

Building Python-C Interface Tools

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Outline

- Motivation
- Introduction of Python/C API
- Calling a Python code in a C code
- Workflow of the Python/C API
- A sample test
- Summary and Future work

Motivation

- Different programming languages have their own advantages
 - C: fast, with strict rules
 - Python: high-level, user-friendly
- Modules developed at different stages may have adopted different languages
- Programs written in different languages and at different times can be challenging to be rewritten and unified
 - Time-consuming
 - Bug-introducing
- Nowadays, interaction and interfacing between different languages is essential in code development and extension

Ways to call Python code in C code

1. Python/C API (Application Programming Interface)

-- realize Python code with dynamic-link library

-- complex, flexible, fast

```
#include <Python.h>
```

2. Cython

-- tool to compile Python code (.pyx) into C code (.c, .h)

-- simple, rigid, slow



- We choose the Python/C API since we care about the speed

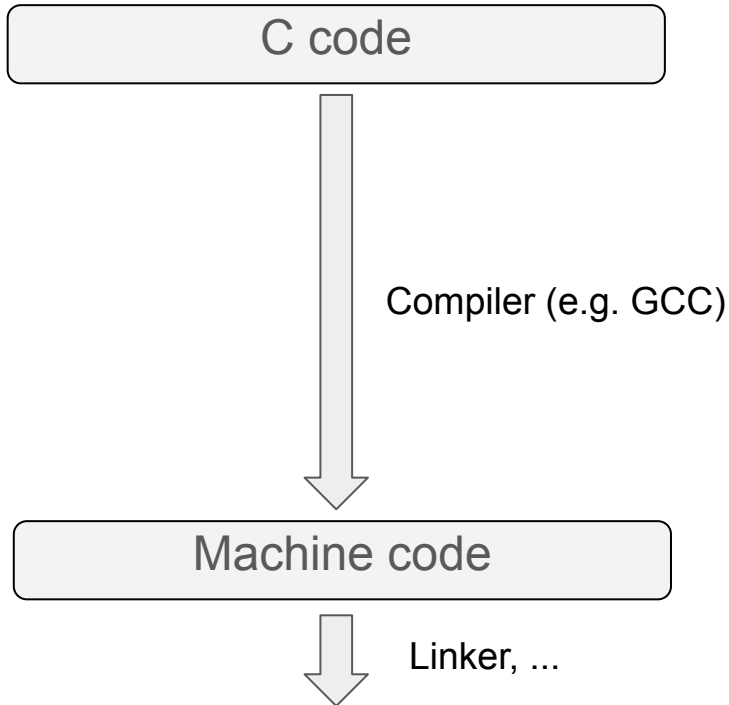
Technical Background



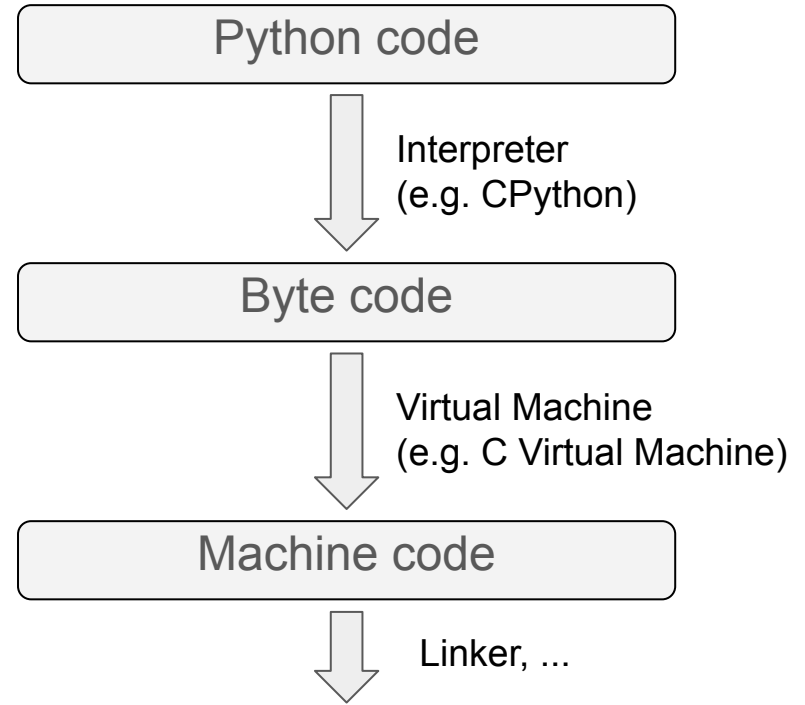
- The official, most widely used Python interpreter, CPython, is written in C.
- CPython includes many practical, concise Python/C API.
- If we want to directly call Python code in C code, we can use these API.
- Python/C API Reference Manual

