AFRL Summer Faculty Research Tasks

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Tentative Research Tasks

Literature Search

My student and I will perform a detailed literature search in the areas of aero-optics and nonequilibrium flows. The goals of this are to:

1. Understand the current state-of-the-art.
2. Identify any current approaches that could supplement our computational capabilities.
3. Allow my student to learn more about how to do a literature search and better familiarize himself with aero-optics and nonequilibrium flows. These are advanced topics and he is a first-year doctoral student so researching previous literature will be especially valuable.
4. Provide literature for our Optical Theory Analysis Research Task.

Timeline

Weeks: 1 - 2

Deliverable(s)

Latex write-up that could easily be inputted into the Literature Review of a Journal/Conference paper in addition to our biweekly written progress report (#1).
Due: June 8th

Optical Theory Analysis

Since most of the previous aero-optics research has been done at low-speeds, most of the theory used was intended for incompressible and ideal (i.e. non-reactive) flows. This task will

investigate the applicability of aero-optical relations for hypersonic conditions (i.e. high-temperature, compressible, and reactive flows). This task will build off of and complement the Literature Review task and identify:

1. The theory that can be utilized in the hypersonic regime.
2. The theory that needs to be modified for the hypersonic regime. Depending on the results of this analysis Optical Theory Development could turn into another research task.

Timeline

Weeks: 2 - 4

Deliverable(s)

Discussion of this in our biweekly progress report (#2).

Nonequilibrium Theory Analysis

I have developed or co-developed state of the art modeling techniques for nonequilibrium flows that range in fidelity, dimension, and computational cost. This includes a one-dimensional code (i.e. shock tube) that can model 2T, STS, and C-R. There is also significant nonequilibrium modeling development ongoing at AFRL/RQ Wright Patterson, which allows for natural collaboration in this area. But the STS codes are only as accurate as the rates (bound-bound and bound-free) that are implemented. There are currently different rates from different research groups, which derive these rates using different approaches and potential energy surfaces. AFRL/RQ Wright Patterson researchers are also generating a database of these rates for conditions of interest. However, there is uncertainty to which set of rates is most appropriate and differences to experimental data still exist. This research task is to implement these rates in the nonequilibrium modeling techniques (1D) and to compare the differences to conditions of interest to hypersonic flows and aero-optics. Using a 1D code for this research task allows for direct comparison and for some conditions, comparisons to experimental data.

Timeline

Weeks: 4 - 7

Deliverable(s)

Discussion of this in our biweekly progress reports (#3, 4, 5).

Code Development

Based on all our previous research tasks, this research task will focus on developing an aero-optics module for a nonequilibrium code(s) of interest. I envision implementing an

aero-optics in a full CFD code (2T, 3D) and also an aero-optics module into a 1D STS code. So this research task could be broken into two different research tasks. The full CFD code with an aero-optics module will allow for hypersonic aero-optics studies to be completed on vehicle scale geometries. The 1D STS code will allow for a higher fidelity aero-optics module to be able to gather a more in-depth understanding of the relation between aero-optics and nonequilibrium.

Timeline

Weeks: 6 - 9

Deliverable(s)

Discussion of this in our biweekly progress reports (#5) and our final report.

Case Studies

This research task will include identifying cases of interest to investigate nonequilibrium effects on aero-optics in hypersonic flows. After identifying the cases of interest, the codes developed in the previous research task will be utilized.

Timeline

Weeks: 9 - 11

Deliverable(s)

Discussion of this in our final report.

Report Writing

Use this week to finalize any previous research tasks and to write the final report.

Timeline

Week: 11

Deliverable(s)

Final report.