

Section 6. 恒星の構造 (2)

6.1 恒星進化の計算

6.2 ポリトロープモデル

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



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

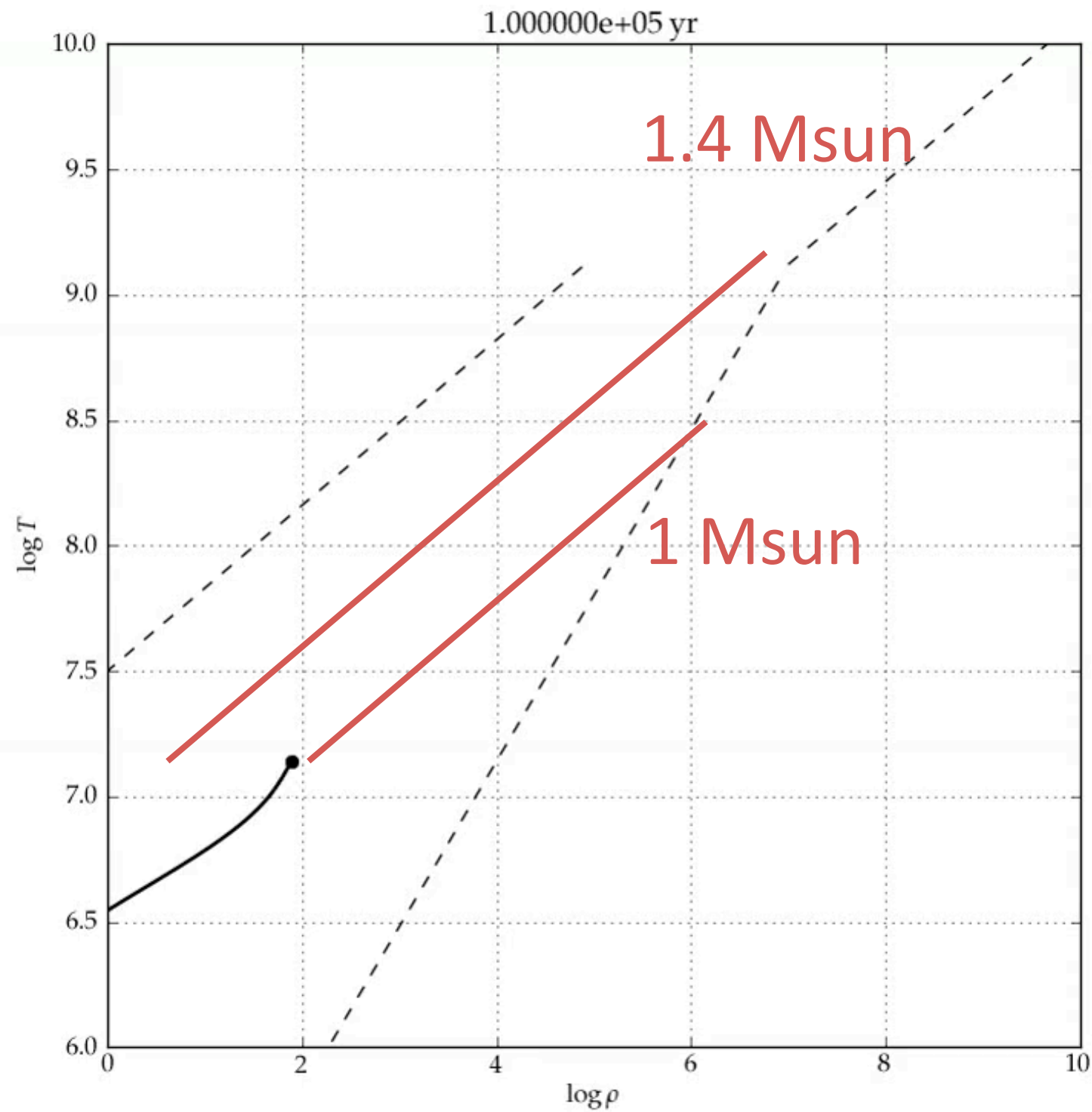
Stellar evolution calculations remain a basic tool of broad impact for astrophysics. New observations constantly test the models, even in 1D. The continued demand requires the construction of a general, modern stellar evolution code that combines the following advantages:

- **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

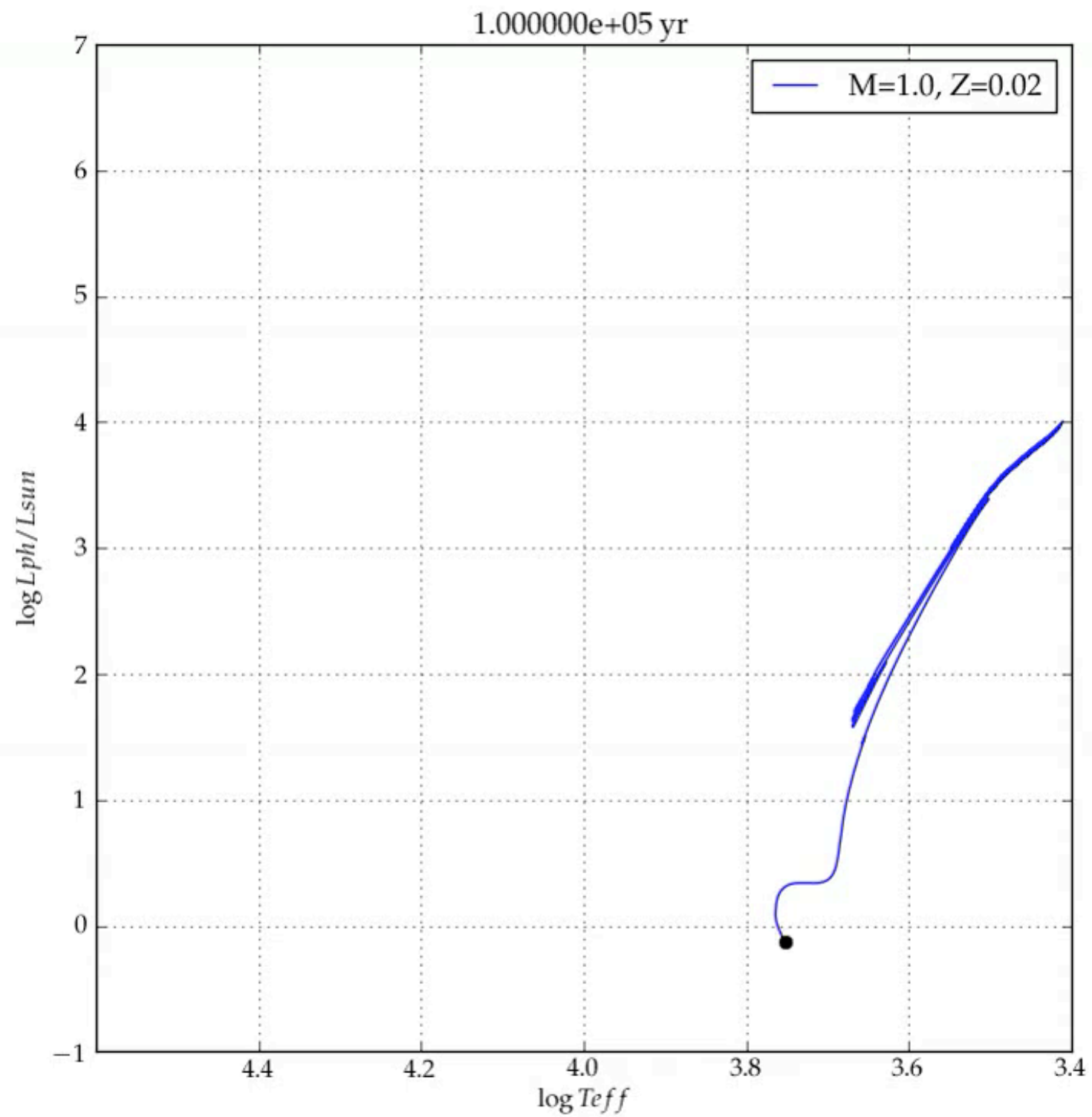
- 10 Aug 2016
» [Documentation Archive](#)
- 19 Jun 2016
» [Release 8845](#)
- 03 Feb 2016
» [Release 8118](#)
- 29 Jan 2016
» [New MESA SDK Version](#)
- 10 Jan 2016
» [Summer School 2016](#)
- 27 Sep 2015
» [Instrument Paper 3](#)
- 14 Sep 2015
» [MESA-Web Updates](#)
- 08 Sep 2015
» [New MESA SDK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

