Daily Research Report

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1 Current Research Direction

The goal is to complete the validation for SWIRL by creating a range of test cases. The last step to complete each case is to include the pressure mode shape as a function of axial wavenumber. The goal is to confirm that the corresponding mode shape for a given axial wavenumber resembles the modes produced from the eigensolver in SWIRL.

2 Research Performed

The axial wavenumbers for a uniform flow case where $m = 2$, $M = 0.3$ and $k = -1$ is presented.
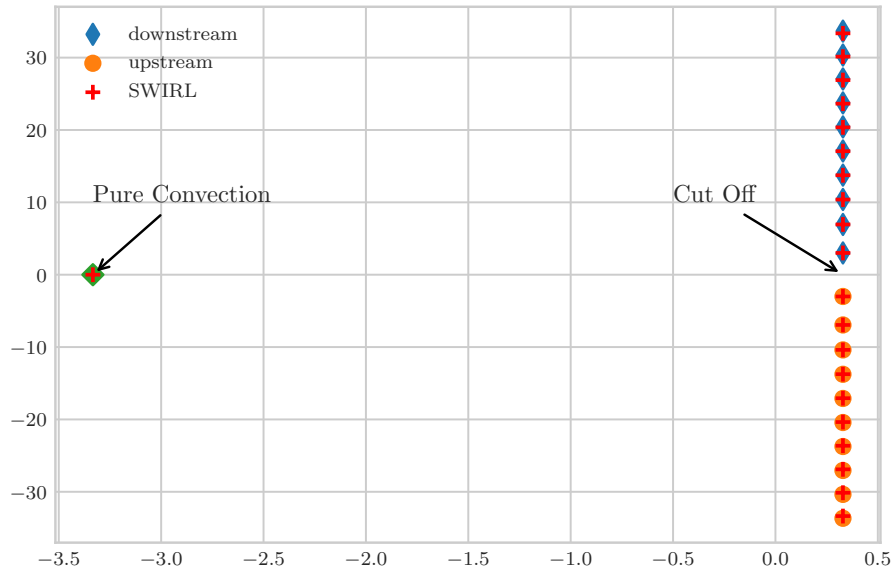
The acoustic modes are along the cut off line (parallel to the imaginary axis) and the convective modes are to the left or right of the line.

The analytical mode shape is going to be

$$p' = p(r)e^{i(m\theta + k_x x - \omega t)} \tag{1}$$

If we only want to look at things with respect to x, let's set $\theta = 0$ $t = 0$, $p(r) = 1(?)$, then

$$p' = e^{\pm i k_x x} \tag{2}$$

quick Python code...

```
i = cmath.sqrt(-1)
p = []
p_real  = []
p_imag  = []
for ii in range(len(x)):
```

```
p_real.append( cmath.exp(i*k_x[ axial wave number index].real*x[ii]).real)
p_imag.append( cmath.exp(i*k_x[ axial wave number index].imag*x[ii]).imag)
```
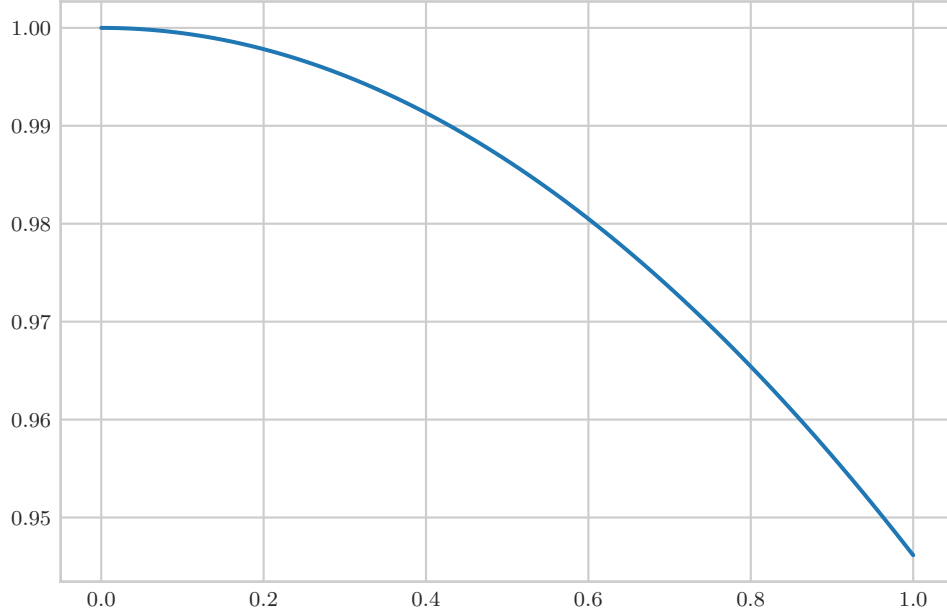
When plotting this I get the following:

