

**Excalibur-Neptune report**  
**2047356-TN-09-1**

Task 4.1 Test cases for 1D multispecies plasma  
model

Ben Dudson, Peter Hill, Ed Higgins, David Dickinson, and Steven  
Wright

*University of York*

David Moxey

*KCL*

March 29, 2022

# Contents

<b>1 Summary</b>	<b>1</b>
<b>2 References</b>	<b>2</b>

## 1 Summary

Task 83-4.1 is to outline test cases for a 1D multispecies plasma model given by system 2-5 of reference [1]. These have already been outlined in section 4 of the report on task 83-2.1 [2] so we direct the reader there for more details. These build on the tests for the single plasma fluid model and compromise the following broad areas:

1. Separate ion and electron temperatures. The simplest extension to the single fluid models but with a range of important effects to check.
2. Enhanced neutral gas models including different excited states of hydrogen.
3. Impurity species. This includes low atomic number species, for which each charge state as a separate species, and high atomic number species where it is often necessary to bundle states together represented by a single fluid.

There are several example cases provided by Hermes-3 [3], with some described in the manual [4]. To summarise briefly, relevant examples provide include

1. **1D-te-ti** : A fluid is evolved in 1D, imposing quasineutrality and zero net current. Both electron and ion pressures are evolved, but there is no exchange of energy between them, or heat conduction.
2. **1D-sheath** and **1D-sheath-conduction** : These are very similar to *case-02* and *case-04* of SD1D [5] except now there are separate ion and electron temperatures.
3. **1D-neon** : An example with a neon impurity species with neutral and ions up to +4 evolved as separate species.

## 2 References

- [1] Wayne Arter and Benjamin Dudson. Equations for ExCALIBUR/NEPTUNE Proxyapps. [https://github.com/ExCALIBUR-NEPTUNE/Documents/blob/main/reports/uksaea\\_reports/CD-EXCALIBUR-FMS0021-1.20-M1.2.1.pdf](https://github.com/ExCALIBUR-NEPTUNE/Documents/blob/main/reports/uksaea_reports/CD-EXCALIBUR-FMS0021-1.20-M1.2.1.pdf).
- [2] Benjamin Dudson, Peter Hill, Ed Higgins, David Dickinson, Steven Wright and David Moxey. 1D fluid model tests. <https://github.com/ExCALIBUR-NEPTUNE/Documents/blob/main/reports/2047356/TN-04.pdf>.
- [3] Ben Dudson. Hermes-3. <https://github.com/bendudson/hermes-3>.
- [4] Ben Dudson. Hermes-3 manual. <https://hermes3.readthedocs.io>.
- [5] Benjamin Dudson. SD1D: Sol and Divertor in 1D. <https://github.com/boutproject/SD1D>.