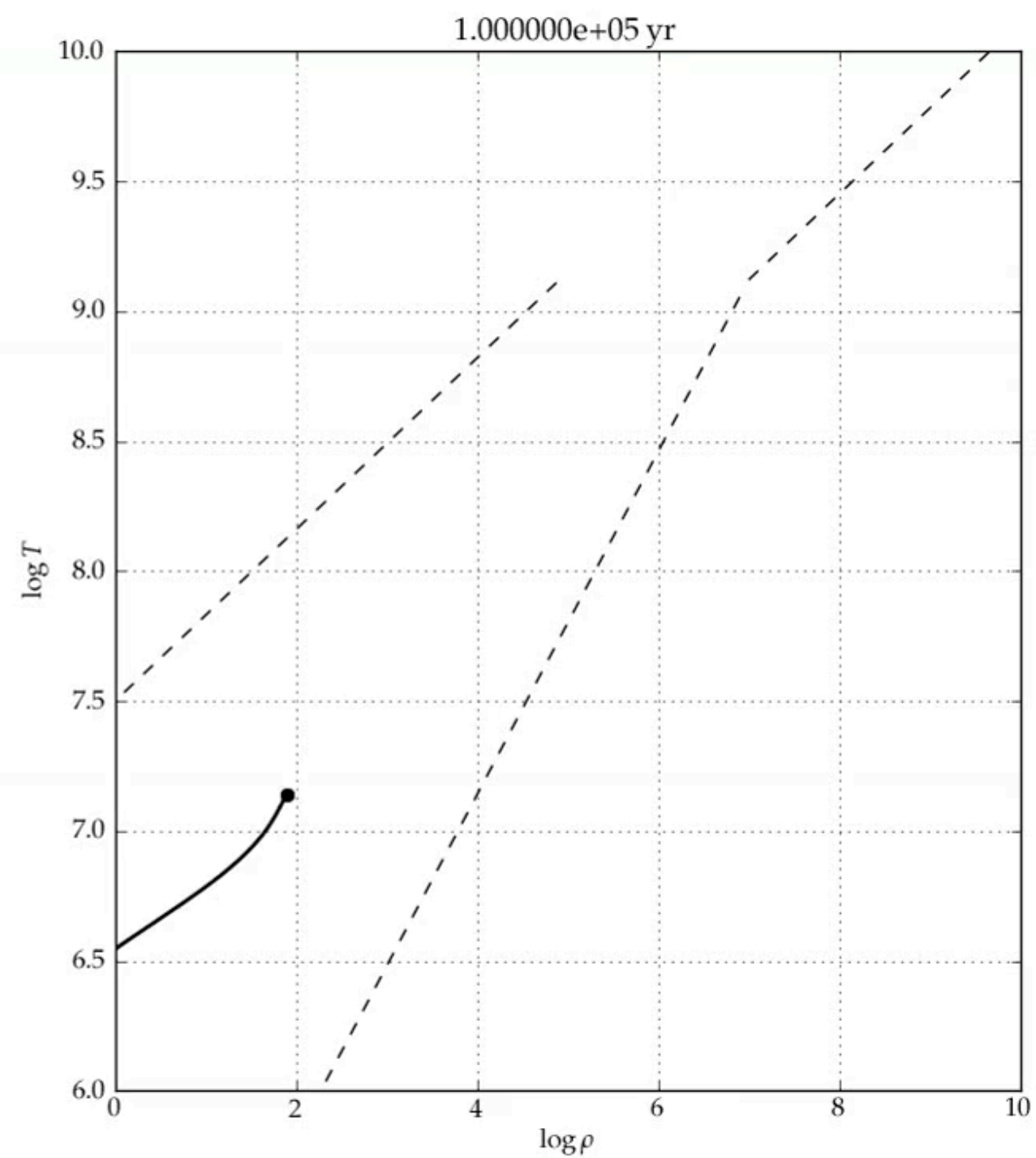
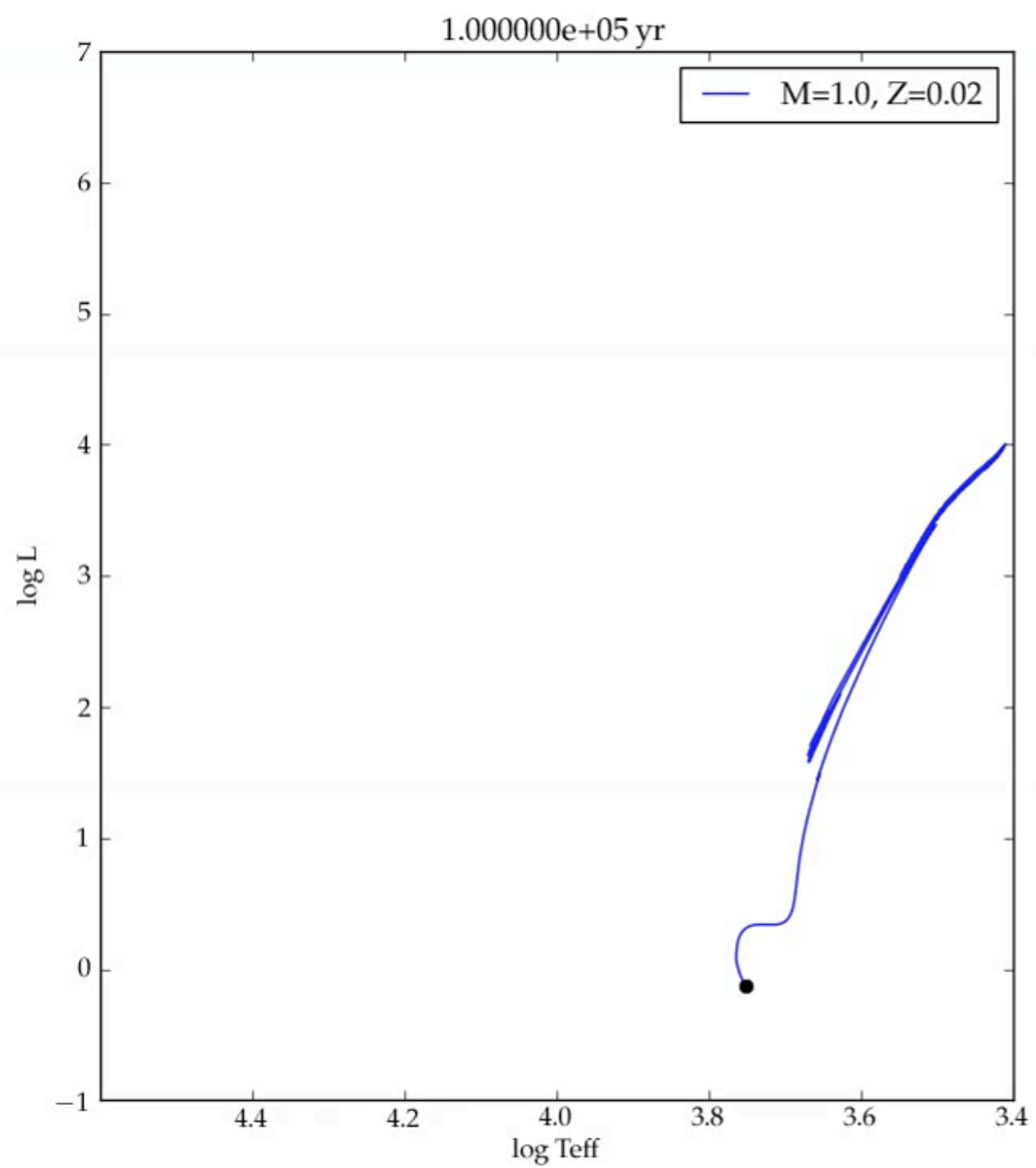
1 Msun (ρ - T)