Figure 1: Analytical Mode Shapes for $k_x, 0$

3 Issues and concerns

it is apparent that there is something off. I think I need to look at the plus and minus of k_x. Also, I have to be sure that my data types are consistent. The data type conflict would be obvious in F90... The zero crossings in the imaginary part are off. Figure 5 has 2 zero crossings besides the origin and Figure 6 has 3. The good thing is that the number of zero crossings are increasing with axial wavenumber index but I should be making hypotheses of what I expect to see and I thought I would see this behavior in the real part as well.

4 Planned Research

Extract modes from SWIRL to see the trends there.

I also need to address the centerline dilema. I was hoping this would aid my intuition and it doesn't really make sense to have a zero crossing so close to the origin.
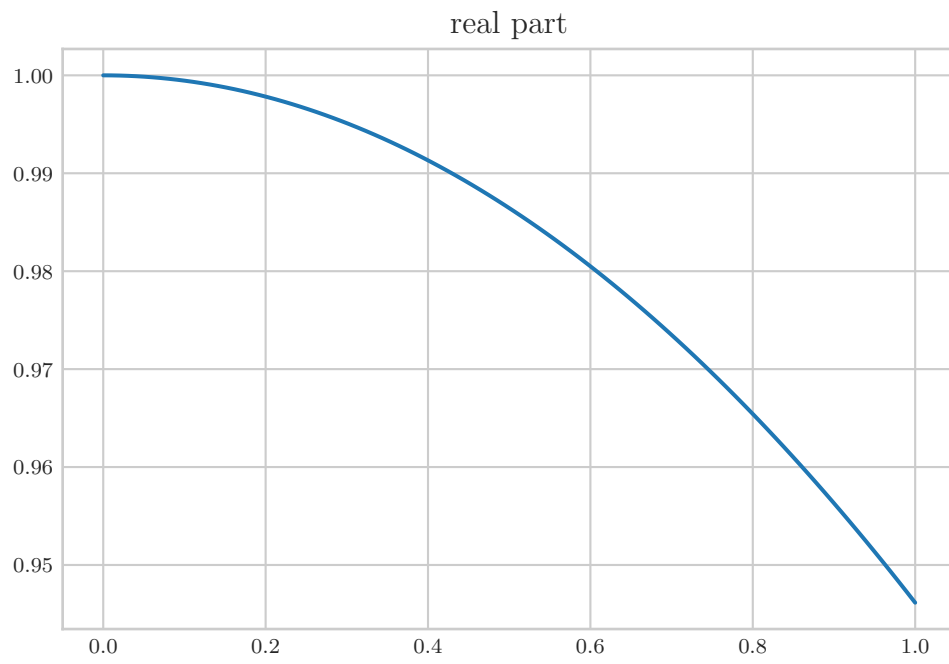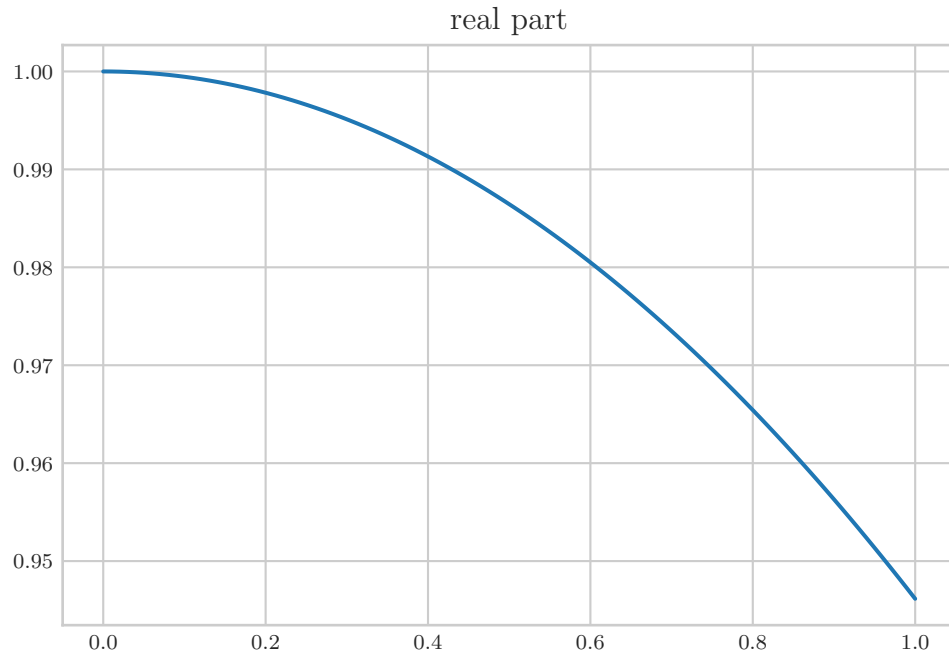
Figure 2: Analytical Mode Shapes for $k_x, 1$

