# PyTOV
## A new code to solve TOV equation

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# Motivation

- Why not develop new TOV code
  - There are many codes to solve TOV equation.
  - There is no interesting aspect with respect to astrophysics.
- Nevertheless, why I am developing new TOV code
  - There are interesting aspects with respect to nuclear and particle physics.
  - It requires massive parameter search in the equation of state.
  - There is few scalable parallel code.

# Features of PyTOV: Quick and Easy

- Written in Python
- Object oriented
- Easy to change coordinate: areal, isotropic, CST

```
from star import TOVStar
from eos import PolytropicEoS, Sly4
# eos = PolytropicEoS(n=1, k=100)
eos = Sly4()
star = TOVStar(eos, H_c=0.4) # H_c: log enthalpy at center
star.get_mass()
star.get_radius('r')  # areal coordinate
star.get_radius('rb') # isotropic coordinate
x_pts = np.linspace(0, 1, num=num_points)
[star.get_sol('rho', 'r')(x) for x in x_pts]  # density profile
[star.get_sol(  'P', 'r')(x) for x in x_pts]  # pressure profile
```

# Features of PyTOV: Scalability

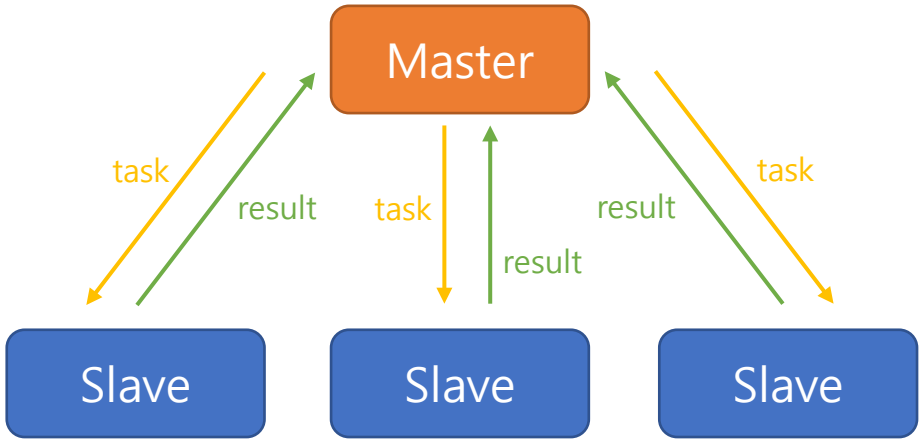
- MPI parallelization
- Generating points efficiently given resolution

```
from starfamily import TOVStarFamily
from eos import PolytropicEoS, Sly4
from mpi4py import MPI
comm = MPI.COMM_WORLD
eos = Sly4()
star_family = TOVStarFamily(eos, min_H_c=0.05)
mr_curve = star_family.get_MR_curve('r', resolution=0.1, comm=comm)
```

```
$ mpirun -np 100 python -m mpi4py mrcurve.py
```