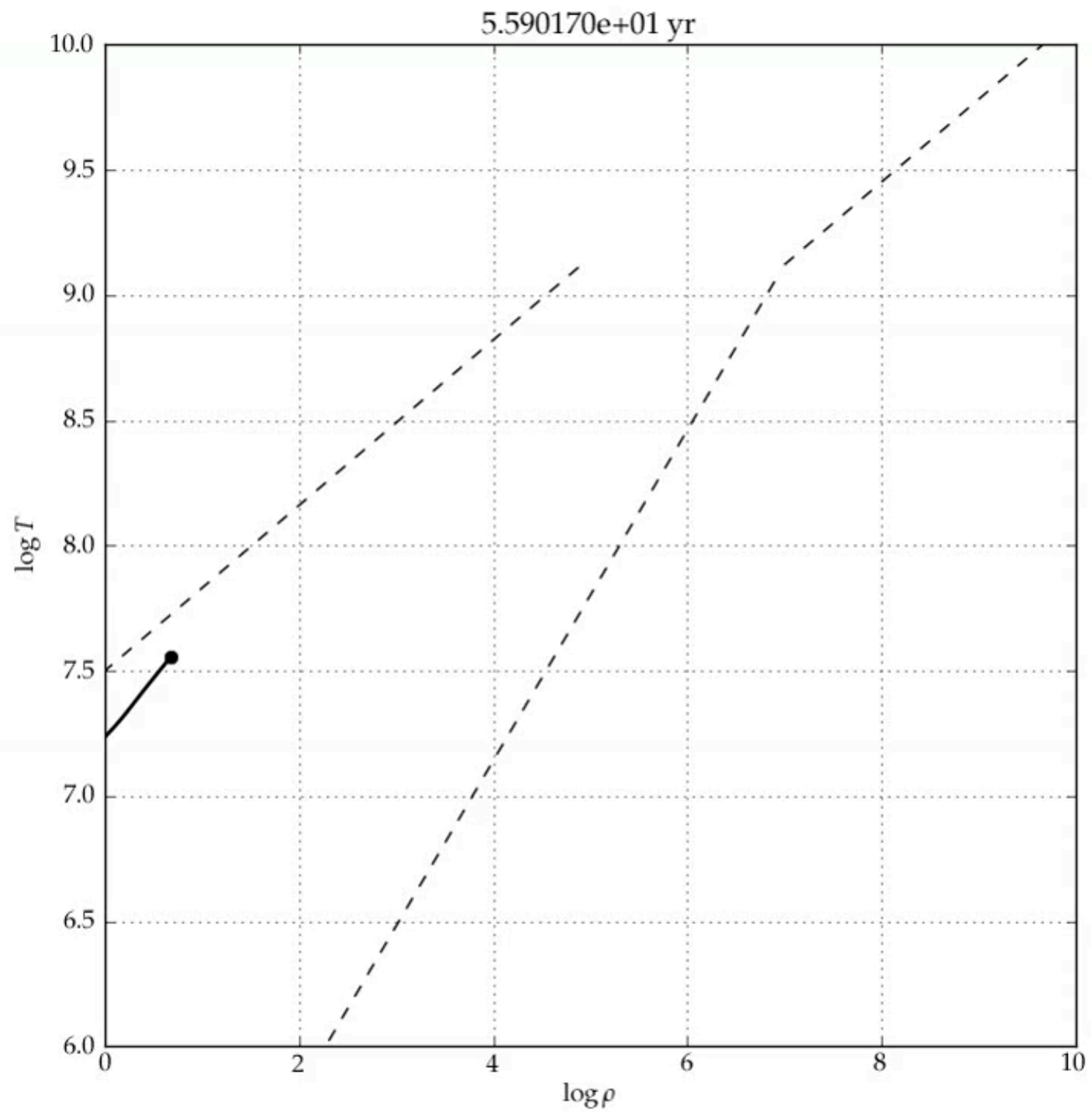
$$T \sim M^{2/3} \rho^{1/3}$$

1 Msun (HR diagram)

