8.558e-10 >>>	5.84 sec
Step:	205,	Entropy=	8.669e-01,	Error=	9.455e-10 >>>	5.75 sec
Step:	206,	Entropy=	8.701e-01,	Error=	1.046e-09 >>>	5.75 sec
Step:	207,	Entropy=	8.732e-01,	Error=	1.157e-09 >>>	5.74 sec
Step:	208,	Entropy=	8.763e-01,	Error=	1.281e-09 >>>	5.79 sec
Step:	209,	Entropy=	8.793e-01,	Error=	1.419e-09 >>>	5.89 sec
Step:	210,	Entropy=	8.822e-01,	Error=	1.573e-09 >>>	6.03 sec
Step:	211,	Entropy=	8.849e-01,	Error=	1.743e-09 >>>	5.79 sec
Step:	212,	Entropy=	8.875e-01,	Error=	1.876e-09 >>>	5.86 sec
Step:	213,	Entropy=	8.899e-01,	Error=	2.081e-09 >>>	5.82 sec
Step:	214,	Entropy=	8.921e-01,	Error=	1.374e-09 >>>	5.94 sec
Step:	215,	Entropy=	8.941e-01,	Error=	1.690e-09 >>>	5.89 sec
Step:	216,	Entropy=	8.960e-01,	Error=	2.079e-09 >>>	5.94 sec
Step:	217,	Entropy=	8.975e-01,	Error=	2.556e-09 >>>	5.78 sec
Step:	218,	Entropy=	8.989e-01,	Error=	3.137e-09 >>>	5.83 sec
Step:	219,	Entropy=	9.000e-01,	Error=	3.842e-09 >>>	6.24 sec
Step:	220,	Entropy=	9.010e-01,	Error=	4.693e-09 >>>	6.28 sec
Step:	221,	Entropy=	9.016e-01,	Error=	5.517e-09 >>>	5.80 sec
Step:	222,	Entropy=	9.021e-01,	Error=	3.956e-09 >>>	5.91 sec
Step:	223,	Entropy=	9.023e-01,	Error=	4.791e-09 >>>	5.88 sec
Step:	224,	Entropy=	9.023e-01,	Error=	5.800e-09 >>>	5.89 sec
Step:	225,	Entropy=	9.021e-01,	Error=	7.016e-09 >>>	5.92 sec
Step:	226,	Entropy=	9.018e-01,	Error=	8.475e-09 >>>	6.05 sec
Step:	227,	Entropy=	9.012e-01,	Error=	1.022e-08 >>>	5.83 sec
Step:	228,	Entropy=	9.005e-01,	Error=	1.186e-08 >>>	6.15 sec
Step:	229,	Entropy=	8.996e-01,	Error=	8.251e-10 >>>	5.81 sec
Step:	230,	Entropy=	8.986e-01,	Error=	9.103e-10 >>>	5.99 sec
Step:	231,	Entropy=	8.975e-01,	Error=	1.008e-09 >>>	6.11 sec
Step:	232,	Entropy=	8.962e-01,	Error=	1.120e-09 >>>	5.86 sec
Step:	233,	Entropy=	8.949e-01,	Error=	1.247e-09 >>>	5.98 sec
Step:	234,	Entropy=	8.936e-01,	Error=	1.392e-09 >>>	5.93 sec
Step:	235,	Entropy=	8.922e-01,	Error=	1.556e-09 >>>	5.94 sec
Step:	236,	Entropy=	8.908e-01,	Error=	1.741e-09 >>>	5.95 sec
Step:	237,	Entropy=	8.894e-01,	Error=	1.951e-09 >>>	5.88 sec
Step:	238,	Entropy=	8.881e-01,	Error=	2.187e-09 >>>	5.97 sec
Step:	239,	Entropy=	8.868e-01,	Error=	2.452e-09 >>>	6.01 sec
Step:	240,	Entropy=	8.855e-01,	Error=	2.750e-09 >>>	6.02 sec
Step:	241,	Entropy=	8.844e-01,	Error=	3.083e-09 >>>	6.18 sec
Step:	242,	Entropy=	8.833e-01,	Error=	3.393e-09 >>>	6.14 sec
Step:	243,	Entropy=	8.824e-01,	Error=	2.495e-09 >>>	6.09 sec
Step:	244,	Entropy=	8.817e-01,	Error=	2.800e-09 >>>	6.12 sec

Step:	245,	Entropy=	8.810e-01,	Error=	3.148e-09 >>>	5.97 sec
Step:	246,	Entropy=	8.806e-01,	Error=	3.543e-09 >>>	6.25 sec
Step:	247,	Entropy=	8.803e-01,	Error=	3.992e-09 >>>	5.92 sec
Step:	248,	Entropy=	8.801e-01,	Error=	4.498e-09 >>>	5.89 sec
Step:	249,	Entropy=	8.802e-01,	Error=	5.068e-09 >>>	5.93 sec
Step:	250,	Entropy=	8.805e-01,	Error=	5.707e-09 >>>	5.92 sec
Step:	251,	Entropy=	8.809e-01,	Error=	6.424e-09 >>>	6.14 sec
Step:	252,	Entropy=	8.816e-01,	Error=	7.224e-09 >>>	6.13 sec
Step:	253,	Entropy=	8.824e-01,	Error=	8.116e-09 >>>	6.11 sec
Step:	254,	Entropy=	8.835e-01,	Error=	9.108e-09 >>>	6.05 sec
Step:	255,	Entropy=	8.847e-01,	Error=	9.442e-09 >>>	6.10 sec
Step:	256,	Entropy=	8.860e-01,	Error=	7.507e-09 >>>	6.08 sec
Step:	257,	Entropy=	8.876e-01,	Error=	8.825e-09 >>>	5.87 sec
Step:	258,	Entropy=	8.893e-01,	Error=	1.037e-08 >>>	5.95 sec
Step:	259,	Entropy=	8.912e-01,	Error=	1.189e-08 >>>	6.16 sec
Step:	260,	Entropy=	8.931e-01,	Error=	5.883e-09 >>>	6.16 sec
Step:	261,	Entropy=	8.952e-01,	Error=	6.427e-09 >>>	6.11 sec
Step:	262,	Entropy=	8.974e-01,	Error=	7.017e-09 >>>	6.12 sec
Step:	263,	Entropy=	8.997e-01,	Error=	7.657e-09 >>>	6.11 sec
Step:	264,	Entropy=	9.021e-01,	Error=	8.920e-09 >>>	6.14 sec
Step:	265,	Entropy=	9.044e-01,	Error=	9.857e-09 >>>	6.30 sec
Step:	266,	Entropy=	9.069e-01,	Error=	9.368e-09 >>>	6.36 sec
Step:	267,	Entropy=	9.093e-01,	Error=	2.018e-09 >>>	6.02 sec
Step:	268,	Entropy=	9.117e-01,	Error=	2.425e-09 >>>	6.24 sec
Step:	269,	Entropy=	9.141e-01,	Error=	2.913e-09 >>>	6.09 sec
Step:	270,	Entropy=	9.165e-01,	Error=	3.362e-09 >>>	6.04 sec
Step:	271,	Entropy=	9.188e-01,	Error=	2.382e-09 >>>	6.11 sec
Step:	272,	Entropy=	9.210e-01,	Error=	2.687e-09 >>>	6.18 sec
Step:	273,	Entropy=	9.231e-01,	Error=	3.321e-09 >>>	6.32 sec
Step:	274,	Entropy=	9.251e-01,	Error=	4.094e-09 >>>	6.19 sec
Step:	275,	Entropy=	9.270e-01,	Error=	5.033e-09 >>>	6.19 sec
Step:	276,	Entropy=	9.287e-01,	Error=	6.168e-09 >>>	6.03 sec
Step:	277,	Entropy=	9.303e-01,	Error=	7.531e-09 >>>	6.11 sec
Step:	278,	Entropy=	9.318e-01,	Error=	8.951e-09 >>>	6.15 sec
Step:	279,	Entropy=	9.331e-01,	Error=	3.274e-09 >>>	6.16 sec
Step:	280,	Entropy=	9.342e-01,	Error=	3.933e-09 >>>	6.20 sec
Step:	281,	Entropy=	9.351e-01,	Error=	4.733e-09 >>>	5.97 sec
Step:	282,	Entropy=	9.359e-01,	Error=	5.701e-09 >>>	6.20 sec
Step:	283,	Entropy=	9.365e-01,	Error=	6.867e-09 >>>	6.15 sec
Step:	284,	Entropy=	9.369e-01,	Error=	8.264e-09 >>>	6.10 sec
Step:	285,	Entropy=	9.372e-01,	Error=	9.932e-09 >>>	6.23 sec
Step:	286,	Entropy=	9.372e-01,	Error=	1.191e-08 >>>	6.08 sec
Step:	287,	Entropy=	9.371e-01,	Error=	1.426e-08 >>>	6.25 sec
Step:	288,	Entropy=	9.369e-01,	Error=	1.703e-08 >>>	6.26 sec
Step:	289,	Entropy=	9.365e-01,	Error=	2.029e-08 >>>	6.37 sec
Step:	290,	Entropy=	9.360e-01,	Error=	2.410e-08 >>>	6.21 sec
Step:	291,	Entropy=	9.353e-01,	Error=	2.651e-08 >>>	6.13 sec
Step:	292,	Entropy=	9.346e-01,	Error=	1.181e-08 >>>	6.25 sec
Step:	293,	Entropy=	9.337e-01,	Error=	1.323e-08 >>>	6.42 sec
Step:	294,	Entropy=	9.328e-01,	Error=	1.479e-08 >>>	6.30 sec
Step:	295,	Entropy=	9.318e-01,	Error=	1.651e-08 >>>	6.13 sec
Step:	296,	Entropy=	9.307e-01,	Error=	1.841e-08 >>>	6.23 sec
Step:	297,	Entropy=	9.296e-01,	Error=	2.050e-08 >>>	6.31 sec
Step:	298,	Entropy=	9.285e-01,	Error=	2.279e-08 >>>	6.32 sec
Step:	299,	Entropy=	9.274e-01,	Error=	2.530e-08 >>>	6.30 sec
Step:	300,	Entropy=	9.263e-01,	Error=	2.806e-08 >>>	6.19 sec
Step:	301,	Entropy=	9.253e-01,	Error=	3.107e-08 >>>	6.29 sec
Step:	302,	Entropy=	9.243e-01,	Error=	3.369e-08 >>>	6.28 sec
Step:	303,	Entropy=	9.234e-01,	Error=	2.263e-08 >>>	6.13 sec
Step:	304,	Entropy=	9.225e-01,	Error=	2.186e-08 >>>	6.24 sec
Step:	305,	Entropy=	9.218e-01,	Error=	1.877e-08 >>>	6.21 sec
Step:	306,	Entropy=	9.212e-01,	Error=	2.218e-08 >>>	6.40 sec
Step:	307,	Entropy=	9.207e-01,	Error=	2.608e-08 >>>	6.14 sec
Step:	308,	Entropy=	9.203e-01,	Error=	3.052e-08 >>>	6.12 sec
Step:	309,	Entropy=	9.200e-01,	Error=	3.557e-08 >>>	6.32 sec

