Weekly Research Report

Jeffrey Severino
University of Toledo
Toledo, OH 43606
email: jseveri@rockets.utoledo.edu

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$\gamma_n^{\pm}$	Kousen Ref. [15]	Kousen report	srcF2008	index	current	index
γ_0^+	$0.620 - 5.014i$	$0.6195 - 5.0139i$	$0.61954 - 5.01386i$	60	0.620755853112 - 5.00592416941i	34
γ_1^+	$-5.820 - 3.897i$	$-5.8195 - 3.8968i$	$-5.81953 - 3.89677i$	58	-0.581267772517 - 3.90050864568i	33
γ_2^+	$0.445 - 9.187i$	$0.4453 - 9.1868i$	$0.44533 - 9.18684i$	59	0.451569491142 - 9.12191317214i	31
γ_3^+	$0.453 - 13.062i$	$0.4539 - 13.062i$	$0.45389 - 13.0615i$	57	0.464247902898 - 12.8487472519i	29
γ_4^+	$0.480 - 16.822i$	$0.4795 - 16.822i$	$0.47952 - 16.8216i$	55	0.492340380223 - 16.3292825150i	27
γ_5^+	$0.503 - 20.531i$	$0.5029 - 20.531i$	$0.50287 - 20.5307i$	51	0.514522630594 -19.5817182568i	25
γ_6^+	$0.522 - 24.213i$	$0.5220 - 24.213i$	$0.52202 - 24.2129i$	50	0.516658239854 -22.5715880605i	23
γ_7^+	$0.538 - 27.880i$	$0.5376 - 27.880i$	$0.53754 - 27.8800i$	48	-	-
γ_8^+	$0.550 - 31.537i$	$0.5502 - 31.537i$	$0.55024 - 31.5368i$	47	-	-
γ_9^+	$0.589 - 49.75i$	$0.5891 - 49.754i$	$0.58745 - 49.7669i$	33	-	-
γ_0^-	$0.410 + 1.290i$	$0.4101 + 1.2904i$	$0.41009 + 1.29037i$	64	0.409973310292 + 1.29020083859i	64
γ_1^-	$1.259 + 6.085i$	$1.2595 + 6.0852i$	$1.25949 + 6.08517i$	63	1.25530612217 + 6.07214375548i	62
γ_2^-	$1.146 + 9.668i$	$1.1457 + 9.6679i$	$1.14567 + 9.66787i$	62	1.13696444935 + 9.59622801724i	60
γ_3^-	$1.022 + 13.315i$	$1.0218 + 13.315i$	$1.02183 + 13.3150i$	61	1.00950576515 + 13.0957277529i	58
γ_4^-	$0.943 + 16.977i$	$0.9425 + 16.977i$	$0.94250 + 16.9767i$	56	0.928059983039 + 16.4791343118i	56
γ_5^-	$0.891 + 20.635i$	$0.8908 + 20.635i$	$0.89075 + 20.6353i$	54	0.856678172769 + 22.6544943903i	52
γ_6^-	$0.855 + 24.288i$	$0.8549 + 24.288i$	$0.85490 + 24.2883i$	53	0.941762848775 + 25.3460188358i	50
γ_7^-	$0.829 + 27.937i$	$0.8288 + 27.937i$	$0.82877 + 27.9369i$	52	-	-
γ_8^-	$0.809 + 31.581i$	$0.8089 + 31.581i$	$0.80891 + 31.5812i$	49	-	-
γ_9^-	$0.755 + 49.77i$	$0.7547 + 49.772i$	$0.75658 + 49.7851i$	39	-	-

Table 1: Table 4.3 data

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,

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

The results shown in 3 are in moderately good agreement. The results were obtained by visually comparing the output in `gam.acc` for 32 grid points. Note that the indicies for the SWIRL deliverable are different that the ones obtained for the most recent version of the code. While the convective axial wavenumbers show agreement to machine precision, this is not particularly insightful given that there are an infinite number of possible solutions that could satisfy the eigenvalue problem. The results that are of concern are propagating modes that are not convecting with the mean flow. The scatter plot of the axial wavenumbers show some sporadic behaviour around the imaginary axis. The results from the MMS along with this plot indicate that more grid points are going to be needed if a finite difference technique is to be used. It should be noted that a spectral differencing method were using for Kousen's report and for srcF2008. Using a higher order scheme would also improve accuracy.

