

Section 7.

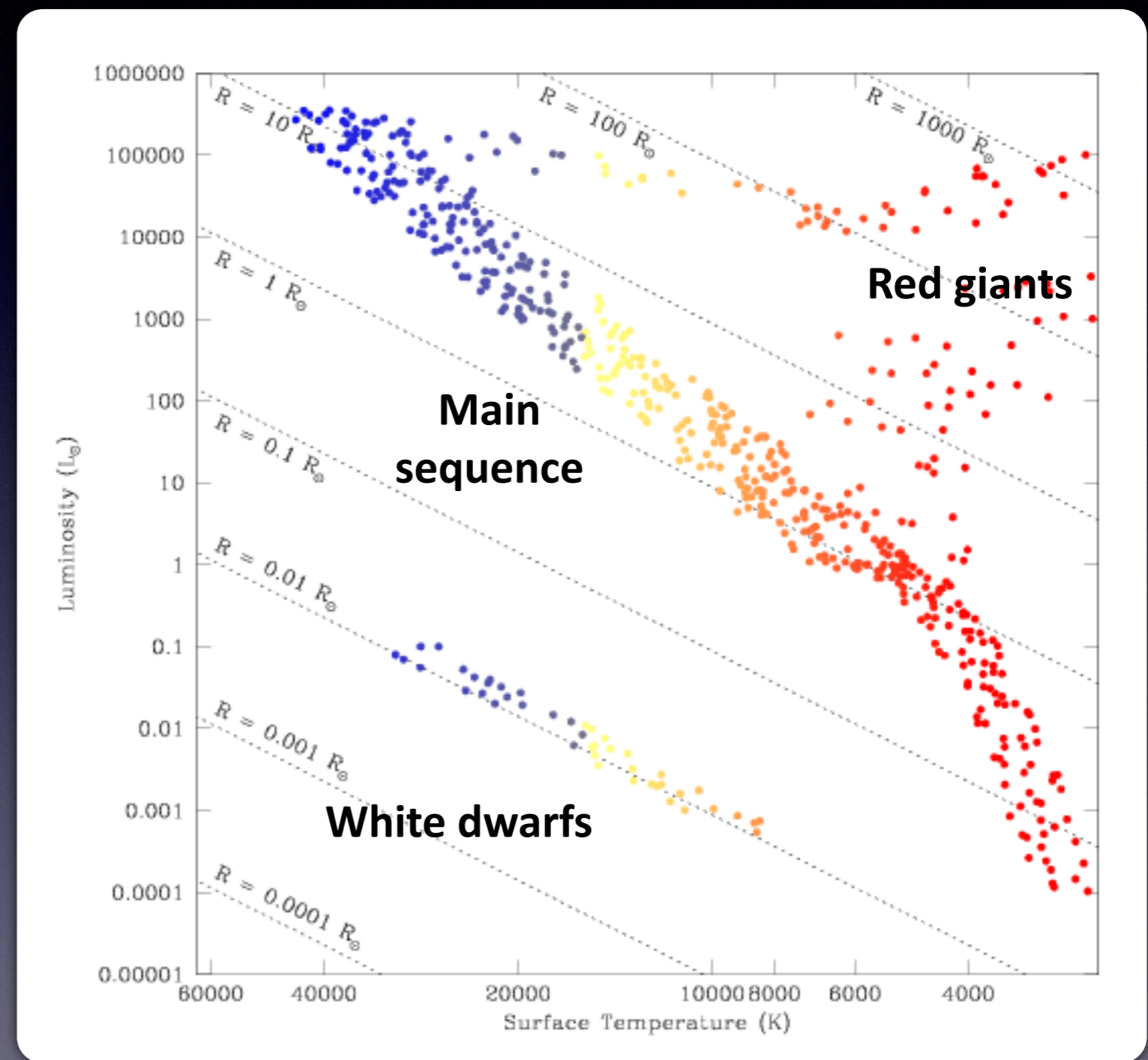
恒星の進化 (3)

7.1 恒星進化の方程式

7.2 恒星進化の計算

Hertzsprung-Russel diagram (HR)

Luminosity (L_{sun})



Temperature (K)





さまざまな疑問を**物理**を使って理解しよう

- 星の中はどうなっているの？
- なぜ重い星の方が大きいのか？
- なぜ星は明るく輝くのか？
- なぜ重い星の方が明るいのか？
- なぜ星は「進化」するのか？
- なぜ質量で星の運命が変わるのか？
- なぜ星は星でいられるのか？
- なぜ一部の星は爆発するのか？
- ...

MESA code

<http://mesa.sourceforge.net/index.html>

MESA

Modules for Experiments
in Stellar Astrophysics

MESA home

code capabilities

prereqs & installation

getting started

using pgstar

using MESA output

beyond inlists (extending
MESA)

troubleshooting

FAQ

star_job defaults

controls defaults

pgstar defaults

binary_controls defaults

news archive

documentation archive

MESA

You may also want to visit [the MESA community portal](#), where users share the inlists from their published results, tools & utilities, and teaching materials.

Why a new 1D stellar evolution code?

