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```
% this experiment is to test whether pqnl1 can work for the expqnle given
% by help spgl1
```

addpath for PQN working

```
%addpath(genpath('/Volumes/Users/linamiao/Dropbox/PQN/'))
cd ../../../../pqnl1;
addpath(genpath(pwd))
cd ../experiments/help_spgl1/modifying/task16bpdn

%stream = RandStream.getGlobalStream;
%reset(stream);

% %problem setting
m = 120; n = 512; k = 20; % m rows, n cols, k nonzeros.
p = randperm(n); x0 = zeros(n,1); x0(p(1:k)) = sign(randn(k,1));
A  = randn(m,n); [Q,R] = qr(A',0);  A = Q';
b  = A*x0;
%
opts.decTol = 1e-3;
opts.optTol = 1e-4;
%opts.iterations = 500;
% opts.nPrevVals = 1; % opt out the nonmonotone line search
%
%save temp A b x0 opts
% clear
% load temp.mat
```

lasso

```
tau = norm(x0,1);
[x_spg,r_spg,g_spg,info_spg] = spgl1(A, b, tau, [], zeros(size(A,2),1), opts); % F

[x_pqn1,r_pqn1,g_pqn1,info_pqn1] = pqnl1_2(A, b, tau, [], zeros(size(A,2),1), opts

figure; subplot(2,1,1);plot(x_spg);subplot(2,1,2);plot(x_pqn1);
info_spg
info_pqn1
```

```
========================================================================
SPGL1_SLIM v. 46  (Tue, 14 Jun 2011) based on v.1017
========================================================================
No. rows              :     120     No. columns              :     512
Initial tau           : 2.00e+01    Two-norm of b            : 2.03e+00
Optimality tol        : 1.00e-04    Target one-norm of x     : 2.00e+01
Basis pursuit tol     : 1.00e-06    Maximum iterations       :    1200