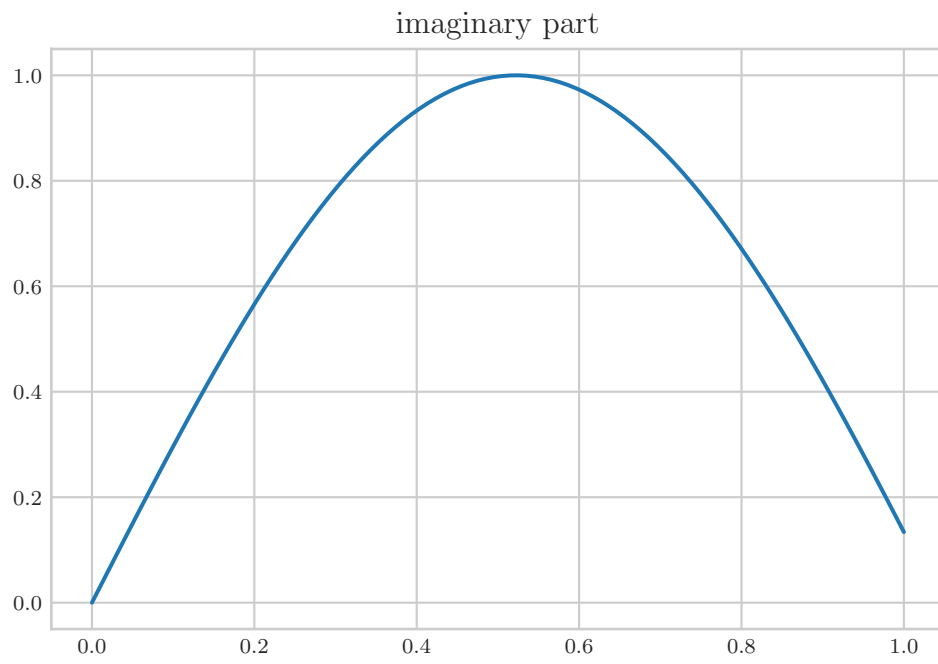Figure 3: Analytical Mode Shapes for $k_x, 2$