The MESA Manifesto discusses the motivation for the MESA project, outlines a MESA code of conduct, and describes the establishment of a MESA Council. Before using MESA, you should read the [manifesto document](#). Here's a brief extract of some of the key points

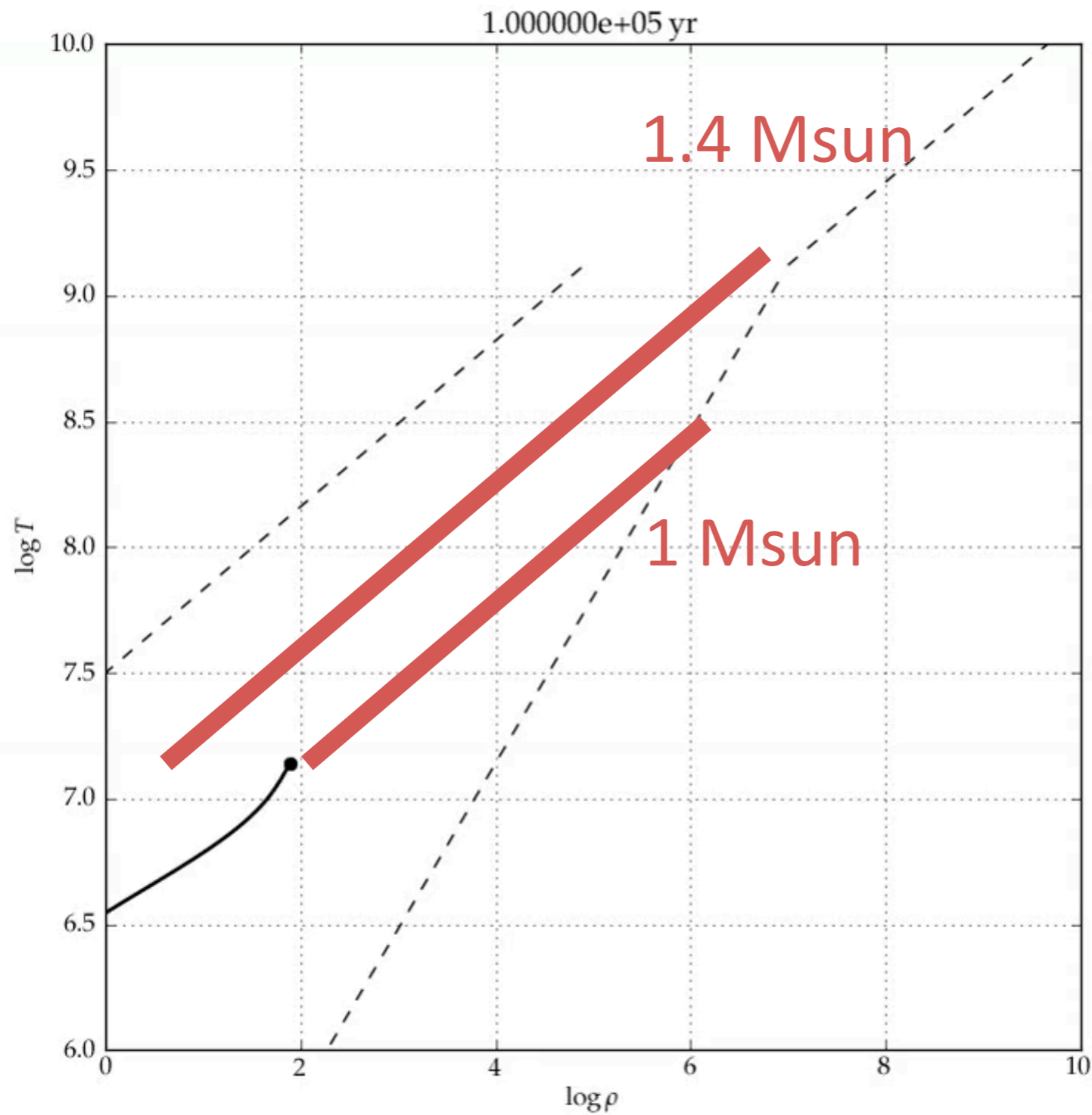
Stellar evolution calculations remain a basic tool of broad impact for astrophysics. New observations constantly test the models, even in 1D. The continued demand requires the construction of a general, modern stellar evolution code that combines the following advantages:

- **Openness:** anyone can download sources from the website.
- **Modularity:** independent modules for physics and for numerical algorithms; the parts can be used stand-alone.
- **Wide Applicability:** capable of calculating the evolution of stars in a wide range of environments.
- **Modern Techniques:** advanced AMR, fully coupled solution for composition and abundances, mass loss and gain, etc.
- **Comprehensive Microphysics:** up-to-date, wide-ranging, flexible, and

