vanderWaalsGas-notes

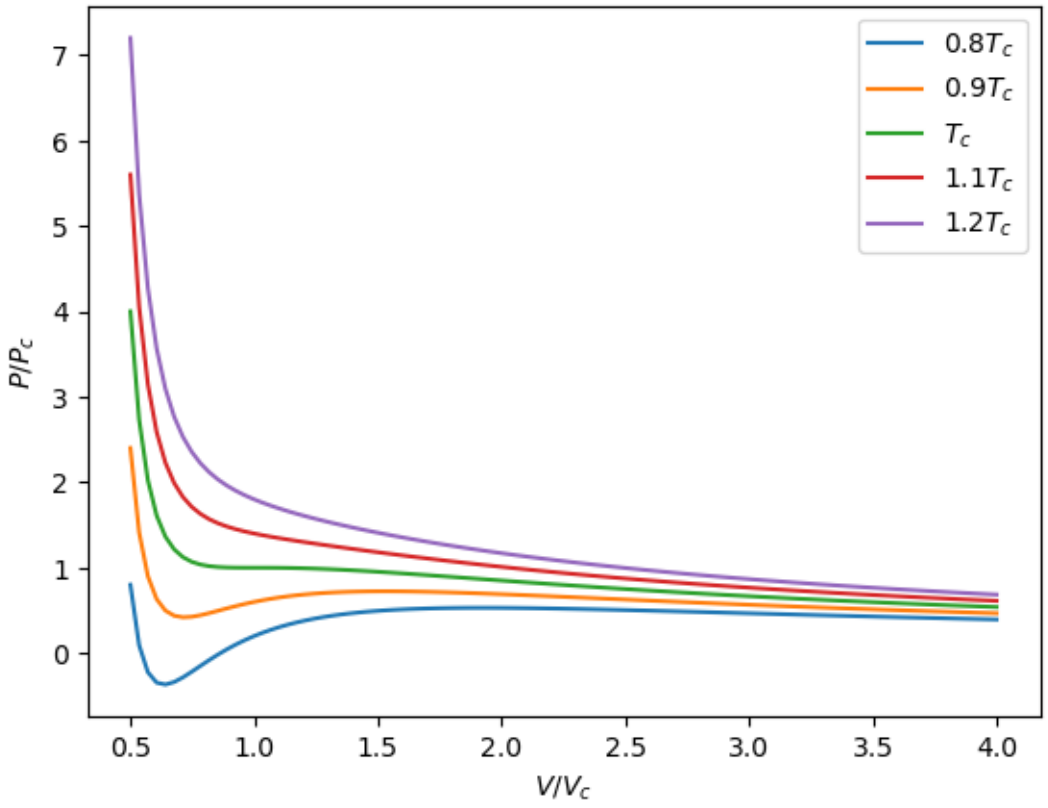
December 6, 2024

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

[2]:
```
def p(v,t):
    return 8*t/(3*v-1)-3/v**2
```

[3]:
```
v = np.linspace(0.5, 4, 100)

fig0 = plt.figure()
ax0 = fig0.add_subplot(111)

ax0.plot(v, p(v,0.8), label=r'$0.8T_c$')
ax0.plot(v, p(v,0.9), label=r'$0.9T_c$')
ax0.plot(v, p(v,1.0), label=r'$T_c$')
ax0.plot(v, p(v,1.1), label=r'$1.1T_c$')
ax0.plot(v, p(v,1.2), label=r'$1.2T_c$')

ax0.legend()

ax0.set_ylabel(r'$P/P_c$')
ax0.set_xlabel(r'$V/V_c$')
```