How we compile C code and call Python code in C code

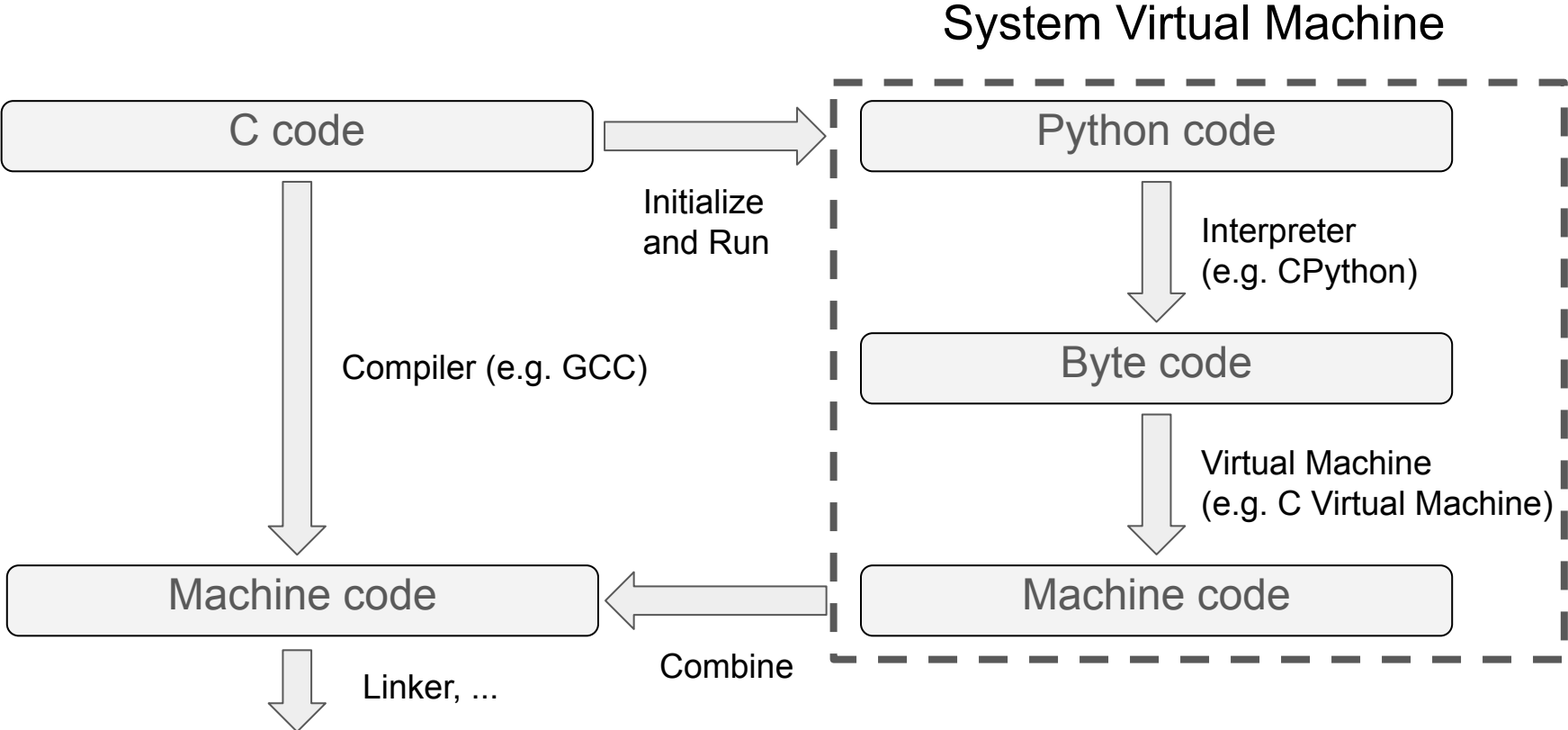
- How we compile C code



- How we compile Python code



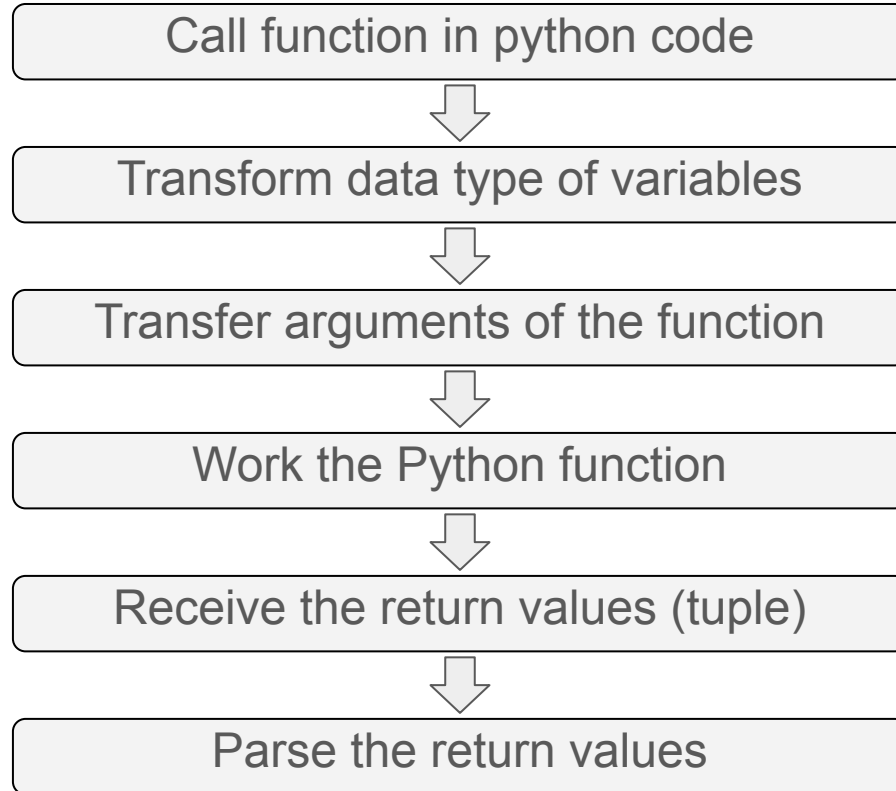
How we compile C code and call Python code in C code



More on the System Virtual Machine (VM)

- An emulation of a computer system
- Implemented by specialized hardware, software, or a combination.
- Run the process of compiling Python code on another CPU or architecture
- Some modules in the VM:
 - `Py_Initialize`: loads all the necessary dependencies and sets all the necessary contents
 - `run_file`: load the Python scripts
 - `run_mod`: handles the execution of the code
 - `Py_Finalize`: clear everything the virtual machine left behind