Latest News

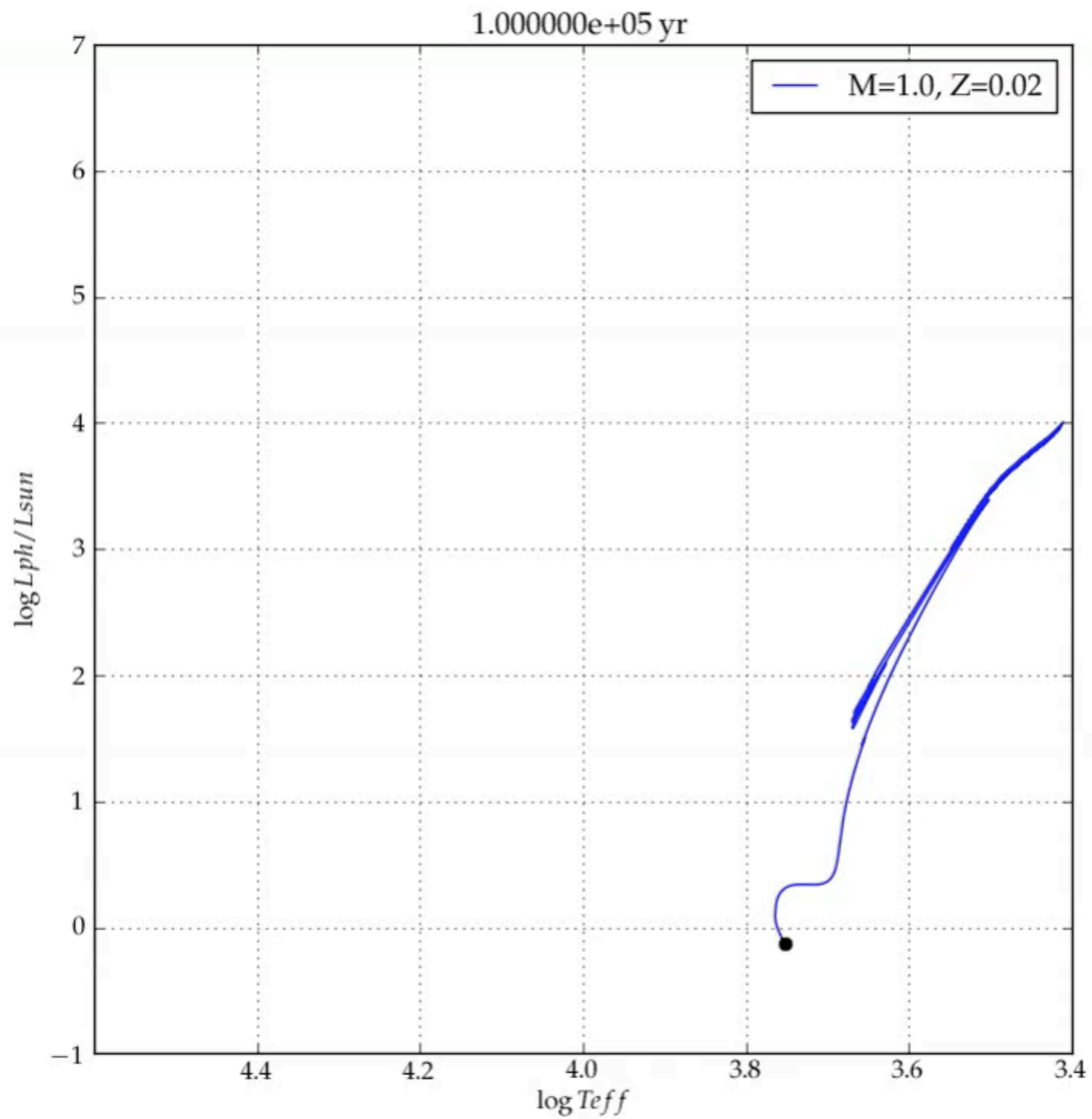
- 10 Aug 2016
» [Documentation Archive](#)
- 19 Jun 2016
» [Release 8845](#)
- 03 Feb 2016
» [Release 8118](#)
- 29 Jan 2016
» [New MESA SDK Version](#)
- 10 Jan 2016
» [Summer School 2016](#)
- 27 Sep 2015
» [Instrument Paper 3](#)
- 14 Sep 2015
» [MESA-Web Updates](#)
- 08 Sep 2015
» [New MESA SDK Version](#)
- 03 Sep 2015
» [Updated MESA Maps](#)
- 27 Aug 2015
» [Summer School Success!](#)

