Weekly Research Report

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1 Current Research Direction

2 Research Performed In the Past 24 hours

2.1 Current Validation Work

A comparison was conducted for a hollow cylinder undergoing uniform flow with acoustic liners along the outer duct perimeter. The azimuthal mode number, reduced frequency, mach number and duct liner admittance is reported below,

$$\begin{aligned} m &= 2 \\ k &= \frac{\omega r_T}{A_T} = -1 \\ M_x &= 0.5 \\ \eta_T &= 0.72 + 0.42i \end{aligned}$$

These results are with no dissipation applied to the radial derivatives and second order central differencing] was used.

3 Issues and Concerns

There is apparent phase shift in the modes from one run to the next. The scatter plot of the axial wavenumbers shows how much the quantities vary with each doubling of grid points.

4 Planned Research

These are only downstream (? is the positive sign on gamma indicative of upstream or down?) propagating modes. What do the upstream modes look like? By plotting the magnitude of the modes, I will be able to see the modes without the effect of phase.

I will plot the upstream modes, plot the modal amplitudes next, then rerun with fourth order differencing.

#	Re{gam}	Im{gam}	Re{gam/ak}	Im{gam/ak}	nz
128	-2.000000	0.0000	2.000000	-0.0000	0
64	0.409970	1.2902	-0.409970	-1.2902	1
34	0.620760	-5.0059	-0.620760	5.0059	1
35	0.666670	-4.2240	-0.666670	4.2240	1
62	1.255300	6.0721	-1.255300	-6.0721	2
31	0.451570	-9.1219	-0.451570	9.1219	2
33	-5.812700	-3.9005	5.812700	3.9005	2
59	0.665780	11.9880	-0.665780	-11.9880	3
30	0.667400	-11.9890	-0.667400	11.9890	3
29	0.464250	-12.8490	-0.464250	12.8490	3
58	1.009500	13.0960	-1.009500	-13.0960	3
60	1.137000	9.5962	-1.137000	-9.5962	3
27	0.492340	-16.3290	-0.492340	16.3290	4
28	0.669480	-15.5360	-0.669480	15.5360	4
32	0.666750	-8.2752	-0.666750	8.2752	4
63	0.666680	4.2240	-0.666680	-4.2240	4
56	0.928060	16.4790	-0.928060	-16.4790	4
25	0.514520	-19.5820	-0.514520	19.5820	5
61	0.666560	8.2751	-0.666560	-8.2751	5
26	0.675220	-18.9260	-0.675220	18.9260	5
55	0.657260	18.9200	-0.657260	-18.9200	5
54	0.877780	19.6840	-0.877780	-19.6840	5
23	0.516660	-22.5720	-0.516660	22.5720	6
57	0.663410	15.5340	-0.663410	-15.5340	6
24	0.697030	-22.1560	-0.697030	22.1560	6
53	0.637510	22.1400	-0.637510	-22.1400	6
52	0.856680	22.6540	-0.856680	-22.6540	6
51	0.520730	25.1730	-0.520730	-25.1730	7
22	0.842520	-25.1800	-0.842520	25.1800	7
50	0.941760	25.3460	-0.941760	-25.3460	7
21	0.391920	-25.2910	-0.391920	25.2910	7
70	-2.000000	0.0000	2.000000	-0.0000	7
49	0.337230	27.8270	-0.337230	-27.8270	8
19	0.238820	-27.8580	-0.238820	27.8580	8
20	1.014200	-27.8190	-1.014200	27.8190	8
48	1.099000	27.8850	-1.099000	-27.8850	8
47	0.181910	30.1430	-0.181910	-30.1430	9
18	1.162000	-30.1340	-1.162000	30.1340	9
17	0.108340	-30.1490	-0.108340	30.1490	9
46	1.231000	30.1650	-1.231000	-30.1650	9
15	-0.014607	-32.1170	0.014607	32.1170	10
45	0.037739	32.1200	-0.037739	-32.1200	10
44	1.353300	32.1260	-1.353300	-32.1260	10
102	-2.000000	0.0000	2.000000	-0.0000	10
73	-2.000000	0.0000	2.000000	-0.0000	10
106	-2.000000	0.0000	2.000000	-0.0000	10