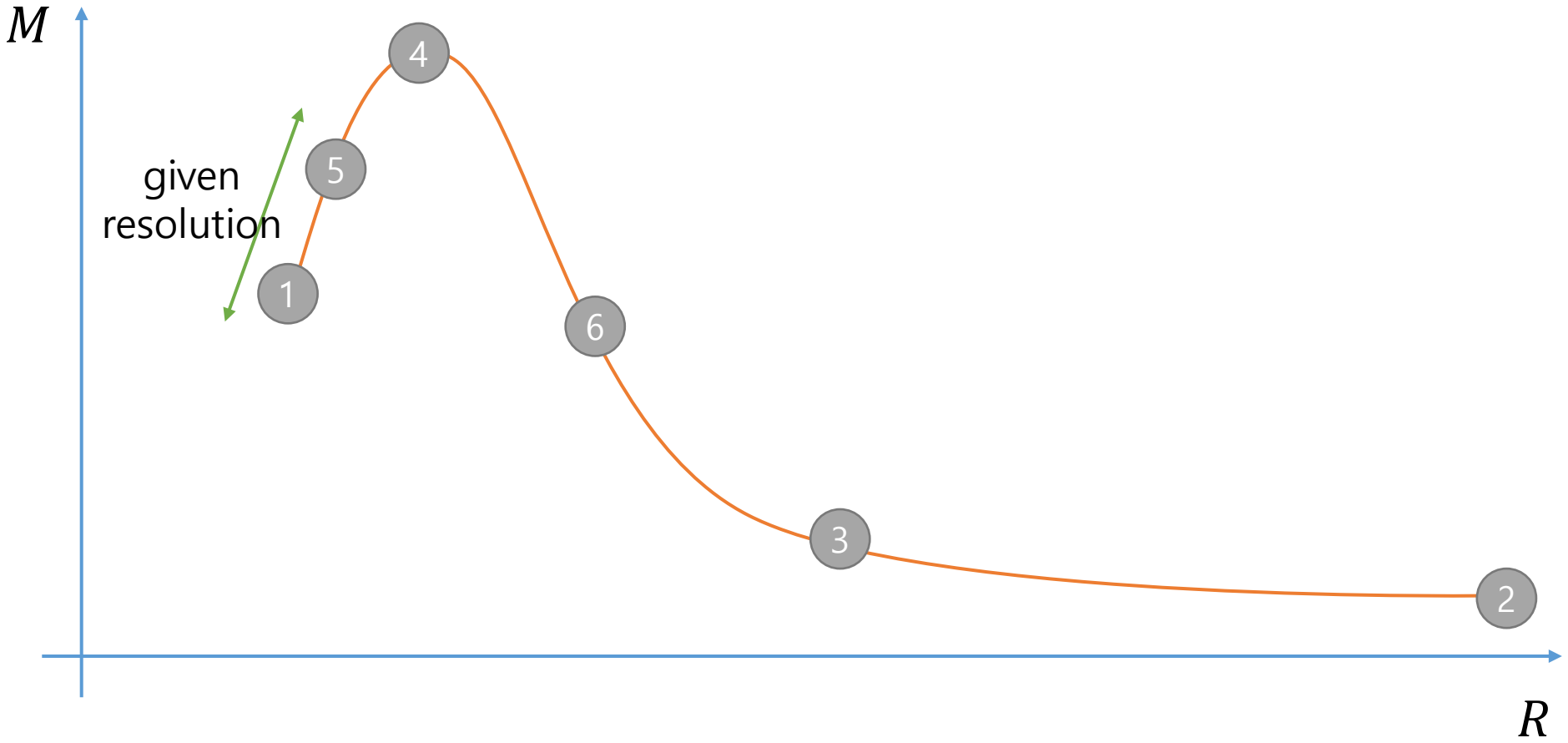
# Implementation Detail

- Numerical method
  - Scipy routines: solve_ivp, root_scalar, minimize_scalar
- Parallelization model
  - mpi4py
  - Load balancing by master and slave