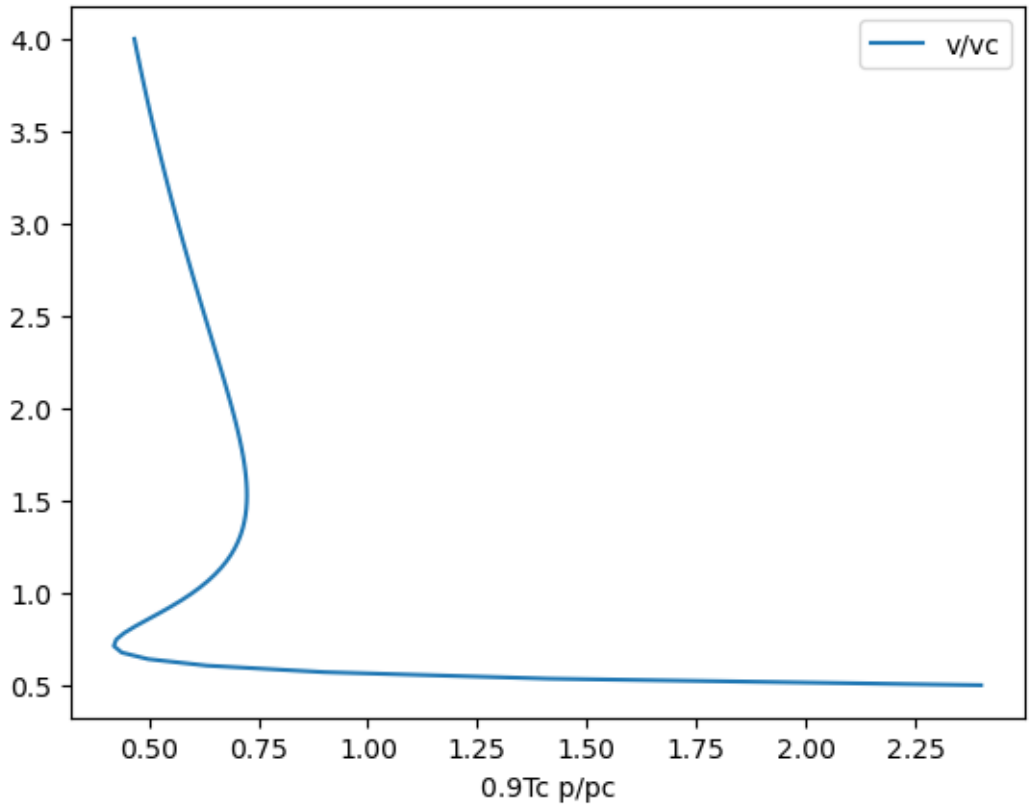
[3]:
```
Text(0.5, 0, '$V/V_c$')
```



[4]:
```
df = pd.DataFrame({'v/vc':v,
                   '0.8Tc p/pc':p(v,0.8),
                   '0.9Tc p/pc':p(v,0.9),
                   '1.0Tc p/pc':p(v,1.0),
                   '1.1Tc p/pc':p(v,1.1),
                   '1.2Tc p/pc':p(v,1.2),
                  })
```

[5]:
```
df.plot(x='0.9Tc p/pc', y='v/vc')
```

[5]:
```
<Axes: xlabel='0.9Tc p/pc'>
```



[6]:
```
df['0.9Tc G'] = -0.9*np.log(3*df['v/vc']-1)+.9/(3*df['v/vc']-1)-9/4/df['v/vc']
```

[7]:
```
pd.set_option('display.max_rows', None)
df
```

[7]:

	v/vc	0.8Tc p/pc	0.9Tc p/pc	1.0Tc p/pc	1.1Tc p/pc	1.2Tc p/pc	\
0	0.500000	0.800000	2.400000	4.000000	5.600000	7.200000	
1	0.535354	0.092574	1.412574	2.732574	4.052574	5.372574	
2	0.570707	-0.223511	0.899894	2.023298	3.146702	4.270106	
3	0.606061	-0.345278	0.632500	1.610278	2.588056	3.565833	
4	0.641414	-0.367368	0.498205	1.363779	2.229353	3.094927	
5	0.676768	-0.338246	0.438224	1.214695	1.991165	2.767636	
6	0.712121	-0.283799	0.420201	1.124201	1.828201	2.532201	
7	0.747475	-0.218211	0.425692	1.069594	1.713497	2.357399	
8	0.782828	-0.149333	0.443925	1.037184	1.630442	2.223700	
9	0.818182	-0.081481	0.468519	1.018519	1.568519	2.118519	
10	0.853535	-0.016952	0.495669	1.008291	1.520912	2.033533	
11	0.888889	0.043125	0.523125	1.003125	1.483125	1.963125	
12	0.924242	0.098297	0.549579	1.000861	1.452143	1.903425	
13	0.959596	0.148501	0.574308	1.000114	1.425921	1.851727	
14	0.994949	0.193893	0.596947	1.000000	1.403054	1.806107	