Figure 1: Propagating Modes - 32 Gridpoints

#	Re{gam}	Im{gam}	Re{gam/ak}	Im{gam/ak}	nz
106	-2.000000	0.000	2.000000	-0.000	10
67	0.000000	0.000	-0.000000	-0.000	10
16	1.301900	-32.113	-1.301900	32.113	10
13	-0.125380	-33.733	0.125380	33.733	11
103	-2.000000	0.000	2.000000	-0.000	11
43	-0.092378	33.737	0.092378	-33.737	11
42	1.462500	33.738	-1.462500	-33.738	11
14	1.429200	-33.733	-1.429200	33.733	11
113	-2.000000	0.000	2.000000	-0.000	12
79	-2.000000	0.000	2.000000	-0.000	12
119	-2.000000	0.000	2.000000	-0.000	12
68	-2.000000	0.000	2.000000	-0.000	12
115	-2.000000	0.000	2.000000	-0.000	13
114	-2.000000	0.000	2.000000	-0.000	13
92	-2.000000	0.000	2.000000	-0.000	13
90	-2.000000	0.000	2.000000	-0.000	13
85	-2.000000	0.000	2.000000	-0.000	13
10	-0.294720	-35.725	0.294720	35.725	13
39	-0.291950	35.723	0.291950	-35.723	13
38	1.628000	35.726	-1.628000	-35.726	13
9	1.625800	-35.723	-1.625800	35.723	13
7	-0.763890	-37.070	0.763890	37.070	14
6	0.666670	45.864	-0.666670	-45.864	14
12	1.524900	-34.972	-1.524900	34.972	14
96	-2.000000	0.000	2.000000	-0.000	14
11	-0.206180	-34.972	0.206180	34.972	14
93	-2.000000	0.000	2.000000	-0.000	14
2	0.666670	81.040	-0.666670	-81.040	14
41	-0.189800	34.974	0.189800	-34.974	14
82	-2.000000	0.000	2.000000	-0.000	14
81	-2.000000	0.000	2.000000	-0.000	14
40	1.541200	34.974	-1.541200	-34.974	14
37	-0.763890	37.070	0.763890	-37.070	14
74	-2.000000	0.000	2.000000	-0.000	14
36	2.097200	37.070	-2.097200	-37.070	14
4	0.666670	-45.864	-0.666670	45.864	14
69	-2.000000	0.000	2.000000	-0.000	14
8	2.097200	-37.070	-2.097200	37.070	14
1	0.666670	-81.040	-0.666670	81.040	14
125	-2.000000	0.000	2.000000	-0.000	15
121	-2.000000	0.000	2.000000	-0.000	15
109	-2.000000	0.000	2.000000	-0.000	15
101	-2.000000	0.000	2.000000	-0.000	15
97	-2.000000	0.000	2.000000	-0.000	15
88	-2.000000	0.000	2.000000	-0.000	15
86	-2.000000	0.000	2.000000	-0.000	15

Figure 2: Propagating Modes - 32 Gridpoints

#	Re{gam}	Im{gam}	Re{gam/ak}	Im{gam/ak}	nz
256	-2.00000	0.0000	2.00000	-0.0000	0
68	0.61983	-5.0120	-0.61983	5.0120	1
128	0.41007	1.2903	-0.41007	-1.2903	1
69	0.66667	-4.1893	-0.66667	4.1893	1
65	0.44678	-9.1715	-0.44678	9.1715	2
126	1.25850	6.0821	-1.25850	-6.0821	2
67	-5.81870	-3.8972	5.81870	3.8972	2
63	0.45639	-13.0120	-0.45639	13.0120	3
122	1.01870	13.2630	-1.01870	-13.2630	3
124	1.14350	9.6510	-1.14350	-9.6510	3
66	0.66667	-8.2349	-0.66667	8.2349	4
61	0.48291	-16.7060	-0.48291	16.7060	4
120	0.93854	16.8600	-0.93854	-16.8600	4
125	0.66666	8.2349	-0.66666	-8.2349	5
59	0.50696	-20.3100	-0.50696	20.3100	5
60	0.66716	-19.2820	-0.66716	19.2820	5
64	0.66672	-11.9960	-0.66672	11.9960	5
123	0.66660	11.9960	-0.66660	-11.9960	5
118	0.88613	20.4130	-0.88613	-20.4130	5
55	0.52656	-23.8360	-0.52656	23.8360	6
62	0.66686	-15.6690	-0.66686	15.6690	6
116	0.84993	23.9100	-0.84993	-23.9100	6
115	0.66430	26.3400	-0.66430	-26.3400	7
119	0.66606	19.2820	-0.66606	-19.2820	7
53	0.54212	-27.2860	-0.54212	27.2860	7
54	0.66869	-26.3410	-0.66869	26.3410	7
114	0.82388	27.3420	-0.82388	-27.3420	7
117	0.66541	22.8400	-0.66541	-22.8400	8
127	0.66667	4.1893	-0.66667	-4.1893	8
56	0.66772	-22.8400	-0.66772	22.8400	8
121	0.66643	15.6690	-0.66643	-15.6690	8
51	0.55419	-30.6550	-0.55419	30.6550	8
112	0.80483	30.6990	-0.80483	-30.6990	8
49	0.56287	-33.9350	-0.56287	33.9350	9
110	0.79135	33.9710	-0.79135	-33.9710	9
47	0.56716	-37.1120	-0.56716	37.1120	10
113	0.66247	29.7790	-0.66247	-29.7790	10
52	0.67033	-29.7810	-0.67033	29.7810	10
48	0.67874	-36.4620	-0.67874	36.4620	10
109	0.65346	36.4580	-0.65346	-36.4580	10
108	0.78366	37.1440	-0.78366	-37.1440	10
111	0.65935	33.1530	-0.65935	-33.1530	11
50	0.67318	-33.1550	-0.67318	33.1550	11
45	0.56121	-40.1690	-0.56121	40.1690	11
46	0.69325	-39.7060	-0.69325	39.7060	11
107	0.63909	39.6980	-0.63909	-39.6980	11