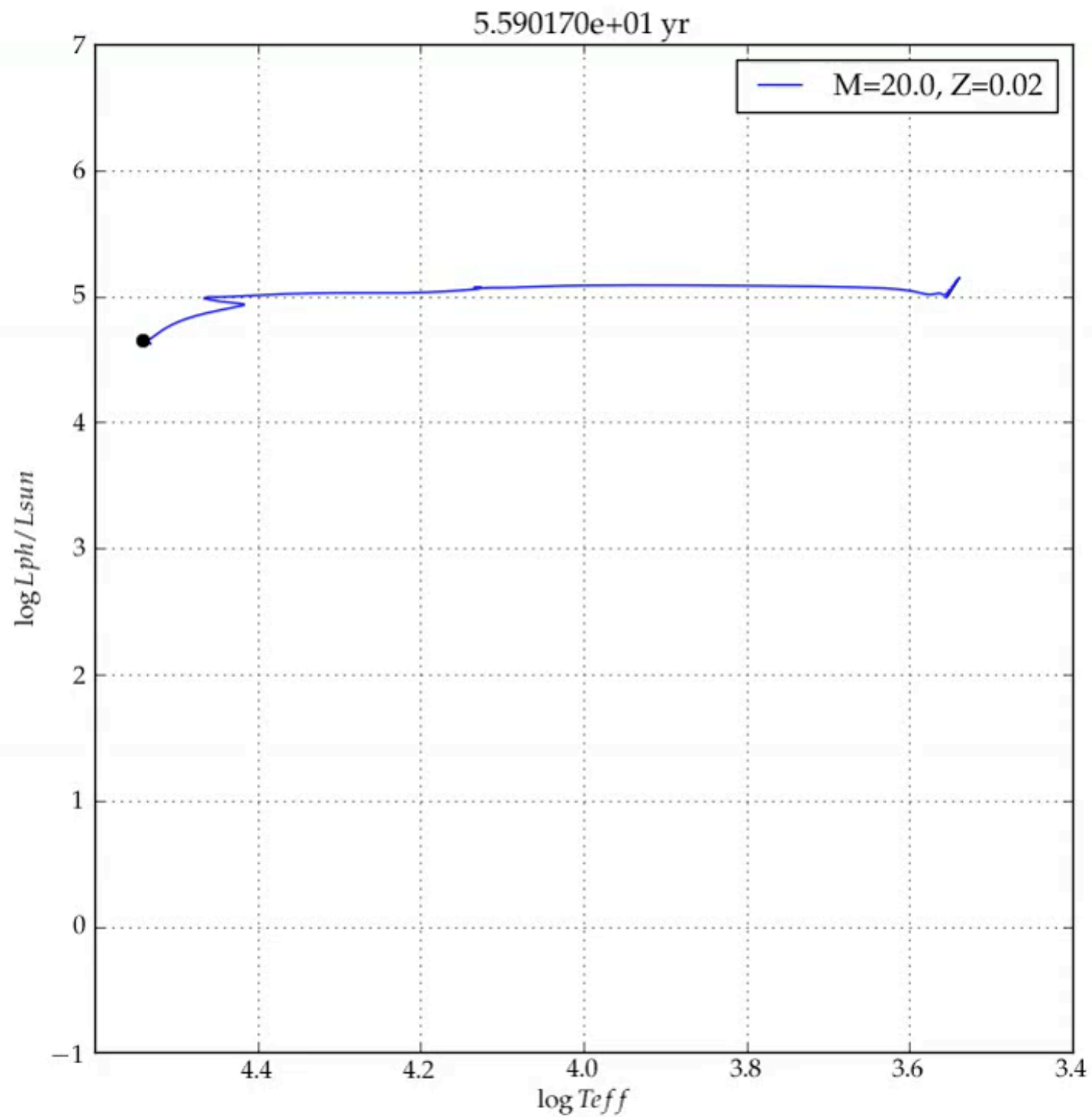


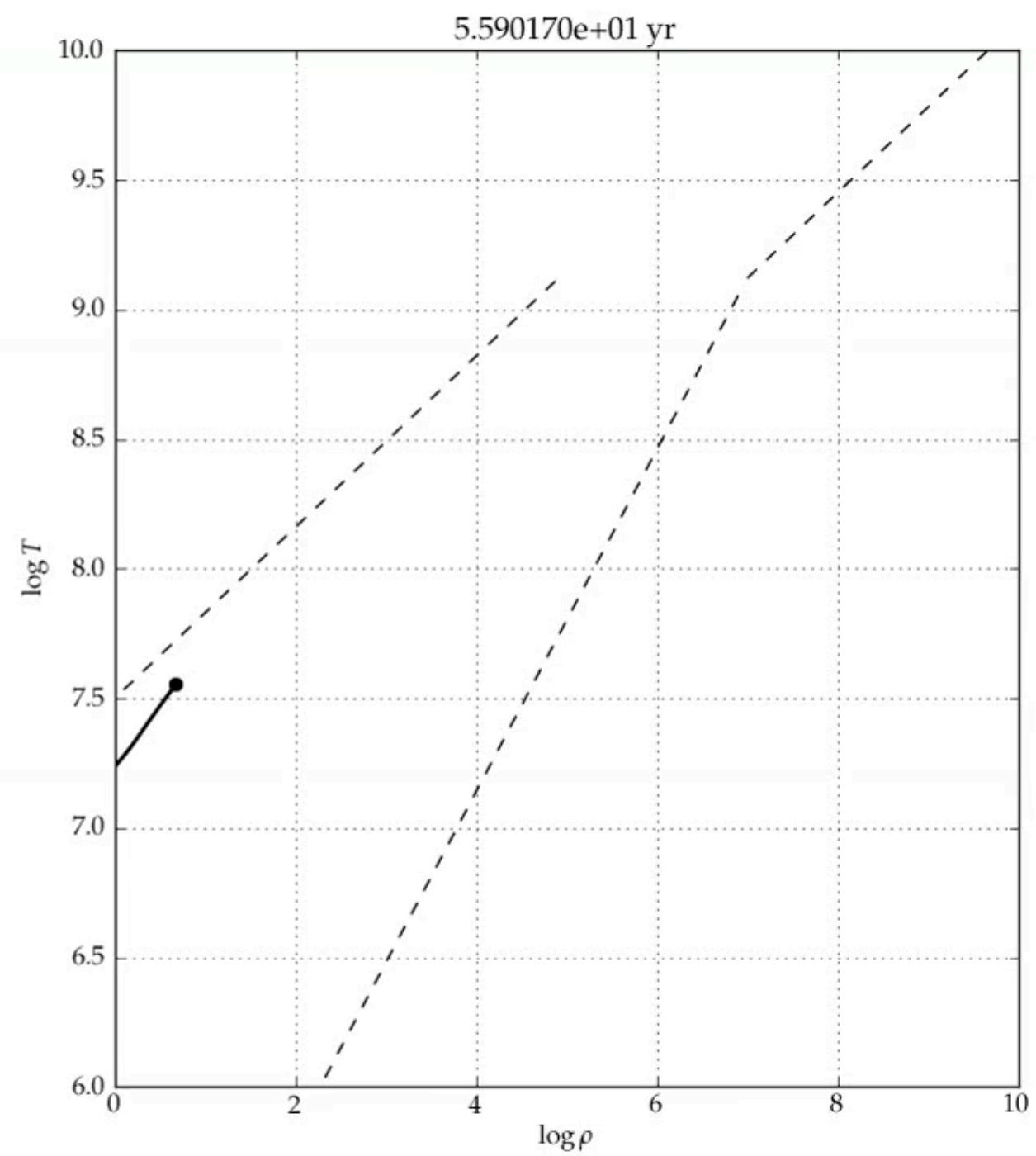
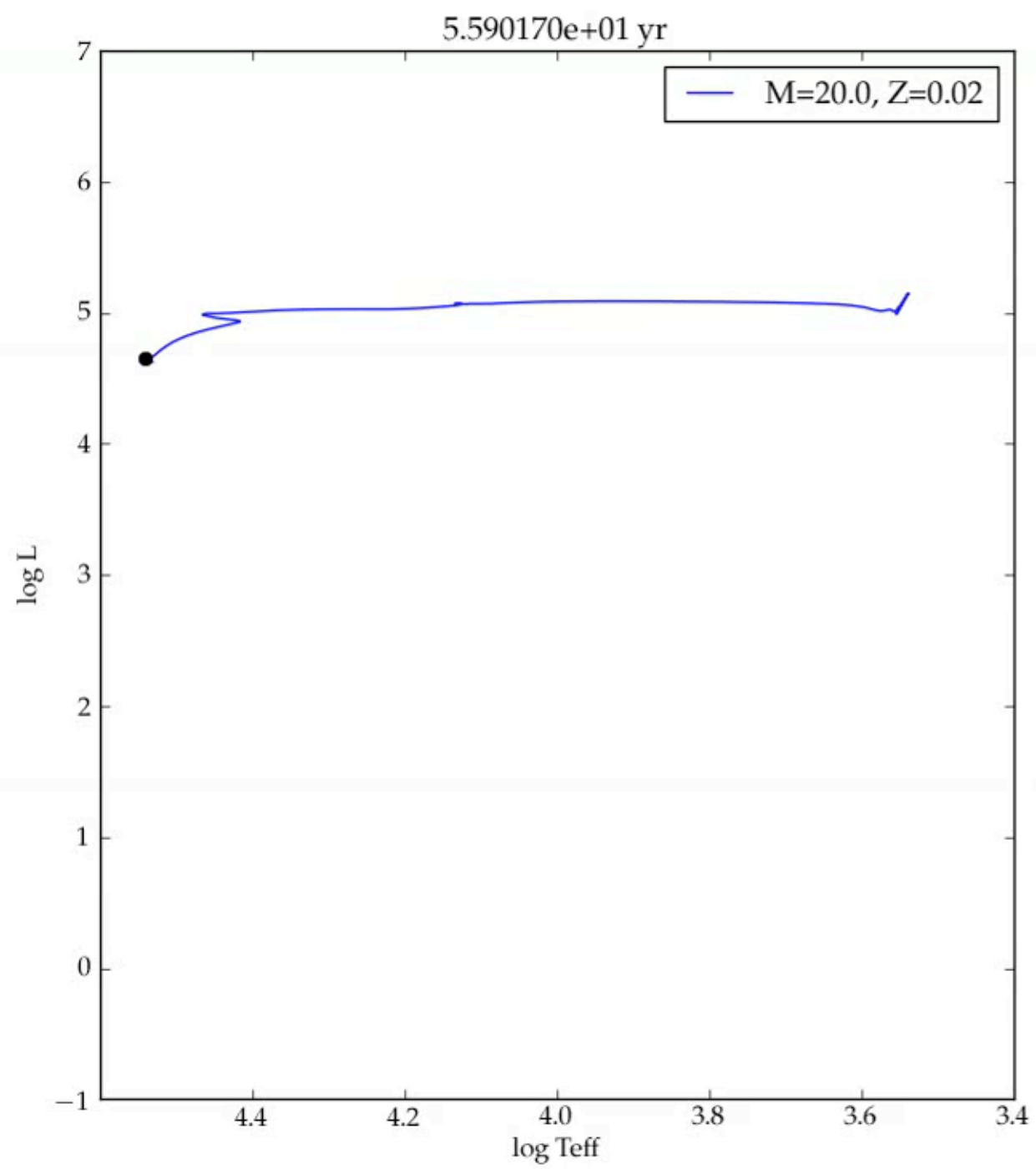