15	1.030303	0.234745	0.617354	0.999962	1.382571	1.765180
16	1.065657	0.271384	0.635522	0.999660	1.363798	1.727936
17	1.101010	0.304156	0.651524	0.998893	1.346261	1.693629
18	1.136364	0.333404	0.665479	0.997555	1.329630	1.661706
19	1.171717	0.359456	0.677529	0.995601	1.313673	1.631746
20	1.207071	0.382621	0.687823	0.993026	1.298228	1.603430
21	1.242424	0.403181	0.696514	0.989847	1.283181	1.576514
22	1.277778	0.421394	0.703747	0.986100	1.268453	1.550806
23	1.313131	0.437497	0.709662	0.981827	1.253992	1.526157
24	1.348485	0.451701	0.714387	0.977074	1.239761	1.502447
25	1.383838	0.464197	0.718043	0.971889	1.225735	1.479581
26	1.419192	0.475156	0.720738	0.966319	1.211901	1.457482
27	1.454545	0.484734	0.722572	0.960410	1.198247	1.436085
28	1.489899	0.493068	0.723635	0.954203	1.184771	1.415339
29	1.525253	0.500282	0.724011	0.947739	1.171468	1.395197
30	1.560606	0.506487	0.723771	0.941055	1.158339	1.375623
31	1.595960	0.511784	0.722984	0.934184	1.145384	1.356584
32	1.631313	0.516261	0.721709	0.927156	1.132604	1.338051
33	1.666667	0.520000	0.720000	0.920000	1.120000	1.320000
34	1.702020	0.523072	0.717906	0.912740	1.107574	1.302408
35	1.737374	0.525543	0.715471	0.905399	1.095327	1.285255
36	1.772727	0.527470	0.712733	0.897996	1.083260	1.268523
37	1.808081	0.528907	0.709729	0.890551	1.071373	1.252195
38	1.843434	0.529902	0.706490	0.883079	1.059668	1.236256
39	1.878788	0.530496	0.703045	0.875594	1.048143	1.220692
40	1.914141	0.530729	0.699420	0.868110	1.036800	1.205490
41	1.949495	0.530637	0.695637	0.860637	1.025637	1.190637
42	1.984848	0.530249	0.691717	0.853185	1.014653	1.176121
43	2.020202	0.529596	0.687679	0.845763	1.003847	1.161931
44	2.055556	0.528702	0.683541	0.838380	0.993219	1.148057
45	2.090909	0.527593	0.679317	0.831041	0.982765	1.134489
46	2.126263	0.526288	0.675020	0.823753	0.972485	1.121218
47	2.161616	0.524808	0.670664	0.816521	0.962377	1.108233
48	2.196970	0.523170	0.666259	0.809349	0.952438	1.095527
49	2.232323	0.521390	0.661815	0.802241	0.942666	1.083092
50	2.267677	0.519482	0.657341	0.795200	0.933059	1.070918
51	2.303030	0.517461	0.652845	0.788230	0.923614	1.058999
52	2.338384	0.515337	0.648335	0.781332	0.914330	1.047327
53	2.373737	0.513123	0.643816	0.774509	0.905202	1.035895
54	2.409091	0.510827	0.639294	0.767762	0.896229	1.024696
55	2.444444	0.508460	0.634776	0.761092	0.887408	1.013723
56	2.479798	0.506030	0.630265	0.754500	0.878736	1.002971
57	2.515152	0.503543	0.625766	0.747988	0.870210	0.992432
58	2.550505	0.501008	0.621282	0.741555	0.861829	0.982102
59	2.585859	0.498431	0.616817	0.735202	0.853588	0.971974
60	2.621212	0.495817	0.612373	0.728930	0.845486	0.962042
61	2.656566	0.493172	0.607954	0.722737	0.837519	0.952302