Figure 3: Propagating Modes - 64 Gridpoints

#	Re{gam}	Im{gam}	Re{gam/ak}	Im{gam/ak}	nz
512	-2.00000	0.0000	2.00000	-0.0000	0
256	0.41009	1.2904	-0.41009	-1.2904	1
234	0.61961	-5.0134	-0.61961	5.0134	1
235	0.66667	-4.1716	-0.66667	4.1716	1
254	1.25920	6.0844	-1.25920	-6.0844	2
231	0.44568	-9.1831	-0.44568	9.1831	2
233	-5.81940	-3.8968	5.81940	3.8968	2
250	1.02110	13.3030	-1.02110	-13.3030	3
229	0.45450	-13.0490	-0.45450	13.0490	3
252	1.14510	9.6638	-1.14510	-9.6638	3
227	0.48037	-16.7940	-0.48037	16.7940	4
248	0.94149	16.9490	-0.94149	-16.9490	4
223	0.50393	-20.4770	-0.50393	20.4770	5
246	0.88953	20.5820	-0.88953	-20.5820	5
213	0.52328	-24.1220	-0.52328	24.1220	6
244	0.85349	24.1970	-0.85349	-24.1970	6
119	0.53898	-27.7370	-0.53898	27.7370	7
242	0.82719	27.7940	-0.82719	-27.7940	7
117	0.55181	-31.3260	-0.55181	31.3260	8
232	0.66667	-8.2081	-0.66667	8.2081	8
240	0.80721	31.3700	-0.80721	-31.3700	8
115	0.56242	-34.8890	-0.56242	34.8890	9
230	0.66667	-11.9740	-0.66667	11.9740	9
238	0.79156	34.9240	-0.79156	-34.9240	9
113	0.57128	-38.4250	-0.57128	38.4250	10
236	0.77902	38.4540	-0.77902	-38.4540	10
253	0.66667	8.2081	-0.66667	-8.2081	11
111	0.57874	-41.9340	-0.57874	41.9340	11
225	0.76879	41.9590	-0.76879	-41.9590	11
109	0.58506	-45.4140	-0.58506	45.4140	12
228	0.66668	-15.6700	-0.66668	15.6700	12
221	0.76035	45.4350	-0.76035	-45.4350	12
107	0.59040	-48.8630	-0.59040	48.8630	13
251	0.66666	11.9740	-0.66666	-11.9740	13
219	0.75335	48.8810	-0.75335	-48.8810	13
118	0.66691	-30.1860	-0.66691	30.1860	14
255	0.66667	4.1716	-0.66667	-4.1716	14
241	0.66638	30.1860	-0.66638	-30.1860	14
105	0.59487	-52.2790	-0.59487	52.2790	14
249	0.66665	15.6700	-0.66665	-15.6700	14
217	0.74756	52.2940	-0.74756	-52.2940	14
243	0.66649	26.5880	-0.66649	-26.5880	15
103	0.59854	-55.6580	-0.59854	55.6580	15
104	0.66993	-54.7430	-0.66993	54.7430	15
216	0.66309	54.7430	-0.66309	-54.7430	15
120	0.66681	-26.5880	-0.66681	26.5880	15