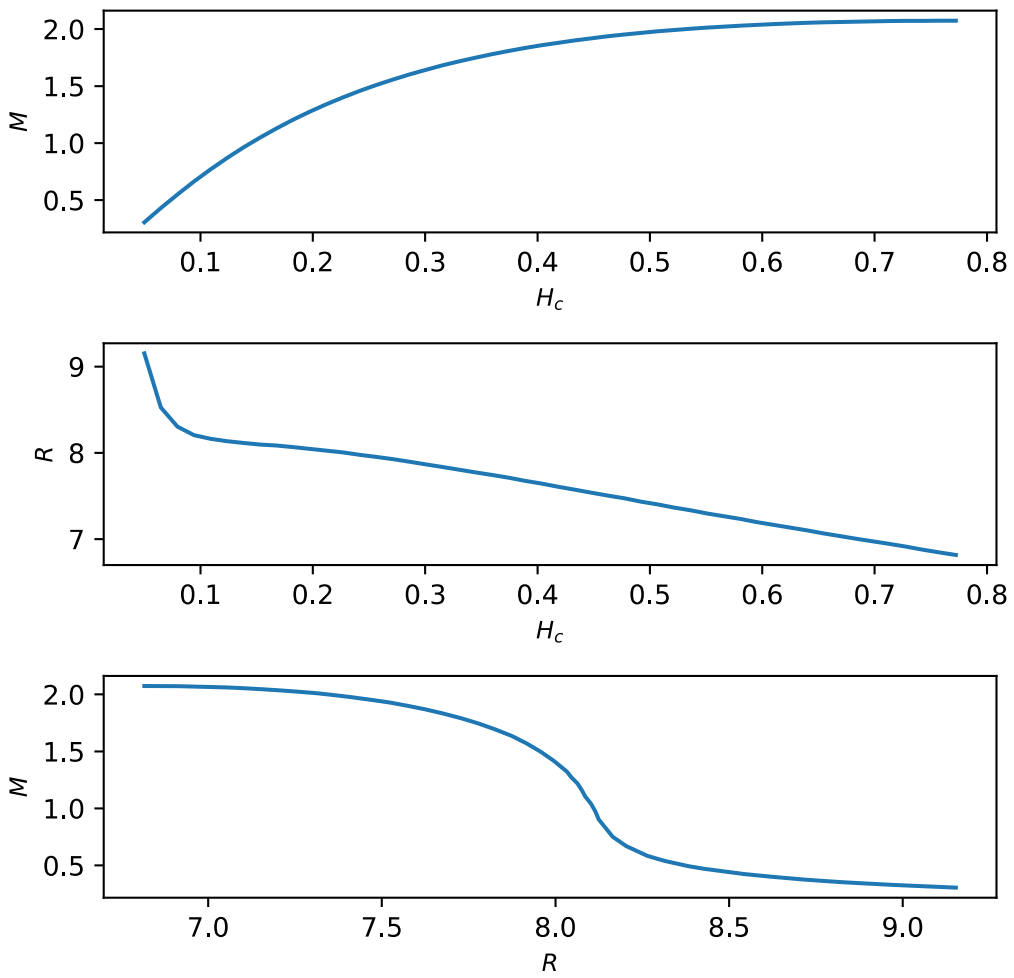
# Non-sequential Point Choosing

- Generating a midpoint for intervals beyond resolution.



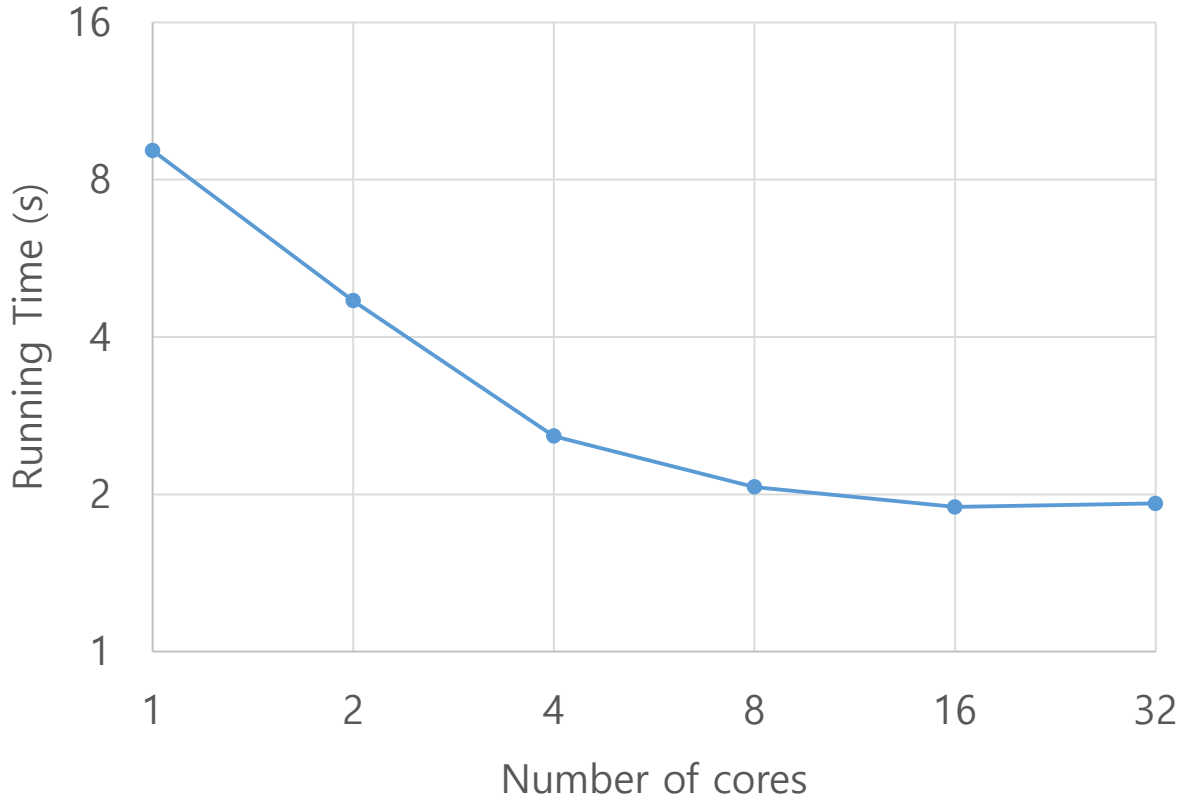
# Code Test – MR Curve of Sly4 EoS

- $c = G = 1$
- Unit of $M_\odot$
- $M_{\max} = 2.07$



# Code Test - Scalability

- Test machine: AWS EC2 c5



# Future Works

- Tidal deformability
- Bayesian analysis (MCMC)

- Thank you for your listening