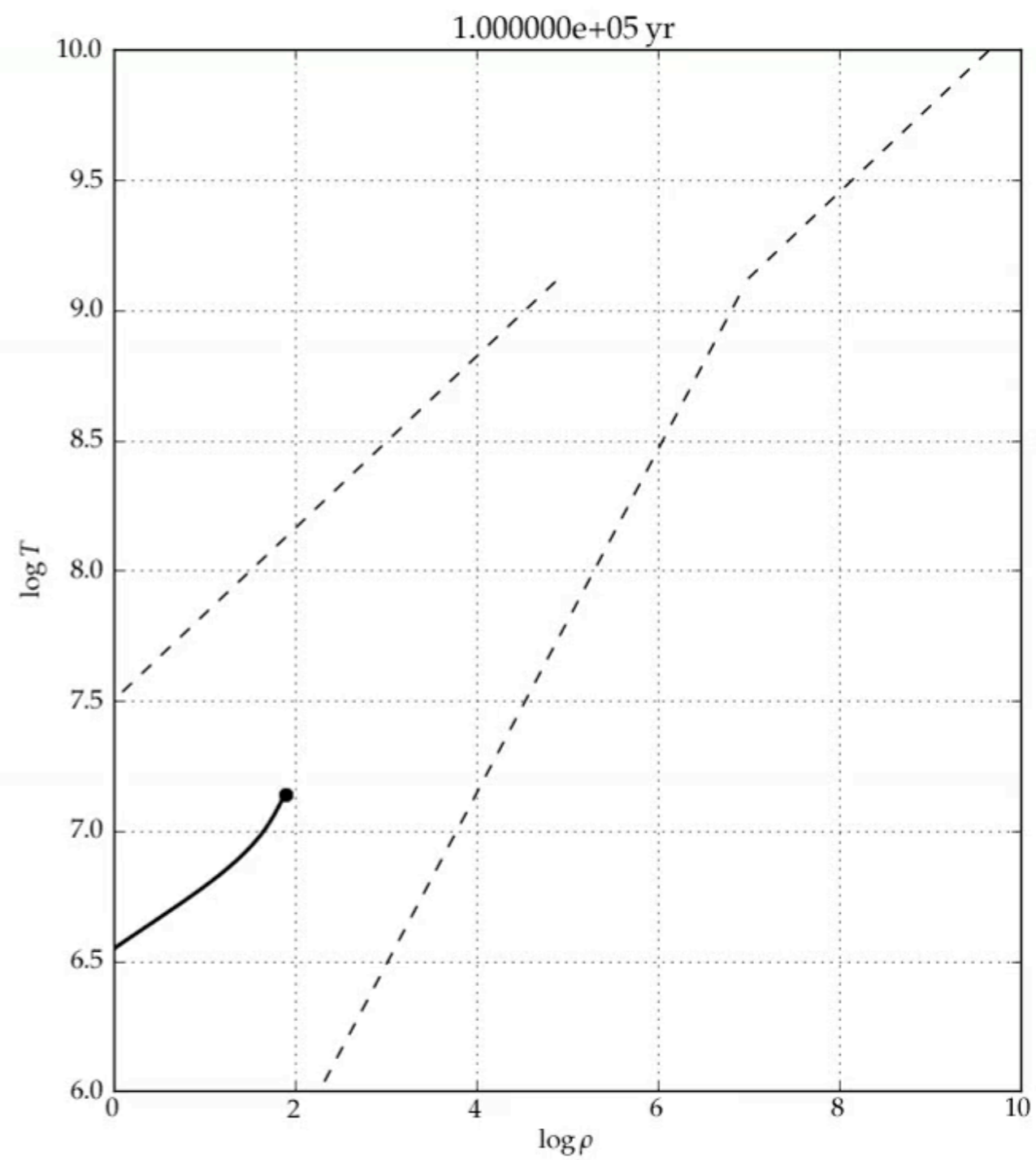
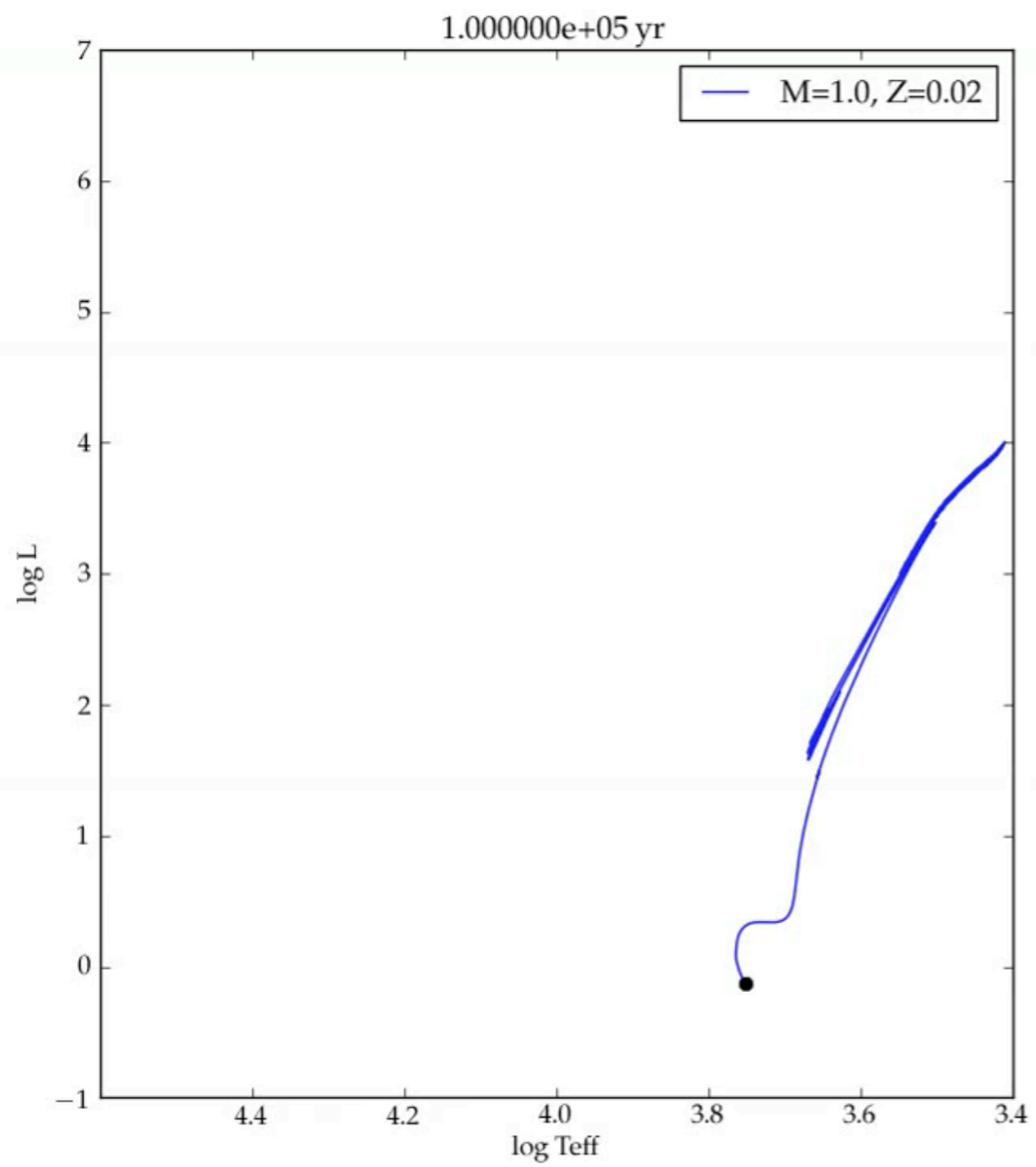
1 Msun (ρ - T)