Workflow

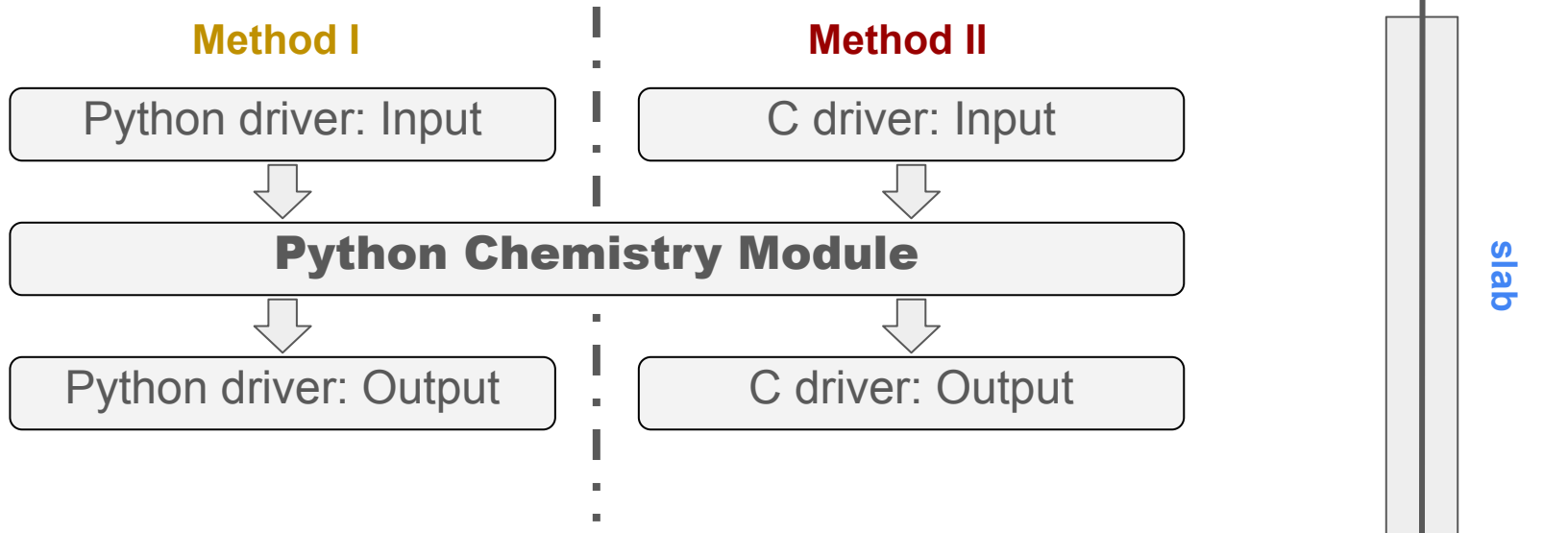


More about data conversion

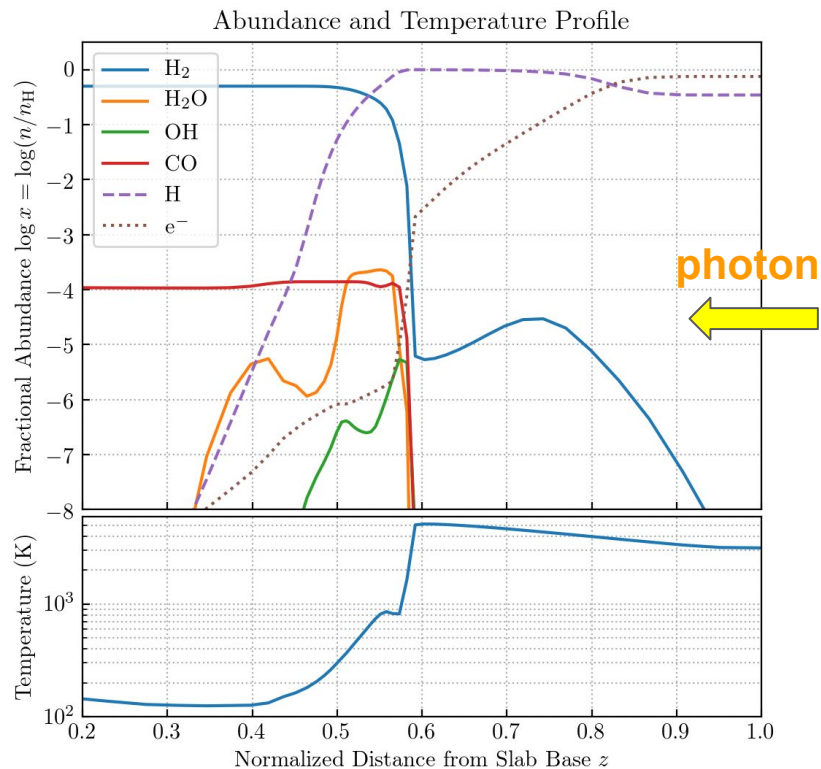
- Most of Python codes are realized with C, thus all Python data types and data structures are a data type defined in C -- “PyObject”
- Special data structures (e.g. ndarray) need to be transformed to basic data structures in Python code

