Helium Flash Structure Dependence on the Core Energy Balance: Imprints on ΔPg

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Overview

- The Helium flash occurs for low-mass stars: $0.6 - 2.0 M_{\odot}$.

- Core energy perturbations determine whether the ignition results in a single centered flash or an off-centered sequence of subflashes.
  Driven primarily by the central stronger emission of thermal neutrinos.

- Helium flash detection challenge: Asteroseismology (ΔP_g) & Subdwarfs are the solution.

- MESA simulations allow an analysis to correlate the ΔP_g and the energy distribution in the core.

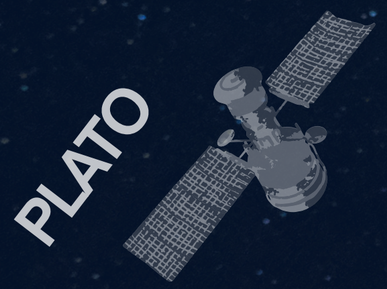
Asteroseismology

STANDARD

$$\Delta P_g = P_{n+1} - P_n$$

ASYMPTOTIC LIMIT

$$\Delta P_g \approx \frac{2\pi^2}{\sqrt{l(l+1)}\int_{r_1}^{r_2} \frac{N}{r} dr}$$



Early Results: Numerical Simulations

Isothermal Model

Central Energy Perturbations Models

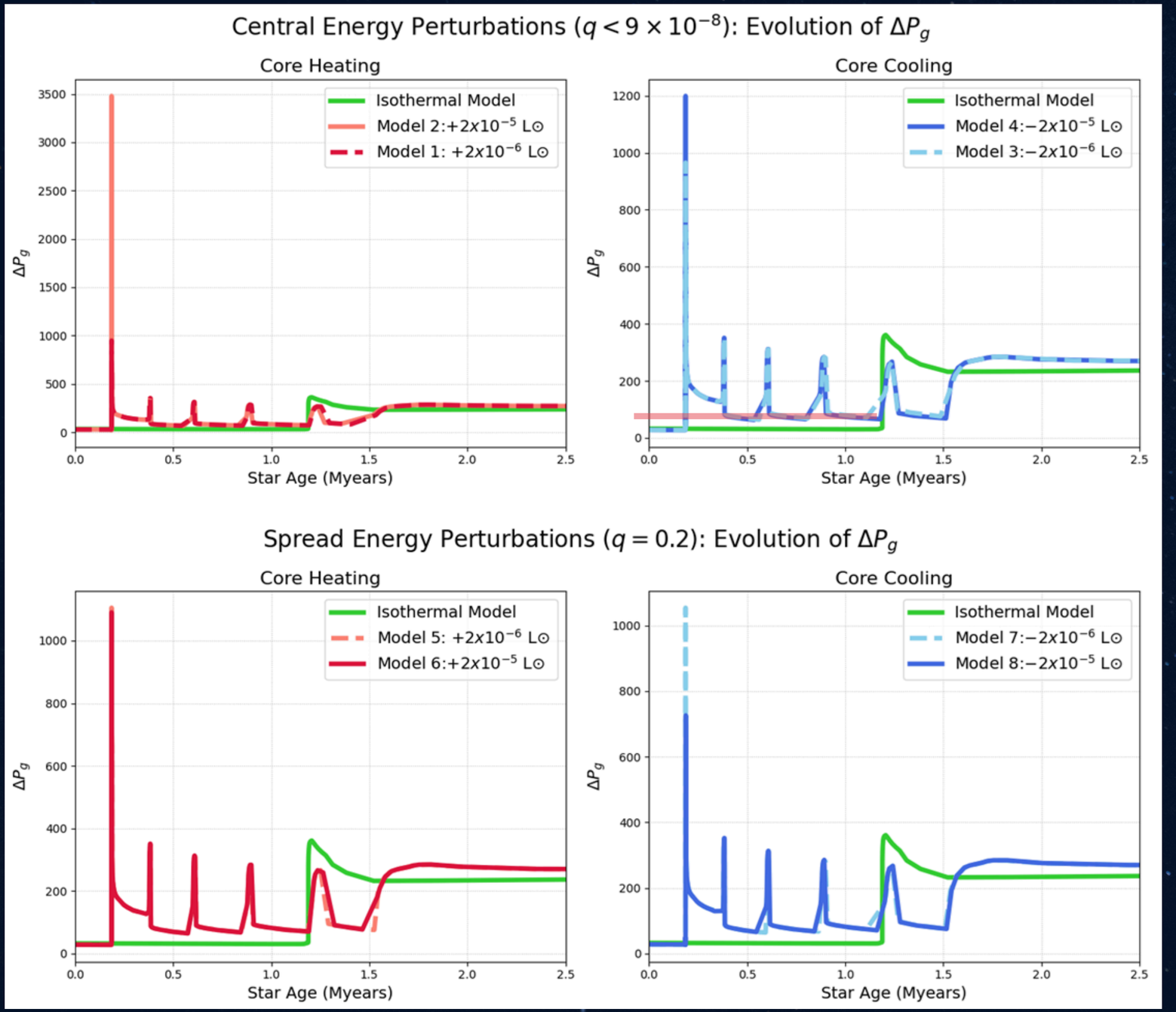
	Energy ($L_\odot$)	Mass Coord. (q)
Model 1:	$+2 \times 10^{-6}$	$< 9 \times 10^{-8}$
Model 2:	$+2 \times 10^{-5}$	$< 9 \times 10^{-8}$