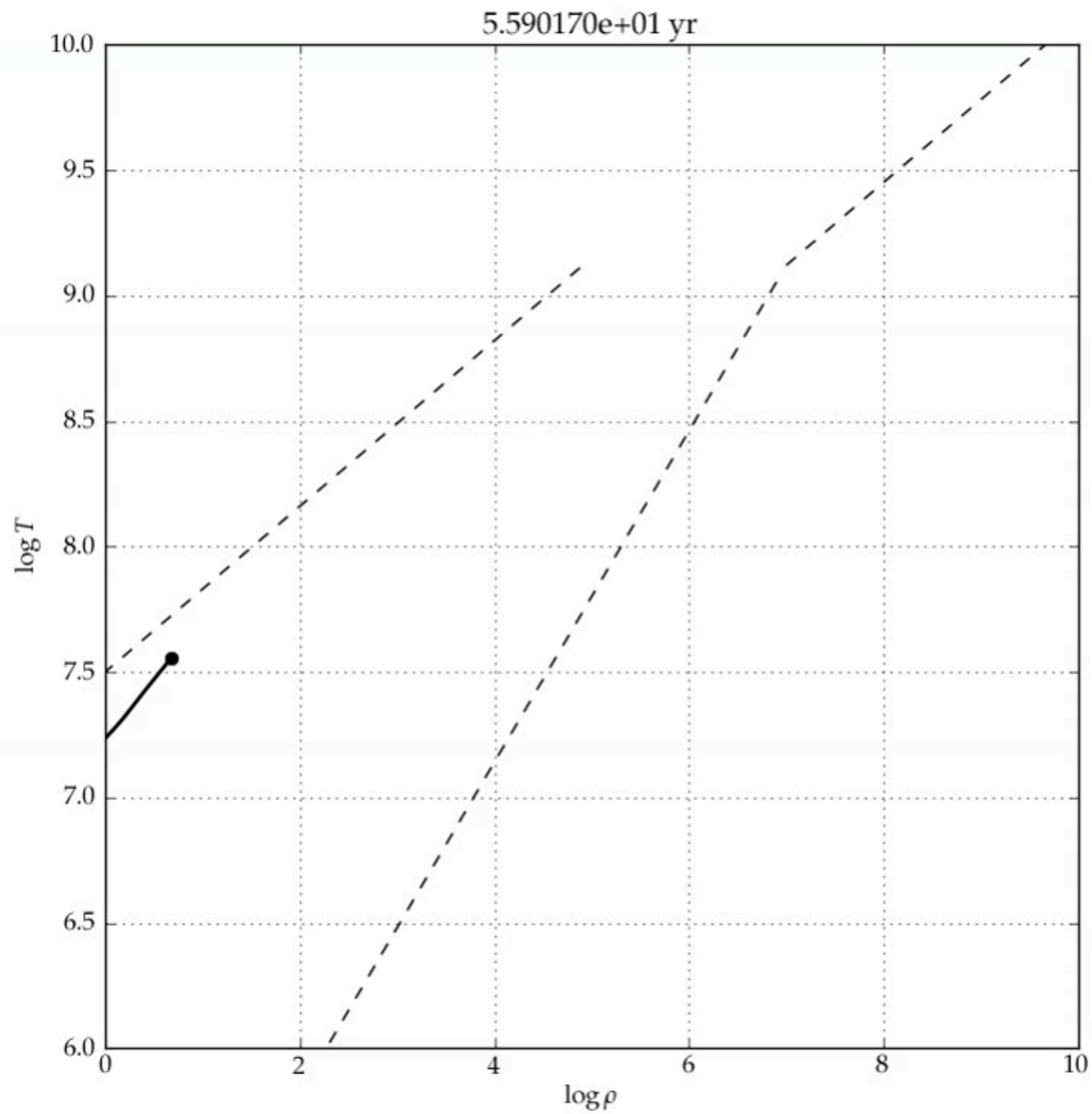
$$T \sim M^{2/3} \rho^{1/3}$$