Sample Test: Chemistry in a Photon-Irradiated Slab

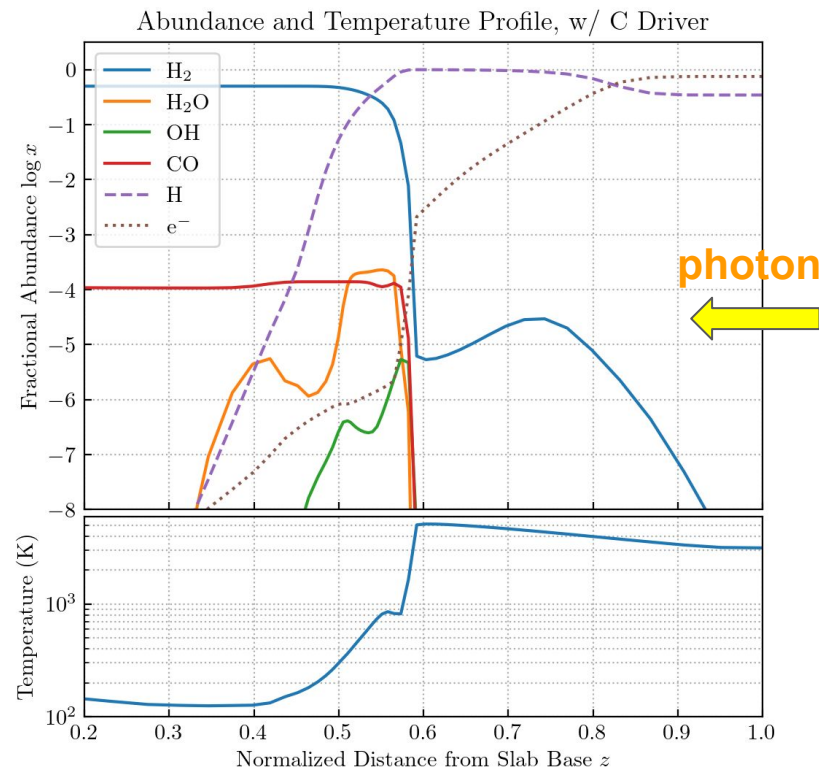
- Environment: photon coming from the top of slab
- Input: Density of the slab
- Output: abundances of molecules and temperature



Results: Full Python vs. C-Python Interfacing



Python Driver + Python Chemistry Module



C Driver + Python Chemistry Module

Summary: Proof of Concept

- Python/C API is a powerful tool to connect the C code and the Python code and transfer the variables.
- The performance is almost not affected by the API in terms of speed.
- The correctness of the results from the API is well tested from the sample test and the errors/accuracy are tolerable.

Future Work

- Apply the Python-C interface tool to more astrophysical models

Thank you