	Energy ($L_\odot$)	Mass Coord. (q)
Model 3:	-2×10^{-6}	$< 9 \times 10^{-8}$
Model 4:	-2×10^{-5}	$< 9 \times 10^{-8}$

Spread Energy Perturbations Models

	Energy ($L_\odot$)	Mass Coord. (q)
Model 5:	$+2 \times 10^{-6}$	0.2
Model 6:	$+2 \times 10^{-5}$	0.2

	Energy ($L_\odot$)	Mass Coord. (q)
Model 7:	-2×10^{-6}	0.2
Model 8:	-2×10^{-5}	0.2


Central Energy Perturbations ($q < 9 \times 10^{-8}$): Evolution of ΔP_g
Core Heating
Isothermal Model
Model 2:+2x10^{-5} L⊙
Model 1: +2x10^{-6} L⊙
ΔP_g
Star Age (Myears)
Core Cooling
Isothermal Model
Model 4:−2x10^{-5} L⊙
Model 3:−2x10^{-6} L⊙
ΔP_g
Star Age (Myears)
Spread Energy Perturbations ($q = 0.2$): Evolution of ΔP_g
Core Heating
Isothermal Model
Model 5: +2x10^{-6} L⊙
Model 6:+2x10^{-5} L⊙
ΔP_g
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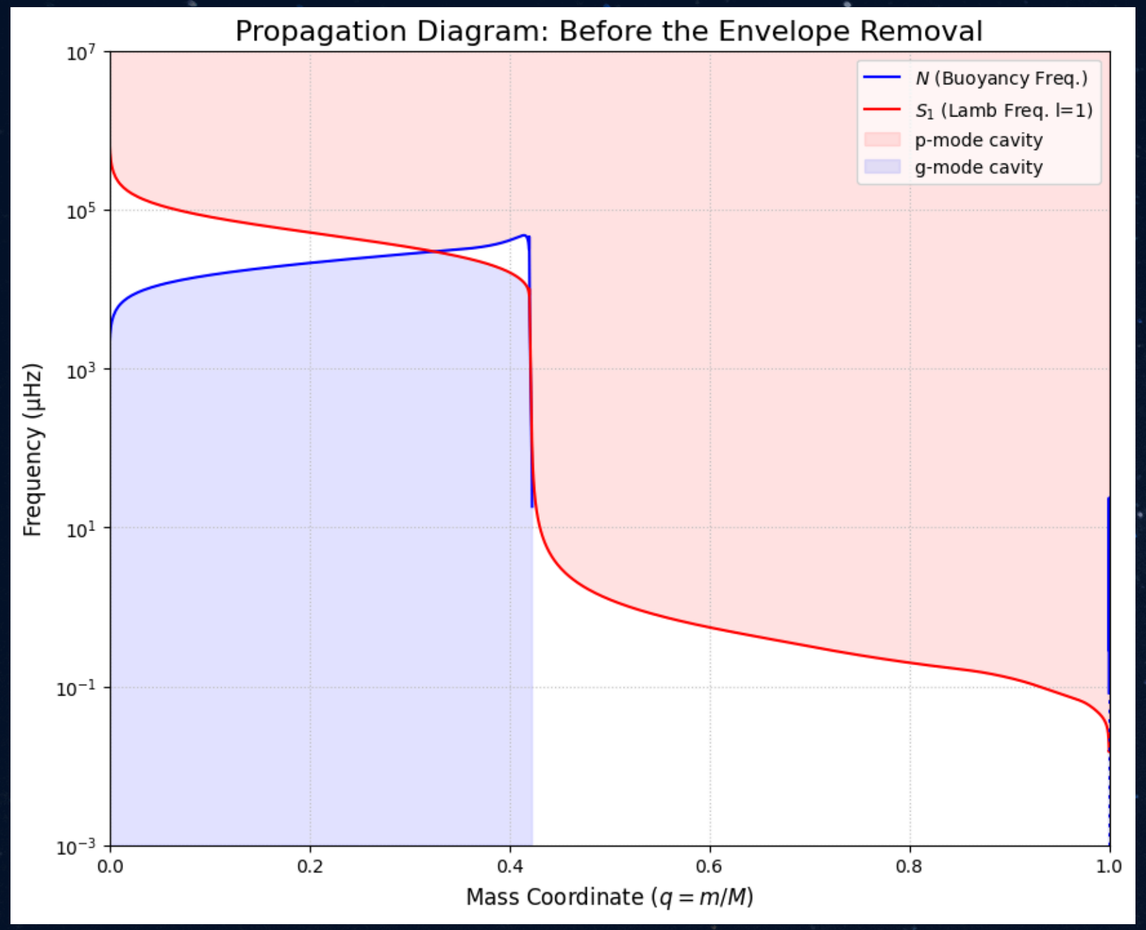
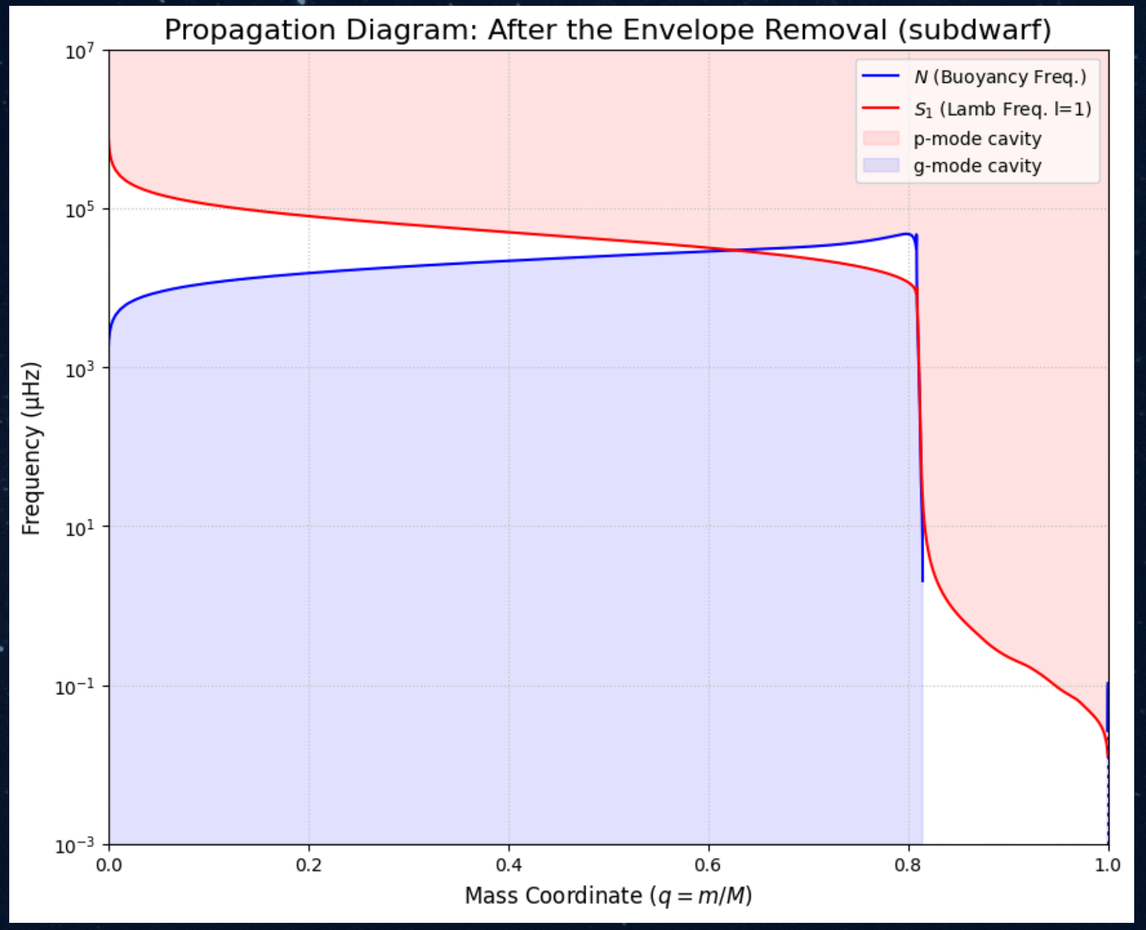
ΔP_g
Star Age (Myears)