1 Msun (HR diagram)

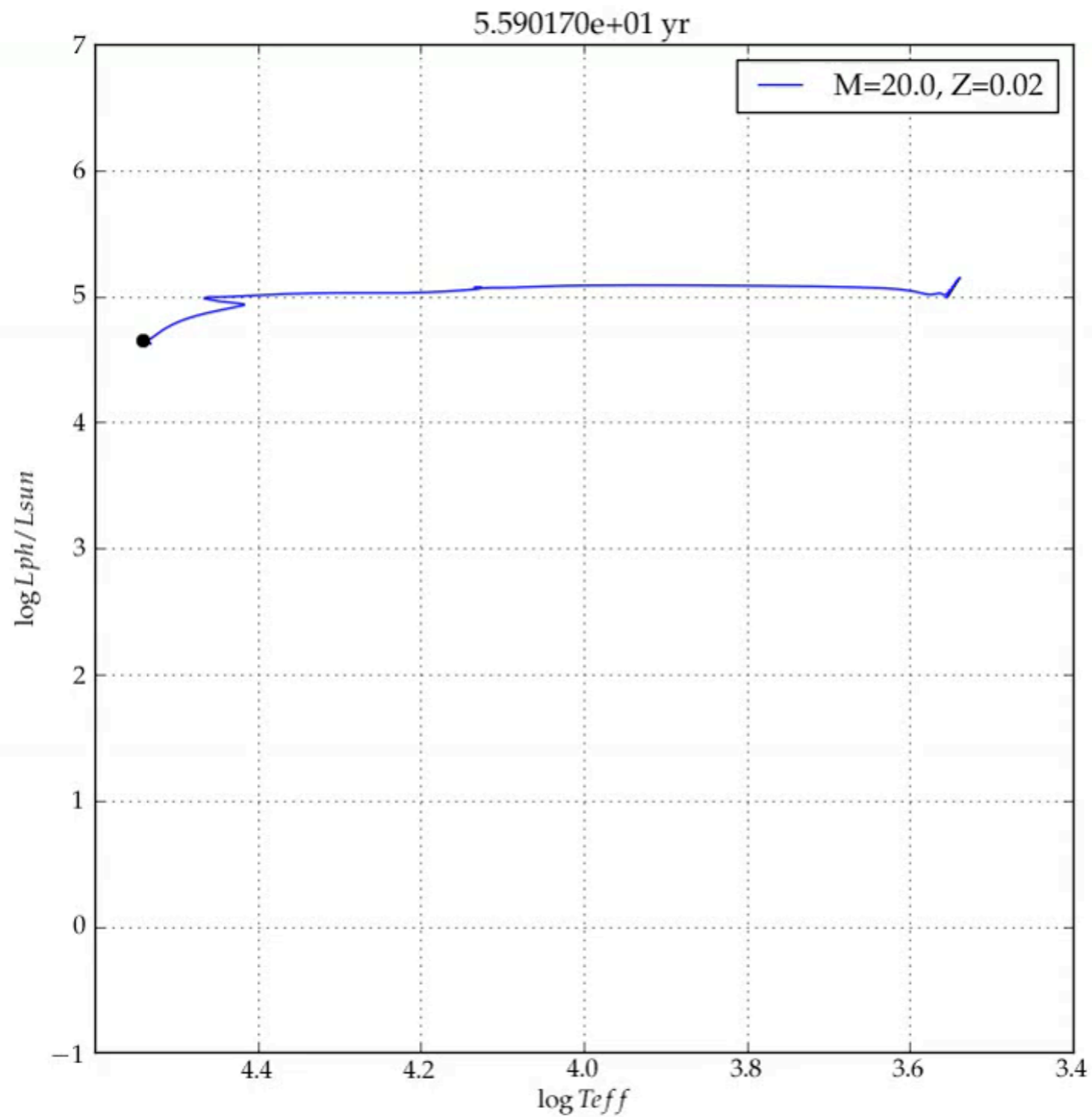