20 Msun (ρ - T)

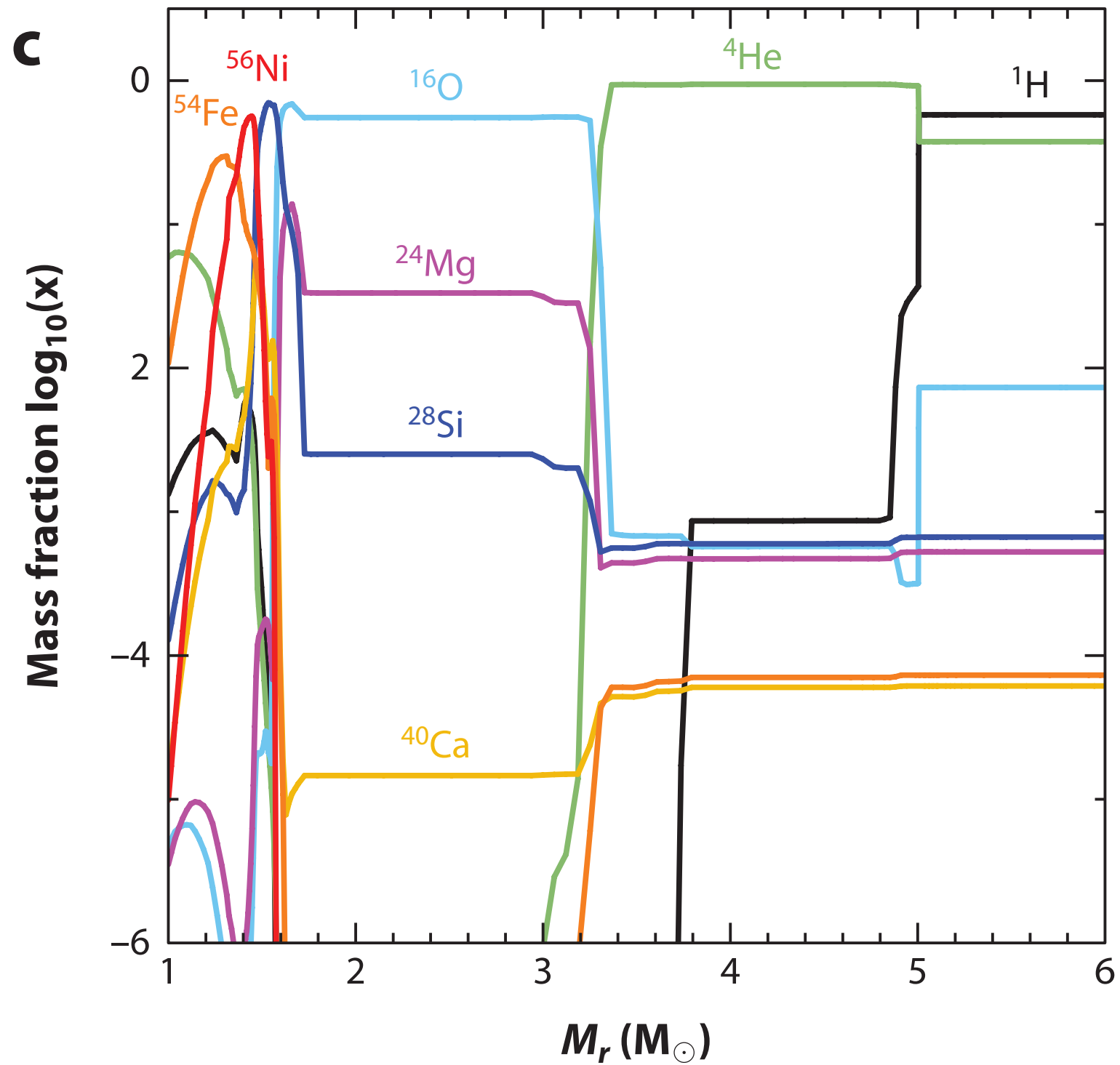


20 Msun (HR diagram)

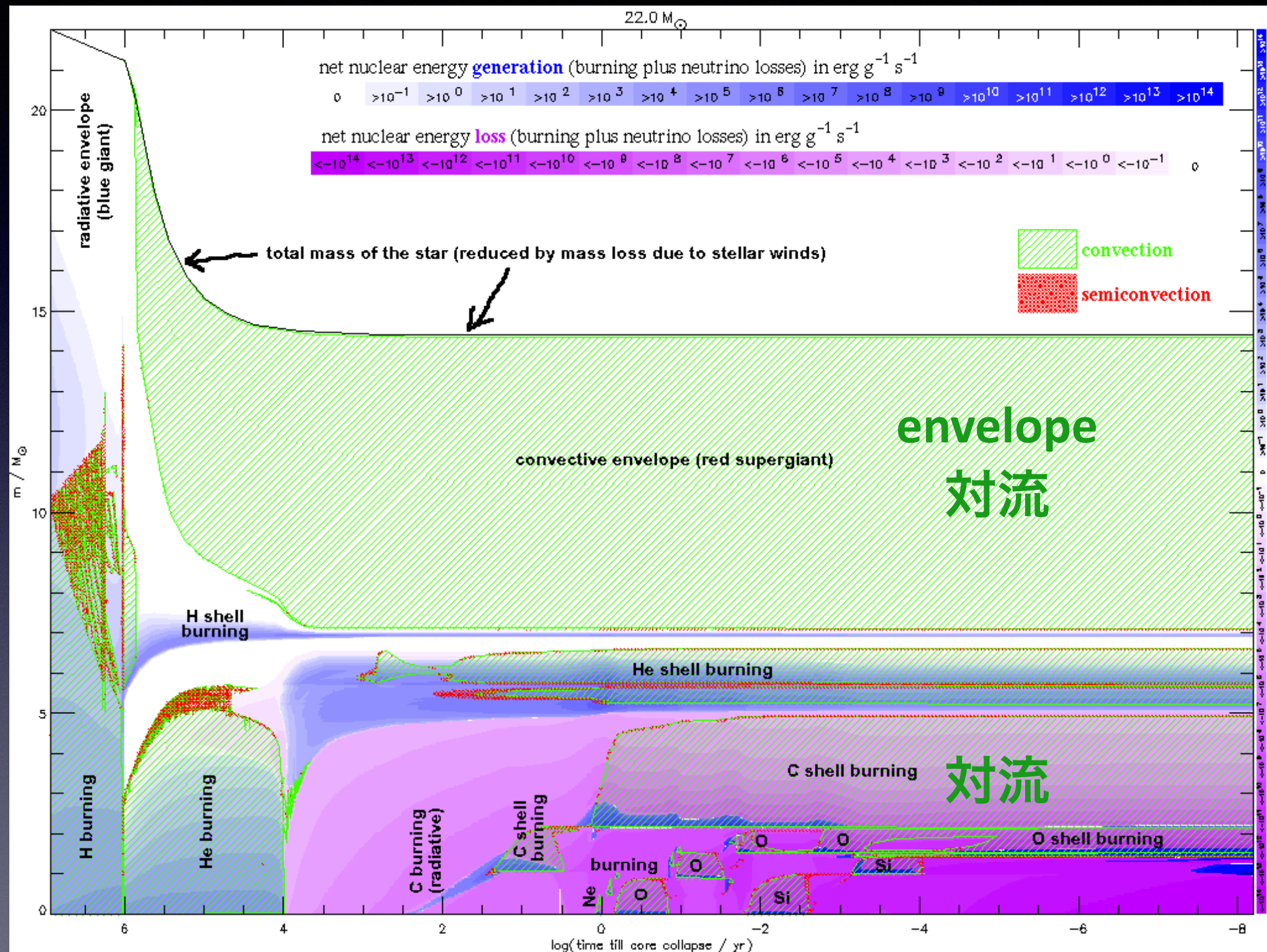




爆発直前の星の元素分布



星の進化：“Kippenhahn diagram”



(C) A. Heger

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

Section 6.

恒星の構造

6.1 恒星進化の計算

6.2 ポリトロープモデル

ポリトロープ

Lane (1870), Emden (1907)

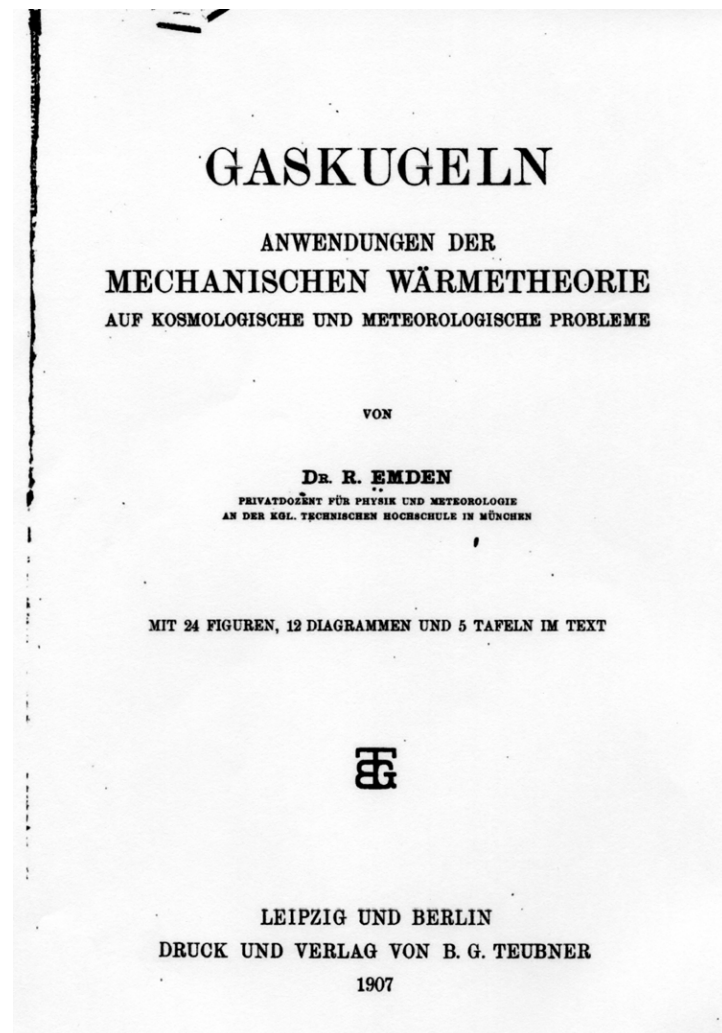


図 13 エムデンの「ガス球論」の表紙 ([34])

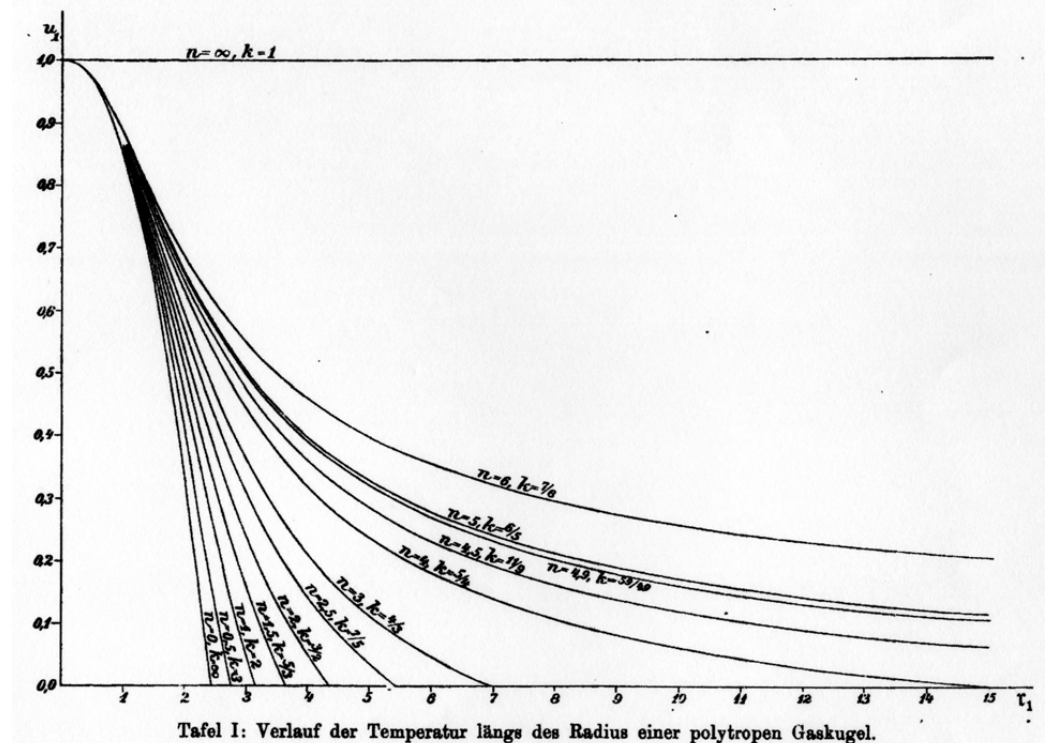


図 12 エムデンの無限の広がりを持つポリトロープ球内の相対的温度分布の計算例
パラメータは n はポリトロープ指数、 k は比熱比 γ にあたる。[34]