Appendix: Propagation Diagrams





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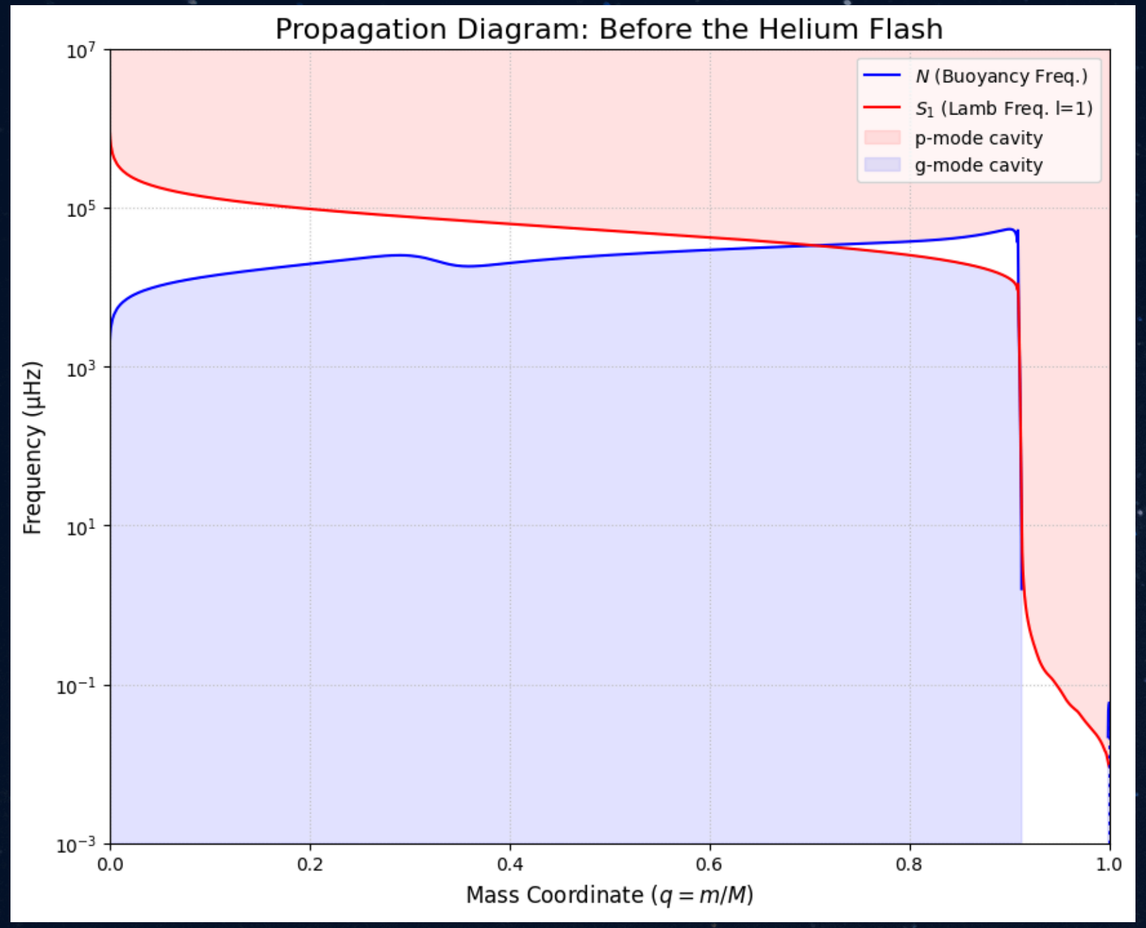