Using more grid points improved the comparison between wavenumbers, however $\gamma_9^{\pm}$ were difficult to identify, however with 32 grid points, $\gamma_{7-9}^{\pm}$ were also difficult to identify. In general, there is okay agreement, but this shows that more grid is needed or a higher order scheme. Note the dissimilarity between

$\gamma_n^{\pm}$	srcF2008	index	32 points	index	64 points	index
γ_0^+	$0.61954 - 5.01386i$	60	$0.620755853112 - 5.00592416941i$	34	$0.619830466387E + 00 - 0.501195898338E + 01i$	68
γ_1^+	$-5.81953 - 3.89677i$	58	$-0.581267772517 - 3.90050864568i$	33	$-0.581874144252E + 01 - 0.389719406459E + 01i$	67
γ_2^+	$0.44533 - 9.18684i$	59	$0.451569491142 - 9.12191317214i$	31	$0.446784510254E + 00 - 0.917151486382E + 01i$	65
γ_3^+	$0.45389 - 13.0615i$	57	$0.464247902898 - 12.8487472519i$	29	$0.456385619609E + 00 - 0.130115227368E + 02i$	63
γ_4^+	$0.47952 - 16.8216i$	55	$0.492340380223 - 16.3292825150i$	27	$0.482906458331E + 00 - 0.167063669858E + 02i$	61
γ_5^+	$0.50287 - 20.5307i$	51	$0.514522630594 - 19.5817182568i$	25	$0.506963241913E + 00 - 0.203096267281E + 02i$	59
γ_6^+	$0.52202 - 24.2129i$	50	$0.516658239854 - 22.5715880605i$	23	$0.526558860613E + 00 - 0.238358532167E + 02i$	55
γ_7^+	$0.53754 - 27.8800i$	48	-	-	$0.542123590089E + 00 - 0.272859574060E + 02i$	53
γ_8^+	$0.55024 - 31.5368i$	47	-	-	$0.554191417366E + 00 - 0.306549838386E + 02i$	51
γ_9^+	$0.58745 - 49.7669i$	33	-	-		
γ_0^-	$0.41009 + 1.29037i$	64	$0.409973310292 + 1.29020083859i$	64	$0.410069261267E + 000.129033632980E + 01i$	128
γ_1^-	$1.25949 + 6.08517i$	63	$1.25530612217 + 6.07214375548i$	62	$0.125845417744E + 010.608210427128E + 01i$	126
γ_2^-	$1.14567 + 9.66787i$	62	$1.13696444935 + 9.59622801724i$	60	$0.114350845928E + 010.965104848780E + 01i$	124
γ_3^-	$1.02183 + 13.3150i$	61	$1.00950576515 + 13.0957277529i$	58	$0.101870775473E + 010.132634680645E + 02i$	122
γ_4^-	$0.94250 + 16.9767i$	56	$0.928059983039 + 16.4791343118i$	56	$0.938535330387E + 000.168600097406E + 02i$	120
γ_5^-	$0.89075 + 20.6353i$	54	$0.856678172769 + 22.6544943903i$	52	$0.886130853983E + 000.204129469402E + 02i$	118
γ_6^-	$0.85490 + 24.2883i$	53	$0.941762848775 + 25.3460188358i$	50	$0.849927767573E + 000.239101576350E + 02i$	116
γ_7^-	$0.82877 + 27.9369i$	52	-	-	$0.823875448687E + 000.273421537697E + 02i$	114
γ_8^-	$0.80891 + 31.5812i$	49	-	-	$0.804827463709E + 000.306993188999E + 02i$	112
γ_9^-	$0.75658 + 49.7851i$	39	-	-		

Table 2: Table 4.3 data with higher resolution

$\gamma_n^{\pm}$	srcF2008	index	128 points	index	216 points	index
γ_0^+	$0.61954 - 5.01386i$	60	$0.619612254146E + 00 - 0.501339663670E + 01i$	234	$0.619559288719E + 00 - 0.501374773990E + 01$	494
γ_1^+	$-5.81953 - 3.89677i$	58	$-0.581944739477E + 01 - 0.389682536102E + 01i$	233	$-0.581952656873E + 01 - 0.389678398044E + 01i$	493
γ_2^+	$0.44533 - 9.18684i$	59	$0.445682448956E + 00 - 0.918312004621E + 01i$	231		
γ_3^+	$0.45389 - 13.0615i$	57	$0.454498201155E + 00 - 0.130494173106E + 02i$	229		
γ_4^+	$0.47952 - 16.8216i$	55	$0.480366242866E + 00 - 0.167938280084E + 02i$	227		

Table 3: Table 4.3 data

indicies, but the wavenumbers are relatively near each other, being only 2-5 indicies away from each other.

It is apparent that the solution is approaching a known answer, but by 216 grid points, we are getting about 5-6 digits of precision.

3 Issues and Concerns

The convective wavenumbe couldn't be calculated when the radius was zero so I used L'Hopital's rule:

```
        do i = 1,np
            r  =  rr(i)
            rx =  rmx(i)
            rt =  rmt(i)
            as =  snd(i)
            if (r.eq. 0.0_rDef ) then
                cv = (omega/as - mode*rt)/rx
            else
            ! WRITE(0,*) rx, r
                cv = (omega/as -mode/r*rt)/rx
            endif
!            WRITE(0,*) cv
            if (abs(cv).gt.cvcmax) cvcmax = abs(cv)
            if (abs(cv).lt.cvcmin) cvcmin = abs(cv)
        enddo
```

4 Planned Research

Go back and obtain the L2 plots for the MMS to put a stamp on it and move on. It'll serve as a guideline And I will only use the points that i *know* will give me decent answers. I realized this is pointless when we know what it takes to get a good answer.