木暮 (2011)

https://tenkyo.net/kaiho/pdf/2011_01/2011-01-03.pdf

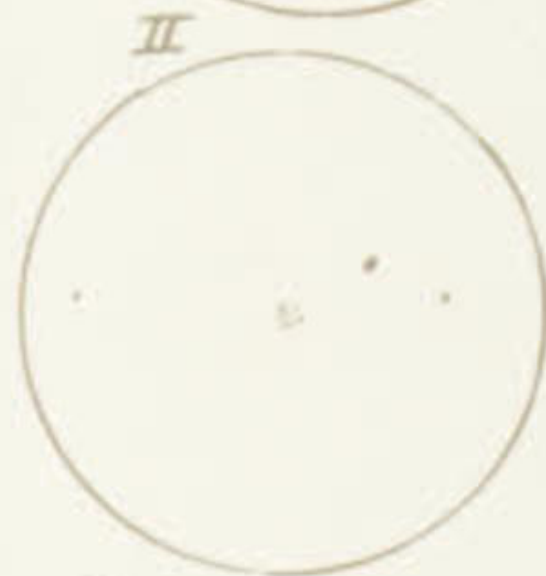
History of Modern Astronomy

現代天文学史



天体物理学の源流と開拓者たち

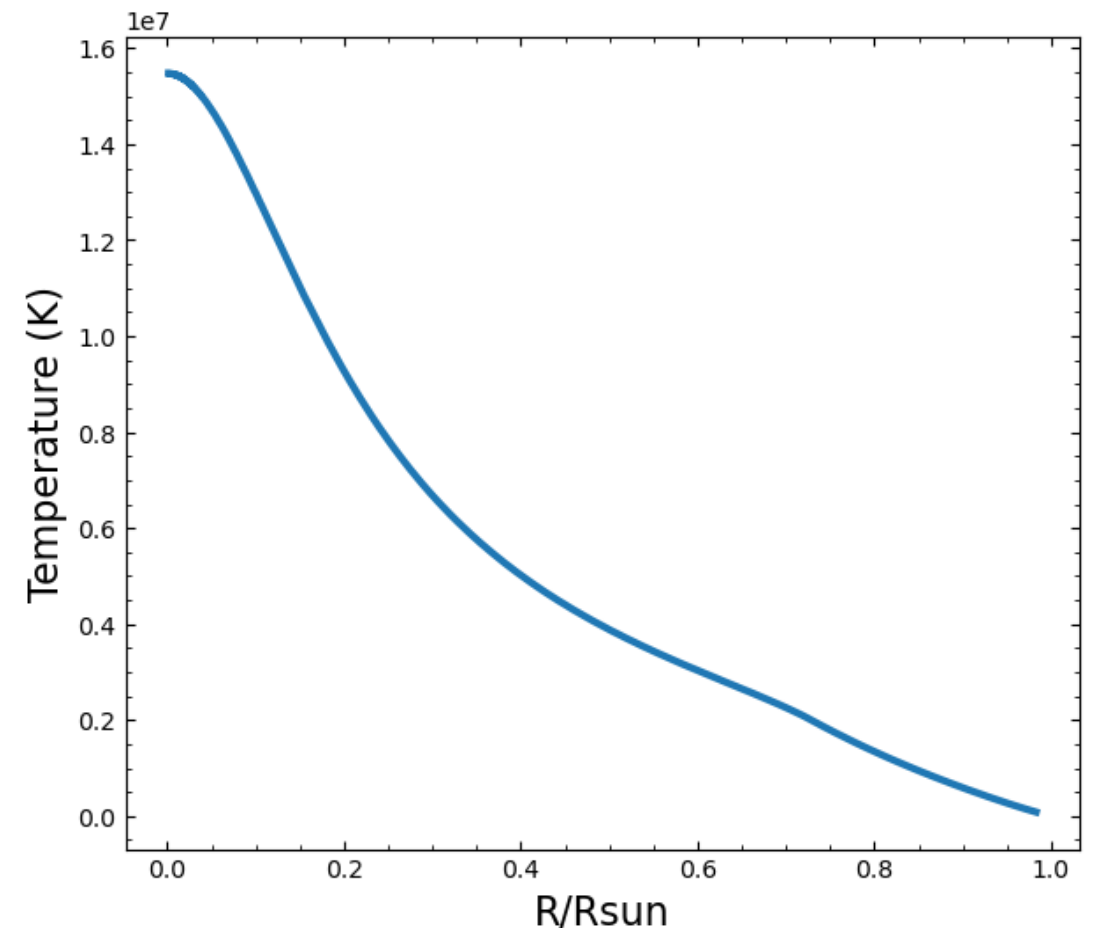
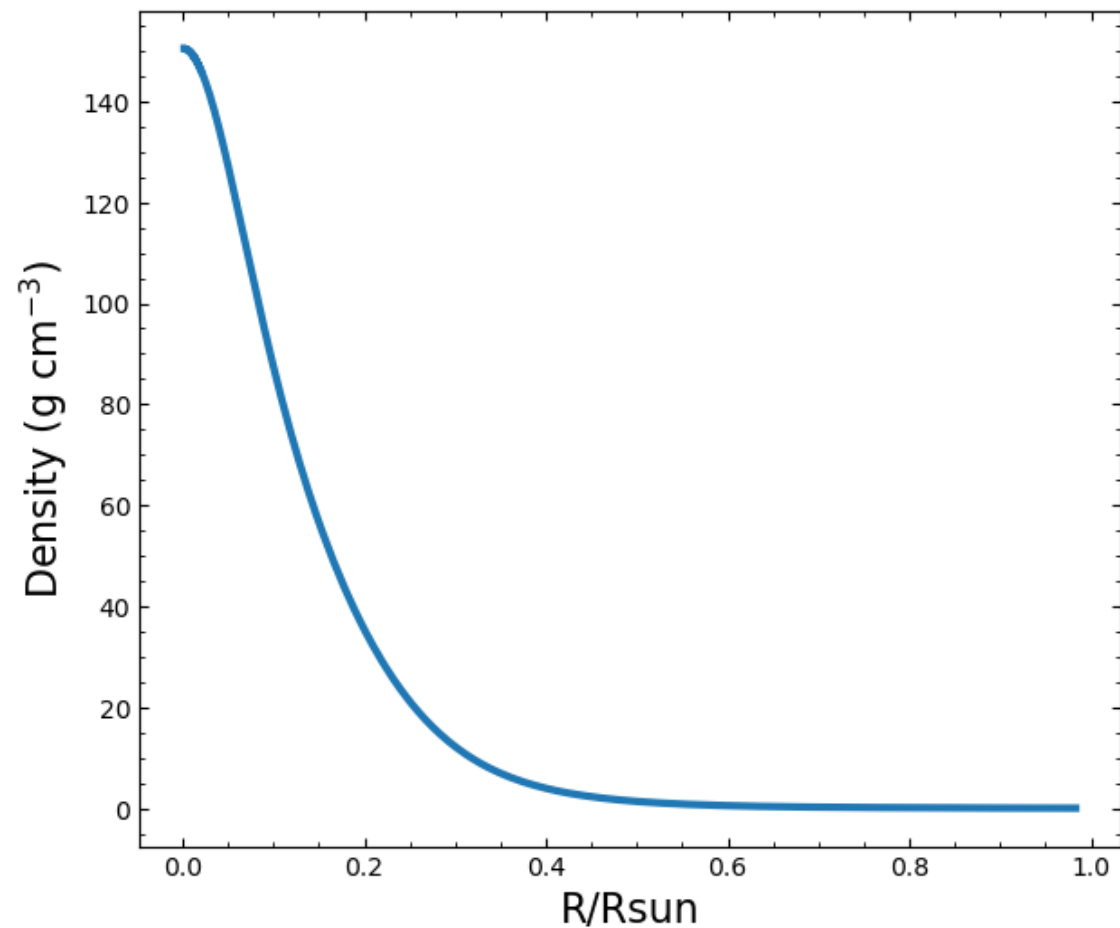
小暮智一
Tomoharu Kogure



*I think the situation
is now like in Fig 3
but it is so hazy
that I could only imagine
I saw the second star &*