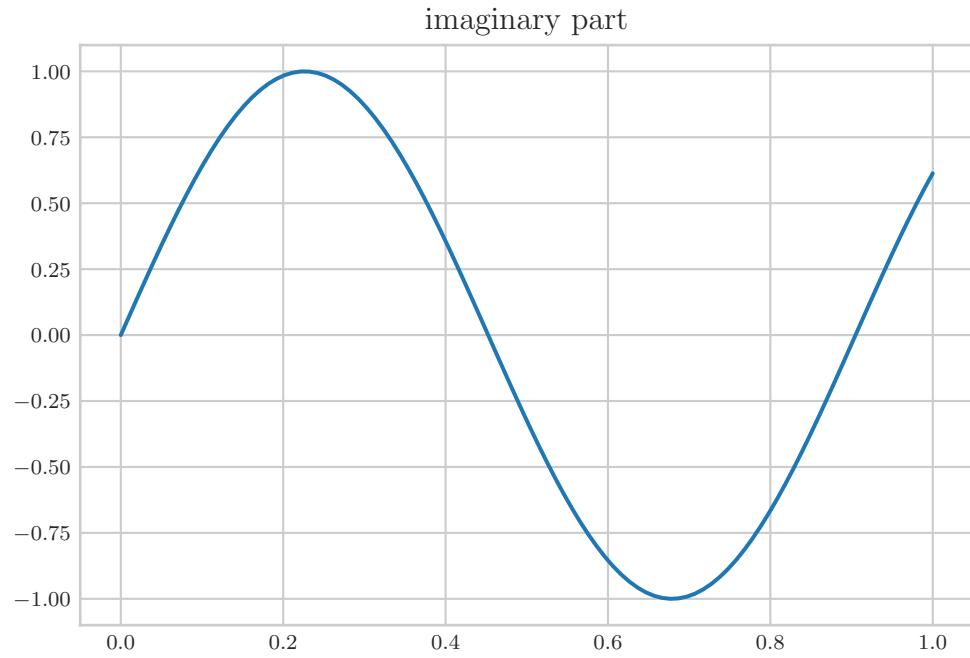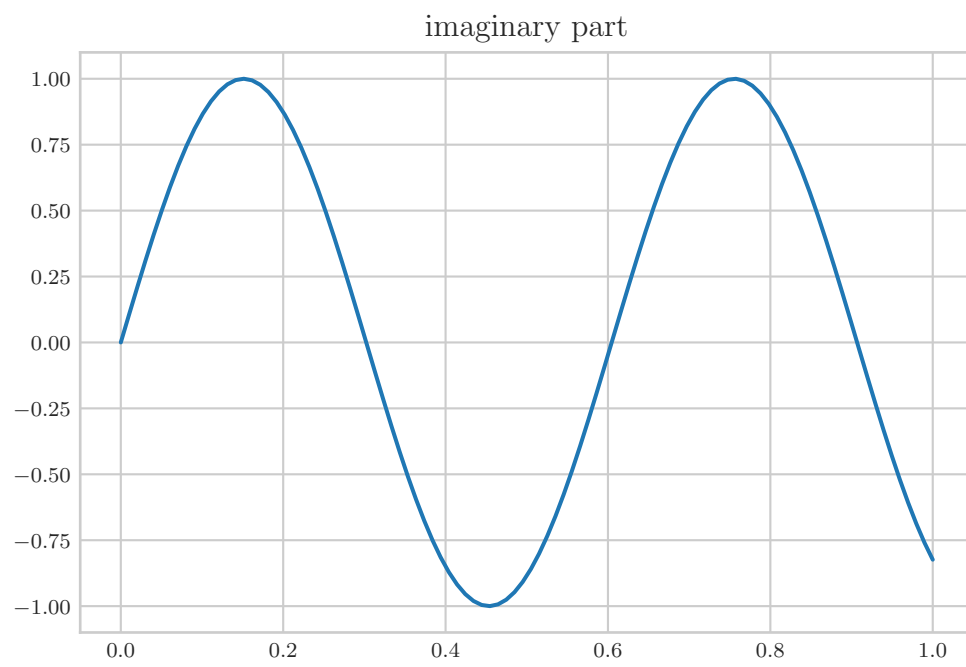Figure 4: Analytical Mode Shapes for $k_x, 0$

Figure 5: Analytical Mode Shapes for $k_x, 1$

Figure 6: Analytical Mode Shapes for $k_x, 2$