Step:	310,	Entropy=	9.200e-01,	Error=	4.127e-08 >>>	6.16 sec
Step:	311,	Entropy=	9.200e-01,	Error=	4.767e-08 >>>	6.26 sec
Step:	312,	Entropy=	9.202e-01,	Error=	5.485e-08 >>>	6.34 sec
Step:	313,	Entropy=	9.206e-01,	Error=	6.284e-08 >>>	6.17 sec
Step:	314,	Entropy=	9.212e-01,	Error=	6.581e-08 >>>	6.32 sec
Step:	315,	Entropy=	9.219e-01,	Error=	7.732e-09 >>>	6.37 sec
Step:	316,	Entropy=	9.228e-01,	Error=	9.233e-09 >>>	6.26 sec
Step:	317,	Entropy=	9.238e-01,	Error=	1.100e-08 >>>	6.14 sec
Step:	318,	Entropy=	9.250e-01,	Error=	1.308e-08 >>>	6.31 sec
Step:	319,	Entropy=	9.264e-01,	Error=	1.552e-08 >>>	6.27 sec
Step:	320,	Entropy=	9.278e-01,	Error=	1.837e-08 >>>	6.25 sec
Step:	321,	Entropy=	9.294e-01,	Error=	2.168e-08 >>>	6.18 sec
Step:	322,	Entropy=	9.311e-01,	Error=	2.552e-08 >>>	6.35 sec
Step:	323,	Entropy=	9.329e-01,	Error=	2.997e-08 >>>	6.18 sec
Step:	324,	Entropy=	9.348e-01,	Error=	3.310e-08 >>>	6.32 sec
Step:	325,	Entropy=	9.368e-01,	Error=	1.634e-08 >>>	6.39 sec
Step:	326,	Entropy=	9.388e-01,	Error=	1.931e-08 >>>	6.33 sec
Step:	327,	Entropy=	9.409e-01,	Error=	2.282e-08 >>>	6.32 sec
Step:	328,	Entropy=	9.430e-01,	Error=	2.692e-08 >>>	6.38 sec
Step:	329,	Entropy=	9.451e-01,	Error=	3.170e-08 >>>	6.25 sec
Step:	330,	Entropy=	9.472e-01,	Error=	3.727e-08 >>>	6.47 sec
Step:	331,	Entropy=	9.493e-01,	Error=	4.263e-08 >>>	6.38 sec
Step:	332,	Entropy=	9.513e-01,	Error=	1.456e-08 >>>	6.47 sec
Step:	333,	Entropy=	9.533e-01,	Error=	1.551e-08 >>>	6.39 sec
Step:	334,	Entropy=	9.552e-01,	Error=	1.847e-08 >>>	6.39 sec
Step:	335,	Entropy=	9.570e-01,	Error=	2.259e-08 >>>	6.40 sec
Step:	336,	Entropy=	9.588e-01,	Error=	2.744e-08 >>>	6.36 sec
Step:	337,	Entropy=	9.604e-01,	Error=	3.312e-08 >>>	6.50 sec
Step:	338,	Entropy=	9.619e-01,	Error=	3.973e-08 >>>	6.92 sec
Step:	339,	Entropy=	9.632e-01,	Error=	4.735e-08 >>>	6.85 sec
Step:	340,	Entropy=	9.644e-01,	Error=	5.611e-08 >>>	6.40 sec
Step:	341,	Entropy=	9.655e-01,	Error=	6.612e-08 >>>	6.57 sec
Step:	342,	Entropy=	9.664e-01,	Error=	7.749e-08 >>>	6.42 sec
Step:	343,	Entropy=	9.671e-01,	Error=	8.531e-08 >>>	6.37 sec
Step:	344,	Entropy=	9.677e-01,	Error=	3.050e-08 >>>	6.50 sec
Step:	345,	Entropy=	9.681e-01,	Error=	3.239e-08 >>>	6.43 sec
Step:	346,	Entropy=	9.683e-01,	Error=	3.439e-08 >>>	6.43 sec
Step:	347,	Entropy=	9.684e-01,	Error=	3.221e-08 >>>	6.56 sec
Step:	348,	Entropy=	9.683e-01,	Error=	2.808e-08 >>>	6.57 sec
Step:	349,	Entropy=	9.680e-01,	Error=	3.349e-08 >>>	6.59 sec
Step:	350,	Entropy=	9.676e-01,	Error=	3.981e-08 >>>	6.62 sec
Step:	351,	Entropy=	9.671e-01,	Error=	4.034e-08 >>>	6.67 sec
Step:	352,	Entropy=	9.664e-01,	Error=	1.612e-08 >>>	6.69 sec
Step:	353,	Entropy=	9.655e-01,	Error=	1.752e-08 >>>	6.51 sec
Step:	354,	Entropy=	9.646e-01,	Error=	1.746e-08 >>>	6.42 sec
Step:	355,	Entropy=	9.635e-01,	Error=	2.024e-08 >>>	6.49 sec
Step:	356,	Entropy=	9.624e-01,	Error=	2.456e-08 >>>	6.49 sec
Step:	357,	Entropy=	9.612e-01,	Error=	2.972e-08 >>>	6.29 sec
Step:	358,	Entropy=	9.599e-01,	Error=	3.584e-08 >>>	6.57 sec
Step:	359,	Entropy=	9.585e-01,	Error=	4.307e-08 >>>	6.50 sec
Step:	360,	Entropy=	9.572e-01,	Error=	5.158e-08 >>>	6.53 sec
Step:	361,	Entropy=	9.558e-01,	Error=	6.155e-08 >>>	6.56 sec
Step:	362,	Entropy=	9.544e-01,	Error=	6.590e-08 >>>	6.55 sec
Step:	363,	Entropy=	9.531e-01,	Error=	2.225e-08 >>>	6.33 sec
Step:	364,	Entropy=	9.518e-01,	Error=	2.386e-08 >>>	6.62 sec
Step:	365,	Entropy=	9.505e-01,	Error=	2.554e-08 >>>	6.59 sec
Step:	366,	Entropy=	9.494e-01,	Error=	2.732e-08 >>>	6.51 sec
Step:	367,	Entropy=	9.483e-01,	Error=	2.919e-08 >>>	6.65 sec
Step:	368,	Entropy=	9.473e-01,	Error=	3.116e-08 >>>	6.66 sec
Step:	369,	Entropy=	9.464e-01,	Error=	3.347e-08 >>>	6.59 sec
Step:	370,	Entropy=	9.456e-01,	Error=	3.940e-08 >>>	6.77 sec
Step:	371,	Entropy=	9.450e-01,	Error=	4.615e-08 >>>	6.53 sec
Step:	372,	Entropy=	9.445e-01,	Error=	5.378e-08 >>>	6.42 sec
Step:	373,	Entropy=	9.441e-01,	Error=	6.239e-08 >>>	6.49 sec
Step:	374,	Entropy=	9.439e-01,	Error=	7.206e-08 >>>	6.60 sec

Step:	375,	Entropy=	9.439e-01,	Error=	7.470e-08 >>>	6.55 sec
Step:	376,	Entropy=	9.441e-01,	Error=	5.164e-08 >>>	6.51 sec
Step:	377,	Entropy=	9.444e-01,	Error=	5.497e-08 >>>	6.58 sec
Step:	378,	Entropy=	9.449e-01,	Error=	3.972e-08 >>>	6.69 sec
Step:	379,	Entropy=	9.456e-01,	Error=	3.178e-08 >>>	6.51 sec
Step:	380,	Entropy=	9.464e-01,	Error=	3.319e-08 >>>	6.66 sec
Step:	381,	Entropy=	9.474e-01,	Error=	1.159e-08 >>>	6.58 sec
Step:	382,	Entropy=	9.486e-01,	Error=	1.248e-08 >>>	6.73 sec
Step:	383,	Entropy=	9.499e-01,	Error=	1.345e-08 >>>	6.65 sec
Step:	384,	Entropy=	9.514e-01,	Error=	1.448e-08 >>>	6.67 sec
Step:	385,	Entropy=	9.530e-01,	Error=	1.429e-08 >>>	6.84 sec
Step:	386,	Entropy=	9.547e-01,	Error=	1.654e-08 >>>	6.71 sec
Step:	387,	Entropy=	9.566e-01,	Error=	1.988e-08 >>>	6.93 sec
Step:	388,	Entropy=	9.585e-01,	Error=	2.383e-08 >>>	6.91 sec
Step:	389,	Entropy=	9.605e-01,	Error=	2.849e-08 >>>	6.80 sec
Step:	390,	Entropy=	9.626e-01,	Error=	3.396e-08 >>>	6.40 sec
Step:	391,	Entropy=	9.647e-01,	Error=	4.035e-08 >>>	6.70 sec
Step:	392,	Entropy=	9.669e-01,	Error=	4.781e-08 >>>	6.71 sec
Step:	393,	Entropy=	9.691e-01,	Error=	5.647e-08 >>>	6.54 sec
Step:	394,	Entropy=	9.713e-01,	Error=	6.649e-08 >>>	6.46 sec
Step:	395,	Entropy=	9.735e-01,	Error=	7.805e-08 >>>	6.60 sec
Step:	396,	Entropy=	9.756e-01,	Error=	7.904e-08 >>>	6.58 sec
Step:	397,	Entropy=	9.777e-01,	Error=	5.758e-08 >>>	6.51 sec
Step:	398,	Entropy=	9.797e-01,	Error=	6.784e-08 >>>	6.64 sec
Step:	399,	Entropy=	9.817e-01,	Error=	7.971e-08 >>>	6.69 sec
Step:	400,	Entropy=	9.835e-01,	Error=	9.341e-08 >>>	6.72 sec

4th-order Trotter (D=50):

To give some idea about the finite bond dimension effect, we further run a simulation with $D = 50$.

```
ORDER = 4;
DKEEP = 50;
[IDX, GATE] = TROTTER(ham, ORDER, DT);
%% initial state as |up>|up>...|up>|down>...|down> with a single domain wall at the center
MPS = QSpace(NSITE,1);
MPS(1) = QCREATE(vac, '1', eid, '1', 'OUT');
MPS(1) = getsub(MPS(1), 2);
for isite = 2 : ceil(NSITE/2)
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 2);
end
for isite = ceil(NSITE/2)+1 : NSITE
    MPS(isite) = QCREATE(MPS(isite-1), '3', eid, '1', 'OUT');
    MPS(isite) = getsub(MPS(isite), 1);
end

%% run tDMRG
SZ5 = zeros(NSTEP,NSITE);
EE5 = zeros(NSTEP,1);
for istep = 1 : NSTEP
    time = tic;
    [MPS, err] = TDMRG_ex(MPS, GATE, DKEEP, IDX);
    if ~mod(ORDER,2)
        IDX = flip(IDX);
        GATE = flip(GATE);
    end

    % measure Sz on each site
```

```

[mpsB, ~] = CANONICAL(MPS, [], NSITE, 0, 1E-16, -1);
eyeL = QSpace(NSITE,1);
eyeL(1) = QCREATE(mpsB(1), '1', 'OUT');
for isite = 1 : NSITE
    tmp = contract(eyeL(isite), [1], conj(mpsB(isite)), [1]);
    if (isite~=NSITE)
        eyeL(isite+1) = contract(tmp, [1,2], mpsB(isite), [1,2]);
    end
    tmp = contract(tmp, [2], sz, [1]);
    tmp = contract(tmp, [1,3,2], mpsB(isite), [1,2,3]);
    SZ5(istep, isite) = real(tmp.data{1});
end

% measure half chain entanglement entropy
[~, lambda] = CANONICAL(mpsB, [], 0, NSITE/2, 1E-16, -1);
EE5(istep) = SEntropy(contract(lambda, [2], lambda, [1]));
fprintf('Step: %5d, Entropy= %10.3e, Error= %10.3e >>> %9.2f sec \n',...
        istep, EE5(istep), err, toc(time));
end

```

```

Step:    1, Entropy=  5.234e-03, Error=  0.000e+00 >>>    4.76 sec
Step:    2, Entropy=  1.746e-02, Error=  0.000e+00 >>>    4.81 sec
Step:    3, Entropy=  3.467e-02, Error=  0.000e+00 >>>    5.63 sec
Step:    4, Entropy=  5.577e-02, Error=  2.220e-16 >>>    5.47 sec
Step:    5, Entropy=  7.998e-02, Error=  0.000e+00 >>>    6.23 sec
Step:    6, Entropy=  1.067e-01, Error=  0.000e+00 >>>    6.56 sec
Step:    7, Entropy=  1.353e-01, Error=  0.000e+00 >>>    6.43 sec
Step:    8, Entropy=  1.654e-01, Error=  0.000e+00 >>>    6.32 sec
Step:    9, Entropy=  1.967e-01, Error=  0.000e+00 >>>    6.33 sec
Step:   10, Entropy=  2.286e-01, Error=  2.220e-16 >>>    6.68 sec
Step:   11, Entropy=  2.609e-01, Error=  0.000e+00 >>>    6.67 sec
Step:   12, Entropy=  2.934e-01, Error=  0.000e+00 >>>    6.64 sec
Step:   13, Entropy=  3.257e-01, Error=  0.000e+00 >>>    6.68 sec
Step:   14, Entropy=  3.576e-01, Error=  0.000e+00 >>>    6.46 sec
Step:   15, Entropy=  3.888e-01, Error=  0.000e+00 >>>    4.82 sec
Step:   16, Entropy=  4.193e-01, Error=  0.000e+00 >>>    4.86 sec
Step:   17, Entropy=  4.487e-01, Error=  0.000e+00 >>>    4.86 sec
Step:   18, Entropy=  4.769e-01, Error=  0.000e+00 >>>    4.90 sec
Step:   19, Entropy=  5.039e-01, Error=  2.220e-16 >>>    4.87 sec
Step:   20, Entropy=  5.294e-01, Error=  0.000e+00 >>>    4.92 sec
Step:   21, Entropy=  5.534e-01, Error=  0.000e+00 >>>    4.90 sec
Step:   22, Entropy=  5.758e-01, Error=  0.000e+00 >>>    4.95 sec
Step:   23, Entropy=  5.965e-01, Error=  0.000e+00 >>>    4.89 sec
Step:   24, Entropy=  6.155e-01, Error=  2.220e-16 >>>    4.92 sec
Step:   25, Entropy=  6.328e-01, Error=  0.000e+00 >>>    4.88 sec
Step:   26, Entropy=  6.483e-01, Error=  0.000e+00 >>>    4.94 sec
Step:   27, Entropy=  6.620e-01, Error=  2.220e-16 >>>    5.08 sec
Step:   28, Entropy=  6.739e-01, Error=  2.220e-16 >>>    5.13 sec
Step:   29, Entropy=  6.841e-01, Error=  2.220e-16 >>>    5.05 sec
Step:   30, Entropy=  6.926e-01, Error=  2.220e-16 >>>    5.22 sec
Step:   31, Entropy=  6.995e-01, Error=  2.220e-16 >>>    5.31 sec
Step:   32, Entropy=  7.047e-01, Error=  0.000e+00 >>>    5.36 sec
Step:   33, Entropy=  7.084e-01, Error=  2.220e-16 >>>    5.04 sec
Step:   34, Entropy=  7.107e-01, Error=  2.220e-16 >>>    5.00 sec
Step:   35, Entropy=  7.117e-01, Error=  2.220e-16 >>>    4.97 sec
Step:   36, Entropy=  7.113e-01, Error=  2.220e-16 >>>    5.02 sec
Step:   37, Entropy=  7.099e-01, Error=  0.000e+00 >>>    4.99 sec
Step:   38, Entropy=  7.073e-01, Error=  0.000e+00 >>>    5.29 sec
Step:   39, Entropy=  7.038e-01, Error=  0.000e+00 >>>    5.31 sec
Step:   40, Entropy=  6.995e-01, Error=  0.000e+00 >>>    5.29 sec
Step:   41, Entropy=  6.945e-01, Error=  2.220e-16 >>>    4.95 sec

```

Step:	42,	Entropy=	6.888e-01,	Error=	2.220e-16 >>>	5.77 sec
Step:	43,	Entropy=	6.827e-01,	Error=	0.000e+00 >>>	6.30 sec
Step:	44,	Entropy=	6.762e-01,	Error=	2.220e-16 >>>	5.95 sec
Step:	45,	Entropy=	6.694e-01,	Error=	2.220e-16 >>>	4.94 sec
Step:	46,	Entropy=	6.625e-01,	Error=	0.000e+00 >>>	5.04 sec
Step:	47,	Entropy=	6.555e-01,	Error=	0.000e+00 >>>	5.01 sec
Step:	48,	Entropy=	6.486e-01,	Error=	0.000e+00 >>>	5.03 sec
Step:	49,	Entropy=	6.418e-01,	Error=	0.000e+00 >>>	4.97 sec
Step:	50,	Entropy=	6.353e-01,	Error=	0.000e+00 >>>	5.02 sec
Step:	51,	Entropy=	6.291e-01,	Error=	0.000e+00 >>>	4.98 sec
Step:	52,	Entropy=	6.234e-01,	Error=	2.220e-16 >>>	5.02 sec
Step:	53,	Entropy=	6.181e-01,	Error=	2.220e-16 >>>	5.04 sec
Step:	54,	Entropy=	6.133e-01,	Error=	0.000e+00 >>>	5.04 sec
Step:	55,	Entropy=	6.092e-01,	Error=	0.000e+00 >>>	5.06 sec
Step:	56,	Entropy=	6.057e-01,	Error=	0.000e+00 >>>	5.02 sec
Step:	57,	Entropy=	6.029e-01,	Error=	0.000e+00 >>>	5.01 sec
Step:	58,	Entropy=	6.008e-01,	Error=	0.000e+00 >>>	5.12 sec
Step:	59,	Entropy=	5.995e-01,	Error=	0.000e+00 >>>	5.05 sec
Step:	60,	Entropy=	5.989e-01,	Error=	0.000e+00 >>>	5.11 sec
Step:	61,	Entropy=	5.991e-01,	Error=	2.220e-16 >>>	5.27 sec
Step:	62,	Entropy=	6.001e-01,	Error=	2.220e-16 >>>	6.03 sec
Step:	63,	Entropy=	6.018e-01,	Error=	2.220e-16 >>>	5.83 sec
Step:	64,	Entropy=	6.043e-01,	Error=	0.000e+00 >>>	5.17 sec
Step:	65,	Entropy=	6.075e-01,	Error=	2.220e-16 >>>	5.14 sec
Step:	66,	Entropy=	6.114e-01,	Error=	2.220e-16 >>>	5.23 sec
Step:	67,	Entropy=	6.159e-01,	Error=	2.220e-16 >>>	5.15 sec
Step:	68,	Entropy=	6.211e-01,	Error=	0.000e+00 >>>	5.36 sec
Step:	69,	Entropy=	6.268e-01,	Error=	0.000e+00 >>>	5.43 sec
Step:	70,	Entropy=	6.331e-01,	Error=	0.000e+00 >>>	6.00 sec
Step:	71,	Entropy=	6.398e-01,	Error=	0.000e+00 >>>	6.12 sec
Step:	72,	Entropy=	6.470e-01,	Error=	0.000e+00 >>>	6.38 sec
Step:	73,	Entropy=	6.545e-01,	Error=	2.220e-16 >>>	6.05 sec
Step:	74,	Entropy=	6.623e-01,	Error=	2.220e-16 >>>	5.77 sec
Step:	75,	Entropy=	6.703e-01,	Error=	2.220e-16 >>>	5.84 sec
Step:	76,	Entropy=	6.785e-01,	Error=	2.220e-16 >>>	5.88 sec
Step:	77,	Entropy=	6.867e-01,	Error=	2.220e-16 >>>	5.65 sec
Step:	78,	Entropy=	6.950e-01,	Error=	0.000e+00 >>>	5.59 sec
Step:	79,	Entropy=	7.033e-01,	Error=	0.000e+00 >>>	5.19 sec
Step:	80,	Entropy=	7.115e-01,	Error=	2.220e-16 >>>	5.40 sec
Step:	81,	Entropy=	7.195e-01,	Error=	0.000e+00 >>>	5.23 sec
Step:	82,	Entropy=	7.273e-01,	Error=	0.000e+00 >>>	5.35 sec
Step:	83,	Entropy=	7.348e-01,	Error=	2.220e-16 >>>	5.44 sec
Step:	84,	Entropy=	7.421e-01,	Error=	0.000e+00 >>>	5.19 sec
Step:	85,	Entropy=	7.490e-01,	Error=	2.220e-16 >>>	5.15 sec
Step:	86,	Entropy=	7.554e-01,	Error=	2.220e-16 >>>	5.41 sec
Step:	87,	Entropy=	7.615e-01,	Error=	0.000e+00 >>>	5.34 sec
Step:	88,	Entropy=	7.671e-01,	Error=	0.000e+00 >>>	5.45 sec
Step:	89,	Entropy=	7.721e-01,	Error=	0.000e+00 >>>	5.39 sec
Step:	90,	Entropy=	7.767e-01,	Error=	0.000e+00 >>>	5.28 sec
Step:	91,	Entropy=	7.807e-01,	Error=	0.000e+00 >>>	5.33 sec
Step:	92,	Entropy=	7.842e-01,	Error=	2.220e-16 >>>	5.24 sec
Step:	93,	Entropy=	7.871e-01,	Error=	2.220e-16 >>>	5.27 sec
Step:	94,	Entropy=	7.895e-01,	Error=	2.220e-16 >>>	5.23 sec
Step:	95,	Entropy=	7.913e-01,	Error=	2.220e-16 >>>	5.47 sec
Step:	96,	Entropy=	7.926e-01,	Error=	2.220e-16 >>>	5.39 sec
Step:	97,	Entropy=	7.934e-01,	Error=	2.220e-16 >>>	5.47 sec
Step:	98,	Entropy=	7.937e-01,	Error=	2.220e-16 >>>	5.48 sec
Step:	99,	Entropy=	7.935e-01,	Error=	2.220e-16 >>>	5.65 sec
Step:	100,	Entropy=	7.928e-01,	Error=	2.220e-16 >>>	5.93 sec
Step:	101,	Entropy=	7.918e-01,	Error=	0.000e+00 >>>	5.40 sec
Step:	102,	Entropy=	7.903e-01,	Error=	2.220e-16 >>>	5.30 sec
Step:	103,	Entropy=	7.885e-01,	Error=	2.220e-16 >>>	5.32 sec
Step:	104,	Entropy=	7.864e-01,	Error=	2.220e-16 >>>	5.39 sec
Step:	105,	Entropy=	7.841e-01,	Error=	2.220e-16 >>>	5.33 sec
Step:	106,	Entropy=	7.815e-01,	Error=	2.220e-16 >>>	5.50 sec

Step:	107,	Entropy=	7.787e-01,	Error=	2.220e-16 >>>	5.38 sec
Step:	108,	Entropy=	7.758e-01,	Error=	2.220e-16 >>>	5.43 sec
Step:	109,	Entropy=	7.729e-01,	Error=	2.220e-16 >>>	5.30 sec
Step:	110,	Entropy=	7.698e-01,	Error=	2.220e-16 >>>	5.33 sec
Step:	111,	Entropy=	7.669e-01,	Error=	2.220e-16 >>>	5.41 sec
Step:	112,	Entropy=	7.639e-01,	Error=	2.220e-16 >>>	5.34 sec
Step:	113,	Entropy=	7.611e-01,	Error=	2.220e-16 >>>	5.42 sec
Step:	114,	Entropy=	7.584e-01,	Error=	2.220e-16 >>>	5.46 sec
Step:	115,	Entropy=	7.558e-01,	Error=	2.220e-16 >>>	5.36 sec
Step:	116,	Entropy=	7.535e-01,	Error=	2.220e-16 >>>	5.36 sec
Step:	117,	Entropy=	7.515e-01,	Error=	2.220e-16 >>>	5.42 sec
Step:	118,	Entropy=	7.497e-01,	Error=	2.220e-16 >>>	5.44 sec
Step:	119,	Entropy=	7.482e-01,	Error=	2.220e-16 >>>	5.44 sec
Step:	120,	Entropy=	7.470e-01,	Error=	2.220e-16 >>>	5.46 sec
Step:	121,	Entropy=	7.462e-01,	Error=	2.220e-16 >>>	5.43 sec
Step:	122,	Entropy=	7.458e-01,	Error=	2.220e-16 >>>	5.61 sec
Step:	123,	Entropy=	7.457e-01,	Error=	2.220e-16 >>>	5.55 sec
Step:	124,	Entropy=	7.460e-01,	Error=	2.220e-16 >>>	5.53 sec
Step:	125,	Entropy=	7.467e-01,	Error=	2.220e-16 >>>	5.47 sec
Step:	126,	Entropy=	7.478e-01,	Error=	2.220e-16 >>>	5.51 sec
Step:	127,	Entropy=	7.493e-01,	Error=	2.220e-16 >>>	5.54 sec
Step:	128,	Entropy=	7.512e-01,	Error=	2.220e-16 >>>	5.49 sec
Step:	129,	Entropy=	7.534e-01,	Error=	2.220e-16 >>>	5.47 sec
Step:	130,	Entropy=	7.560e-01,	Error=	2.220e-16 >>>	5.51 sec
Step:	131,	Entropy=	7.589e-01,	Error=	2.220e-16 >>>	5.54 sec
Step:	132,	Entropy=	7.621e-01,	Error=	2.220e-16 >>>	5.56 sec
Step:	133,	Entropy=	7.656e-01,	Error=	2.220e-16 >>>	5.49 sec
Step:	134,	Entropy=	7.693e-01,	Error=	2.220e-16 >>>	5.52 sec
Step:	135,	Entropy=	7.733e-01,	Error=	2.220e-16 >>>	5.52 sec
Step:	136,	Entropy=	7.775e-01,	Error=	2.220e-16 >>>	5.48 sec
Step:	137,	Entropy=	7.819e-01,	Error=	2.220e-16 >>>	5.60 sec
Step:	138,	Entropy=	7.863e-01,	Error=	2.220e-16 >>>	5.60 sec
Step:	139,	Entropy=	7.909e-01,	Error=	2.220e-16 >>>	5.68 sec
Step:	140,	Entropy=	7.956e-01,	Error=	2.220e-16 >>>	5.69 sec
Step:	141,	Entropy=	8.003e-01,	Error=	2.220e-16 >>>	5.65 sec
Step:	142,	Entropy=	8.049e-01,	Error=	2.220e-16 >>>	5.98 sec
Step:	143,	Entropy=	8.096e-01,	Error=	2.220e-16 >>>	6.41 sec
Step:	144,	Entropy=	8.141e-01,	Error=	2.220e-16 >>>	6.41 sec
Step:	145,	Entropy=	8.185e-01,	Error=	2.220e-16 >>>	6.02 sec
Step:	146,	Entropy=	8.229e-01,	Error=	2.220e-16 >>>	5.66 sec
Step:	147,	Entropy=	8.270e-01,	Error=	2.220e-16 >>>	5.61 sec
Step:	148,	Entropy=	8.309e-01,	Error=	2.220e-16 >>>	5.87 sec
Step:	149,	Entropy=	8.346e-01,	Error=	2.220e-16 >>>	5.87 sec
Step:	150,	Entropy=	8.381e-01,	Error=	2.220e-16 >>>	5.94 sec
Step:	151,	Entropy=	8.413e-01,	Error=	2.220e-16 >>>	6.18 sec
Step:	152,	Entropy=	8.442e-01,	Error=	2.220e-16 >>>	5.90 sec
Step:	153,	Entropy=	8.468e-01,	Error=	2.220e-16 >>>	5.60 sec
Step:	154,	Entropy=	8.491e-01,	Error=	2.220e-16 >>>	5.64 sec
Step:	155,	Entropy=	8.511e-01,	Error=	4.441e-16 >>>	5.61 sec
Step:	156,	Entropy=	8.528e-01,	Error=	6.661e-16 >>>	5.61 sec
Step:	157,	Entropy=	8.541e-01,	Error=	8.882e-16 >>>	5.72 sec
Step:	158,	Entropy=	8.551e-01,	Error=	1.110e-15 >>>	5.61 sec
Step:	159,	Entropy=	8.558e-01,	Error=	1.332e-15 >>>	5.82 sec
Step:	160,	Entropy=	8.562e-01,	Error=	1.998e-15 >>>	5.91 sec
Step:	161,	Entropy=	8.563e-01,	Error=	2.665e-15 >>>	5.84 sec
Step:	162,	Entropy=	8.560e-01,	Error=	3.553e-15 >>>	5.95 sec
Step:	163,	Entropy=	8.556e-01,	Error=	4.663e-15 >>>	6.20 sec
Step:	164,	Entropy=	8.548e-01,	Error=	6.439e-15 >>>	5.95 sec
Step:	165,	Entropy=	8.538e-01,	Error=	8.438e-15 >>>	5.83 sec
Step:	166,	Entropy=	8.527e-01,	Error=	1.132e-14 >>>	5.77 sec
Step:	167,	Entropy=	8.513e-01,	Error=	1.510e-14 >>>	5.94 sec
Step:	168,	Entropy=	8.498e-01,	Error=	2.021e-14 >>>	5.73 sec
Step:	169,	Entropy=	8.481e-01,	Error=	2.687e-14 >>>	5.82 sec
Step:	170,	Entropy=	8.463e-01,	Error=	3.553e-14 >>>	6.18 sec
Step:	171,	Entropy=	8.445e-01,	Error=	4.707e-14 >>>	5.92 sec

Step:	172,	Entropy=	8.426e-01,	Error=	6.239e-14 >>>	6.20 sec
Step:	173,	Entropy=	8.406e-01,	Error=	8.260e-14 >>>	6.11 sec
Step:	174,	Entropy=	8.387e-01,	Error=	1.088e-13 >>>	5.80 sec
Step:	175,	Entropy=	8.369e-01,	Error=	1.432e-13 >>>	5.75 sec
Step:	176,	Entropy=	8.351e-01,	Error=	1.676e-13 >>>	5.82 sec
Step:	177,	Entropy=	8.333e-01,	Error=	6.595e-14 >>>	5.72 sec
Step:	178,	Entropy=	8.317e-01,	Error=	7.971e-14 >>>	5.75 sec
Step:	179,	Entropy=	8.303e-01,	Error=	9.637e-14 >>>	5.81 sec
Step:	180,	Entropy=	8.290e-01,	Error=	1.168e-13 >>>	5.92 sec
Step:	181,	Entropy=	8.279e-01,	Error=	1.412e-13 >>>	5.80 sec
Step:	182,	Entropy=	8.270e-01,	Error=	1.705e-13 >>>	6.01 sec
Step:	183,	Entropy=	8.263e-01,	Error=	1.907e-13 >>>	5.73 sec
Step:	184,	Entropy=	8.258e-01,	Error=	3.064e-14 >>>	5.88 sec
Step:	185,	Entropy=	8.256e-01,	Error=	3.664e-14 >>>	5.77 sec
Step:	186,	Entropy=	8.256e-01,	Error=	4.419e-14 >>>	6.02 sec
Step:	187,	Entropy=	8.259e-01,	Error=	5.285e-14 >>>	5.89 sec
Step:	188,	Entropy=	8.265e-01,	Error=	6.373e-14 >>>	5.89 sec
Step:	189,	Entropy=	8.273e-01,	Error=	7.661e-14 >>>	6.08 sec
Step:	190,	Entropy=	8.283e-01,	Error=	9.237e-14 >>>	6.01 sec
Step:	191,	Entropy=	8.297e-01,	Error=	1.112e-13 >>>	5.86 sec
Step:	192,	Entropy=	8.312e-01,	Error=	1.341e-13 >>>	6.00 sec
Step:	193,	Entropy=	8.330e-01,	Error=	1.619e-13 >>>	5.91 sec
Step:	194,	Entropy=	8.351e-01,	Error=	1.954e-13 >>>	5.85 sec
Step:	195,	Entropy=	8.373e-01,	Error=	2.256e-13 >>>	5.81 sec
Step:	196,	Entropy=	8.398e-01,	Error=	1.257e-13 >>>	6.03 sec
Step:	197,	Entropy=	8.424e-01,	Error=	1.508e-13 >>>	5.97 sec
Step:	198,	Entropy=	8.452e-01,	Error=	1.814e-13 >>>	5.88 sec
Step:	199,	Entropy=	8.481e-01,	Error=	2.192e-13 >>>	5.94 sec
Step:	200,	Entropy=	8.511e-01,	Error=	2.662e-13 >>>	6.00 sec
Step:	201,	Entropy=	8.542e-01,	Error=	3.242e-13 >>>	5.99 sec
Step:	202,	Entropy=	8.574e-01,	Error=	3.961e-13 >>>	6.06 sec
Step:	203,	Entropy=	8.606e-01,	Error=	4.836e-13 >>>	6.25 sec
Step:	204,	Entropy=	8.639e-01,	Error=	2.378e-13 >>>	6.40 sec
Step:	205,	Entropy=	8.671e-01,	Error=	2.676e-13 >>>	6.01 sec
Step:	206,	Entropy=	8.703e-01,	Error=	3.011e-13 >>>	5.93 sec
Step:	207,	Entropy=	8.735e-01,	Error=	3.391e-13 >>>	5.96 sec
Step:	208,	Entropy=	8.766e-01,	Error=	3.815e-13 >>>	6.06 sec
Step:	209,	Entropy=	8.796e-01,	Error=	4.292e-13 >>>	6.06 sec
Step:	210,	Entropy=	8.825e-01,	Error=	4.832e-13 >>>	6.37 sec
Step:	211,	Entropy=	8.852e-01,	Error=	5.438e-13 >>>	6.31 sec
Step:	212,	Entropy=	8.878e-01,	Error=	6.122e-13 >>>	6.49 sec
Step:	213,	Entropy=	8.902e-01,	Error=	6.650e-13 >>>	6.48 sec
Step:	214,	Entropy=	8.924e-01,	Error=	5.587e-13 >>>	6.34 sec
Step:	215,	Entropy=	8.944e-01,	Error=	6.337e-13 >>>	6.27 sec
Step:	216,	Entropy=	8.962e-01,	Error=	4.947e-13 >>>	6.04 sec
Step:	217,	Entropy=	8.978e-01,	Error=	5.507e-13 >>>	6.03 sec
Step:	218,	Entropy=	8.991e-01,	Error=	6.137e-13 >>>	6.09 sec
Step:	219,	Entropy=	9.003e-01,	Error=	6.857e-13 >>>	6.07 sec
Step:	220,	Entropy=	9.012e-01,	Error=	7.676e-13 >>>	6.07 sec
Step:	221,	Entropy=	9.018e-01,	Error=	8.618e-13 >>>	6.01 sec
Step:	222,	Entropy=	9.023e-01,	Error=	9.699e-13 >>>	6.06 sec
Step:	223,	Entropy=	9.025e-01,	Error=	1.080e-12 >>>	6.03 sec
Step:	224,	Entropy=	9.025e-01,	Error=	9.666e-13 >>>	6.13 sec
Step:	225,	Entropy=	9.023e-01,	Error=	1.092e-12 >>>	6.15 sec
Step:	226,	Entropy=	9.019e-01,	Error=	1.241e-12 >>>	6.20 sec
Step:	227,	Entropy=	9.013e-01,	Error=	1.414e-12 >>>	6.06 sec
Step:	228,	Entropy=	9.006e-01,	Error=	1.141e-12 >>>	6.14 sec
Step:	229,	Entropy=	8.997e-01,	Error=	1.257e-12 >>>	6.22 sec
Step:	230,	Entropy=	8.987e-01,	Error=	1.329e-12 >>>	6.60 sec
Step:	231,	Entropy=	8.975e-01,	Error=	1.091e-12 >>>	6.36 sec
Step:	232,	Entropy=	8.963e-01,	Error=	1.205e-12 >>>	6.36 sec
Step:	233,	Entropy=	8.950e-01,	Error=	1.340e-12 >>>	6.63 sec
Step:	234,	Entropy=	8.936e-01,	Error=	1.502e-12 >>>	6.71 sec
Step:	235,	Entropy=	8.922e-01,	Error=	1.695e-12 >>>	6.16 sec
Step:	236,	Entropy=	8.908e-01,	Error=	1.927e-12 >>>	6.21 sec

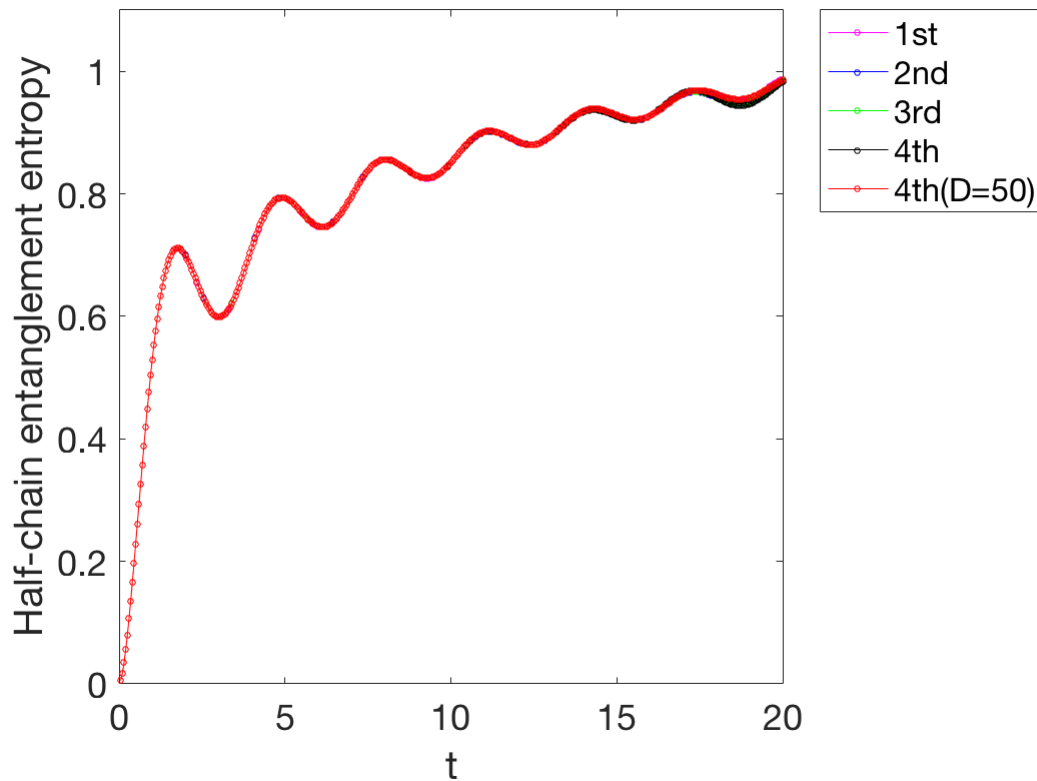
Step:	237,	Entropy=	8.894e-01,	Error=	2.118e-12 >>>	6.23 sec
Step:	238,	Entropy=	8.880e-01,	Error=	1.786e-12 >>>	6.17 sec
Step:	239,	Entropy=	8.867e-01,	Error=	2.013e-12 >>>	6.21 sec
Step:	240,	Entropy=	8.855e-01,	Error=	2.292e-12 >>>	6.36 sec
Step:	241,	Entropy=	8.843e-01,	Error=	2.520e-12 >>>	6.26 sec
Step:	242,	Entropy=	8.832e-01,	Error=	1.879e-12 >>>	6.33 sec
Step:	243,	Entropy=	8.823e-01,	Error=	2.020e-12 >>>	6.12 sec
Step:	244,	Entropy=	8.815e-01,	Error=	2.177e-12 >>>	6.27 sec
Step:	245,	Entropy=	8.809e-01,	Error=	2.353e-12 >>>	6.27 sec
Step:	246,	Entropy=	8.804e-01,	Error=	2.549e-12 >>>	6.21 sec
Step:	247,	Entropy=	8.801e-01,	Error=	2.770e-12 >>>	6.23 sec
Step:	248,	Entropy=	8.800e-01,	Error=	2.945e-12 >>>	6.30 sec
Step:	249,	Entropy=	8.801e-01,	Error=	2.256e-12 >>>	6.16 sec
Step:	250,	Entropy=	8.803e-01,	Error=	2.377e-12 >>>	6.29 sec
Step:	251,	Entropy=	8.808e-01,	Error=	2.274e-12 >>>	6.29 sec
Step:	252,	Entropy=	8.814e-01,	Error=	1.453e-12 >>>	6.33 sec
Step:	253,	Entropy=	8.823e-01,	Error=	1.499e-12 >>>	6.46 sec
Step:	254,	Entropy=	8.833e-01,	Error=	1.552e-12 >>>	6.50 sec
Step:	255,	Entropy=	8.846e-01,	Error=	1.613e-12 >>>	6.55 sec
Step:	256,	Entropy=	8.860e-01,	Error=	1.686e-12 >>>	6.33 sec
Step:	257,	Entropy=	8.875e-01,	Error=	1.772e-12 >>>	6.21 sec
Step:	258,	Entropy=	8.893e-01,	Error=	1.697e-12 >>>	6.37 sec
Step:	259,	Entropy=	8.912e-01,	Error=	1.878e-12 >>>	6.36 sec
Step:	260,	Entropy=	8.932e-01,	Error=	1.610e-12 >>>	6.32 sec
Step:	261,	Entropy=	8.953e-01,	Error=	1.797e-12 >>>	6.29 sec
Step:	262,	Entropy=	8.975e-01,	Error=	1.710e-12 >>>	6.37 sec
Step:	263,	Entropy=	8.999e-01,	Error=	1.851e-12 >>>	6.35 sec
Step:	264,	Entropy=	9.023e-01,	Error=	2.180e-12 >>>	6.56 sec
Step:	265,	Entropy=	9.047e-01,	Error=	2.583e-12 >>>	6.36 sec
Step:	266,	Entropy=	9.072e-01,	Error=	3.078e-12 >>>	6.42 sec
Step:	267,	Entropy=	9.097e-01,	Error=	3.680e-12 >>>	6.34 sec
Step:	268,	Entropy=	9.122e-01,	Error=	4.412e-12 >>>	6.65 sec
Step:	269,	Entropy=	9.146e-01,	Error=	4.600e-12 >>>	6.58 sec
Step:	270,	Entropy=	9.170e-01,	Error=	2.701e-12 >>>	6.61 sec
Step:	271,	Entropy=	9.194e-01,	Error=	3.181e-12 >>>	6.58 sec
Step:	272,	Entropy=	9.217e-01,	Error=	3.858e-12 >>>	6.99 sec
Step:	273,	Entropy=	9.239e-01,	Error=	2.909e-12 >>>	6.83 sec
Step:	274,	Entropy=	9.259e-01,	Error=	3.351e-12 >>>	6.47 sec
Step:	275,	Entropy=	9.279e-01,	Error=	2.019e-12 >>>	6.49 sec
Step:	276,	Entropy=	9.297e-01,	Error=	2.185e-12 >>>	6.73 sec
Step:	277,	Entropy=	9.314e-01,	Error=	2.370e-12 >>>	6.43 sec
Step:	278,	Entropy=	9.329e-01,	Error=	2.578e-12 >>>	6.47 sec
Step:	279,	Entropy=	9.343e-01,	Error=	2.812e-12 >>>	6.50 sec
Step:	280,	Entropy=	9.355e-01,	Error=	3.076e-12 >>>	6.48 sec
Step:	281,	Entropy=	9.365e-01,	Error=	3.373e-12 >>>	6.48 sec
Step:	282,	Entropy=	9.374e-01,	Error=	3.708e-12 >>>	6.55 sec
Step:	283,	Entropy=	9.380e-01,	Error=	3.744e-12 >>>	6.84 sec
Step:	284,	Entropy=	9.385e-01,	Error=	2.500e-12 >>>	6.85 sec
Step:	285,	Entropy=	9.388e-01,	Error=	2.648e-12 >>>	6.70 sec
Step:	286,	Entropy=	9.389e-01,	Error=	2.811e-12 >>>	6.79 sec
Step:	287,	Entropy=	9.389e-01,	Error=	3.205e-12 >>>	6.88 sec
Step:	288,	Entropy=	9.387e-01,	Error=	3.676e-12 >>>	6.53 sec
Step:	289,	Entropy=	9.384e-01,	Error=	3.411e-12 >>>	6.60 sec
Step:	290,	Entropy=	9.379e-01,	Error=	3.660e-12 >>>	6.51 sec
Step:	291,	Entropy=	9.373e-01,	Error=	3.940e-12 >>>	6.48 sec
Step:	292,	Entropy=	9.366e-01,	Error=	4.258e-12 >>>	6.70 sec
Step:	293,	Entropy=	9.357e-01,	Error=	4.464e-12 >>>	6.57 sec
Step:	294,	Entropy=	9.348e-01,	Error=	3.718e-12 >>>	6.60 sec
Step:	295,	Entropy=	9.338e-01,	Error=	4.142e-12 >>>	6.47 sec
Step:	296,	Entropy=	9.328e-01,	Error=	4.528e-12 >>>	6.57 sec
Step:	297,	Entropy=	9.317e-01,	Error=	3.676e-12 >>>	6.52 sec
Step:	298,	Entropy=	9.306e-01,	Error=	4.220e-12 >>>	6.58 sec
Step:	299,	Entropy=	9.295e-01,	Error=	4.943e-12 >>>	6.56 sec
Step:	300,	Entropy=	9.284e-01,	Error=	5.833e-12 >>>	6.58 sec
Step:	301,	Entropy=	9.273e-01,	Error=	6.888e-12 >>>	6.53 sec

Step:	302,	Entropy=	9.263e-01,	Error=	5.446e-12 >>>	6.64 sec
Step:	303,	Entropy=	9.253e-01,	Error=	6.218e-12 >>>	6.70 sec
Step:	304,	Entropy=	9.244e-01,	Error=	7.331e-12 >>>	6.68 sec
Step:	305,	Entropy=	9.236e-01,	Error=	8.875e-12 >>>	6.65 sec
Step:	306,	Entropy=	9.229e-01,	Error=	9.973e-12 >>>	6.67 sec
Step:	307,	Entropy=	9.223e-01,	Error=	8.412e-12 >>>	6.56 sec
Step:	308,	Entropy=	9.218e-01,	Error=	1.017e-11 >>>	6.53 sec
Step:	309,	Entropy=	9.214e-01,	Error=	1.112e-11 >>>	6.51 sec
Step:	310,	Entropy=	9.212e-01,	Error=	6.122e-12 >>>	6.61 sec
Step:	311,	Entropy=	9.211e-01,	Error=	6.738e-12 >>>	6.67 sec
Step:	312,	Entropy=	9.212e-01,	Error=	7.382e-12 >>>	6.50 sec
Step:	313,	Entropy=	9.215e-01,	Error=	6.693e-12 >>>	6.56 sec
Step:	314,	Entropy=	9.219e-01,	Error=	4.483e-12 >>>	6.66 sec
Step:	315,	Entropy=	9.224e-01,	Error=	4.744e-12 >>>	6.64 sec
Step:	316,	Entropy=	9.232e-01,	Error=	5.037e-12 >>>	6.67 sec
Step:	317,	Entropy=	9.240e-01,	Error=	5.366e-12 >>>	6.59 sec
Step:	318,	Entropy=	9.250e-01,	Error=	5.737e-12 >>>	6.73 sec
Step:	319,	Entropy=	9.262e-01,	Error=	6.158e-12 >>>	6.68 sec
Step:	320,	Entropy=	9.275e-01,	Error=	6.636e-12 >>>	6.72 sec
Step:	321,	Entropy=	9.289e-01,	Error=	7.183e-12 >>>	6.66 sec
Step:	322,	Entropy=	9.304e-01,	Error=	8.040e-12 >>>	6.75 sec
Step:	323,	Entropy=	9.321e-01,	Error=	8.853e-12 >>>	6.67 sec
Step:	324,	Entropy=	9.338e-01,	Error=	8.841e-12 >>>	6.76 sec
Step:	325,	Entropy=	9.357e-01,	Error=	7.326e-12 >>>	6.69 sec
Step:	326,	Entropy=	9.375e-01,	Error=	8.280e-12 >>>	6.64 sec
Step:	327,	Entropy=	9.395e-01,	Error=	9.398e-12 >>>	6.67 sec
Step:	328,	Entropy=	9.415e-01,	Error=	1.071e-11 >>>	6.69 sec
Step:	329,	Entropy=	9.435e-01,	Error=	1.225e-11 >>>	6.78 sec
Step:	330,	Entropy=	9.455e-01,	Error=	1.405e-11 >>>	6.65 sec
Step:	331,	Entropy=	9.475e-01,	Error=	1.372e-11 >>>	6.93 sec
Step:	332,	Entropy=	9.495e-01,	Error=	1.101e-11 >>>	6.79 sec
Step:	333,	Entropy=	9.515e-01,	Error=	1.225e-11 >>>	6.62 sec
Step:	334,	Entropy=	9.534e-01,	Error=	1.446e-11 >>>	6.89 sec
Step:	335,	Entropy=	9.552e-01,	Error=	1.716e-11 >>>	6.80 sec
Step:	336,	Entropy=	9.570e-01,	Error=	2.040e-11 >>>	6.76 sec
Step:	337,	Entropy=	9.586e-01,	Error=	2.429e-11 >>>	6.75 sec
Step:	338,	Entropy=	9.602e-01,	Error=	2.894e-11 >>>	6.71 sec
Step:	339,	Entropy=	9.617e-01,	Error=	3.244e-11 >>>	6.74 sec
Step:	340,	Entropy=	9.630e-01,	Error=	2.259e-11 >>>	6.72 sec
Step:	341,	Entropy=	9.642e-01,	Error=	2.632e-11 >>>	6.85 sec
Step:	342,	Entropy=	9.653e-01,	Error=	3.081e-11 >>>	6.93 sec
Step:	343,	Entropy=	9.663e-01,	Error=	3.026e-11 >>>	6.78 sec
Step:	344,	Entropy=	9.671e-01,	Error=	2.688e-11 >>>	6.92 sec
Step:	345,	Entropy=	9.677e-01,	Error=	3.031e-11 >>>	6.81 sec
Step:	346,	Entropy=	9.683e-01,	Error=	3.215e-11 >>>	6.88 sec
Step:	347,	Entropy=	9.686e-01,	Error=	1.909e-11 >>>	6.78 sec
Step:	348,	Entropy=	9.688e-01,	Error=	2.033e-11 >>>	7.09 sec
Step:	349,	Entropy=	9.689e-01,	Error=	2.163e-11 >>>	6.88 sec
Step:	350,	Entropy=	9.689e-01,	Error=	2.300e-11 >>>	6.83 sec
Step:	351,	Entropy=	9.687e-01,	Error=	2.444e-11 >>>	6.86 sec
Step:	352,	Entropy=	9.684e-01,	Error=	2.596e-11 >>>	7.04 sec
Step:	353,	Entropy=	9.680e-01,	Error=	2.757e-11 >>>	6.96 sec
Step:	354,	Entropy=	9.675e-01,	Error=	2.929e-11 >>>	7.15 sec
Step:	355,	Entropy=	9.668e-01,	Error=	3.116e-11 >>>	7.12 sec
Step:	356,	Entropy=	9.661e-01,	Error=	3.323e-11 >>>	7.11 sec
Step:	357,	Entropy=	9.654e-01,	Error=	3.555e-11 >>>	6.91 sec
Step:	358,	Entropy=	9.646e-01,	Error=	3.819e-11 >>>	6.88 sec
Step:	359,	Entropy=	9.637e-01,	Error=	4.121e-11 >>>	6.80 sec
Step:	360,	Entropy=	9.628e-01,	Error=	4.315e-11 >>>	6.83 sec
Step:	361,	Entropy=	9.619e-01,	Error=	2.342e-11 >>>	6.91 sec
Step:	362,	Entropy=	9.610e-01,	Error=	2.455e-11 >>>	6.87 sec
Step:	363,	Entropy=	9.600e-01,	Error=	2.609e-11 >>>	6.90 sec
Step:	364,	Entropy=	9.592e-01,	Error=	2.793e-11 >>>	6.93 sec
Step:	365,	Entropy=	9.583e-01,	Error=	3.009e-11 >>>	7.10 sec
Step:	366,	Entropy=	9.575e-01,	Error=	3.153e-11 >>>	6.95 sec

Step:	367,	Entropy=	9.568e-01,	Error=	2.883e-11 >>>	7.14 sec
Step:	368,	Entropy=	9.561e-01,	Error=	3.336e-11 >>>	7.16 sec
Step:	369,	Entropy=	9.555e-01,	Error=	3.762e-11 >>>	7.34 sec
Step:	370,	Entropy=	9.551e-01,	Error=	3.375e-11 >>>	7.15 sec
Step:	371,	Entropy=	9.547e-01,	Error=	4.033e-11 >>>	6.86 sec
Step:	372,	Entropy=	9.544e-01,	Error=	4.697e-11 >>>	6.99 sec
Step:	373,	Entropy=	9.543e-01,	Error=	4.983e-11 >>>	6.82 sec
Step:	374,	Entropy=	9.542e-01,	Error=	5.854e-11 >>>	7.02 sec
Step:	375,	Entropy=	9.543e-01,	Error=	6.533e-11 >>>	7.19 sec
Step:	376,	Entropy=	9.546e-01,	Error=	5.213e-11 >>>	7.34 sec
Step:	377,	Entropy=	9.549e-01,	Error=	5.948e-11 >>>	7.28 sec
Step:	378,	Entropy=	9.554e-01,	Error=	6.796e-11 >>>	7.12 sec
Step:	379,	Entropy=	9.560e-01,	Error=	7.656e-11 >>>	6.83 sec
Step:	380,	Entropy=	9.568e-01,	Error=	5.054e-11 >>>	7.06 sec
Step:	381,	Entropy=	9.577e-01,	Error=	5.514e-11 >>>	7.00 sec
Step:	382,	Entropy=	9.587e-01,	Error=	6.014e-11 >>>	7.08 sec
Step:	383,	Entropy=	9.598e-01,	Error=	6.132e-11 >>>	7.07 sec
Step:	384,	Entropy=	9.610e-01,	Error=	4.485e-11 >>>	6.96 sec
Step:	385,	Entropy=	9.623e-01,	Error=	4.863e-11 >>>	6.91 sec
Step:	386,	Entropy=	9.637e-01,	Error=	5.274e-11 >>>	6.96 sec
Step:	387,	Entropy=	9.651e-01,	Error=	5.724e-11 >>>	7.06 sec
Step:	388,	Entropy=	9.667e-01,	Error=	6.218e-11 >>>	7.24 sec
Step:	389,	Entropy=	9.683e-01,	Error=	6.754e-11 >>>	7.10 sec
Step:	390,	Entropy=	9.699e-01,	Error=	6.790e-11 >>>	7.03 sec
Step:	391,	Entropy=	9.716e-01,	Error=	6.641e-11 >>>	7.12 sec
Step:	392,	Entropy=	9.733e-01,	Error=	7.328e-11 >>>	7.19 sec
Step:	393,	Entropy=	9.750e-01,	Error=	8.094e-11 >>>	7.01 sec
Step:	394,	Entropy=	9.767e-01,	Error=	5.202e-11 >>>	7.17 sec
Step:	395,	Entropy=	9.783e-01,	Error=	5.704e-11 >>>	6.99 sec
Step:	396,	Entropy=	9.800e-01,	Error=	6.279e-11 >>>	7.17 sec
Step:	397,	Entropy=	9.816e-01,	Error=	6.941e-11 >>>	7.02 sec
Step:	398,	Entropy=	9.831e-01,	Error=	7.702e-11 >>>	7.07 sec
Step:	399,	Entropy=	9.846e-01,	Error=	8.581e-11 >>>	7.15 sec
Step:	400,	Entropy=	9.860e-01,	Error=	8.356e-11 >>>	7.03 sec

Analysis:

```
ts = DT*[1:NSTEP];
% plot the half-chain entanglement entropy
figure;
plot(ts, EE1, '-mo', 'MarkerSize', 3);
hold on;
plot(ts, EE2, '-bo', 'MarkerSize', 3);
plot(ts, EE3, '-go', 'MarkerSize', 3);
plot(ts, EE4, '-ko', 'MarkerSize', 3);
plot(ts, EE5, '-ro', 'MarkerSize', 3);
axis([0, 20, 0, 1.1]);
hold off;
ylabel('Half-chain entanglement entropy');
xlabel('t');
legend('1st', '2nd', '3rd', '4th', '4th(D=50)');
legend('Location', 'northeastoutside');
set(gca, 'FontSize', 18);
```



```
% the exact values of S_z
fvals = zeros(NSITE,NSITE-1);
for it = (1:size(fvals,2))
    fvals(:,it) = (besselj(it-(NSITE/2),ts)).^2;
end
fvals = -0.5*fvals;

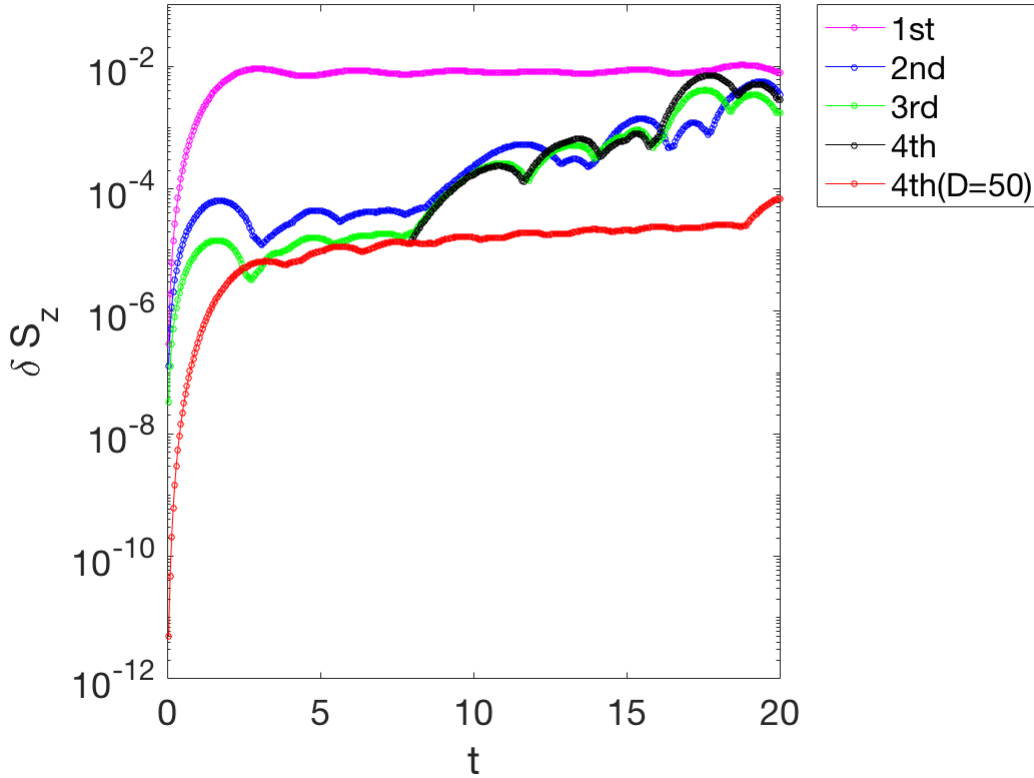
SZ_ex = zeros(numel(ts),NSITE/2); % exact values
for it = (1:(NSITE/2))
    SZ_ex(:,it) = sum(fvals(:,(NSITE/2-it+1):(it+NSITE/2-1)),2);
end
SZ_ex = [-fliplr(SZ_ex),SZ_ex];

% plot the errors of S_z over time
figure;
err1 = max(abs(SZ1-SZ_ex),[],2);
err2 = max(abs(SZ2-SZ_ex),[],2);
err3 = max(abs(SZ3-SZ_ex),[],2);
err4 = max(abs(SZ4-SZ_ex),[],2);
err5 = max(abs(SZ5-SZ_ex),[],2);
semilogy(ts,err1,'-mo','MarkerSize',3);
hold on;
semilogy(ts,err2,'-bo','MarkerSize',3);
semilogy(ts,err3,'-go','MarkerSize',3);
semilogy(ts,err4,'-ko','MarkerSize',3);
semilogy(ts,err5,'-ro','MarkerSize',3);
hold off;
axis([0,20,1E-12,1E-1]);
```

```

yticks([1E-12 1E-10 1E-8 1E-6 1E-4 1E-2])
ylabel('\delta S_z');
xlabel('t');
legend('1st', '2nd', '3rd', '4th', '4th(D=50) ');
legend('Location', 'northeastoutside');
set(gca, 'FontSize', 18);

```



Conclusion:

- (1) The truncation errors within our simulated time are smaller than 10^{-7} . However, as the entanglement entropy grows unboundedly, such errors accumulate over time and contribute to the inaccuracy in the long run. By comparing $D = 20$ and $D = 50$ results, we could see the "runaway time" for $D = 20$ to be around $t = 8$.
- (2) The 1st order Trotter decomposition gives inaccurate results just in a few time steps. And as expected, the 4th order Trotter decomposition performs the best in the short time ($t < 8$). But, in the later time, the (2-4)th order Trotter decompositions all give similar accuracy as the accumulated truncation errors take over.