Figure 4: Propagating Modes - 128 Gridpoints

#	Re{gam}	Im{gam}	Re{gam/ak}	Im{gam/ak}	nz
1024	-2.00000	0.0000	2.00000	-0.0000	0
512	0.41010	1.2904	-0.41010	-1.2904	1
494	0.61956	-5.0137	-0.61956	5.0137	1
495	0.66667	-4.1627	-0.66667	4.1627	1
510	1.25940	6.0850	-1.25940	-6.0850	2
491	0.44542	-9.1859	-0.44542	9.1859	2
493	-5.81950	-3.8968	5.81950	3.8968	2
489	0.45404	-13.0590	-0.45404	13.0590	3
506	1.02160	13.3120	-1.02160	-13.3120	3
508	1.14550	9.6669	-1.14550	-9.6669	3
487	0.47973	-16.8150	-0.47973	16.8150	4
504	0.94225	16.9700	-0.94225	-16.9700	4
485	0.50314	-20.5180	-0.50314	20.5180	5
502	0.89044	20.6220	-0.89044	-20.6220	5
481	0.52234	-24.1910	-0.52234	24.1910	6
500	0.85454	24.2660	-0.85454	-24.2660	6
477	0.53792	-27.8450	-0.53792	27.8450	7
498	0.82835	27.9020	-0.82835	-27.9020	7
473	0.55066	-31.4850	-0.55066	31.4850	8
496	0.80845	31.5300	-0.80845	-31.5300	8
469	0.56122	-35.1140	-0.56122	35.1140	9
483	0.79284	35.1500	-0.79284	-35.1500	9
465	0.57008	-38.7340	-0.57008	38.7340	10
479	0.78028	38.7630	-0.78028	-38.7630	10
461	0.57761	-42.3440	-0.57761	42.3440	11
475	0.76995	42.3680	-0.76995	-42.3680	11
455	0.58408	-45.9450	-0.58408	45.9450	12
471	0.76133	45.9660	-0.76133	-45.9660	12
451	0.58969	-49.5380	-0.58969	49.5380	13
467	0.75401	49.5560	-0.75401	-49.5560	13
447	0.59460	-53.1210	-0.59460	53.1210	14
492	0.66667	-8.1932	-0.66667	8.1932	14
463	0.74774	53.1370	-0.74774	-53.1370	14
443	0.59893	-56.6950	-0.59893	56.6950	15
459	0.74230	56.7090	-0.74230	-56.7090	15
439	0.60277	-60.2590	-0.60277	60.2590	16
457	0.73755	60.2710	-0.73755	-60.2710	16
435	0.60619	-63.8130	-0.60619	63.8130	17
453	0.73336	63.8240	-0.73336	-63.8240	17
429	0.60925	-67.3570	-0.60925	67.3570	18
449	0.72966	67.3660	-0.72966	-67.3660	18
425	0.61200	-70.8890	-0.61200	70.8890	19
490	0.66667	-11.9560	-0.66667	11.9560	19
445	0.72636	70.8980	-0.72636	-70.8980	19
419	0.61448	-74.4100	-0.61448	74.4100	20
441	0.72342	74.4180	-0.72342	-74.4180	20

Figure 5: Propagating Modes - 256 Gridpoints

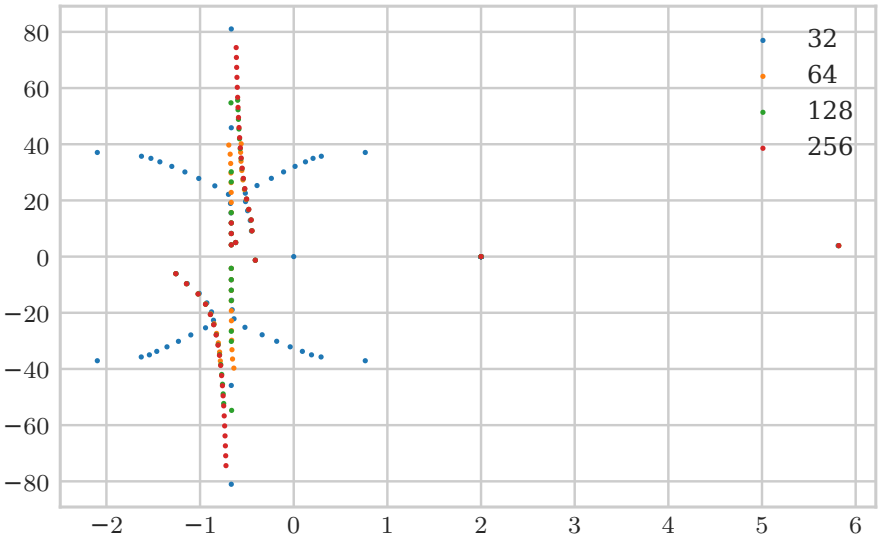

Figure 6: Propagating Modes - 32 points

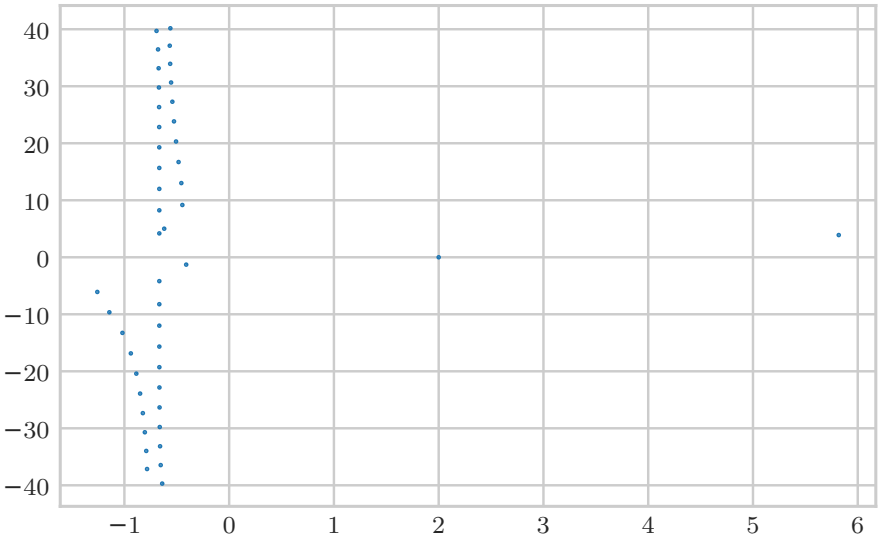

Figure 7: Propagating Modes - 64 points

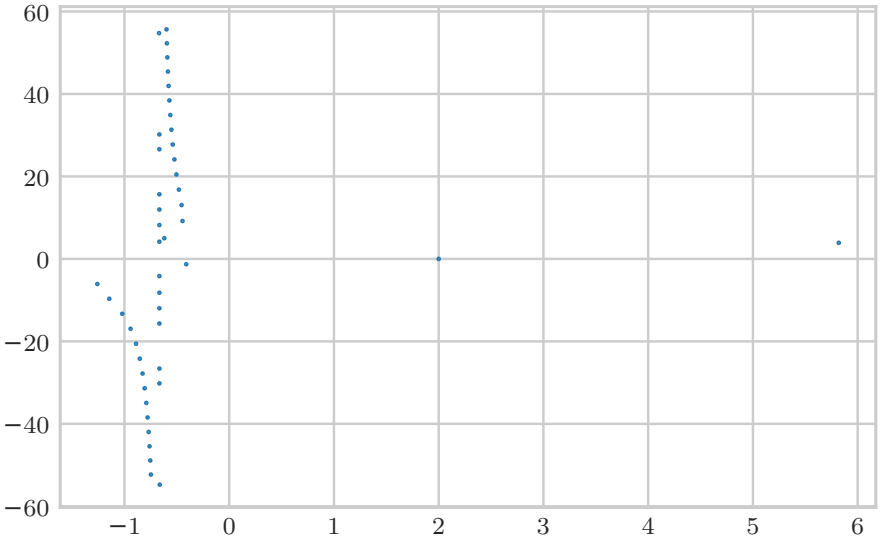

Figure 8: Propagating Modes - 128 points

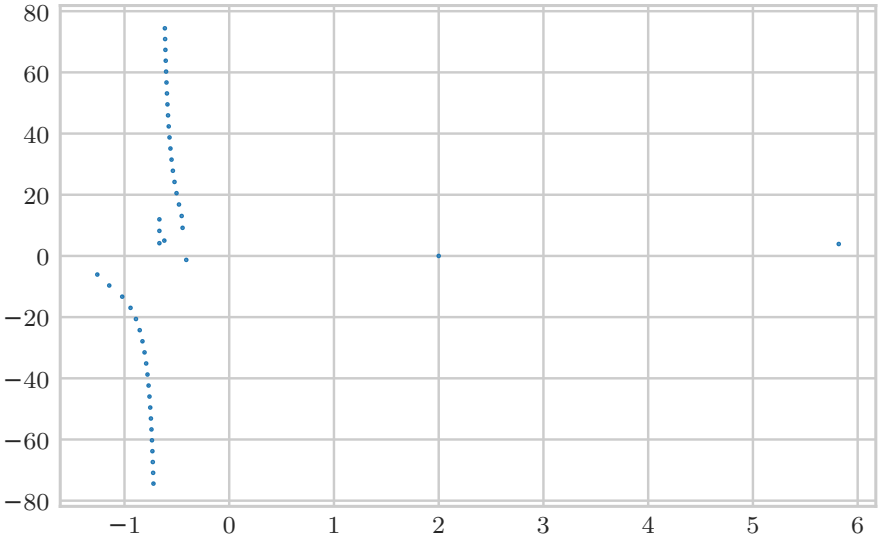

Figure 9: Propagating Modes - 256 points

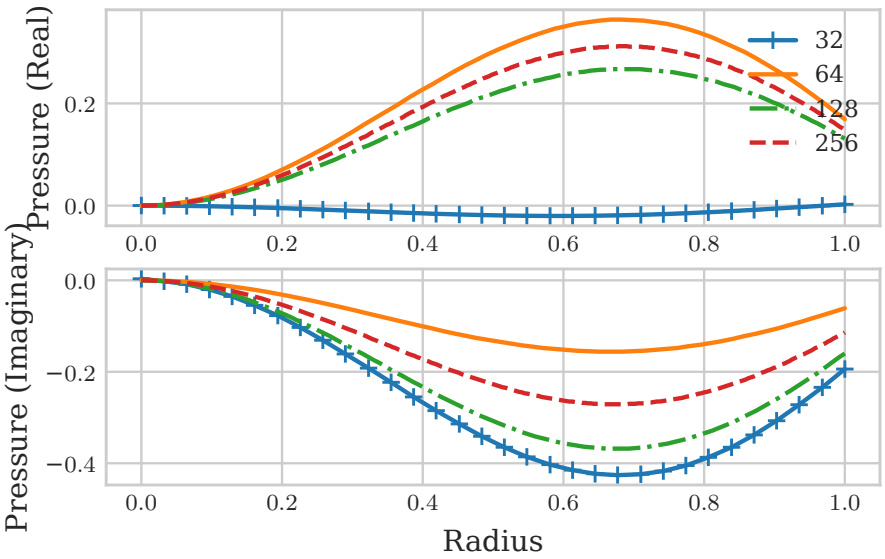

Figure 10: Propagating Mode $\gamma_0^+ = 0.620 - 5.014i$

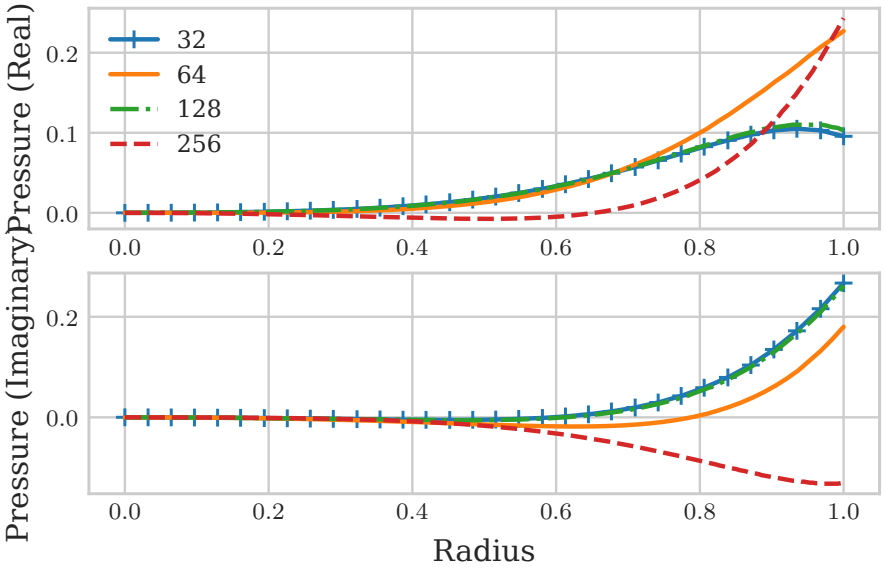

Figure 11: Propagating Mode $\gamma_1^+ = -5.820 - 3.897i$

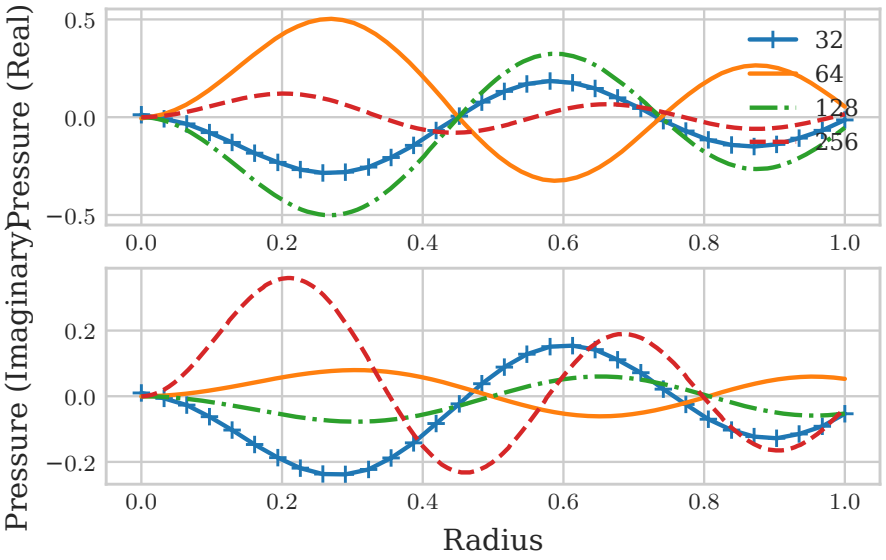

Figure 12: Propagating Mode $\gamma_2^+ = -0.445 - 9.187i$

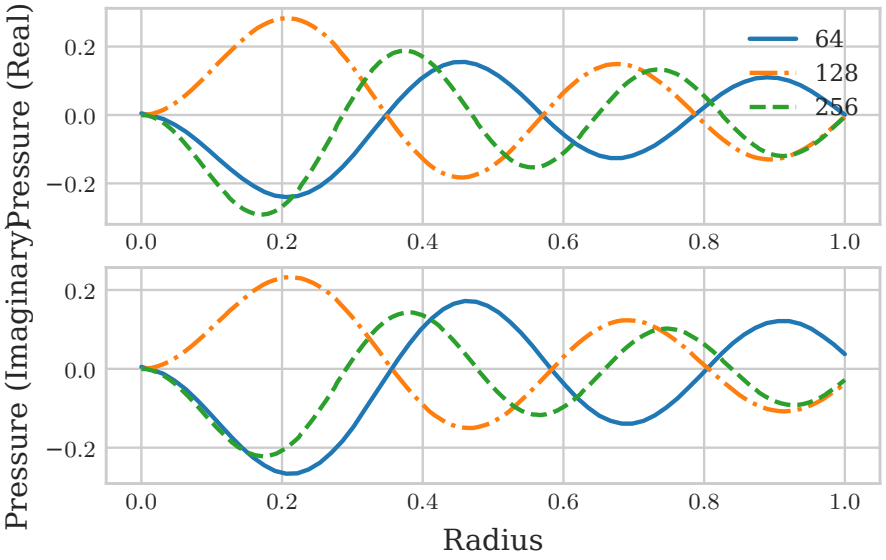

Figure 13: Propagating Mode $\gamma_3^+ = -0.453 - 13.062i$

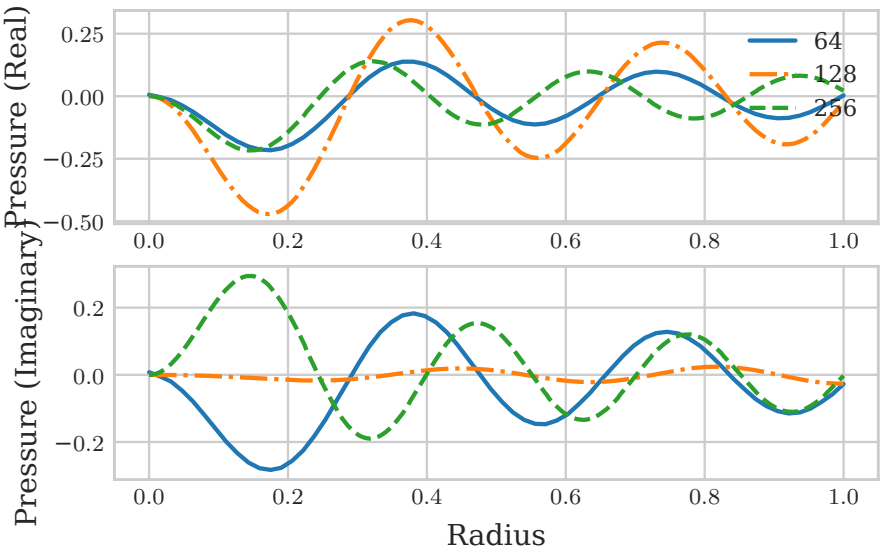

Figure 14: Propagating Mode $\gamma_4^+ = 0.480 - 16.822i$

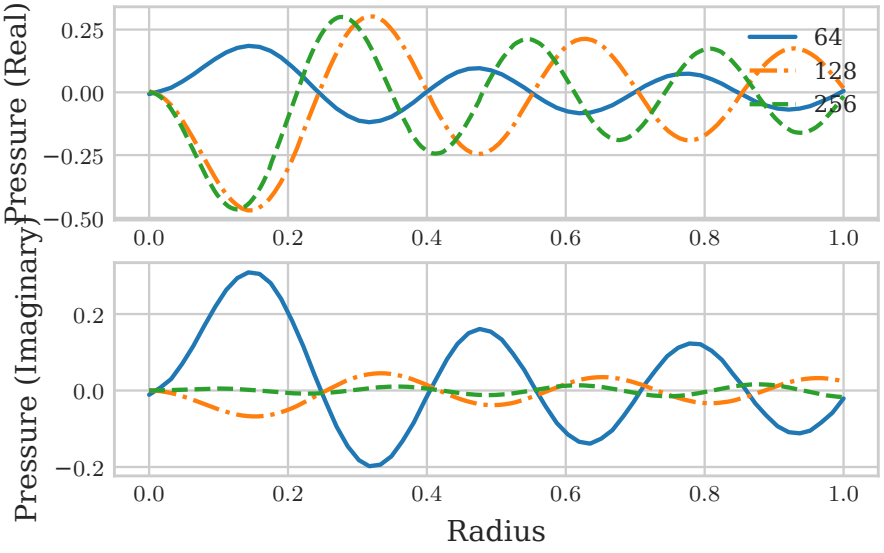

Figure 15: Propagating Mode $\gamma_5^+ = 0.503 - 20.531$

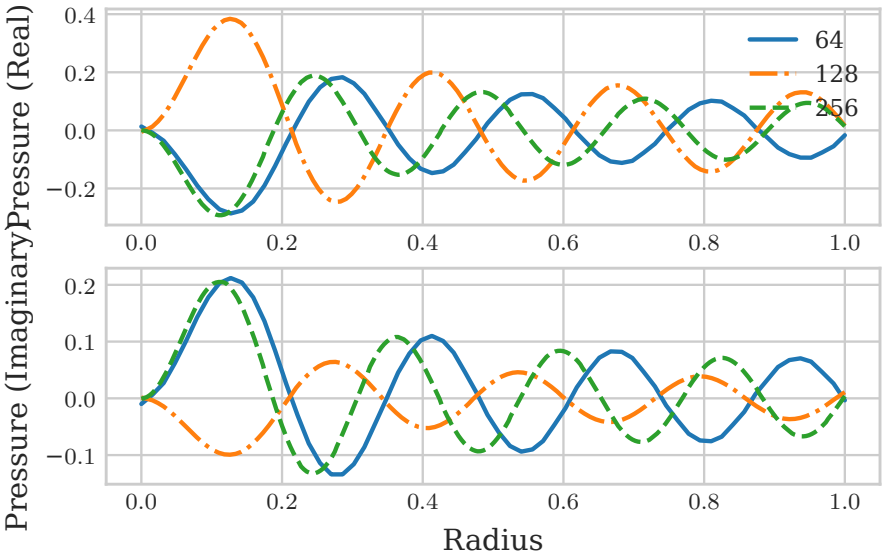

Figure 16: Propagating Mode $\gamma_6^+ = 0.522 - 24.213i$

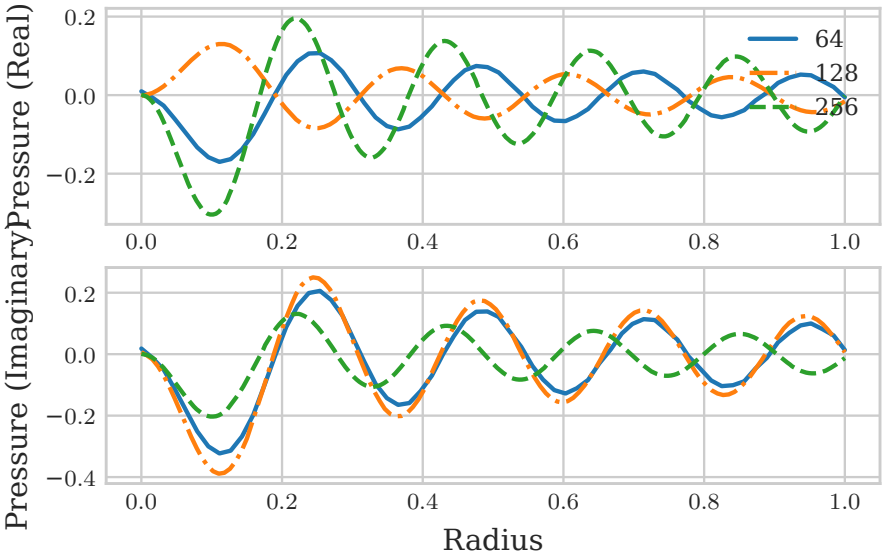

Figure 17: Propagating Mode $\gamma_7^+ = 0.538 - 27.880i$