62	2.691919	0.490500	0.603562	0.716624	0.829686	0.942748
63	2.727273	0.487806	0.599198	0.710591	0.821983	0.933376
64	2.762626	0.485094	0.594865	0.704637	0.814408	0.924179
65	2.797980	0.482368	0.590565	0.698761	0.806958	0.915155
66	2.833333	0.479631	0.586298	0.692964	0.799631	0.906298
67	2.868687	0.476886	0.582065	0.687245	0.792424	0.897603
68	2.904040	0.474136	0.577869	0.681602	0.785335	0.889067
69	2.939394	0.471384	0.573709	0.676035	0.778361	0.880686
70	2.974747	0.468632	0.569588	0.670544	0.771500	0.872456
71	3.010101	0.465881	0.565504	0.665126	0.764749	0.864372
72	3.045455	0.463135	0.561459	0.659783	0.758107	0.856431
73	3.080808	0.460394	0.557453	0.654512	0.751571	0.848630
74	3.116162	0.457661	0.553487	0.649313	0.745138	0.840964
75	3.151515	0.454937	0.549560	0.644184	0.738808	0.833431
76	3.186869	0.452223	0.545674	0.639125	0.732577	0.826028
77	3.222222	0.449520	0.541827	0.634135	0.726443	0.818751
78	3.257576	0.446830	0.538021	0.629213	0.720405	0.811596
79	3.292929	0.444153	0.534255	0.624357	0.714460	0.804562
80	3.328283	0.441490	0.530529	0.619568	0.708607	0.797645
81	3.363636	0.438843	0.526843	0.614843	0.702843	0.790843
82	3.398990	0.436212	0.523197	0.610182	0.697167	0.784152
83	3.434343	0.433597	0.519590	0.605584	0.691577	0.777571
84	3.469697	0.430999	0.516023	0.601047	0.686071	0.771096
85	3.505051	0.428419	0.512495	0.596572	0.680648	0.764724
86	3.540404	0.425857	0.509006	0.592156	0.675305	0.758455
87	3.575758	0.423313	0.505556	0.587799	0.670042	0.752285
88	3.611111	0.420788	0.502144	0.583500	0.664856	0.746212
89	3.646465	0.418283	0.498770	0.579258	0.659746	0.740234
90	3.681818	0.415796	0.495434	0.575072	0.654710	0.734348
91	3.717172	0.413330	0.492136	0.570942	0.649748	0.728554
92	3.752525	0.410883	0.488874	0.566865	0.644856	0.722847
93	3.787879	0.408456	0.485649	0.562842	0.640035	0.717228
94	3.823232	0.406049	0.482460	0.558871	0.635282	0.711693
95	3.858586	0.403662	0.479307	0.554952	0.630596	0.706241
96	3.893939	0.401296	0.476189	0.551083	0.625977	0.700870
97	3.929293	0.398950	0.473107	0.547264	0.621422	0.695579
98	3.964646	0.396624	0.470059	0.543494	0.616930	0.690365
99	4.000000	0.394318	0.467045	0.539773	0.612500	0.685227