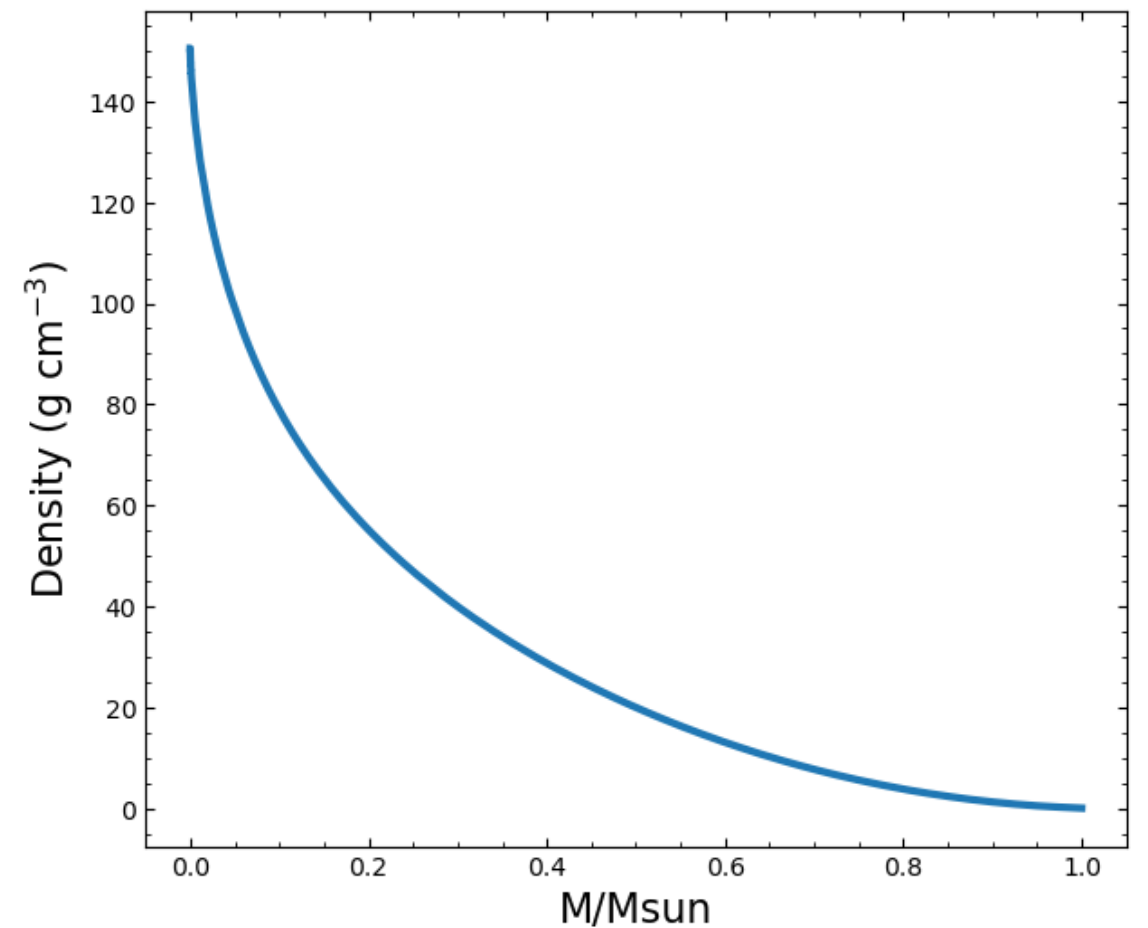
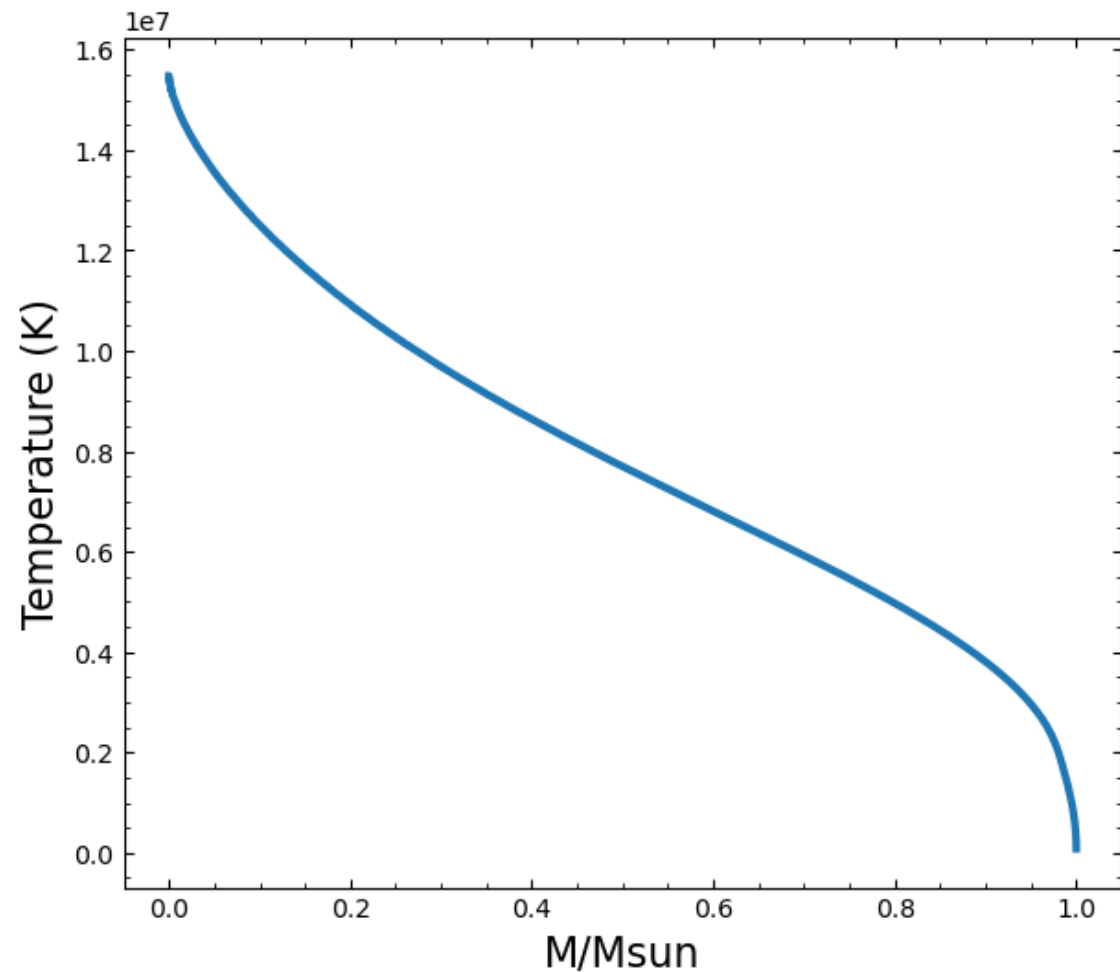
京都大学学術出版会