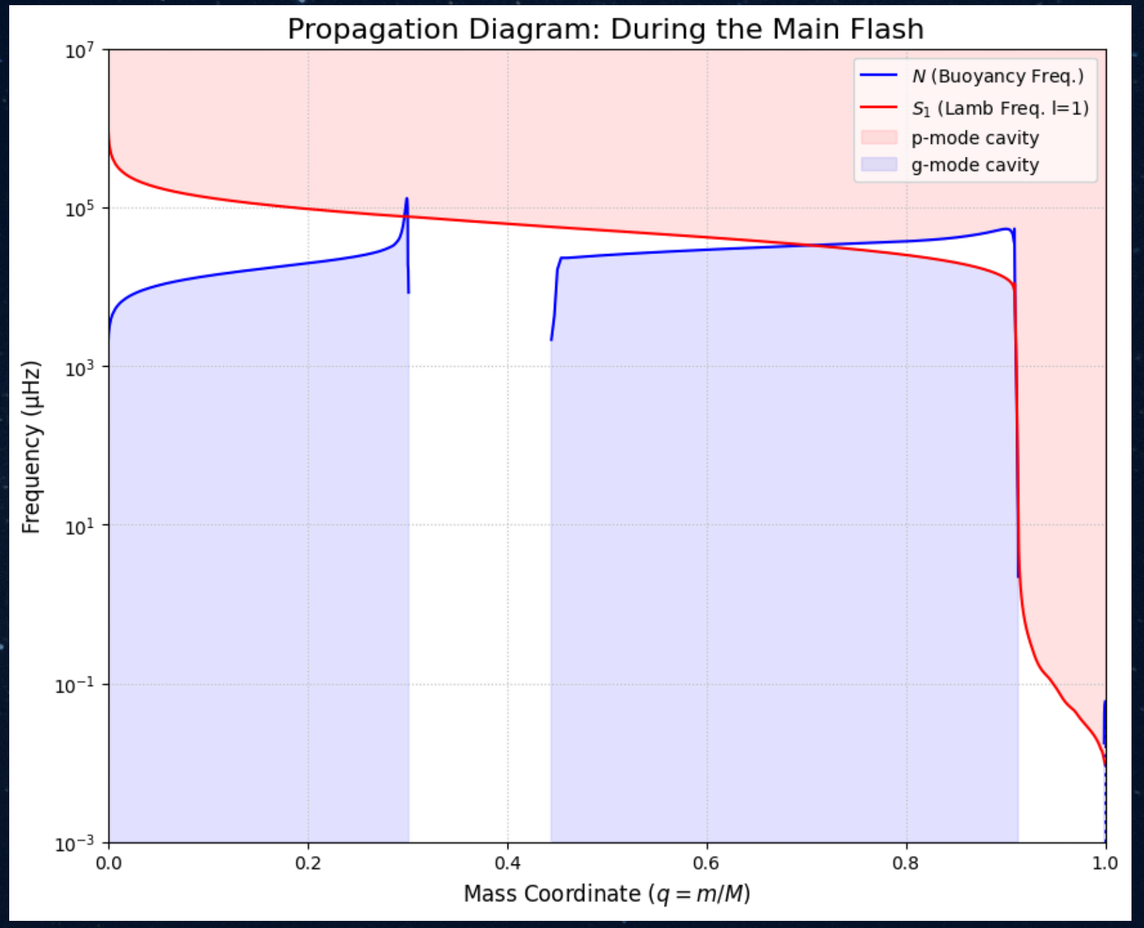

Appendix: Helium Flash Structure

Isothermal Core

No energy perturbation

Maximum temperature at the center

Centered Single Flash

Non-isothermal Core

Dark matter annihilation

Emission of thermal neutrinos

Shift the point of maximum temperature

Off -centered Ignition + Subflash sequence