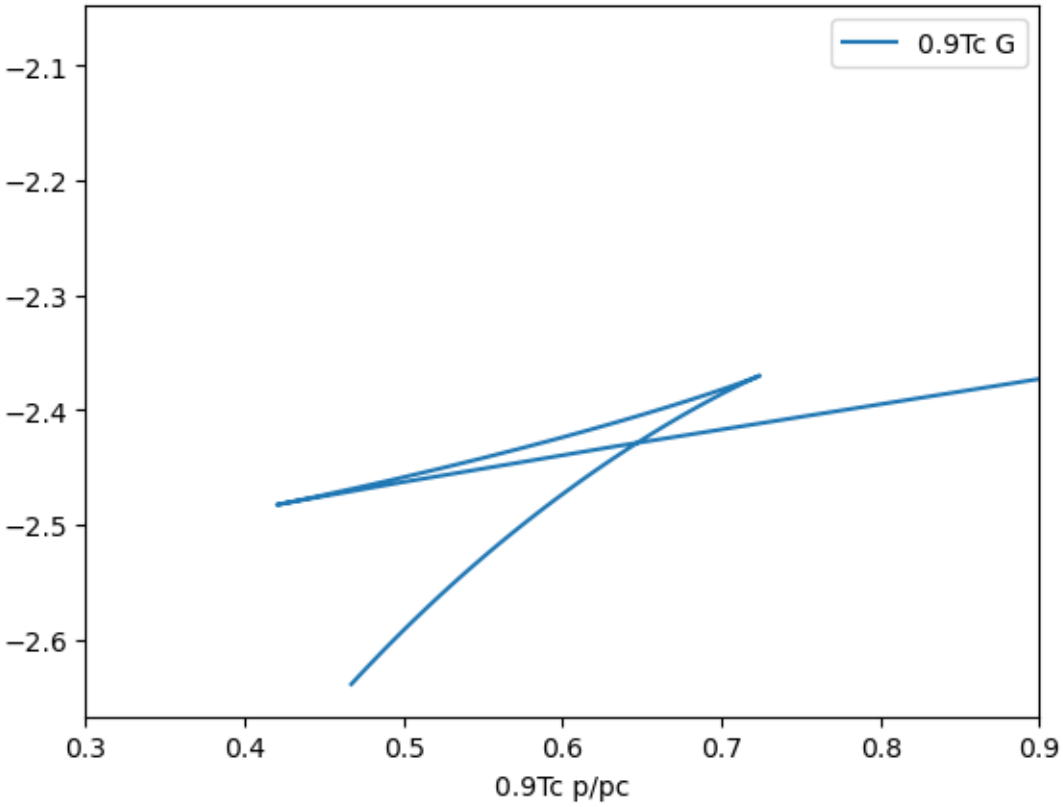
	0.9Tc G
0	-2.076168
1	-2.267132
2	-2.373092
3	-2.431896
4	-2.463201
5	-2.477965
6	-2.482625

```
7  -2.481103
8  -2.475861
9  -2.468474
10 -2.459962
11 -2.450993
12 -2.442001
13 -2.433269
14 -2.424975
15 -2.417228
16 -2.410090
17 -2.403592
18 -2.397740
19 -2.392527
20 -2.387937
21 -2.383948
22 -2.380531
23 -2.377659
24 -2.375302
25 -2.373430
26 -2.372015
27 -2.371028
28 -2.370441
29 -2.370230
30 -2.370369
31 -2.370836
32 -2.371608
33 -2.372665
34 -2.373988
35 -2.375559
36 -2.377361
37 -2.379378
38 -2.381596
39 -2.384000
40 -2.386579
41 -2.389320
42 -2.392211
43 -2.395243
44 -2.398406
45 -2.401690
46 -2.405088
47 -2.408590
48 -2.412190
49 -2.415881
50 -2.419656
51 -2.423509
52 -2.427434
53 -2.431427
```

```
54 -2.435481
55 -2.439593
56 -2.443758
57 -2.447972
58 -2.452231
59 -2.456531
60 -2.460869
61 -2.465242
62 -2.469647
63 -2.474081
64 -2.478541
65 -2.483025
66 -2.487530
67 -2.492055
68 -2.496597
69 -2.501154
70 -2.505725
71 -2.510308
72 -2.514900
73 -2.519502
74 -2.524110
75 -2.528724
76 -2.533343
77 -2.537966
78 -2.542590
79 -2.547216
80 -2.551841
81 -2.556466
82 -2.561090
83 -2.565711
84 -2.570328
85 -2.574942
86 -2.579551
87 -2.584154
88 -2.588752
89 -2.593343
90 -2.597927
91 -2.602503
92 -2.607071
93 -2.611631
94 -2.616181
95 -2.620723
96 -2.625254
97 -2.629776
98 -2.634287
99 -2.638788
```