Standard Solar Model



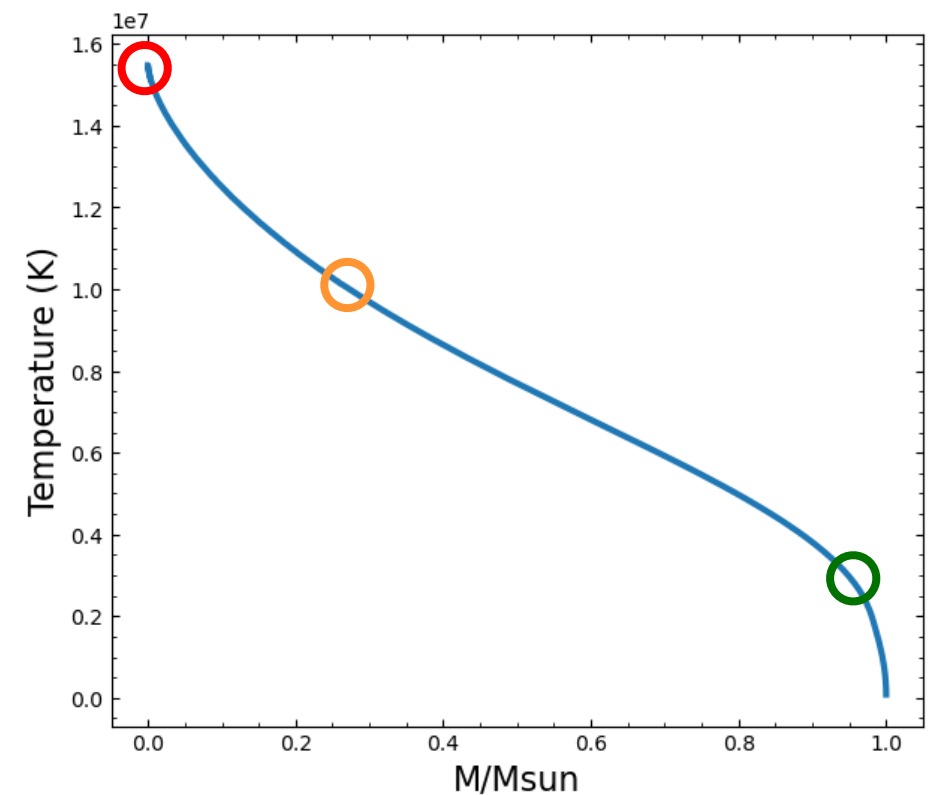
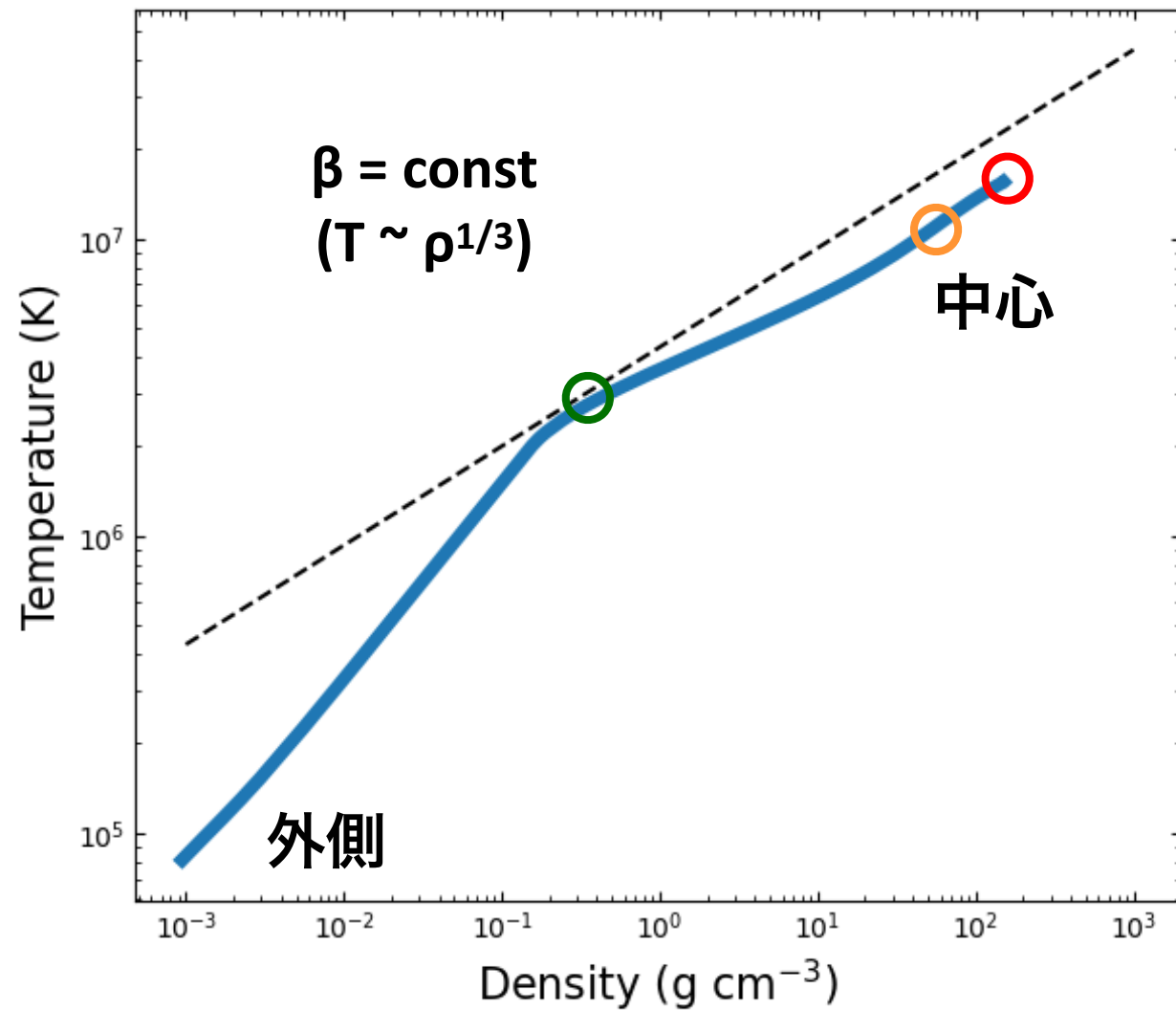
<https://www.sns.ias.edu/~jnb/SNdata/sndata.html>

Standard Solar Model



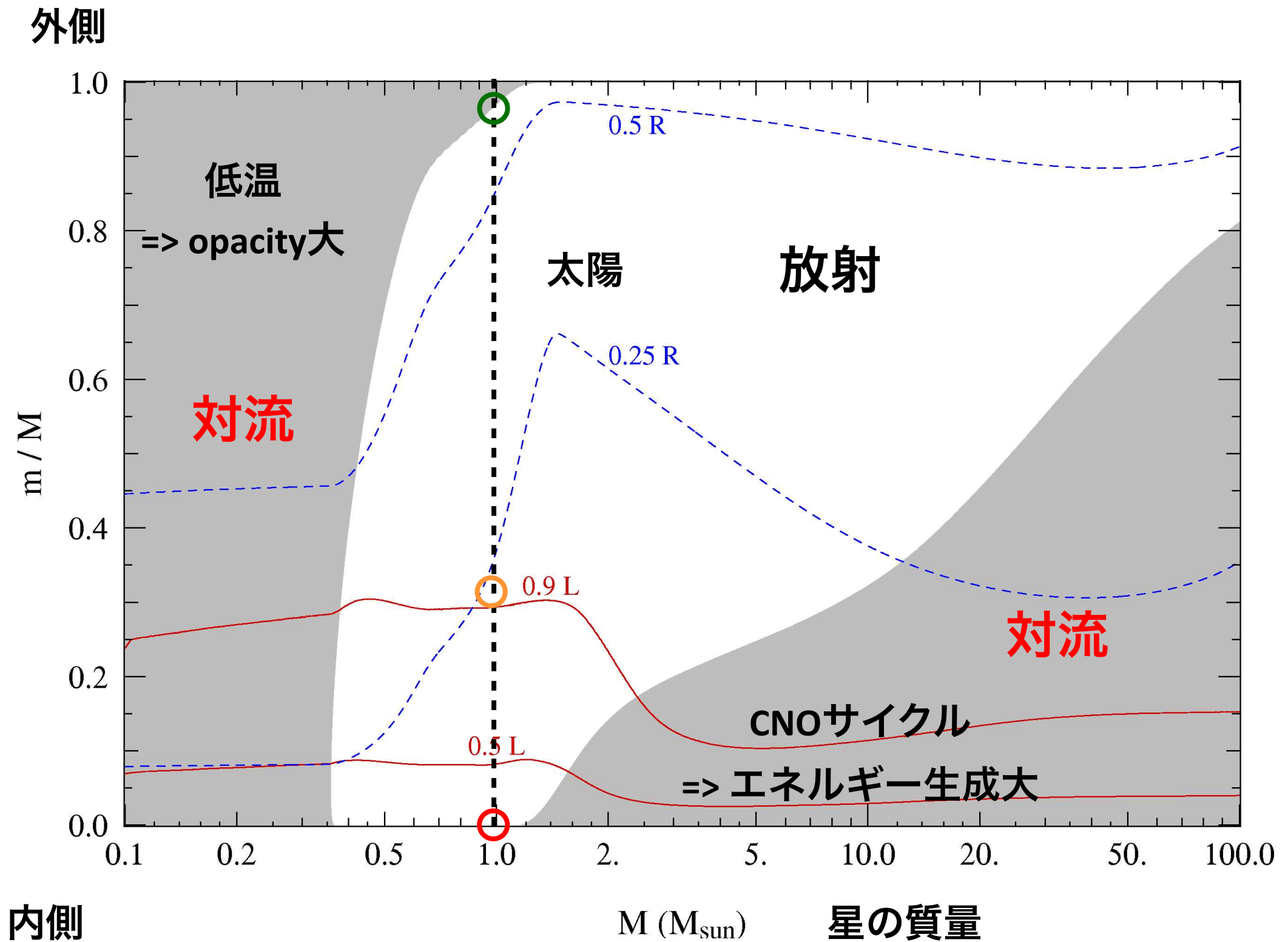
<https://www.sns.ias.edu/~jnb/SNdata/sndata.html>

Standard Solar Model



<https://www.sns.ias.edu/~jnb/SNdata/sndata.html>

星内部のエネルギー輸送



レポート課題 5

5-1. $n=1.5, 3$ の場合にレーンエムデン方程式を数値的に解け

(解いた方法も簡単に説明すること)

5-2. ポリトロープモデル ($n=1.5, 3$)の結果とStandard Solar Modelを比較し、考察せよ。

まとめ

- 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

- ポリトロープモデル

- $P = K \rho^{1+1/n}$ でかける場合
 - 縮退圧：EOS自体がこの形
 - 対流：星の構造がこの関係を満たす (断熱勾配)
 - エディントン標準モデル： ($\beta = P_{\text{gas}}/P = \text{const}$)