 Iter      Objective    Relative Gap      gNorm    stepG    nnzX    nnzG
    0   2.0335130e+00  4.0927346e+00    4.23e-01     0.0       0       0
    1   5.4542566e-01  1.4917990e+00    7.84e-02     0.0     155       0
    2   3.7589419e-01  5.0216411e-01    5.21e-02     0.0     254       0
    3   3.3934257e-01  2.6827232e-01    3.59e-02     0.0     220       0
    4   3.0554144e-01  2.6560766e-01    3.53e-02     0.0     198       0
    5   2.5444318e-01  2.4752346e-01    2.79e-02     0.0     146       0
    6   2.7296792e-01  7.5563234e-01    5.63e-02    -0.3     161       0
    7   2.3315325e-01  2.1002295e-01    2.51e-02     0.0     159       0
    8   2.1915284e-01  8.3389399e-02    1.99e-02     0.0     165       0
    9   2.1464088e-01  7.4209747e-02    1.89e-02     0.0     158       0
   10   1.9106975e-01  1.0040852e-01    1.87e-02     0.0     136       0
   11   1.8563683e-01  1.1333017e-01    1.88e-02    -0.3     139       0
   12   1.8457281e-01  2.1354371e-01    2.36e-02     0.0     140       0
   13   1.7538594e-01  9.5610563e-02    1.72e-02     0.0     141       0
   14   1.7198768e-01  5.9094199e-02    1.54e-02     0.0     140       0
   15   1.6897233e-01  5.5896180e-02    1.50e-02     0.0     136       0
   16   1.4388672e-01  1.6557832e-01    1.83e-02     0.0     118       0
   17   1.4362169e-01  1.8577965e-01    1.94e-02    -0.3     125       0
   18   1.3700520e-01  8.9582831e-02    1.44e-02     0.0     127       0
   19   1.3340186e-01  4.7673273e-02    1.21e-02     0.0     128       0
   20   1.3215119e-01  3.5976551e-02    1.15e-02     0.0     123       0
   21   1.2665228e-01  3.5006827e-02    1.10e-02     0.0     118       0
   22   1.3264620e-01  2.1311961e-01    1.93e-02    -0.3     112       0
   23   1.1400071e-01  8.4472310e-02    1.28e-02    -0.3     127       0
   24   1.1127674e-01  4.2699533e-02    1.05e-02     0.0     124       0
   25   1.0962027e-01  3.2131495e-02    9.74e-03     0.0     120       0
   26   1.0625048e-01  3.8830799e-02    9.69e-03     0.0     117       0
   27   1.0861021e-01  1.5843038e-01    1.54e-02    -0.3     118       0
   28   1.0281602e-01  7.1496578e-02    1.12e-02    -0.3     129       0
   29   1.0028769e-01  2.9781071e-02    8.91e-03     0.0     116       0
   30   9.9649500e-02  2.5865081e-02    8.67e-03     0.0     116       0
   31   9.5201573e-02  2.6891152e-02    8.35e-03     0.0     114       0
   32   9.3147190e-02  5.9436610e-02    9.94e-03    -0.3     117       0
   33   9.5698236e-02  1.1826812e-01    1.24e-02    -0.3     122       0
   34   8.9957871e-02  5.8888670e-02    9.70e-03     0.0     119       0
   35   8.8780474e-02  2.1025558e-02    7.65e-03     0.0     118       0
   36   8.8217311e-02  1.9819476e-02    7.57e-03     0.0     118       0
   37   7.8377566e-02  2.5578834e-02    7.10e-03     0.0     111       0
   38   7.9510259e-02  1.2066750e-01    1.21e-02    -0.3     115       0
   39   7.8986540e-02  7.7608981e-02    9.30e-03     0.0     116       0
   40   7.4954976e-02  2.1293210e-02    6.78e-03     0.0     117       0
   41   7.4490927e-02  1.7583013e-02    6.52e-03     0.0     115       0
   42   7.3378538e-02  1.5938944e-02    6.35e-03     0.0     114       0
   43   6.1441403e-02  1.3273754e-01    9.95e-03     0.0     101       0
   44   6.5404526e-02  1.8739864e-01    1.44e-02    -0.3     113       0
```

45	5.4438033e-02	4.2609814e-02	6.14e-03	0.0	126	0
46	5.1632294e-02	3.0417996e-02	5.57e-03	0.0	119	0
47	5.1070778e-02	1.2310704e-02	4.58e-03	0.0	115	0
48	5.0146693e-02	1.2706880e-02	4.48e-03	0.0	113	0
49	4.8134252e-02	2.3046009e-02	4.71e-03	0.0	108	0
50	4.7017770e-02	1.7241660e-02	4.49e-03	-0.3	110	0
51	4.6569645e-02	9.3201669e-03	4.02e-03	0.0	108	0
52	4.6164377e-02	1.0718263e-02	4.07e-03	0.0	109	0
53	4.4654840e-02	1.5691769e-02	4.13e-03	0.0	109	0
54	4.3987343e-02	1.6005272e-02	4.22e-03	-0.3	111	0
55	4.3607621e-02	8.4442874e-03	3.77e-03	0.0	110	0
56	4.3213014e-02	9.8244601e-03	3.82e-03	0.0	110	0
57	4.2015066e-02	1.9433966e-02	4.09e-03	0.0	109	0
58	4.1194287e-02	1.1782119e-02	3.80e-03	-0.3	111	0
59	4.0874755e-02	7.4719325e-03	3.52e-03	0.0	109	0
60	4.0457767e-02	8.6204676e-03	3.56e-03	0.0	107	0
61	3.8657015e-02	3.9101790e-02	4.66e-03	0.0	106	0
62	3.8212733e-02	5.4244898e-02	5.73e-03	-0.3	112	0
63	3.6215521e-02	6.9580311e-03	3.17e-03	0.0	109	0
64	3.5946525e-02	7.3728920e-03	3.17e-03	0.0	109	0
65	3.5546865e-02	6.5467602e-03	3.09e-03	0.0	107	0
66	3.1254482e-02	2.2290933e-02	3.51e-03	0.0	103	0
67	3.5812617e-02	5.5861910e-02	5.22e-03	-0.3	109	0
68	3.1692174e-02	3.8243174e-02	4.34e-03	0.0	118	0
69	2.9538997e-02	7.4593088e-03	2.70e-03	0.0	113	0
70	2.9262125e-02	5.0299586e-03	2.56e-03	0.0	113	0
71	2.8814164e-02	4.8431382e-03	2.50e-03	0.0	108	0
72	2.7437114e-02	3.5219801e-02	3.85e-03	0.0	106	0
73	2.6973434e-02	2.0330740e-02	3.09e-03	-0.3	111	0
74	2.6196045e-02	6.3823223e-03	2.37e-03	0.0	107	0
75	2.6014828e-02	4.2157291e-03	2.24e-03	0.0	107	0
76	2.5664371e-02	4.6836455e-03	2.24e-03	0.0	107	0
77	2.3394737e-02	4.2502239e-02	3.59e-03	0.0	101	0
78	2.1376497e-02	3.5045105e-02	3.50e-03	-0.3	107	0
79	2.0188582e-02	5.2104217e-03	1.85e-03	0.0	106	0
80	1.9939688e-02	5.2245791e-03	1.85e-03	0.0	105	0
81	1.9666559e-02	3.9258021e-03	1.74e-03	0.0	104	0
82	1.9060353e-02	1.3767335e-02	2.20e-03	0.0	104	0
83	1.8713313e-02	4.5127686e-03	1.69e-03	-0.3	104	0
84	1.8545657e-02	3.4105806e-03	1.63e-03	0.0	104	0
85	1.8366393e-02	3.1650652e-03	1.60e-03	0.0	102	0
86	1.7837693e-02	1.6273692e-02	2.23e-03	0.0	104	0
87	1.7432845e-02	4.4192527e-03	1.59e-03	-0.3	104	0
88	1.7289107e-02	3.0425355e-03	1.52e-03	0.0	104	0
89	1.7121989e-02	3.2302260e-03	1.51e-03	0.0	103	0
90	1.6087744e-02	2.1593525e-02	2.33e-03	0.0	103	0
91	1.6480345e-02	1.6971006e-02	2.07e-03	-0.3	104	0
92	1.5286715e-02	4.0925470e-03	1.43e-03	0.0	103	0
93	1.5134371e-02	2.8581201e-03	1.34e-03	0.0	103	0
94	1.5004673e-02	2.7161810e-03	1.32e-03	0.0	102	0
95	1.3704507e-02	5.3949301e-03	1.30e-03	0.0	97	0
96	1.3649500e-02	1.1951400e-02	1.70e-03	-0.3	101	0
97	1.3342749e-02	5.1285143e-03	1.29e-03	0.0	98	0
98	1.3174112e-02	2.8905408e-03	1.19e-03	0.0	99	0

99	1.3087526e-02	2.1823783e-03	1.14e-03	0.0	99	0
100	1.2488432e-02	3.0622942e-03	1.15e-03	0.0	99	0
101	1.2542801e-02	1.2088643e-02	1.54e-03	-0.3	99	0
102	1.2142007e-02	8.5578324e-03	1.40e-03	-0.3	101	0
103	1.1899745e-02	2.1462059e-03	1.05e-03	0.0	100	0
104	1.1831467e-02	1.7749834e-03	1.03e-03	0.0	100	0
105	1.1241729e-02	2.7407699e-03	1.02e-03	0.0	98	0
106	1.1115821e-02	1.3082495e-02	1.53e-03	-0.3	101	0
107	1.0605136e-02	2.9210527e-03	9.94e-04	-0.3	99	0
108	1.0510599e-02	1.8597108e-03	9.30e-04	0.0	99	0
109	1.0398040e-02	1.9747874e-03	9.22e-04	0.0	97	0
110	9.8243461e-03	9.9503444e-03	1.27e-03	0.0	98	0
111	9.9422330e-03	9.0416568e-03	1.21e-03	-0.3	95	0
112	9.4804010e-03	3.5769987e-03	9.34e-04	0.0	98	0
113	9.3889632e-03	1.7130671e-03	8.29e-04	0.0	97	0
114	9.3175772e-03	1.5943497e-03	8.18e-04	0.0	97	0
115	8.0076302e-03	5.2021139e-03	8.68e-04	0.0	93	0
116	8.3924528e-03	1.4669826e-02	1.42e-03	-0.3	98	0
117	7.8518395e-03	4.4683189e-03	8.26e-04	0.0	92	0
118	7.6473540e-03	1.7975130e-03	7.02e-04	0.0	93	0
119	7.5990704e-03	1.2135154e-03	6.66e-04	0.0	93	0
120	7.3956007e-03	1.7229459e-03	6.72e-04	0.0	92	0
121	7.2136521e-03	1.0142785e-02	1.02e-03	-0.3	93	0
122	6.7148950e-03	3.9578744e-03	7.41e-04	-0.3	94	0
123	6.5878965e-03	1.3971198e-03	5.94e-04	0.0	92	0
124	6.5347092e-03	1.2318443e-03	5.82e-04	0.0	92	0
125	6.3931963e-03	1.1108366e-03	5.58e-04	0.0	91	0
126	6.4837523e-03	1.0501210e-02	1.03e-03	-0.3	90	0
127	6.4709103e-03	6.8394984e-03	8.03e-04	-0.3	89	0
128	6.0125316e-03	1.3852066e-03	5.48e-04	0.0	90	0
129	5.9710981e-03	9.3119107e-04	5.19e-04	0.0	90	0
130	5.8947429e-03	9.6826052e-04	5.16e-04	0.0	90	0
131	5.0862002e-03	6.8999643e-03	6.90e-04	0.0	82	0
132	5.1613215e-03	1.1751781e-02	1.01e-03	-0.3	86	0
133	4.6412204e-03	1.3003124e-03	4.34e-04	0.0	86	0
134	4.5617726e-03	1.2374309e-03	4.30e-04	0.0	87	0
135	4.5167811e-03	8.5735069e-04	4.04e-04	0.0	87	0
136	4.3460550e-03	9.0364691e-04	3.91e-04	0.0	87	0
137	4.2883360e-03	1.6496169e-03	4.14e-04	-0.3	85	0
138	4.3966287e-03	6.6453138e-03	6.82e-04	0.0	84	0
139	4.1807518e-03	1.4992107e-03	4.00e-04	0.0	85	0
140	4.1323905e-03	6.6494215e-04	3.61e-04	0.0	85	0
141	4.1059578e-03	6.6864647e-04	3.59e-04	0.0	85	0
142	3.4234271e-03	2.0858467e-03	3.79e-04	0.0	81	0
143	3.6314467e-03	4.3215560e-03	4.91e-04	-0.3	82	0
144	3.4752151e-03	5.8430160e-03	5.61e-04	0.0	80	0
145	3.2759127e-03	8.3859996e-04	3.03e-04	0.0	81	0
146	3.2496124e-03	6.5135116e-04	2.92e-04	0.0	81	0
147	3.2114043e-03	5.1458535e-04	2.82e-04	0.0	81	0
148	2.9077275e-03	5.2666636e-03	4.85e-04	0.0	73	0
149	2.8485612e-03	2.2540710e-03	3.38e-04	-0.3	74	0
150	2.7545120e-03	8.4909045e-04	2.63e-04	0.0	74	0
151	2.7323680e-03	5.0624236e-04	2.43e-04	0.0	74	0
152	2.6990231e-03	5.4630024e-04	2.42e-04	0.0	73	0

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153   2.5653945e-03   2.4610143e-03   3.12e-04    0.0     68        0
154   2.5405897e-03   4.1369215e-03   4.06e-04   -0.3     69        0
155   2.3853193e-03   5.9013891e-04   2.20e-04    0.0     68        0
156   2.3619874e-03   3.9840953e-04   2.08e-04    0.0     68        0
157   2.3405503e-03   3.7788259e-04   2.05e-04    0.0     68        0
158   2.1643365e-03   6.1008053e-04   2.03e-04    0.0     68        0
159   2.1555051e-03   1.6612609e-03   2.45e-04   -0.3     62        0
160   2.2902040e-03   4.7090972e-03   4.12e-04    0.0     67        0
161   2.0586672e-03   6.1727677e-04   1.93e-04    0.0     64        0
162   2.0356250e-03   3.4811883e-04   1.79e-04    0.0     65        0
163   2.0205734e-03   3.1033000e-04   1.76e-04    0.0     64        0
164   1.7862022e-03   6.1464303e-04   1.73e-04    0.0     60        0
165   1.9637359e-03   3.9711904e-03   3.38e-04   -0.3     59        0
166   1.7697012e-03   2.5296577e-03   2.65e-04   -0.3     59        0
167   1.6652495e-03   4.7913192e-04   1.57e-04    0.0     58        0
168   1.6511927e-03   4.1801114e-04   1.53e-04    0.0     58        0
169   1.6275464e-03   2.5018471e-04   1.43e-04    0.0     58        0
170   1.5269008e-03   1.8969453e-03   2.10e-04    0.0     52        0
171   1.5507252e-03   1.4607451e-03   1.93e-04   -0.3     54        0
172   1.4565292e-03   5.7141352e-04   1.44e-04    0.0     54        0
173   1.4414533e-03   2.8067111e-04   1.28e-04    0.0     54        0
174   1.4307134e-03   2.5490421e-04   1.26e-04    0.0     54        0
175   1.2970293e-03   4.4447332e-04   1.25e-04    0.0     48        0
176   1.2988326e-03   1.2373055e-03   1.65e-04   -0.3     47        0
177   1.2628867e-03   3.5021664e-04   1.17e-04    0.0     46        0
178   1.2451194e-03   2.3090564e-04   1.11e-04    0.0     47        0
179   1.2372090e-03   2.0578673e-04   1.09e-04    0.0     47        0
180   1.1800507e-03   2.1846627e-04   1.05e-04    0.0     43        0
181   1.1627862e-03   5.5912985e-04   1.18e-04   -0.3     42        0
182   1.1744113e-03   1.1941937e-03   1.51e-04   -0.3     43        0
183   1.1211147e-03   2.4697085e-04   1.02e-04    0.0     42        0
184   1.1128361e-03   1.6547249e-04   9.67e-05    0.0     42        0
185   1.1020426e-03   1.9038807e-04   9.72e-05    0.0     42        0
186   9.3097962e-04   1.7040417e-03   1.53e-04    0.0     38        0
187   9.7790244e-04   1.7243903e-03   1.62e-04   -0.3     38        0
188   8.7584809e-04   5.5421239e-04   9.69e-05    0.0     36        0
189   8.5463506e-04   2.4104984e-04   8.06e-05    0.0     38        0
190   8.4738799e-04   1.6969162e-04   7.62e-05    0.0     37        0
191   8.2413497e-04   1.8746021e-04   7.45e-05    0.0     35        0
192   8.3445129e-04   7.9023779e-04   1.04e-04   -0.3     35        0
193   8.1226396e-04   5.5054765e-04   9.01e-05   -0.3     34        0
194   7.7943855e-04   1.4320060e-04   6.93e-05    0.0     33        0
195   7.7489599e-04   1.3319786e-04   6.83e-05    0.0     33        0
196   7.5706439e-04   1.0827509e-04   6.58e-05    0.0     33        0
197   7.4394447e-04   1.3446113e-03   1.12e-04   -0.3     29        0
198   7.2085334e-04   1.5599640e-03   1.36e-04   -0.3     25        0
199   6.2673068e-04   1.8279098e-04   5.92e-05    0.0     26        0
200   6.1431606e-04   1.1171663e-04   5.55e-05    0.0     26        0
201   6.0844078e-04   9.7185754e-05   5.38e-05    0.0     26        0
```

EXIT -- Optimal solution found

```
Products with A    :    286     Total time   (secs) :    1.2
Products with A'   :    202     Project time (secs) :    0.2
```

```
   Newton iterations    :        0      Mat-vec time (secs):       0.5
   Line search its      :      140      Subspace iterations :        0



   ========================================================================
   PQNL1_SLIM v. 46  (Tue, 14 Jun 2011) based on v.1017
   ========================================================================
   No. rows              :       120     No. columns           :       512
   Initial tau           : 2.00e+01     Two-norm of b         : 2.03e+00
   Optimality tol        : 1.00e-04     Target one-norm of x  : 2.00e+01
   Basis pursuit tol     : 1.00e-06     Maximum iterations    :      1200

    Iter      Objective    Relative Gap       gNorm    stepG     nnzX     nnzG
       0  2.0335130e+00  4.0927346e+00    4.23e-01     0.0        0        0
   Inside of minConf_PQN
    Iteration    FunEvals Projections     Step Length         rNorm2          O
            1         1           4     1.00000e+00     6.41073e-01     3.143
            2         1          10     1.00000e+00     5.31080e-01     1.970
            3         1          19     1.00000e+00     4.15233e-01     1.160
            4         1          28     1.00000e+00     3.57841e-01     9.060
            5         1          39     1.00000e+00     3.12463e-01     7.320
            6         1          48     1.00000e+00     2.78698e-01     5.398
            7         1          57     1.00000e+00     2.57599e-01     4.410
            8         1          71     1.00000e+00     2.37042e-01     4.285
            9         1          85     1.00000e+00     2.22830e-01     3.984
           10         1          98     1.00000e+00     2.06893e-01     3.588
           11         1         112     1.00000e+00     1.92809e-01     3.152
           12         1         131     1.00000e+00     1.78116e-01     3.166
           13         1         147     1.00000e+00     1.67600e-01     2.583
           14         1         169     1.00000e+00     1.56440e-01     2.187
           15         1         188     1.00000e+00     1.50054e-01     2.146
           16         1         202     1.00000e+00     1.42124e-01     2.044
           17         1         219     1.00000e+00     1.34418e-01     1.834
           18         1         237     1.00000e+00     1.30504e-01     1.595
           19         1         257     1.00000e+00     1.24615e-01     1.335
           20         1         278     1.00000e+00     1.18962e-01     1.634
           21         1         298     1.00000e+00     1.15007e-01     1.558
           22         1         318     1.00000e+00     1.06286e-01     1.437
           23         1         340     1.00000e+00     9.85494e-02     1.409
           24         1         368     1.00000e+00     9.32720e-02     1.274
           25         1         390     1.00000e+00     8.67203e-02     9.406
           26         1         409     1.00000e+00     7.95991e-02     1.093
           27         1         431     1.00000e+00     7.37627e-02     1.114
           28         1         460     1.00000e+00     6.45465e-02     1.143
           29         1         482     1.00000e+00     5.84977e-02     1.085
           30         1         517     1.00000e+00     5.04013e-02     1.000
           31         1         551     1.00000e+00     4.49325e-02     9.011
           32         1         587     1.00000e+00     3.90574e-02     8.194
           33         1         616     1.00000e+00     3.40650e-02     6.712
           34         1         656     1.00000e+00     2.89367e-02     6.088
           35         1         698     1.00000e+00     2.49446e-02     5.350
           36         1         710     1.00000e+00     2.24703e-02     3.592
           37         1         747     1.00000e+00     1.77141e-02     3.582
           38         1         773     1.00000e+00     1.52234e-02     3.230
```

```
   39              1        806     1.00000e+00      1.28144e-02      2.518
   40              1        831     1.00000e+00      1.08436e-02      2.173
   41              1        861     1.00000e+00      9.17127e-03      1.869
   42              1        895     1.00000e+00      7.61091e-03      1.774
   43              1        918     1.00000e+00      6.54046e-03      1.524
   44              1        942     1.00000e+00      5.64029e-03      1.062
   45              1        973     1.00000e+00      4.86235e-03      8.290
   46              1       1000     1.00000e+00      4.21127e-03      9.058
   47              1       1031     1.00000e+00      3.57681e-03      8.671
   48              1       1075     1.00000e+00      2.95564e-03      7.538
   49              1       1115     1.00000e+00      2.38938e-03      5.857
   50              1       1150     1.00000e+00      1.98936e-03      4.503
   51              1       1171     1.00000e+00      1.68266e-03      3.690
   52              1       1196     1.00000e+00      1.43529e-03      3.013
   53              1       1220     1.00000e+00      1.20202e-03      2.514
   54              1       1247     1.00000e+00      1.03881e-03      2.277
   55              1       1280     1.00000e+00      9.01156e-04      1.774
   56              1       1307     1.00000e+00      7.46938e-04      1.335
   57              1       1334     1.00000e+00      6.50301e-04      1.268
   58              1       1370     1.00000e+00      5.50569e-04      1.121
   59              1       1393     1.00000e+00      4.63952e-04      1.001
   60              1       1421     1.00000e+00      3.90914e-04      9.554
   61              1       1450     1.00000e+00      3.29492e-04      8.891
   62              1       1468     1.00000e+00      2.78947e-04      5.746
   63              1       1497     1.00000e+00      2.27436e-04      4.964
   64              1       1521     1.00000e+00      2.03692e-04      4.422
   65              1       1543     1.00000e+00      1.64087e-04      3.722
   66              1       1563     1.00000e+00      1.43982e-04      3.177
   67              1       1593     1.00000e+00      1.19542e-04      2.692
   68              1       1620     1.00000e+00      9.93151e-05      2.383
Optimal solution found
   68   9.9315056e-05   8.6130227e-05    1.19e-05     0.0        20          0
 EXIT -- Optimal solution found

 Products with A      :       70      Total time   (secs) :     11.8
 Products with A'     :       70      Project time (secs) :     12.3
 Newton iterations    :        0      Mat-vec time (secs) :      0.1


 info_spg =

          tau: 20
        rNorm: 6.0844e-04
         rGap: 9.7186e-05
        gNorm: 5.3821e-05
         stat: 4
         iter: 201
       nProdA: 286
      nProdAt: 202
      nNewton: 0
  timeProject: 0.1991
  timeMatProd: 0.4952
      itnLSQR: 0
      options: [1x1 struct]
```

```
           timeTotal: 1.2074

              xNorm1: [201x1 double]
              rNorm2: [201x1 double]
              lambda: [201x1 double]


    info_pqn1 =

                 tau: 20
               rNorm: 9.9315e-05
                rGap: 8.6130e-05
               gNorm: 1.1947e-05
                stat: 4
                iter: 68
               nProdA: 70
              nProdAt: 70
              nNewton: 0
          timeProject: 12.3430
          timeMatProd: 0.1467
              itnLSQR: 0
              options: [1x1 struct]
            timeTotal: 11.7767
               xNorm1: [68x1 double]
               rNorm2: [68x1 double]
               lambda: [68x1 double]
```
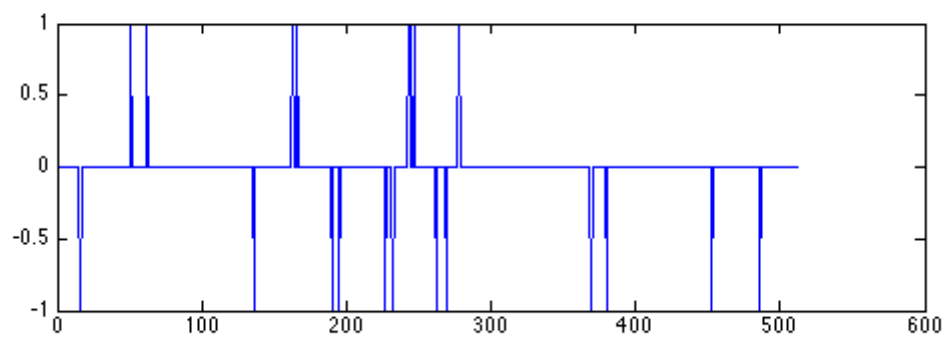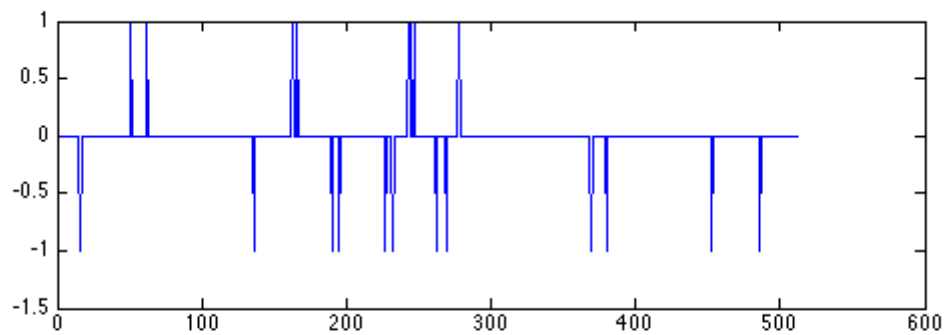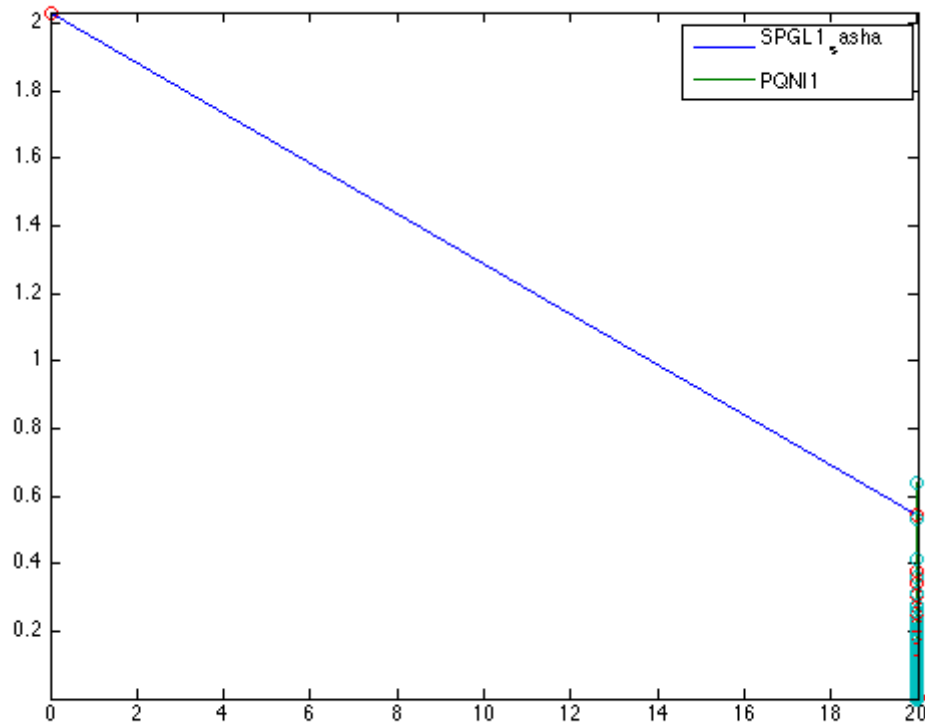
show result

```
figure('Name','Solution paths')
plot(info_spg.xNorm1,info_spg.rNorm2,info_pqn1.xNorm1,info_pqn1.rNorm2);hold on
scatter(info_spg.xNorm1,info_spg.rNorm2);
scatter(info_pqn1.xNorm1,info_pqn1.rNorm2);hold off
legend('SPGL1_sasha','PQNl1')
axis tight
```