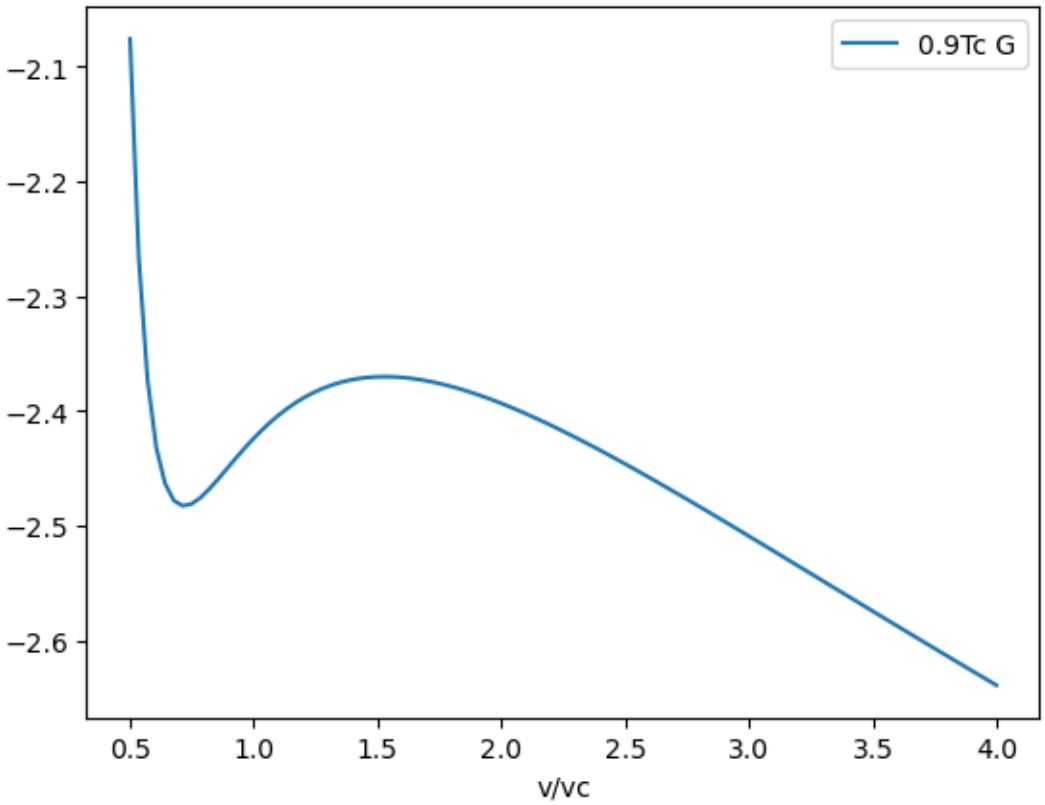
[8]:
```
df.plot(x='0.9Tc p/pc', y='0.9Tc G', xlim=(0.3, 0.9))
```

[8]: <Axes: xlabel='0.9Tc p/pc'>



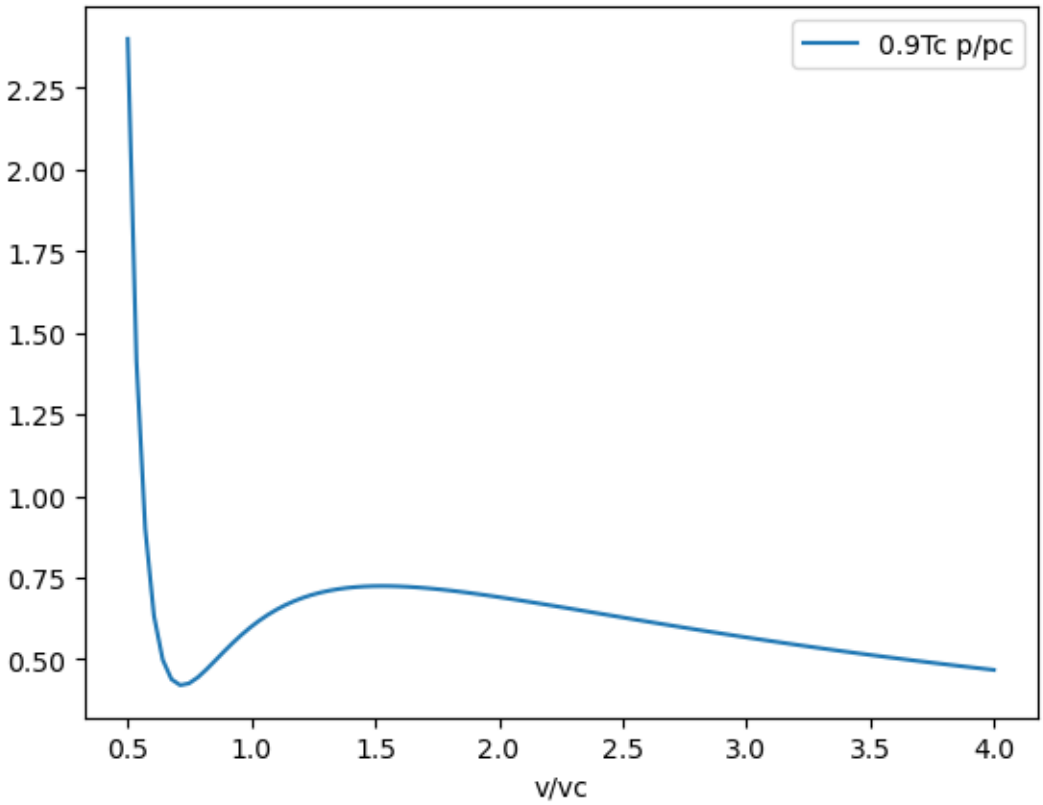
[9]:
```
df.plot(x='v/vc', y='0.9Tc G')
```