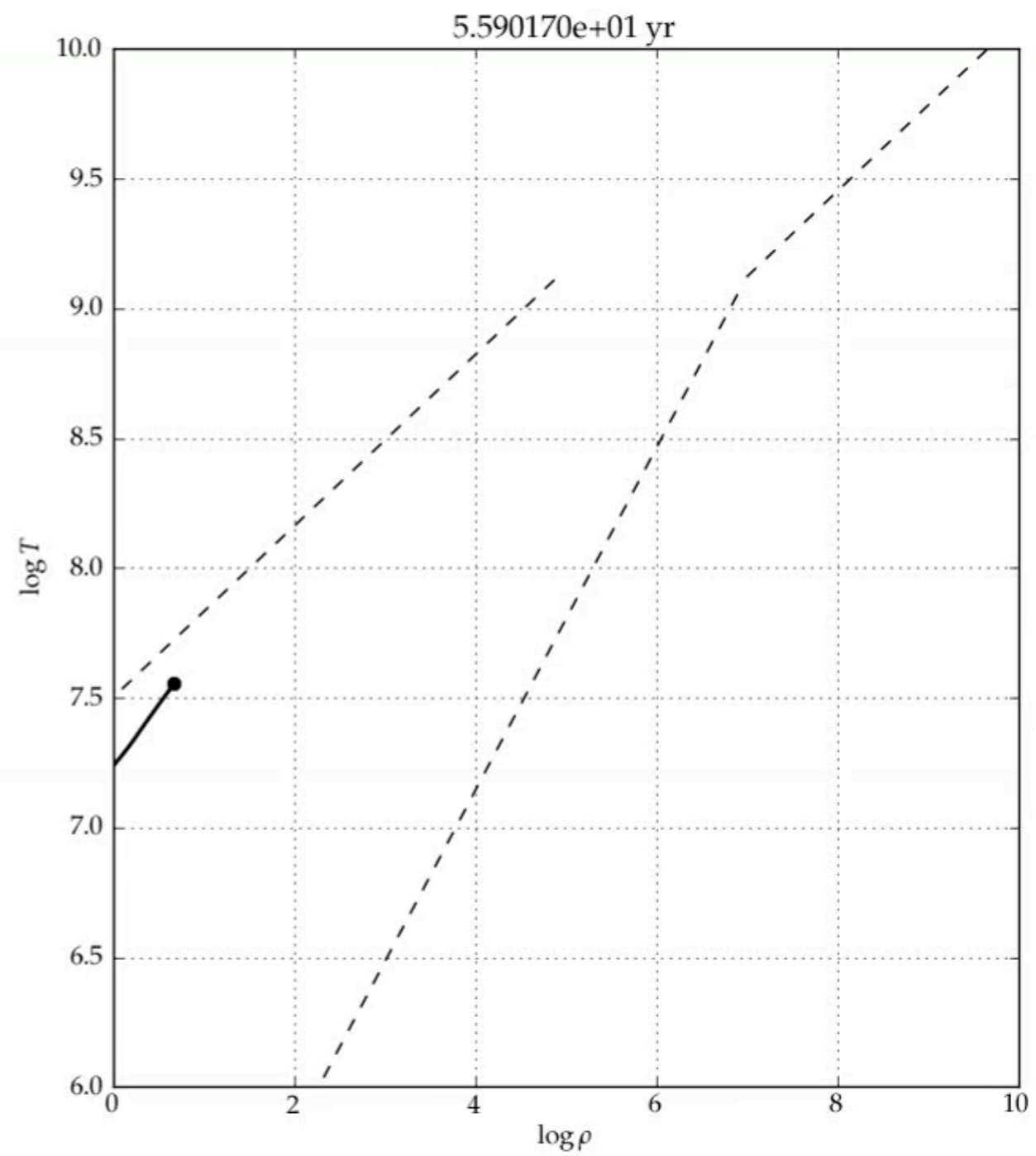
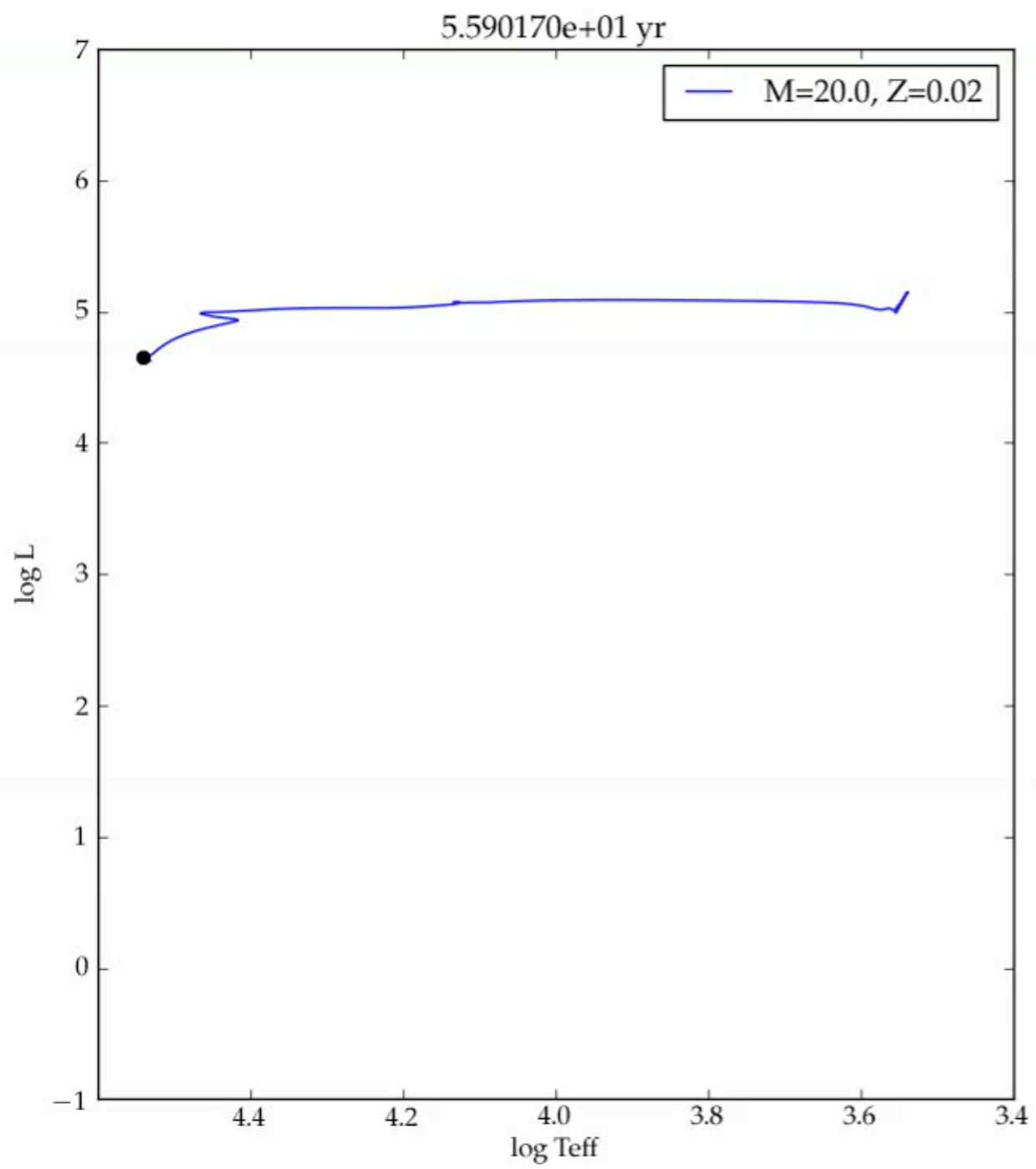


20 Msun (ρ - T)

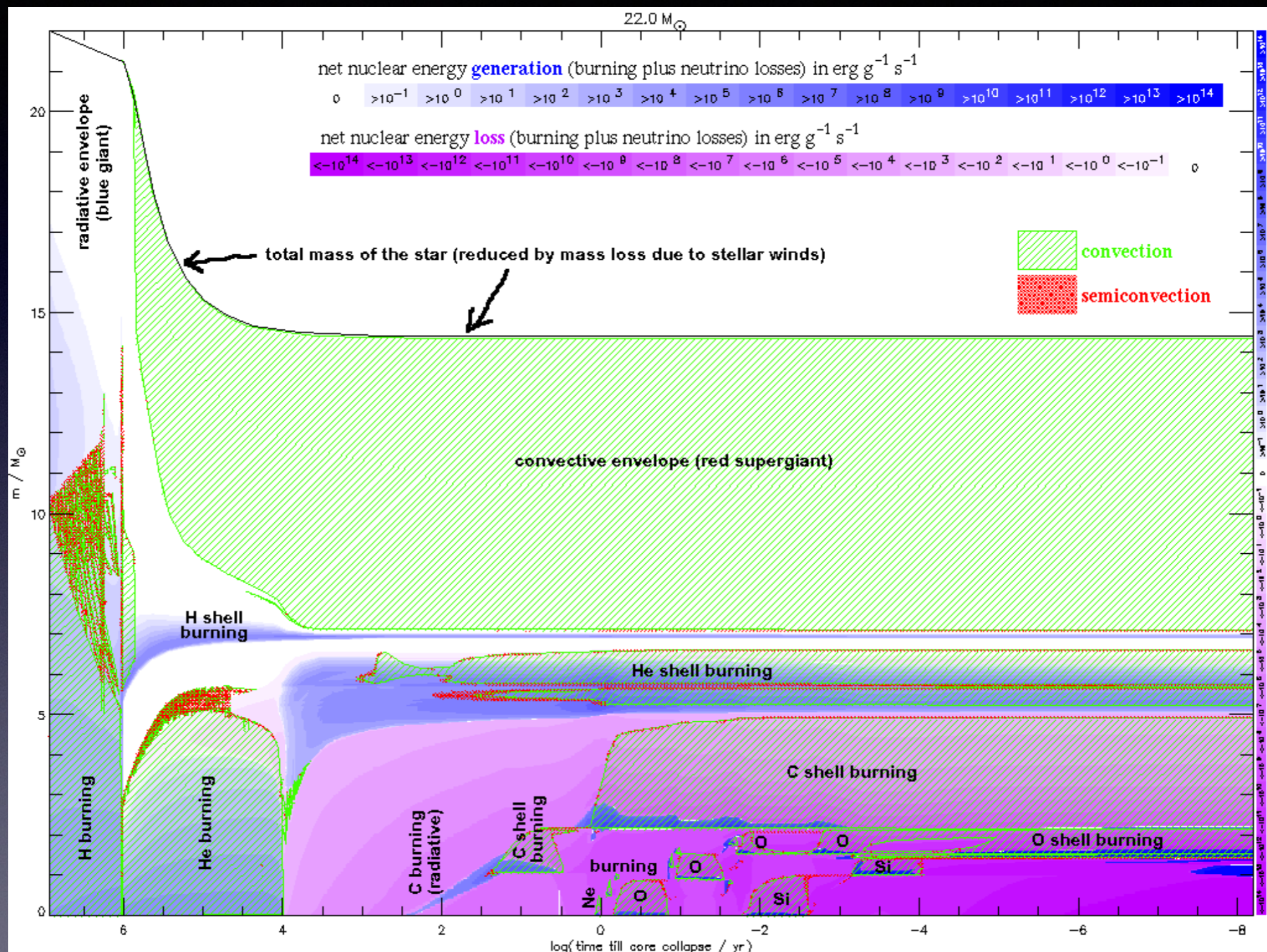


20 Msun (HR diagram)





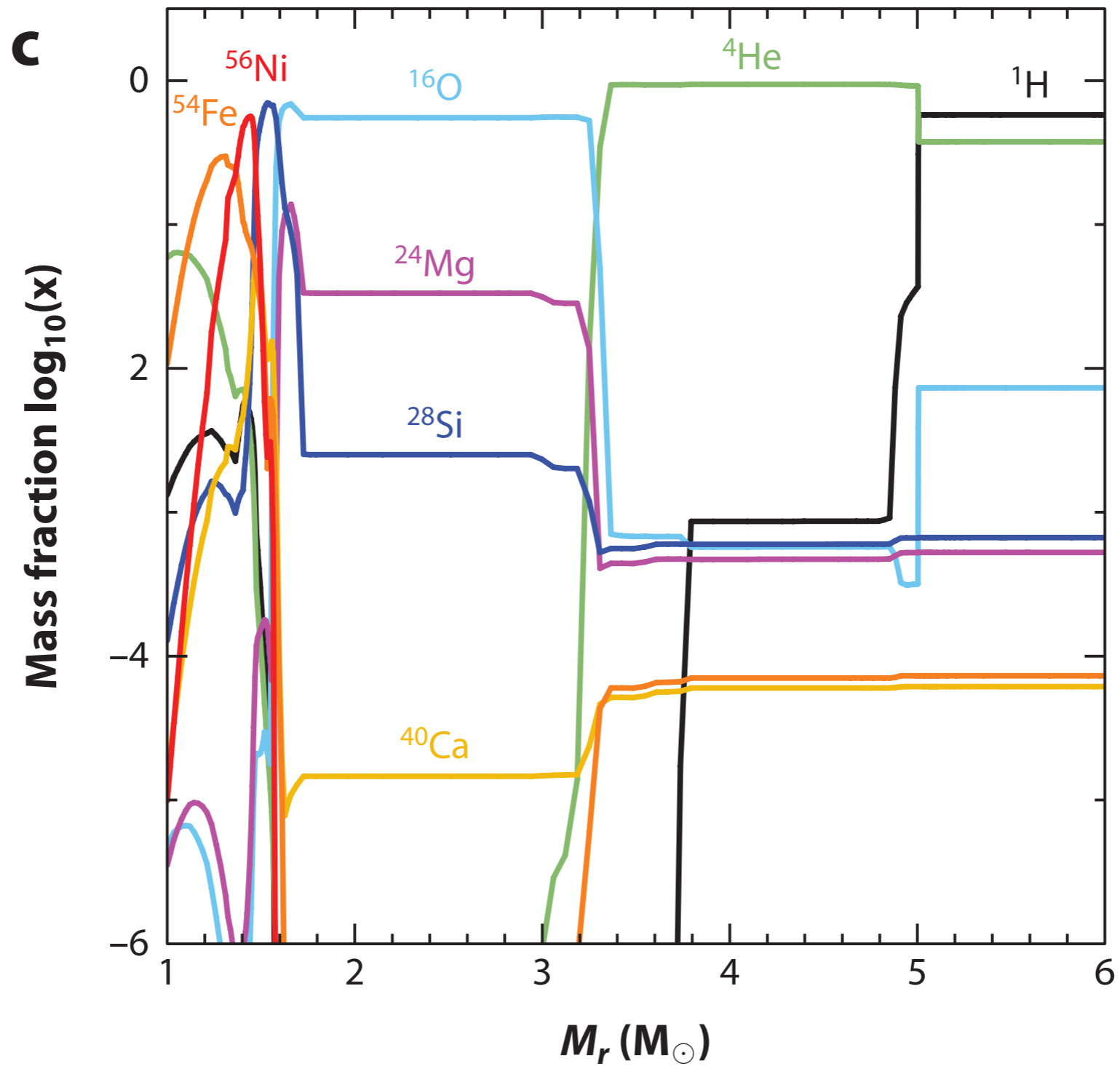
“Kippenhahn diagram”



(C) A. Heger

<https://2sn.org/stellarevolution/explain.gif>

爆発直前の星の元素分布



まとめ

- **恒星進化の方程式**

- 静水圧平衡 (運動方程式)
- 状態方程式
- エネルギー輸送
- エネルギー生成 (核融合)

- **恒星進化の計算**

- 各時間での平衡状態を求める
- HR図上での進化 (星の明るさ、半径)
- 星の中の元素組成の変化