bpdn

```
[x_spg,r_spg,g_spg,info_spg] = spgl1(A, b, 0, 0, zeros(size(A,2),1), opts); % Find

[x_pqn1,r_pqn1,g_pqn1,info_pqn1] = pqnl1_2(A, b, 0, 0, zeros(size(A,2),1), opts);

figure; subplot(2,1,1);plot(x_spg);subplot(2,1,2);plot(x_pqn1);
info_spg
info_pqn1
```

```
================================================================================
SPGL1_SLIM v. 46  (Tue, 14 Jun 2011) based on v.1017
================================================================================
No. rows                 :        120    No. columns              :        512
Initial tau              : 0.00e+00     Two-norm of b            : 2.03e+00
```

```
    Optimality tol         : 1.00e-04    Target objective     : 0.00e+00
    Basis pursuit tol      : 1.00e-06    Maximum iterations   :     1200

    Iter      Objective    Relative Gap   Rel Error      gNorm    stepG     nnzX
       0   2.0335130e+00  0.0000000e+00    1.00e+00   4.231e-01      0.0        0
       1   1.9116542e+00  1.9903973e+00    1.00e+00   3.155e-01     -0.3        1
       2   1.1063324e+00  1.2930784e+00    1.00e+00   2.032e-01      0.0       48
       3   1.0019412e+00  3.6649099e-01    1.00e+00   1.210e-01      0.0       73
       4   9.8287342e-01  1.9859751e-01    9.83e-01   1.041e-01      0.0       57
       5   9.6507351e-01  1.5674759e-01    9.65e-01   1.001e-01      0.0       50
       6   9.5530593e-01  2.0735975e-01    9.55e-01   1.058e-01      0.0       46
       7   9.7064991e-01  6.4512158e-01    9.71e-01   1.478e-01      0.0       35
       8   9.4955488e-01  8.6651195e-02    9.50e-01   9.438e-02      0.0       44
       9   9.4812834e-01  2.6650455e-02    9.48e-01   8.869e-02      0.0       43
      10   9.4774263e-01  2.6437974e-02    9.48e-01   8.877e-02      0.0       41
      11   4.4996803e-01  1.7771989e+00    4.50e-01   7.717e-02      0.0       63
      12   2.7566318e-01  6.1519884e-01    2.76e-01   5.074e-02      0.0      220
      13   1.9024380e-01  1.8967232e-01    1.90e-01   2.028e-02      0.0      229
      14   1.7962870e-01  1.0426154e-01    1.80e-01   1.675e-02      0.0      215
      15   1.6636179e-01  9.3265120e-02    1.66e-01   1.550e-02      0.0      190
      16   1.4922179e-01  1.3787134e-01    1.49e-01   1.779e-02      0.0      146
      17   1.6142178e-01  3.5809457e-01    1.61e-01   2.560e-02     -0.3      140
      18   1.4212299e-01  1.2345620e-01    1.42e-01   1.652e-02      0.0      168
      19   1.3350034e-01  6.6779994e-02    1.34e-01   1.263e-02      0.0      150
      20   1.3187373e-01  4.8637540e-02    1.32e-01   1.178e-02      0.0      146
      21   1.2724540e-01  4.8315815e-02    1.27e-01   1.165e-02      0.0      139
      22   1.1951044e-01  1.7577763e-01    1.20e-01   1.570e-02      0.0      112
      23   1.0920111e-01  9.8598558e-02    1.09e-01   1.340e-02     -0.3      134
      24   1.0554818e-01  4.1428234e-02    1.06e-01   9.758e-03      0.0      128
      25   1.0413472e-01  3.9445195e-02    1.04e-01   9.679e-03      0.0      125
      26   1.0247522e-01  3.0000357e-02    1.02e-01   9.049e-03      0.0      122
      27   1.0159454e-01  8.3973429e-02    1.02e-01   1.151e-02      0.0      119
      28   1.0309830e-01  1.2855067e-01    1.03e-01   1.362e-02     -0.3      117
      29   9.6069091e-02  3.1209886e-02    9.61e-02   8.678e-03      0.0      125
      30   9.5405615e-02  2.4627341e-02    9.54e-02   8.337e-03      0.0      118
      31   9.3732048e-02  2.5915852e-02    9.37e-02   8.288e-03      0.0      115
      32   9.4589283e-02  2.2437877e-01    9.46e-02   1.672e-02      0.0       95
      33   9.2088433e-02  1.9512358e-01    9.21e-02   1.601e-02     -0.3      108
      34   7.5550614e-02  4.9172950e-02    7.56e-02   8.299e-03      0.0      136
      35   7.1148312e-02  2.9645205e-02    7.11e-02   7.076e-03      0.0      117
      36   7.0081859e-02  1.7209419e-02    7.01e-02   6.351e-03      0.0      114
      37   6.8362105e-02  1.7108229e-02    6.84e-02   6.132e-03      0.0      106
      38   6.5707131e-02  3.6125763e-02    6.57e-02   6.813e-03      0.0      101
      39   6.4524701e-02  2.8875433e-02    6.45e-02   6.398e-03     -0.3      106
      40   6.3905084e-02  1.4962091e-02    6.39e-02   5.667e-03      0.0      104
      41   6.3306147e-02  1.7304741e-02    6.33e-02   5.728e-03      0.0      105
      42   6.1566997e-02  2.7304821e-02    6.16e-02   6.097e-03      0.0      104
      43   6.0545006e-02  1.9755218e-02    6.05e-02   5.648e-03     -0.3      107
      44   6.0044397e-02  1.4904928e-02    6.00e-02   5.385e-03      0.0      103
      45   5.9408040e-02  1.3981307e-02    5.94e-02   5.276e-03      0.0      104
      46   5.7517507e-02  4.2328916e-02    5.75e-02   6.472e-03      0.0      102
      47   5.5084574e-02  2.5006536e-02    5.51e-02   5.525e-03     -0.3      108
      48   5.4515092e-02  1.1542470e-02    5.45e-02   4.817e-03      0.0      104
      49   5.4063091e-02  1.1068613e-02    5.41e-02   4.744e-03      0.0      104
```

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50	5.0782325e-02	1.9771215e-02	5.08e-02	4.907e-03	0.0	101
51	5.2855175e-02	6.8349035e-02	5.29e-02	7.280e-03	−0.3	105
52	5.0435484e-02	2.8556021e-02	5.04e-02	5.305e-03	0.0	109
53	4.8651252e-02	1.0153458e-02	4.87e-02	4.296e-03	0.0	106
54	4.8368567e-02	9.9779080e-03	4.84e-02	4.264e-03	0.0	105
55	4.6908308e-02	1.0192982e-02	4.69e-02	4.161e-03	0.0	102
56	4.7614080e-02	8.4210750e-02	4.76e-02	7.241e-03	−0.3	98
57	4.1954259e-02	3.7766949e-02	4.20e-02	5.307e-03	−0.3	109
58	3.9891722e-02	8.7710161e-03	3.99e-02	3.600e-03	0.0	107
59	3.9339296e-02	9.0094499e-03	3.93e-02	3.577e-03	0.0	105
60	3.8694485e-02	9.5572004e-03	3.87e-02	3.502e-03	0.0	103
61	3.8224218e-02	3.6798945e-02	3.82e-02	4.861e-03	0.0	105
62	3.8671412e-02	3.9619343e-02	3.87e-02	4.760e-03	−0.3	101
63	3.6702347e-02	8.6944001e-03	3.67e-02	3.332e-03	0.0	105
64	3.6466540e-02	7.3128656e-03	3.65e-02	3.224e-03	0.0	101
65	3.5954344e-02	7.1590295e-03	3.60e-02	3.181e-03	0.0	101
66	2.7899172e-02	4.4318330e-02	2.79e-02	4.079e-03	0.0	94
67	3.5211618e-02	8.0193954e-02	3.52e-02	6.589e-03	−0.3	101
68	2.7517954e-02	3.1216024e-02	2.75e-02	3.629e-03	0.0	114
69	2.5115101e-02	1.0116309e-02	2.51e-02	2.562e-03	0.0	102
70	2.4679943e-02	4.3979484e-03	2.47e-02	2.224e-03	0.0	103
71	2.4206127e-02	5.9816341e-03	2.42e-02	2.240e-03	0.0	100
72	2.3371937e-02	7.7042536e-03	2.34e-02	2.220e-03	0.0	99
73	2.3090514e-02	8.4686927e-03	2.31e-02	2.283e-03	−0.3	98
74	2.2853882e-02	7.8894035e-03	2.29e-02	2.179e-03	0.0	98
75	2.2612220e-02	6.7781455e-03	2.26e-02	2.157e-03	0.0	97
76	2.2418097e-02	4.4080654e-03	2.24e-02	1.994e-03	0.0	97
77	2.2169701e-02	5.9910755e-03	2.22e-02	2.082e-03	0.0	96
78	2.2034176e-02	1.4775194e-02	2.20e-02	2.395e-03	0.0	99
79	2.1590369e-02	8.5273932e-03	2.16e-02	2.183e-03	−0.3	95
80	2.1309510e-02	3.7178071e-03	2.13e-02	1.883e-03	0.0	95
81	2.1178401e-02	3.7856776e-03	2.12e-02	1.884e-03	0.0	95
82	1.9333889e-02	6.0512923e-03	1.93e-02	1.830e-03	0.0	93
83	2.0839112e-02	2.8478977e-02	2.08e-02	3.195e-03	−0.3	92
84	1.8897244e-02	1.3550408e-02	1.89e-02	2.118e-03	−0.3	93
85	1.8184093e-02	3.8135368e-03	1.82e-02	1.695e-03	0.0	94
86	1.8056217e-02	3.2888666e-03	1.81e-02	1.641e-03	0.0	93
87	1.7625346e-02	3.5121353e-03	1.76e-02	1.603e-03	0.0	92
88	1.7008928e-02	2.5654491e-02	1.70e-02	2.503e-03	0.0	79
89	1.6006040e-02	1.0693273e-02	1.60e-02	1.906e-03	−0.3	88
90	1.5481065e-02	3.8681261e-03	1.55e-02	1.472e-03	0.0	86
91	1.5289438e-02	3.2036629e-03	1.53e-02	1.424e-03	0.0	85
92	1.5031717e-02	3.2684433e-03	1.50e-02	1.377e-03	0.0	84
93	1.5424722e-02	1.7571438e-02	1.54e-02	2.158e-03	0.0	78
94	1.4574241e-02	1.0114997e-02	1.46e-02	1.635e-03	−0.3	76
95	1.4225953e-02	2.7084181e-03	1.42e-02	1.305e-03	0.0	76
96	1.4146840e-02	2.2742198e-03	1.41e-02	1.274e-03	0.0	76
97	1.3339244e-02	4.0507798e-03	1.33e-02	1.307e-03	0.0	70
98	1.3198166e-02	9.9833094e-03	1.32e-02	1.619e-03	−0.3	71
99	1.3989811e-02	2.3933544e-02	1.40e-02	2.223e-03	0.0	67
100	1.2782350e-02	7.8173204e-03	1.28e-02	1.427e-03	0.0	66
101	1.2552893e-02	2.3142998e-03	1.26e-02	1.163e-03	0.0	68
102	1.2477691e-02	1.7699209e-03	1.25e-02	1.126e-03	0.0	66
103	1.1993004e-02	3.3286289e-03	1.20e-02	1.181e-03	0.0	64

104	1.1863168e-02	7.5789274e-03	1.19e-02	1.378e-03	-0.3	63
105	1.2056215e-02	1.2074762e-02	1.21e-02	1.602e-03	0.0	57
106	1.1536665e-02	5.1902264e-03	1.15e-02	1.219e-03	0.0	58
107	1.1398465e-02	2.1774390e-03	1.14e-02	1.079e-03	0.0	55
108	1.1335822e-02	1.9729007e-03	1.13e-02	1.063e-03	0.0	55
109	1.0511539e-02	2.6207102e-03	1.05e-02	1.055e-03	0.0	43
110	1.1167681e-02	1.2601194e-02	1.12e-02	1.620e-03	-0.3	41
111	1.0700031e-02	1.0733225e-02	1.07e-02	1.456e-03	0.0	35
112	1.0283636e-02	2.3733143e-03	1.03e-02	1.032e-03	0.0	39
113	1.0225479e-02	1.5094744e-03	1.02e-02	9.874e-04	0.0	36
114	1.0188164e-02	1.2366960e-03	1.02e-02	9.728e-04	0.0	32
115	1.0037083e-02	1.2271058e-03	1.00e-02	9.734e-04	0.0	29
116	1.0095986e-02	5.7223390e-03	1.01e-02	1.205e-03	-0.3	25
117	1.0095033e-02	4.0255659e-03	1.01e-02	1.132e-03	0.0	26
118	3.7479046e-03	6.0046208e-03	3.75e-03	5.032e-04	0.0	47
119	3.1424518e-03	1.0940620e-03	3.14e-03	3.099e-04	0.0	43
120	3.0283939e-03	7.5282969e-04	3.03e-03	2.785e-04	0.0	43
121	2.8436559e-03	9.2314902e-04	2.84e-03	2.797e-04	0.0	40
122	2.8389629e-03	3.4413959e-03	2.84e-03	3.680e-04	0.0	43
123	2.6598395e-03	1.0207169e-03	2.66e-03	2.705e-04	-0.3	40
124	2.5959513e-03	5.8336430e-04	2.60e-03	2.380e-04	0.0	41
125	2.5693087e-03	5.7220878e-04	2.57e-03	2.368e-04	0.0	41
126	2.4169426e-03	5.7969603e-04	2.42e-03	2.250e-04	0.0	38
127	2.3722935e-03	1.0763446e-03	2.37e-03	2.500e-04	-0.3	35
128	2.3533552e-03	1.8234088e-03	2.35e-03	2.767e-04	-0.3	35
129	2.2982461e-03	6.5126493e-04	2.30e-03	2.217e-04	0.0	36
130	2.2800606e-03	4.0608944e-04	2.28e-03	2.073e-04	0.0	36
131	2.2534731e-03	4.2256448e-04	2.25e-03	2.064e-04	0.0	35
132	2.0172357e-03	2.2561686e-03	2.02e-03	2.768e-04	0.0	23
133	2.2744865e-03	6.6195582e-03	2.27e-03	5.043e-04	-0.3	24
134	1.9667213e-03	1.0187468e-03	1.97e-03	2.187e-04	0.0	23
135	1.9016852e-03	6.3163453e-04	1.90e-03	1.970e-04	0.0	23
136	1.8828393e-03	3.3538987e-04	1.88e-03	1.792e-04	0.0	23
137	1.8520129e-03	4.4462464e-04	1.85e-03	1.810e-04	0.0	23
138	1.7937343e-03	8.2148378e-04	1.79e-03	1.949e-04	0.0	21
139	1.7697517e-03	7.3530775e-04	1.77e-03	1.921e-04	-0.3	21
140	1.7525886e-03	2.0628926e-04	1.75e-03	1.627e-04	0.0	21
141	1.7416996e-03	3.3537211e-04	1.74e-03	1.685e-04	0.0	21
142	1.7123014e-03	4.9144130e-04	1.71e-03	1.745e-04	0.0	21
143	1.7031493e-03	5.9171988e-04	1.70e-03	1.810e-04	-0.3	21
144	1.6940396e-03	2.6288734e-04	1.69e-03	1.636e-04	0.0	21
145	1.6869489e-03	3.3214498e-04	1.69e-03	1.669e-04	0.0	21
146	1.6792045e-03	2.9246123e-04	1.68e-03	1.647e-04	0.0	21
147	1.6759794e-03	7.5044665e-04	1.68e-03	1.878e-04	0.0	20
148	1.6723266e-03	9.3279510e-04	1.67e-03	1.966e-04	0.0	20
149	1.6611621e-03	2.0178764e-04	1.66e-03	1.602e-04	0.0	20
150	1.6589156e-03	1.2431195e-04	1.66e-03	1.563e-04	0.0	20
151	1.6530737e-03	1.2945964e-04	1.65e-03	1.569e-04	0.0	20
152	1.6539847e-03	6.5337950e-04	1.65e-03	1.867e-04	0.0	20
153	1.6476530e-03	2.1243097e-04	1.65e-03	1.643e-04	-0.3	20
154	1.6465431e-03	9.8681715e-05	1.65e-03	1.581e-04	0.0	20
155	1.6463924e-03	5.3723866e-05	1.65e-03	1.556e-04	0.0	20
156	6.9503917e-04	2.2040267e-03	6.95e-04	1.119e-04	0.0	20
157	4.1357069e-04	4.1239028e-04	4.14e-04	5.636e-05	0.0	20

```
  158   3.2934579e-04   2.2490380e-04    3.29e-04   3.421e-05      0.0       20
  159   3.1328376e-04   1.2029456e-04    3.13e-04   2.926e-05      0.0       20
  160   2.8537913e-04   1.0595308e-04    2.85e-04   2.674e-05      0.0       20
  161   2.6540119e-04   2.4720481e-04    2.65e-04   3.270e-05      0.0       20
  162   2.9096173e-04   7.0497476e-04    2.91e-04   5.361e-05     -0.3       20
  163   2.4508737e-04   1.3541226e-04    2.45e-04   2.580e-05      0.0       20
  164   2.3543969e-04   6.1448022e-05    2.35e-04   2.131e-05      0.0       20
  165   2.3257586e-04   5.4125594e-05    2.33e-04   2.085e-05      0.0       20
  166   2.2036040e-04   7.6851823e-05    2.20e-04   2.123e-05      0.0       20
  167   2.3004883e-04   3.2106659e-04    2.30e-04   3.107e-05     -0.3       20
  168   2.2765166e-04   3.6903133e-04    2.28e-04   3.524e-05     -0.3       20
  169   2.0011857e-04   5.8633704e-05    2.00e-04   1.871e-05      0.0       20
  170   1.9820638e-04   4.3349261e-05    1.98e-04   1.775e-05      0.0       20
  171   1.9532971e-04   3.8970458e-05    1.95e-04   1.731e-05      0.0       20
  172   1.7069852e-04   1.7448052e-04    1.71e-04   2.146e-05      0.0       20
  173   1.8758789e-04   4.5756859e-04    1.88e-04   3.732e-05     -0.3       20
  174   1.6535289e-04   1.1978576e-04    1.65e-04   1.886e-05      0.0       20
  175   1.5886074e-04   3.4178314e-05    1.59e-04   1.464e-05      0.0       20
  176   1.5760214e-04   2.9727183e-05    1.58e-04   1.422e-05      0.0       20
  177   1.5289959e-04   4.0591293e-05    1.53e-04   1.412e-05      0.0       20
  178   1.5315921e-04   1.7307424e-04    1.53e-04   2.044e-05      0.0       20
  179   1.4086987e-04   5.7197791e-05    1.41e-04   1.449e-05     -0.3       20
  180   1.3702577e-04   3.2779312e-05    1.37e-04   1.276e-05      0.0       20
  181   1.3555159e-04   2.6597318e-05    1.36e-04   1.222e-05      0.0       20
  182   1.3307130e-04   3.2296399e-05    1.33e-04   1.219e-05      0.0       20
  183   1.3211776e-04   6.2261926e-05    1.32e-04   1.349e-05     -0.3       20
  184   1.2983582e-04   1.0415843e-04    1.30e-04   1.548e-05     -0.3       20
  185   1.2742034e-04   2.2621839e-05    1.27e-04   1.129e-05      0.0       20
  186   1.2666726e-04   2.0100457e-05    1.27e-04   1.110e-05      0.0       20
  187   1.2244188e-04   2.5553357e-05    1.22e-04   1.107e-05      0.0       20
  188   1.1976357e-04   1.3568981e-04    1.20e-04   1.610e-05     -0.3       20
  189   1.1546542e-04   2.4159559e-05    1.15e-04   1.049e-05     -0.3       20
  190   1.1449209e-04   2.0566486e-05    1.14e-04   1.018e-05      0.0       20
  191   1.1335193e-04   2.0989737e-05    1.13e-04   1.012e-05      0.0       20
  192   1.0341907e-04   8.2335782e-05    1.03e-04   1.213e-05      0.0       20
  193   1.1158688e-04   1.1648886e-04    1.12e-04   1.427e-05     -0.3       20
  194   1.0134793e-04   8.2269328e-05    1.01e-04   1.225e-05      0.0       20
  195   9.8545652e-05   1.8545683e-05    9.85e-05   8.919e-06      0.0       20

EXIT -- Found a root

Products with A      :      261      Total time  (secs) :      1.1
Products with A'     :      196      Project time (secs) :      0.2
Newton iterations    :        4      Mat-vec time (secs) :      0.5
Line search its      :       82      Subspace iterations :        0


=========================================================================
PQNL1_SLIM v. 46  (Tue, 14 Jun 2011) based on v.1017
=========================================================================
No. rows             :      120      No. columns         :      512
Initial tau          : 0.00e+00      Two-norm of b       : 2.03e+00
Optimality tol       : 1.00e-04      Target objective    : 0.00e+00
Basis pursuit tol    : 1.00e-06      Maximum iterations  :     1200
```

```
                0   2.0335130e+00   0.0000000e+00    1.00e+00   4.231e-01      0.0          0

        Inside of minConf_PQN
         Iteration    FunEvals Projections    Step Length        rNorm2          O
                 1       1          4      1.00000e+00   1.20066e+00    2.811
                 2       1         10      1.00000e+00   1.09837e+00    1.491
                 3       1         17      1.00000e+00   1.02486e+00    9.430
                 4       1         26      1.00000e+00   9.88533e-01    6.667
                 5       1         35      1.00000e+00   9.69977e-01    4.833
                 6       1         44      1.00000e+00   9.60238e-01    2.841
                 7       1         53      1.00000e+00   9.55667e-01    2.111
        break of testUpdateTau    7  9.5566678e-01  1.3843721e-01   9.56e-01  9.7

        Inside of minConf_PQN
         Iteration    FunEvals Projections    Step Length        rNorm2          O
                 8       1          4      1.00000e+00   3.45422e-01    1.550
                 9       1         10      1.00000e+00   3.10017e-01    1.002
                10       1         19      1.00000e+00   2.75920e-01    5.592
                11       1         27      1.00000e+00   2.57733e-01    4.032
                12       1         37      1.00000e+00   2.45596e-01    3.131
                13       1         48      1.00000e+00   2.33639e-01    2.553
                14       1         59      1.00000e+00   2.24330e-01    2.488
                15       1         73      1.00000e+00   2.16871e-01    2.447
                16       1         91      1.00000e+00   2.07217e-01    2.444
                17       1        105      1.00000e+00   1.98537e-01    2.089
                18       1        121      1.00000e+00   1.91136e-01    1.744
                19       1        141      1.00000e+00   1.84117e-01    1.739
                20       1        157      1.00000e+00   1.78642e-01    1.842
                21       1        172      1.00000e+00   1.70156e-01    1.795
                22       1        188      1.00000e+00   1.63191e-01    1.635
                23       1        210      1.00000e+00   1.54612e-01    1.493
                24       1        229      1.00000e+00   1.44331e-01    1.487
                25       1        254      1.00000e+00   1.35022e-01    1.524
                26       1        271      1.00000e+00   1.27353e-01    1.449
                27       1        291      1.00000e+00   1.19610e-01    1.300
                28       1        317      1.00000e+00   1.10195e-01    1.149
                29       1        336      1.00000e+00   1.01331e-01    1.108
                30       1        360      1.00000e+00   9.42514e-02    9.115
                31       1        379      1.00000e+00   8.67596e-02    7.490
                32       1        397      1.00000e+00   8.37687e-02    5.587
                33       1        412      1.00000e+00   8.17333e-02    4.003
                34       1        431      1.00000e+00   8.00025e-02    2.668
                35       1        442      1.00000e+00   7.96144e-02    1.979
        break of testUpdateTau   35  7.9614374e-02  2.0658756e-02   7.96e-02  8.4

        Inside of minConf_PQN
         Iteration    FunEvals Projections    Step Length        rNorm2          O
                36       1          4      1.00000e+00   2.93453e-02    1.293
                37       1         10      1.00000e+00   2.62267e-02    8.354
                38       1         19      1.00000e+00   2.31095e-02    4.630
                39       1         27      1.00000e+00   2.16550e-02    3.171
                40       1         37      1.00000e+00   2.06741e-02    2.373
                41       1         48      1.00000e+00   1.97625e-02    2.037
```

42	1	60	1.00000e+00	1.91014e-02	1.869
43	1	75	1.00000e+00	1.85462e-02	1.802
44	1	89	1.00000e+00	1.78074e-02	1.667
45	1	108	1.00000e+00	1.70899e-02	1.471
46	1	124	1.00000e+00	1.66765e-02	1.323
47	1	140	1.00000e+00	1.59631e-02	1.359
48	1	153	1.00000e+00	1.55984e-02	1.329
49	1	170	1.00000e+00	1.48974e-02	1.367
50	1	191	1.00000e+00	1.42459e-02	1.293
51	1	211	1.00000e+00	1.34291e-02	1.246
52	1	234	1.00000e+00	1.27753e-02	1.116
53	1	251	1.00000e+00	1.21851e-02	1.155
54	1	270	1.00000e+00	1.15995e-02	1.099
55	1	293	1.00000e+00	1.09562e-02	8.798
56	1	309	1.00000e+00	1.04804e-02	5.785
57	1	324	1.00000e+00	1.02195e-02	4.240
58	1	345	1.00000e+00	1.00627e-02	3.304
59	1	365	1.00000e+00	9.96311e-03	2.753
60	1	382	1.00000e+00	9.91554e-03	2.317

break of testUpdateTau   60   9.9155361e-03   2.6675705e-03   9.92e-03   1.0

Inside of minConf_PQN

Iteration	FunEvals	Projections	Step Length	rNorm2	O
61	1	4	1.00000e+00	3.64644e-03	1.599
62	1	10	1.00000e+00	3.25372e-03	1.017
63	1	19	1.00000e+00	2.87190e-03	5.603
64	1	28	1.00000e+00	2.68973e-03	3.849
65	1	36	1.00000e+00	2.56680e-03	2.963
66	1	47	1.00000e+00	2.44401e-03	2.643
67	1	60	1.00000e+00	2.35464e-03	2.553
68	1	75	1.00000e+00	2.28295e-03	2.363
69	1	91	1.00000e+00	2.19690e-03	2.073
70	1	104	1.00000e+00	2.11056e-03	1.810
71	1	116	1.00000e+00	2.05936e-03	1.576
72	1	131	1.00000e+00	1.98169e-03	1.728
73	1	144	1.00000e+00	1.93859e-03	1.750
74	1	167	1.00000e+00	1.85792e-03	1.663
75	1	193	1.00000e+00	1.77028e-03	1.538
76	1	217	1.00000e+00	1.69017e-03	1.442
77	1	232	1.00000e+00	1.59160e-03	1.554
78	1	254	1.00000e+00	1.51465e-03	1.641
79	1	273	1.00000e+00	1.42042e-03	1.414
80	1	289	1.00000e+00	1.34907e-03	9.940
81	1	308	1.00000e+00	1.29620e-03	6.524
82	1	315	1.00000e+00	1.27760e-03	5.275
83	1	327	1.00000e+00	1.26493e-03	4.137
84	1	338	1.00000e+00	1.25212e-03	3.094
85	1	351	1.00000e+00	1.24765e-03	2.222

break of testUpdateTau   85   1.2476515e-03   2.8089256e-04   1.25e-03   1.3

Inside of minConf_PQN

Iteration	FunEvals	Projections	Step Length	rNorm2	O
86	1	4	1.00000e+00	4.46885e-04	1.976
87	1	10	1.00000e+00	3.99302e-04	1.275

```
        88          1          19   1.00000e+00      3.50145e-04      7.231
        89          1          27   1.00000e+00      3.27399e-04      5.084
        90          1          36   1.00000e+00      3.10803e-04      3.674
        91          1          47   1.00000e+00      2.96767e-04      3.210
        92          1          58   1.00000e+00      2.86017e-04      2.970
        93          1          72   1.00000e+00      2.77320e-04      2.837
        94          1          85   1.00000e+00      2.66121e-04      2.611
        95          1         104   1.00000e+00      2.54756e-04      2.399
        96          1         116   1.00000e+00      2.48533e-04      2.097
        97          1         130   1.00000e+00      2.38020e-04      2.247
        98          1         138   1.00000e+00      2.32572e-04      1.827
        99          1         157   1.00000e+00      2.18640e-04      1.760
       100          1         171   1.00000e+00      2.10644e-04      1.921
       101          1         188   1.00000e+00      1.98175e-04      2.008
       102          1         205   1.00000e+00      1.87446e-04      1.802
       103          1         224   1.00000e+00      1.74632e-04      1.710
       104          1         248   1.00000e+00      1.65533e-04      1.588
       105          1         271   1.00000e+00      1.54285e-04      1.285
       106          1         290   1.00000e+00      1.45424e-04      1.049
       107          1         304   1.00000e+00      1.41465e-04      8.139
       108          1         318   1.00000e+00      1.38257e-04      5.560
       109          1         335   1.00000e+00      1.36646e-04      4.285
       110          1         351   1.00000e+00      1.35737e-04      3.447
       111          1         363   1.00000e+00      1.35402e-04      2.791
break of testUpdateTau   111   1.3540159e-04   3.0579456e-05   1.35e-04   1.4

Inside of minConf_PQN
 Iteration   FunEvals Projections    Step Length        rNorm2            O
       112          1           4   1.00000e+00      4.87286e-05      2.186
Optimal solution found


 EXIT -- Found a root

 Products with A     :      119     Total time   (secs) :      8.3
 Products with A'    :      119     Project time (secs) :      8.9
 Newton iterations   :        6     Mat-vec time (secs) :      0.3


info_spg =

          tau: 19.9996
        rNorm: 9.8546e-05
         rGap: 1.8546e-05
        gNorm: 8.9192e-06
         stat: 1
         iter: 195
       nProdA: 261
      nProdAt: 196
      nNewton: 4
   timeProject: 0.1839
   timeMatProd: 0.4751
      itnLSQR: 0
      options: [1x1 struct]
```
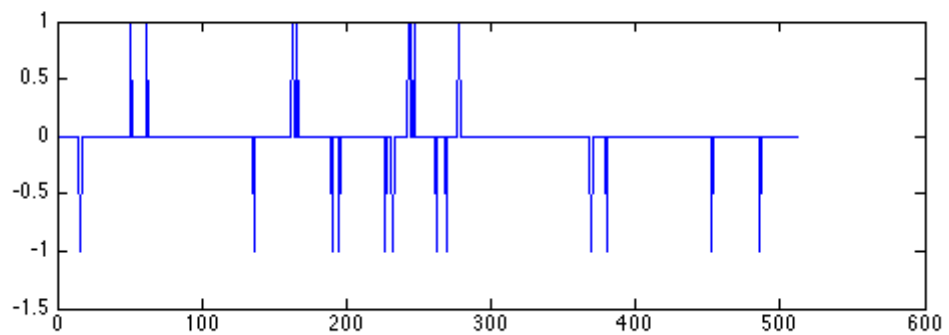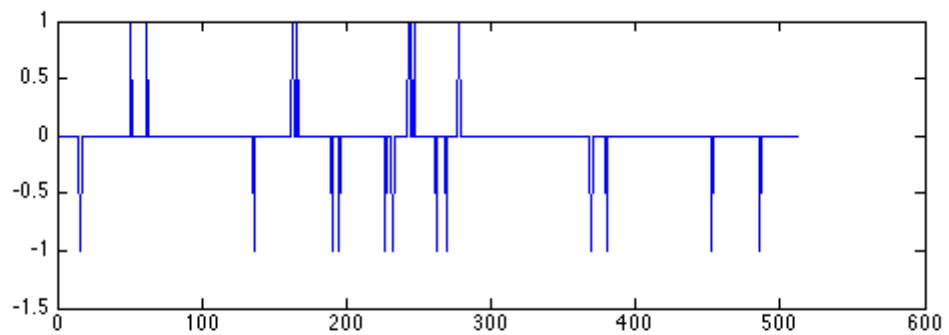
```
         timeTotal: 1.0844

            xNorm1: [195x1 double]
            rNorm2: [195x1 double]
            lambda: [195x1 double]


  info_pqn1 =

               tau: 19.9998
             rNorm: 4.8729e-05
              rGap: 1.8628e-05
             gNorm: 5.2248e-06
              stat: 1
              iter: 112
            nProdA: 119
           nProdAt: 119
           nNewton: 6
       timeProject: 8.8985
       timeMatProd: 0.3149
            itnLSQR: 0
           options: [1x1 struct]
         timeTotal: 8.3221
            xNorm1: [112x1 double]
            rNorm2: [112x1 double]
            lambda: [112x1 double]
```
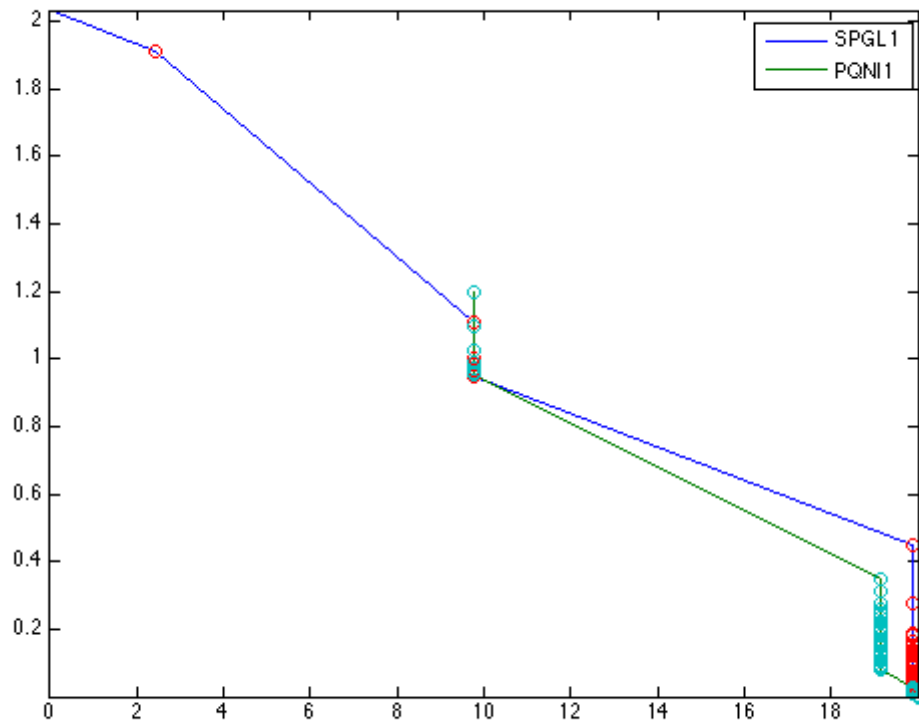
show result

```
figure('Name','Solution paths')
plot(info_spg.xNorm1,info_spg.rNorm2,info_pqn1.xNorm1,info_pqn1.rNorm2);hold on
scatter(info_spg.xNorm1,info_spg.rNorm2);
scatter(info_pqn1.xNorm1,info_pqn1.rNorm2);hold off
legend('SPGL1','PQNl1')
axis tight
```


check functions

open ./minConF_PQN_2.m open ./pqnl1_2.m

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