[9]: <Axes: xlabel='v/vc'>



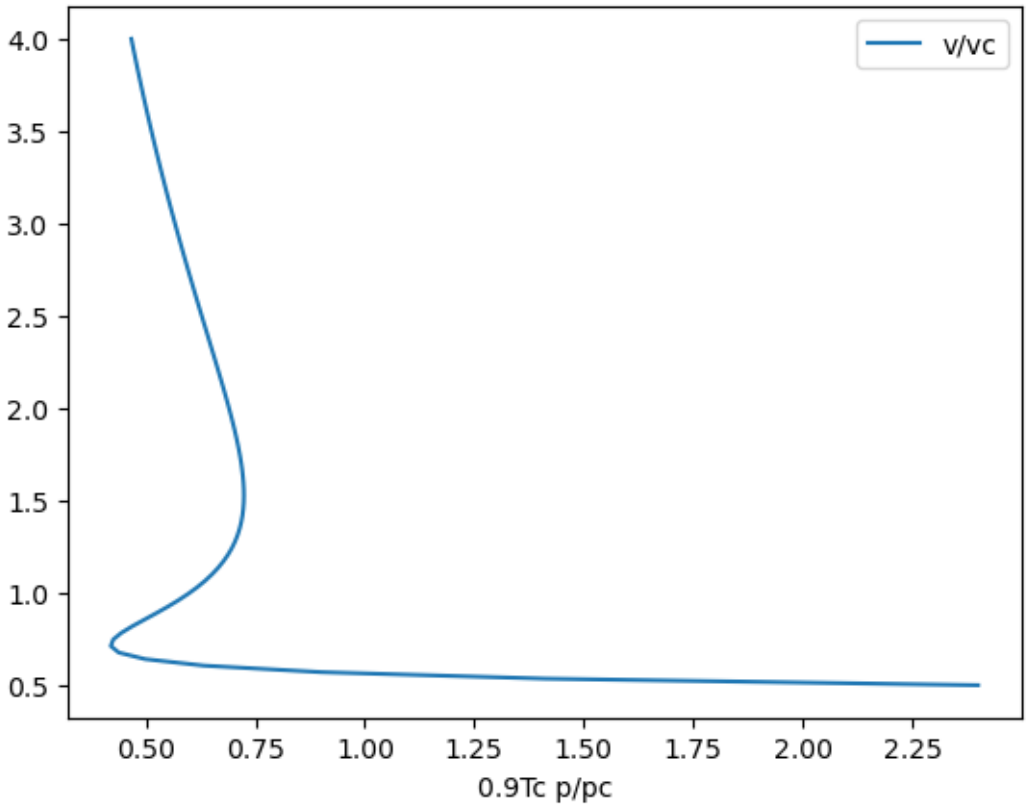
[10]:
```
df.plot(x='v/vc', y='0.9Tc p/pc')
```

[10]: <Axes: xlabel='v/vc'>



[11]:
```
df.plot(y='v/vc', x='0.9Tc p/pc')
```

[11]: <Axes: xlabel='0.9Tc p/pc'>


v/vc
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
0.9Tc p/pc

[ ]:

[ ]:

[ ]: