The background of the slide is a dark blue, textured surface resembling a spiral-bound notebook. At the top, there is a black horizontal band with a series of silver-colored metal rings, representing the spiral binding. The main body of the notebook is a deep blue color with a fine, grainy texture.

Vibrational instability of population III stars due to the ε -mechanism

Hiroto Shibahashi
(University of Tokyo)

in collaboration with Takafumi Sonoi

“Solar Spoon”

**Dilke, F.W.W. & Gough, D.O. 1972,
Nature, 240, 262**

**Local analysis for vibrational instability of
gravity waves in the sun and
the resultant mixing and intermittence of
nuclear burning as a possible solution to
the solar neutrino problem**

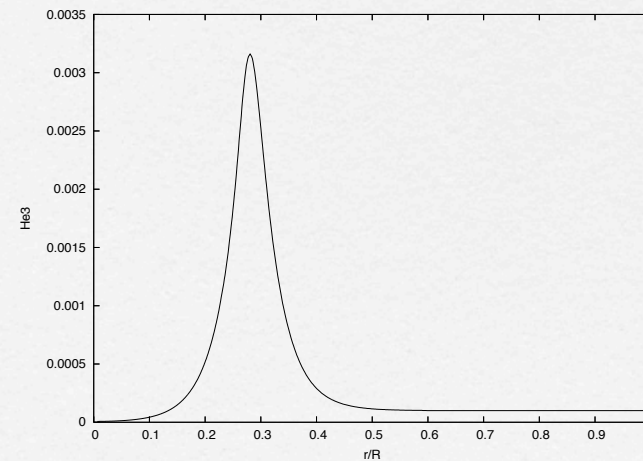
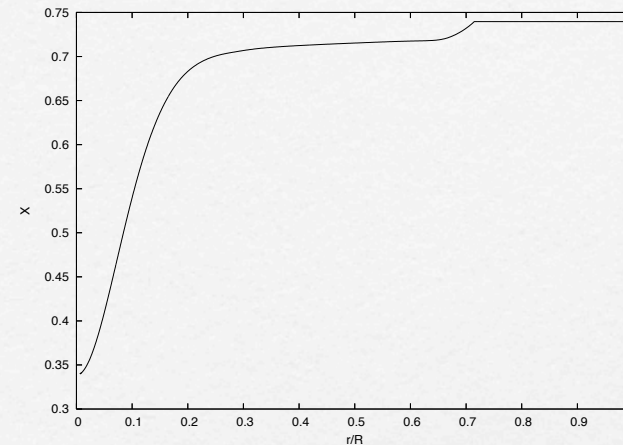
pp-chain



(1) slow, $\epsilon_T \approx 4$

(2) fast

(3) fast, T-sensitive



Global analysis of g-modes stability

- Dziembowski+ Warsaw group 1973**
- J.C-D+ Cambridge group 1974**
- Boury+ Liege group 1975**
- Shibahashi+ Tokyo group 1975**

presence of convective envelope

⇒ uncertain conclusion

common practice

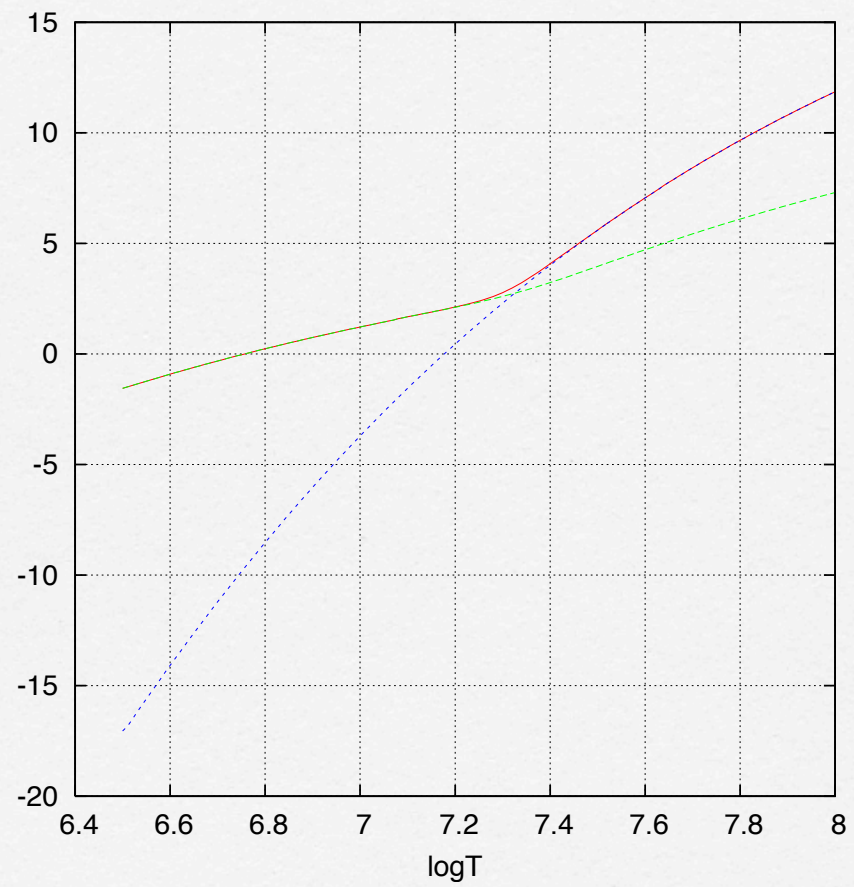
**$M < 1.5M_{\text{sun}}$: pp-chain
radiative core
convective envelope**

**$M > 1.5M_{\text{sun}}$: CNO cycle
convective core
radiative envelope**

Population III stars

**the 1st generation stars
no metal
no CNO cycle
only pp-chain**

$\log \epsilon$

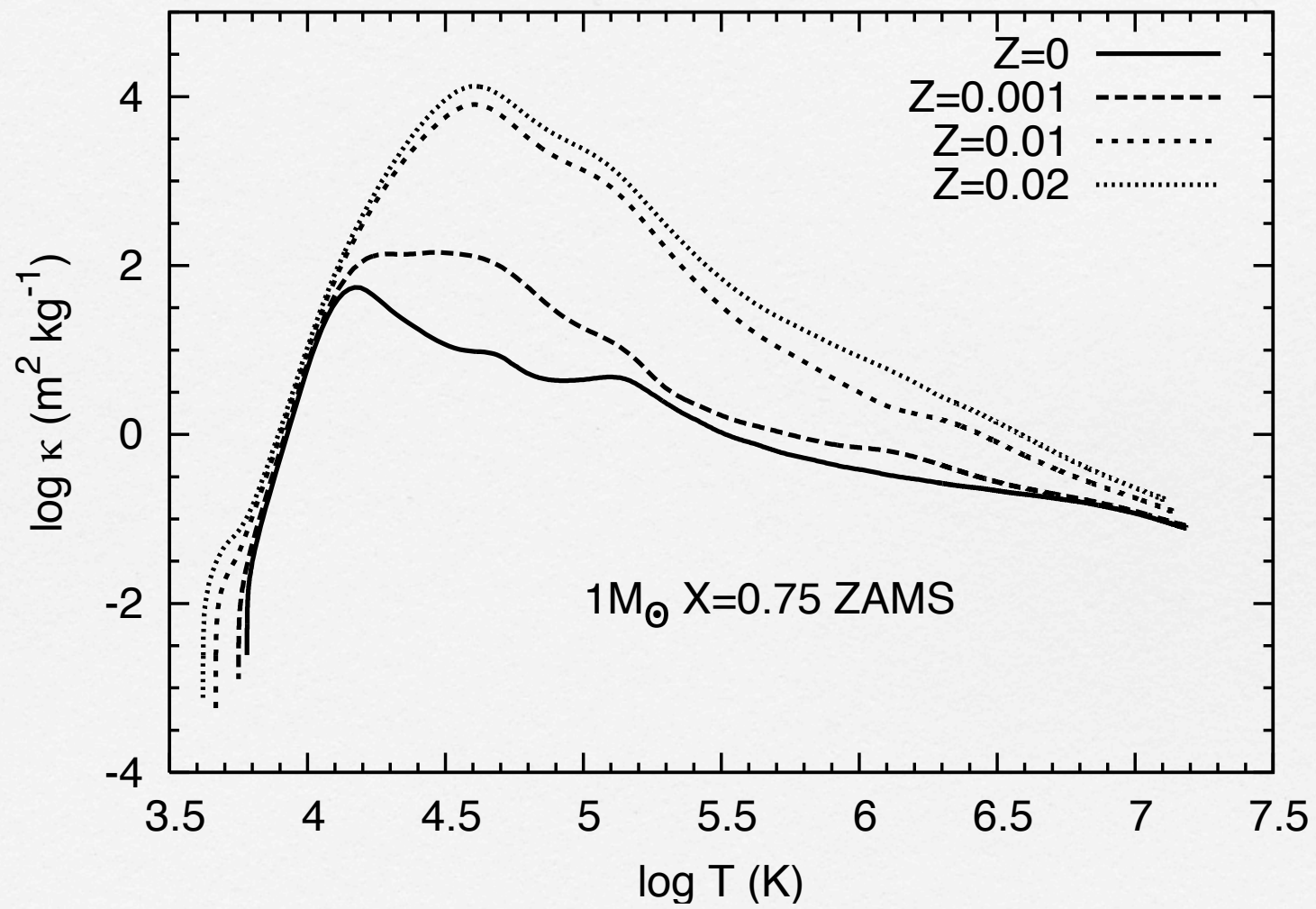


$$\rho \propto M/R^3$$

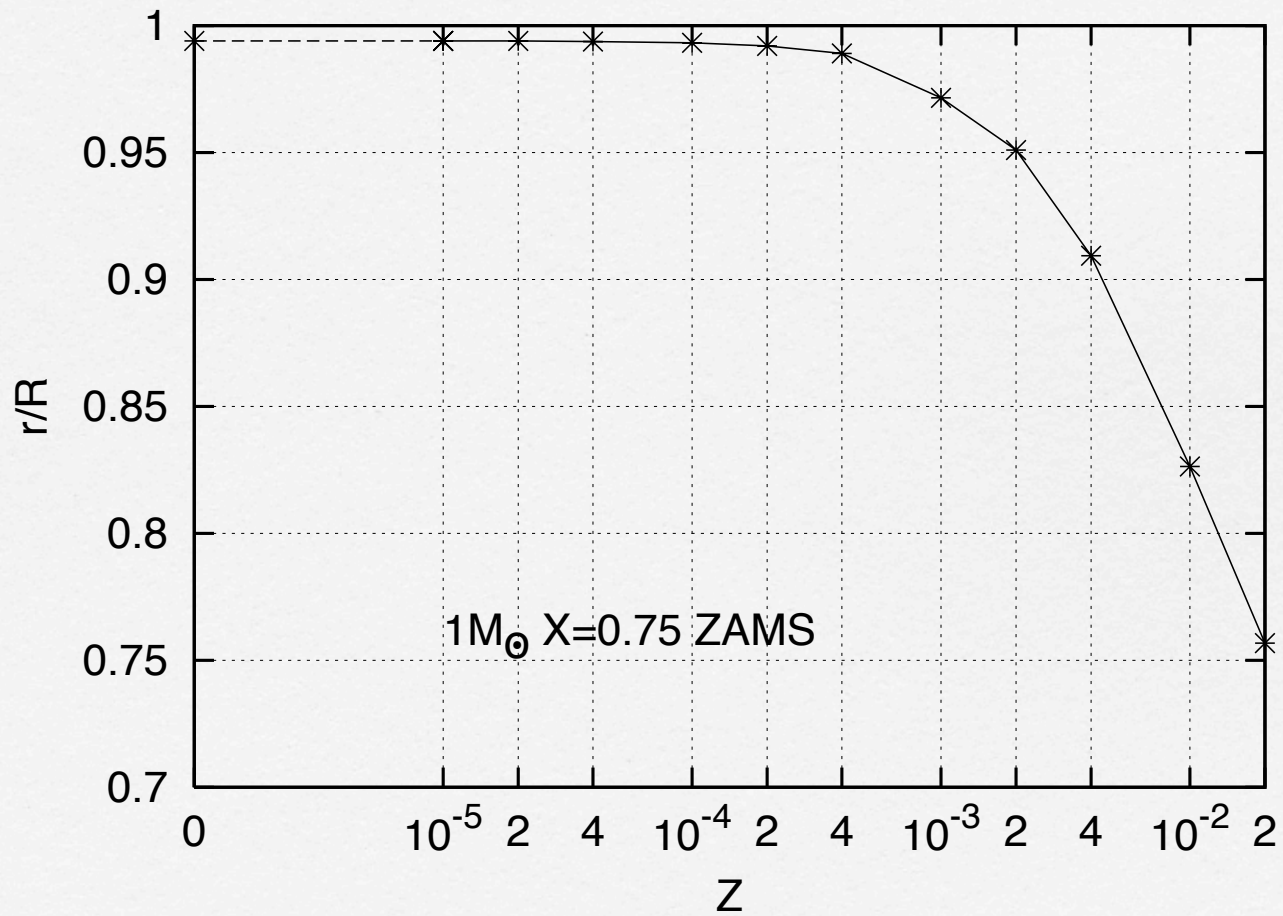
$$p_c \propto GM^2/R^4$$

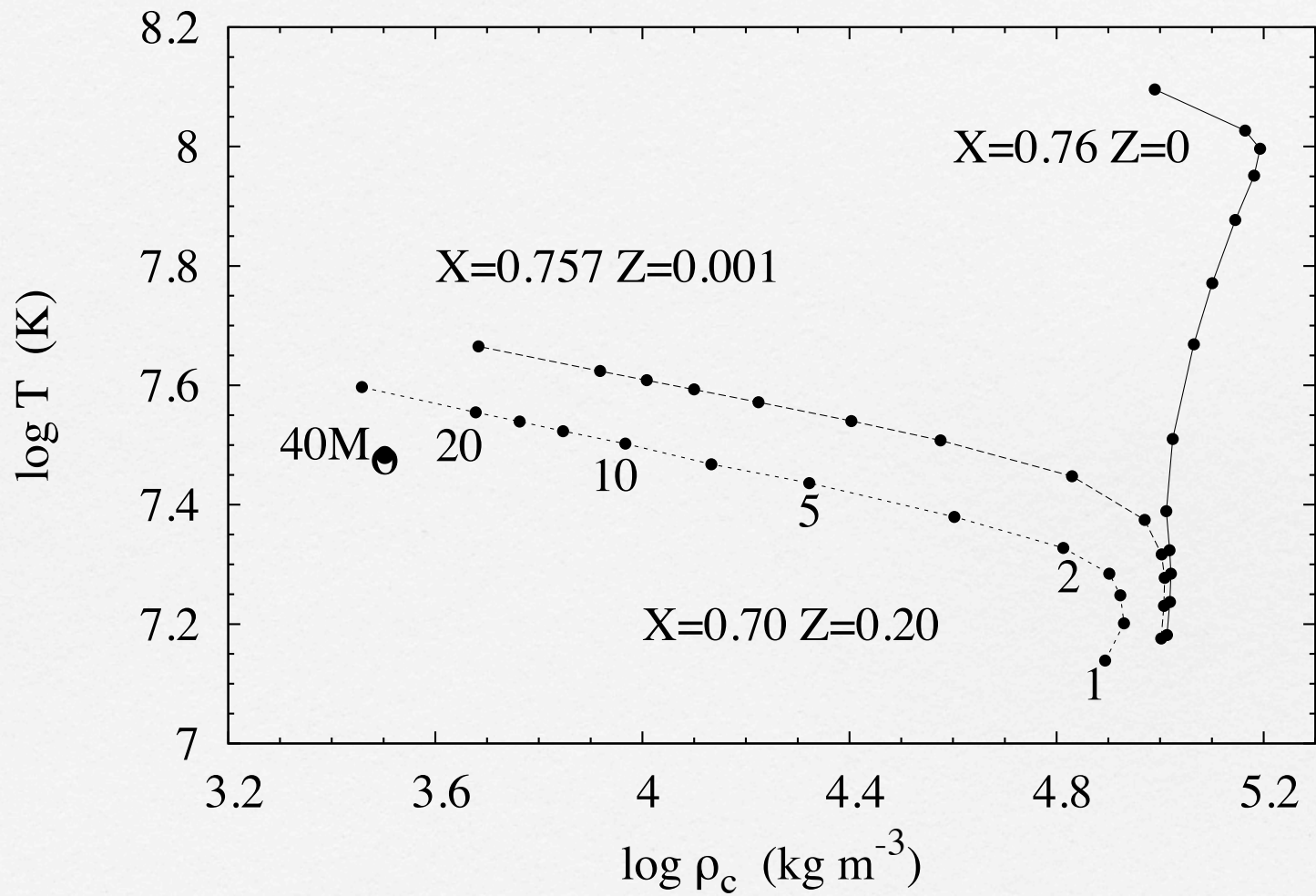
$$T_c/\mu \propto GM/R$$

$$L \propto \mu^4 M^3/\kappa$$



location of base of convective envelope

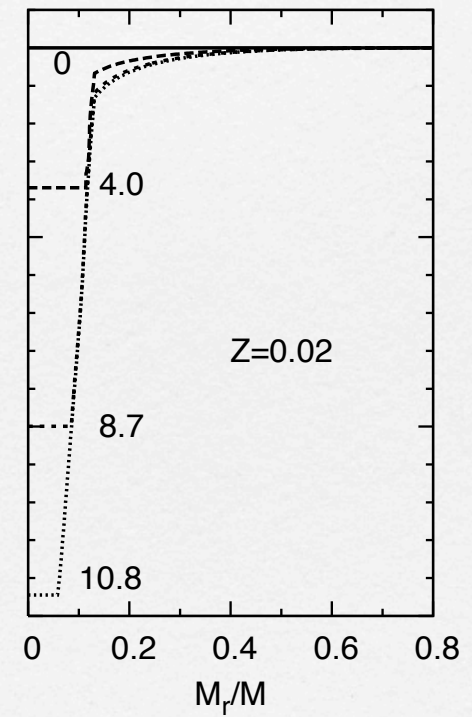
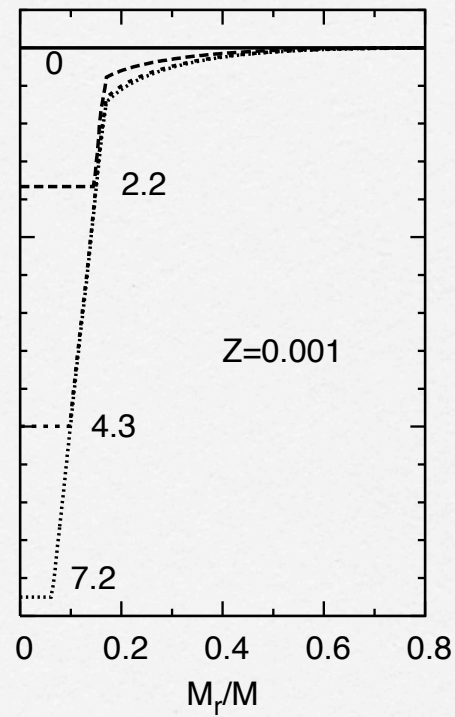
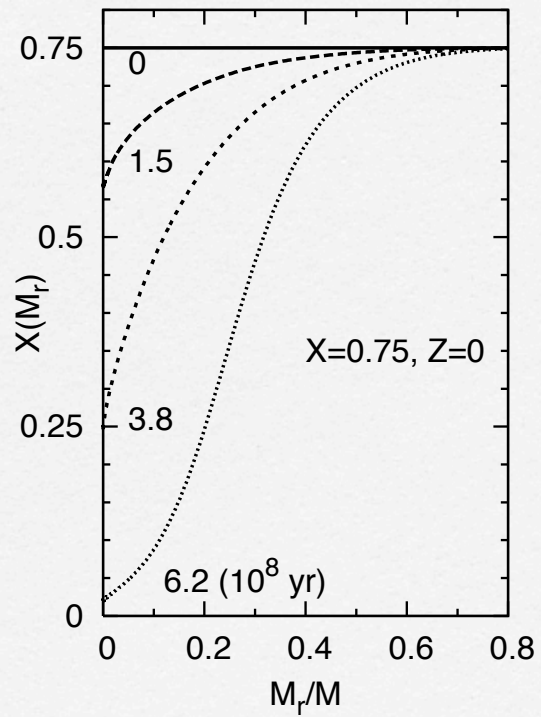


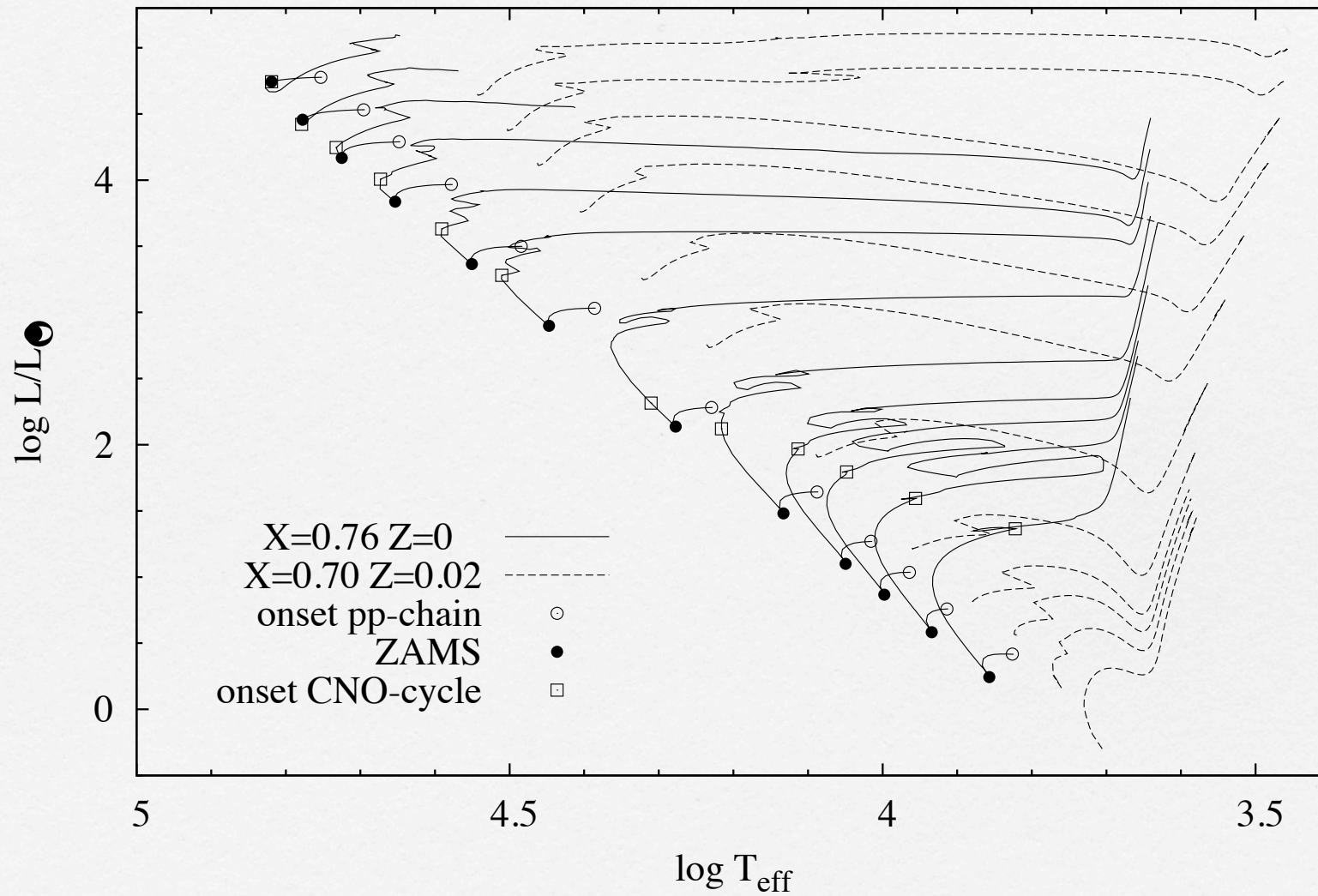


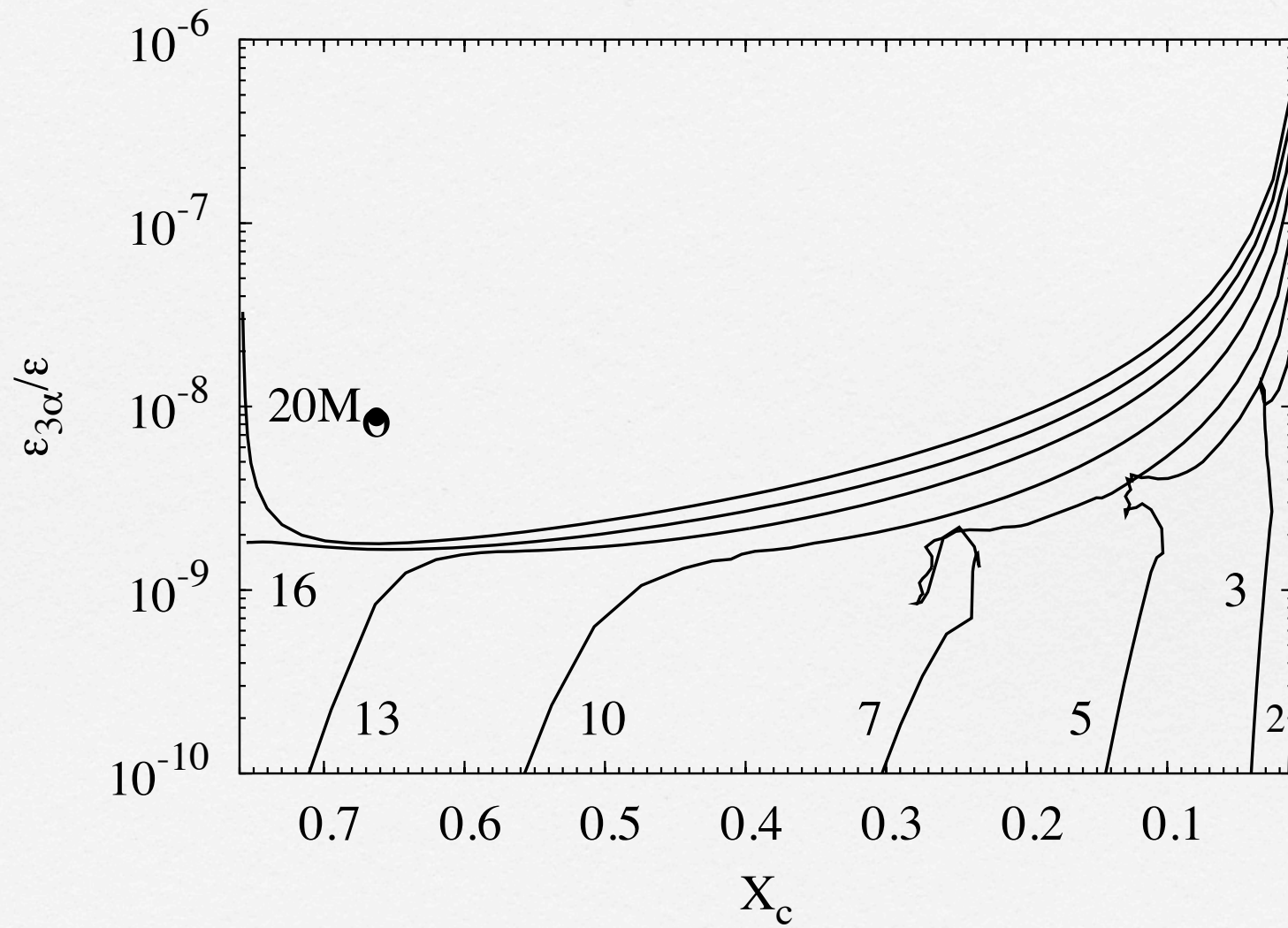
important characteristics of pop III stars

- no convective envelope
(but for $M < 0.8 M_{\text{sun}}$)**
- energy source is the pp-chain**
- high central temperature**
- compact**

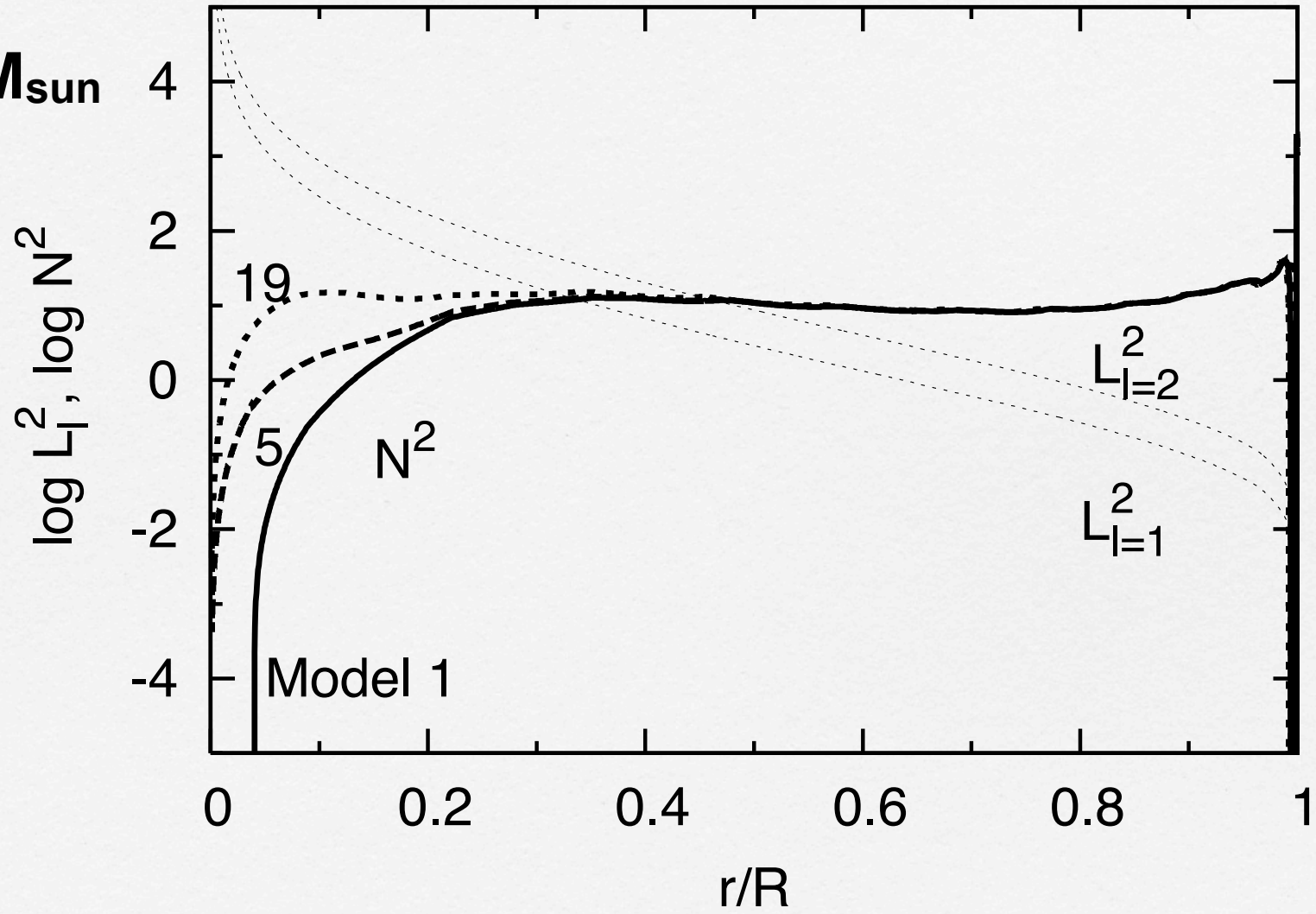
2 M_{sun} star

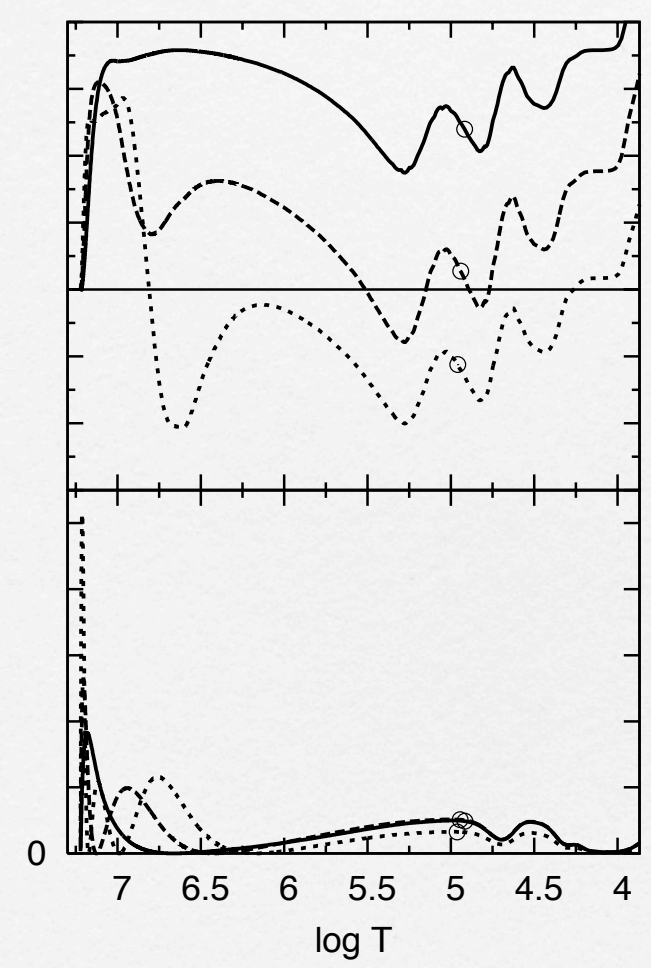
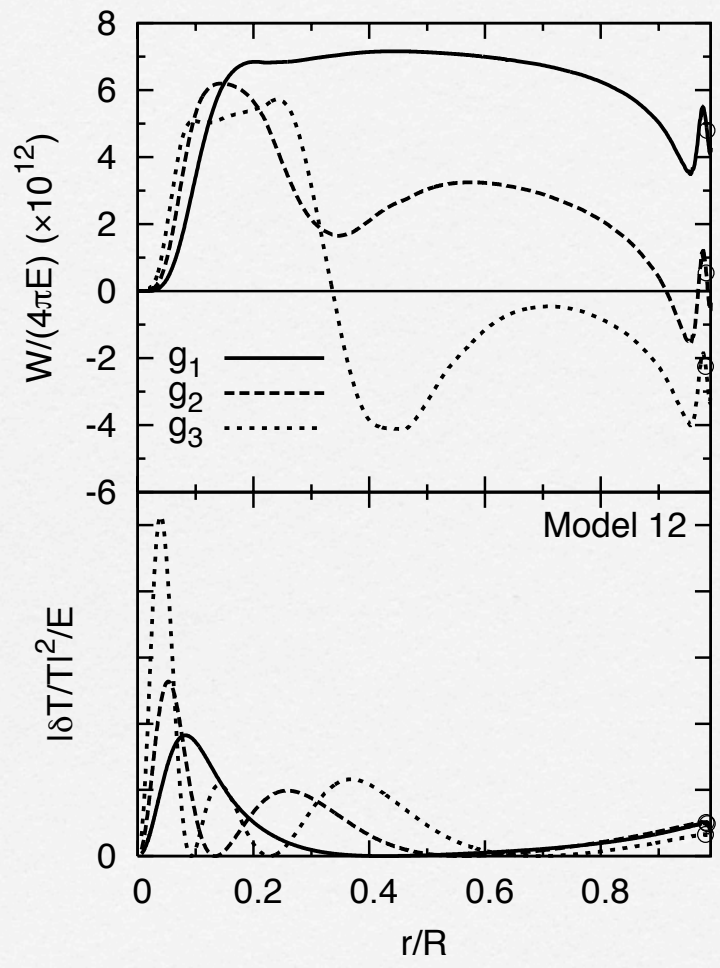


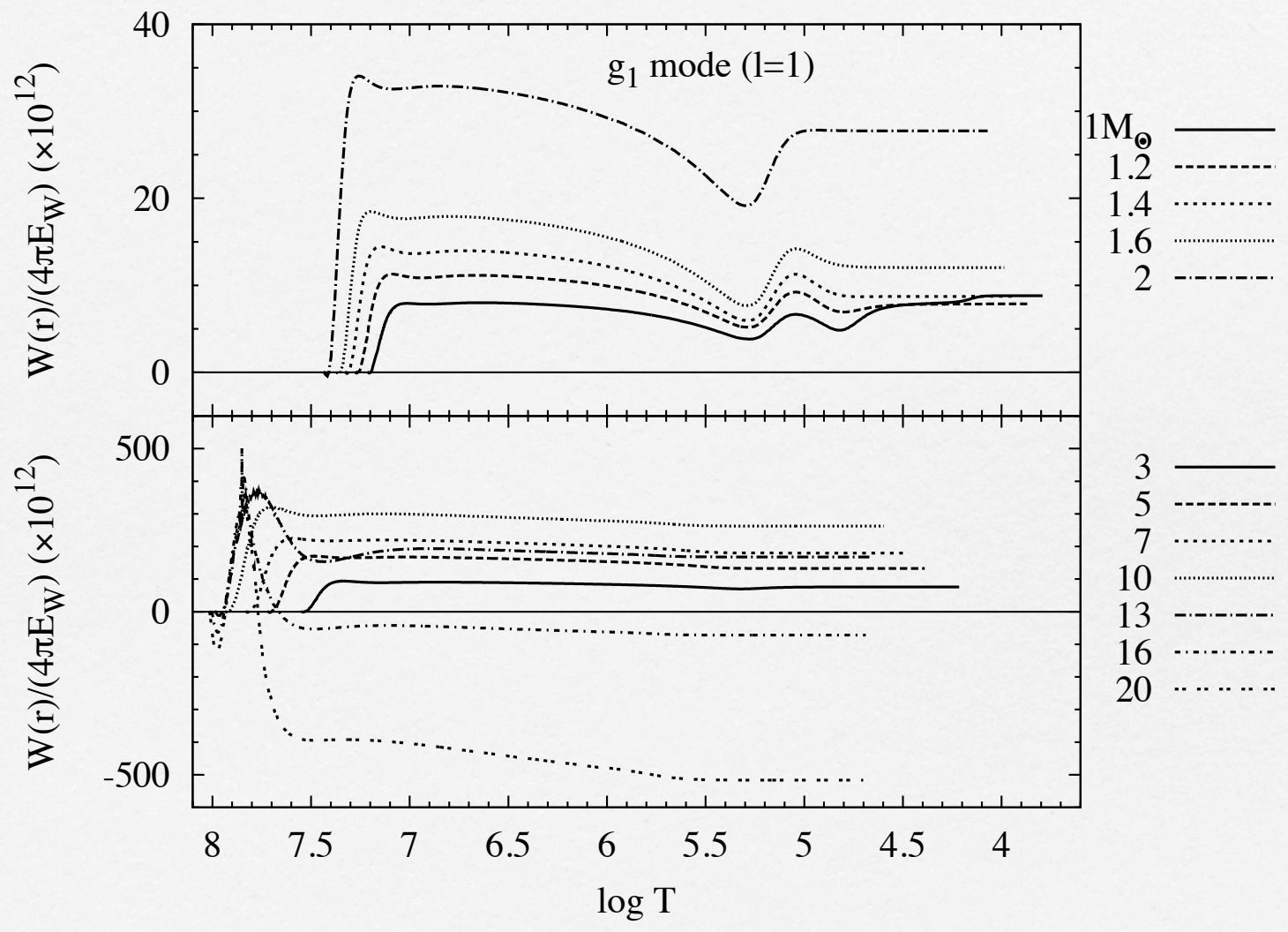


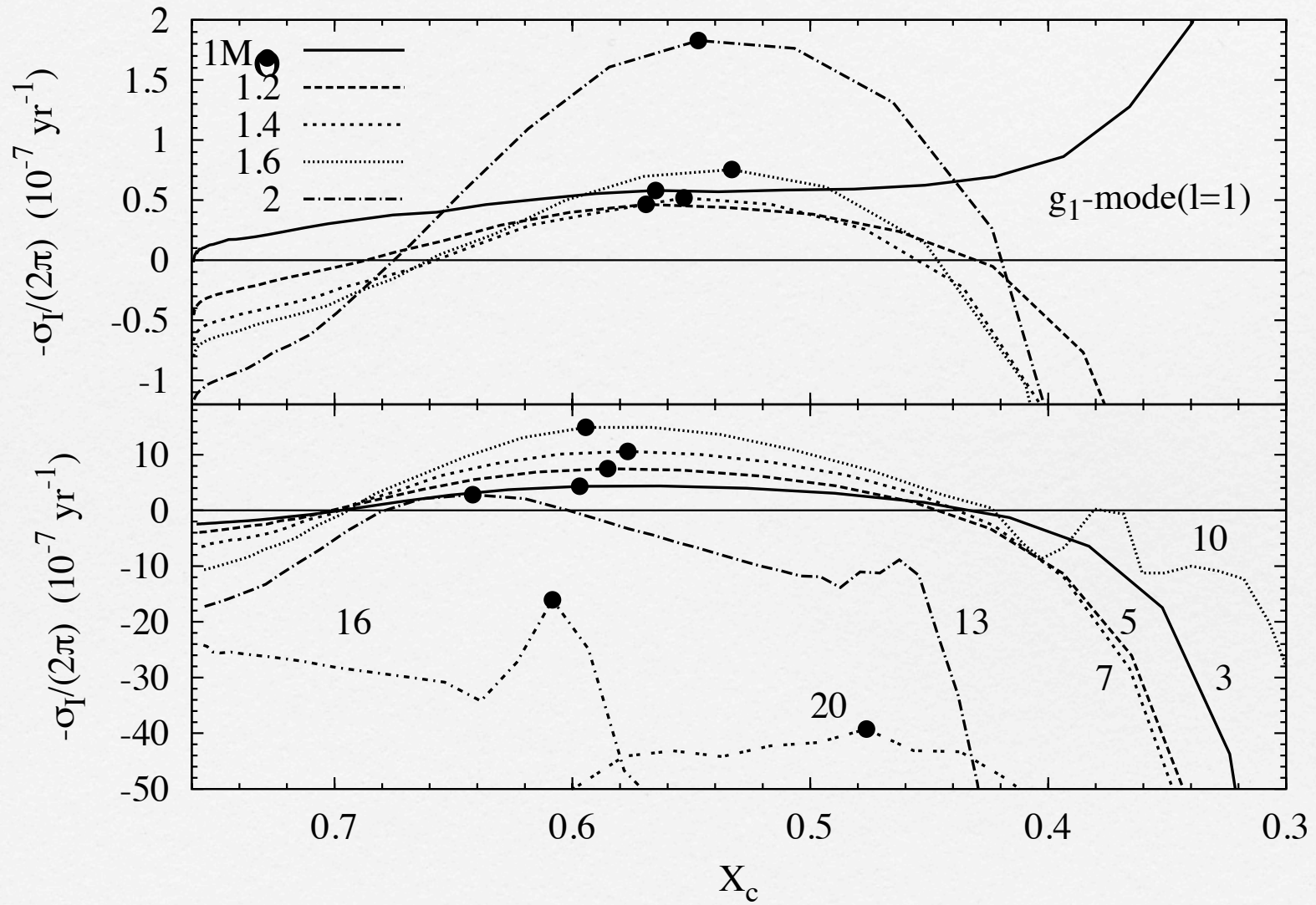


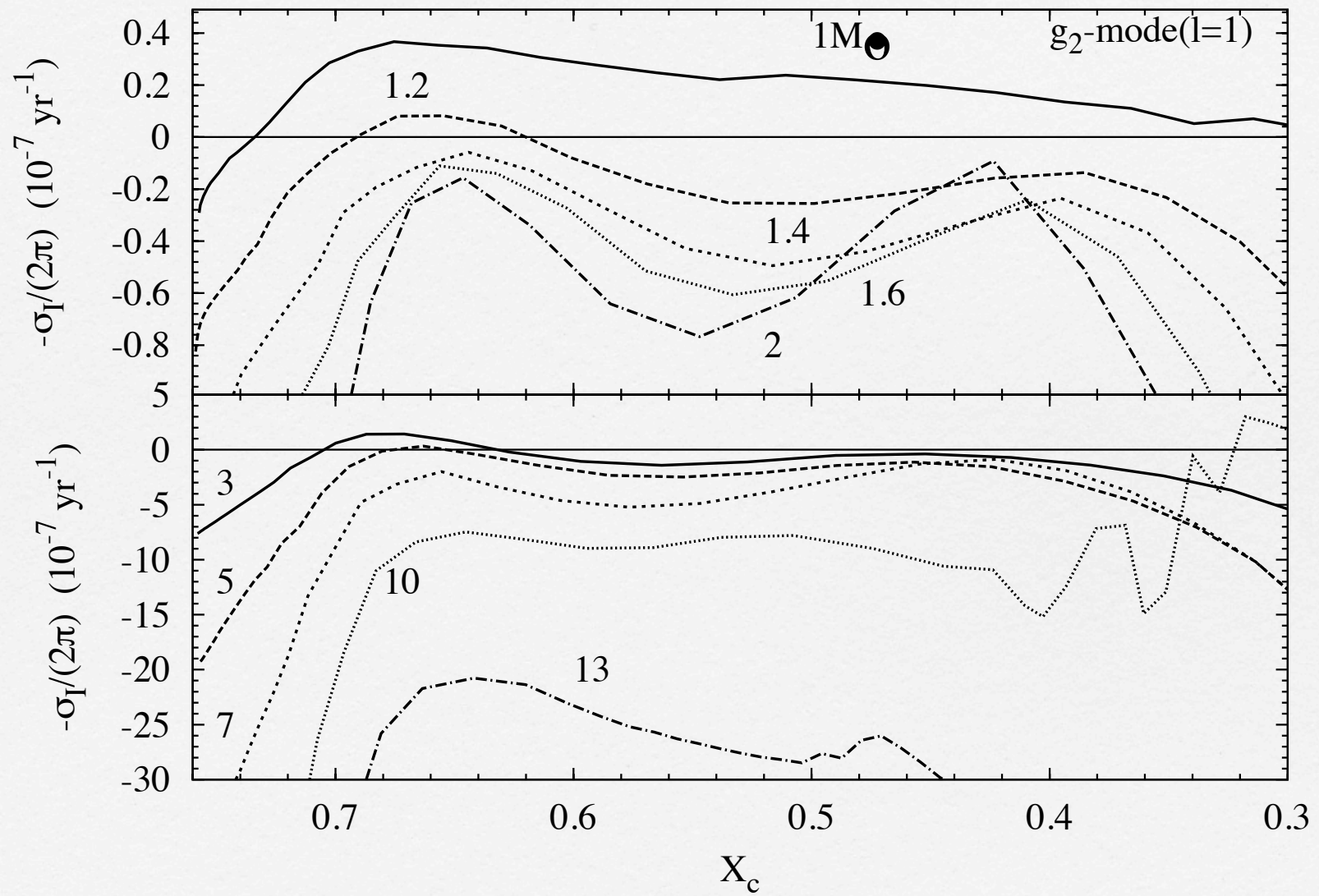
$1 M_{\text{sun}}$

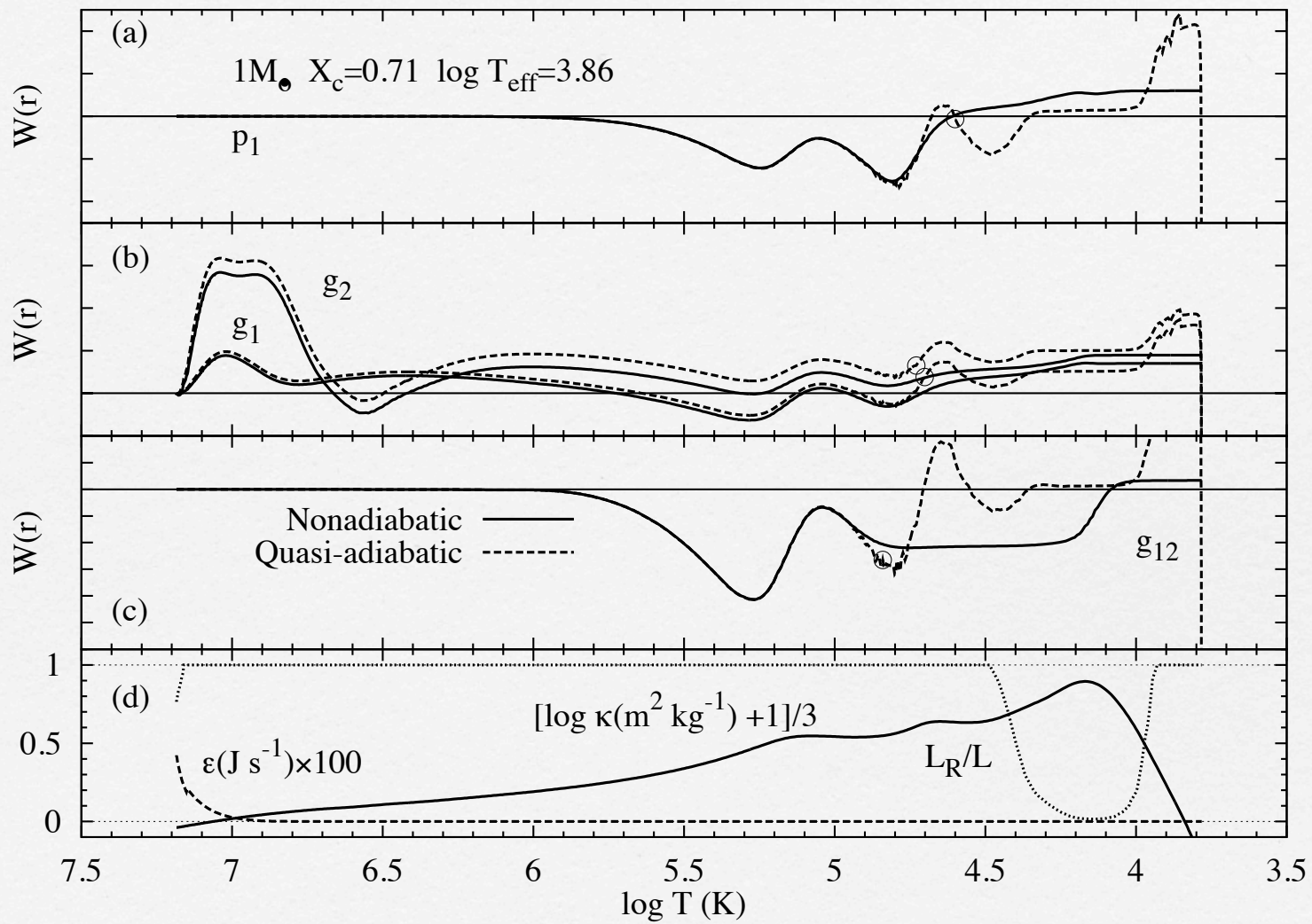


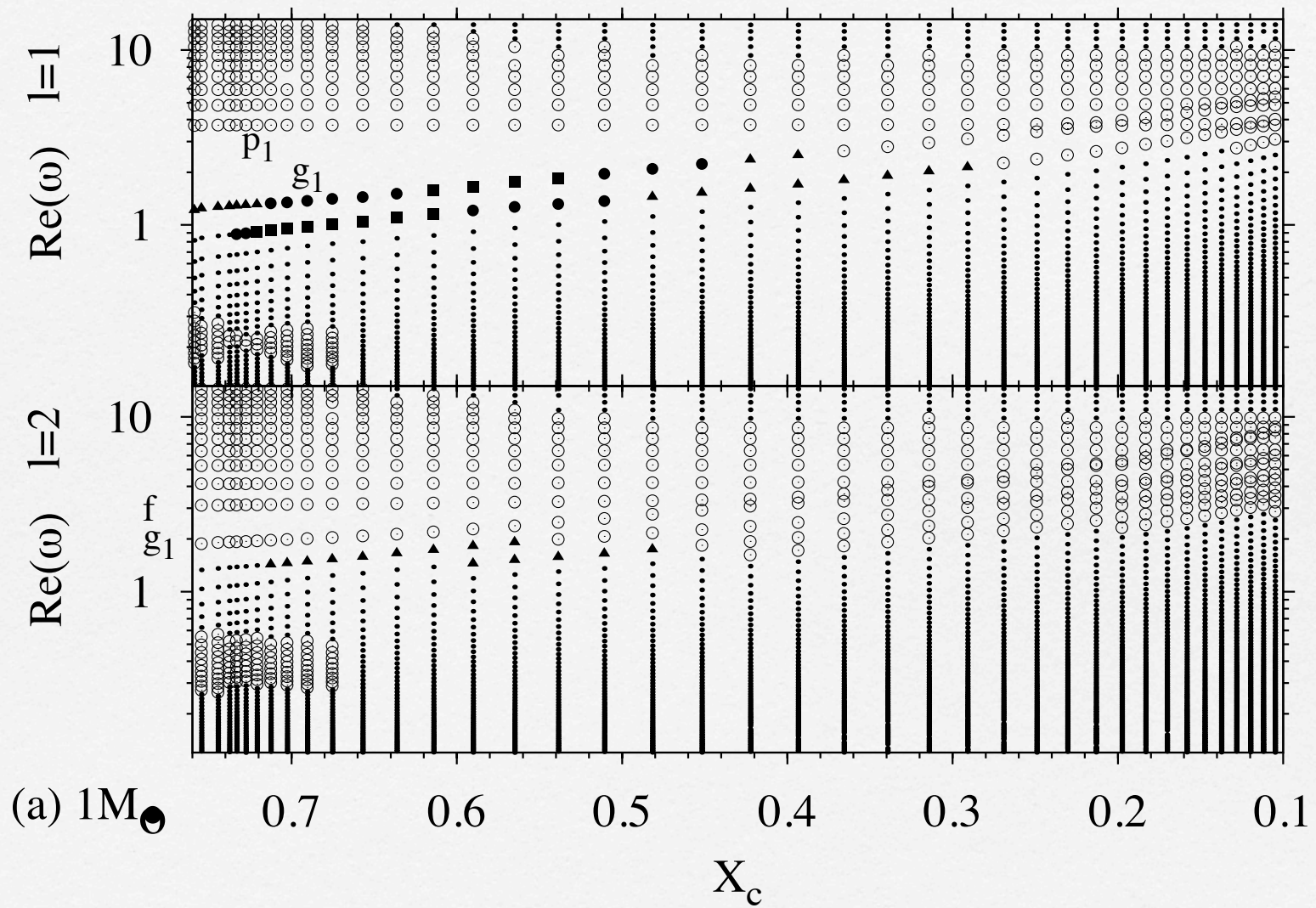


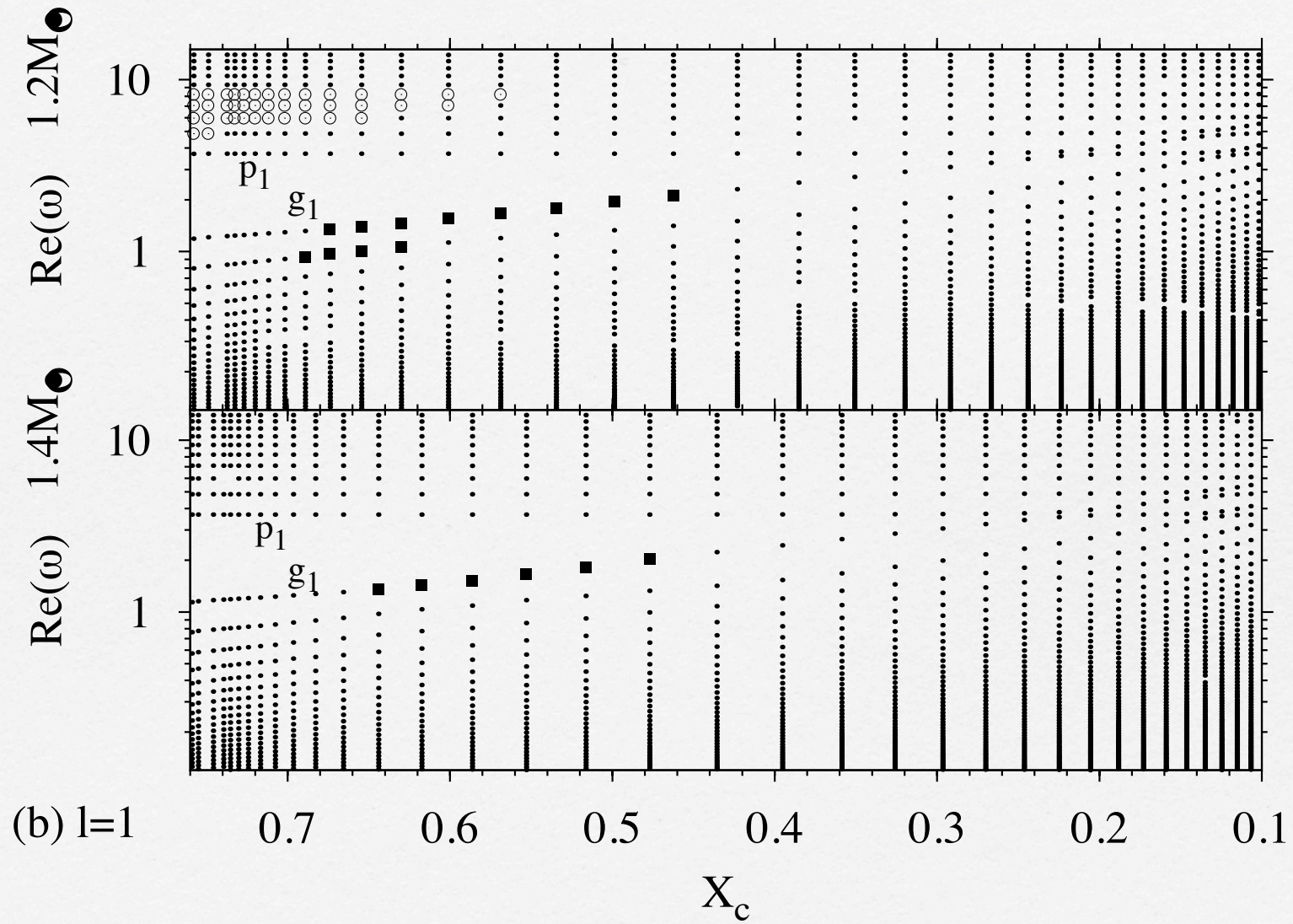


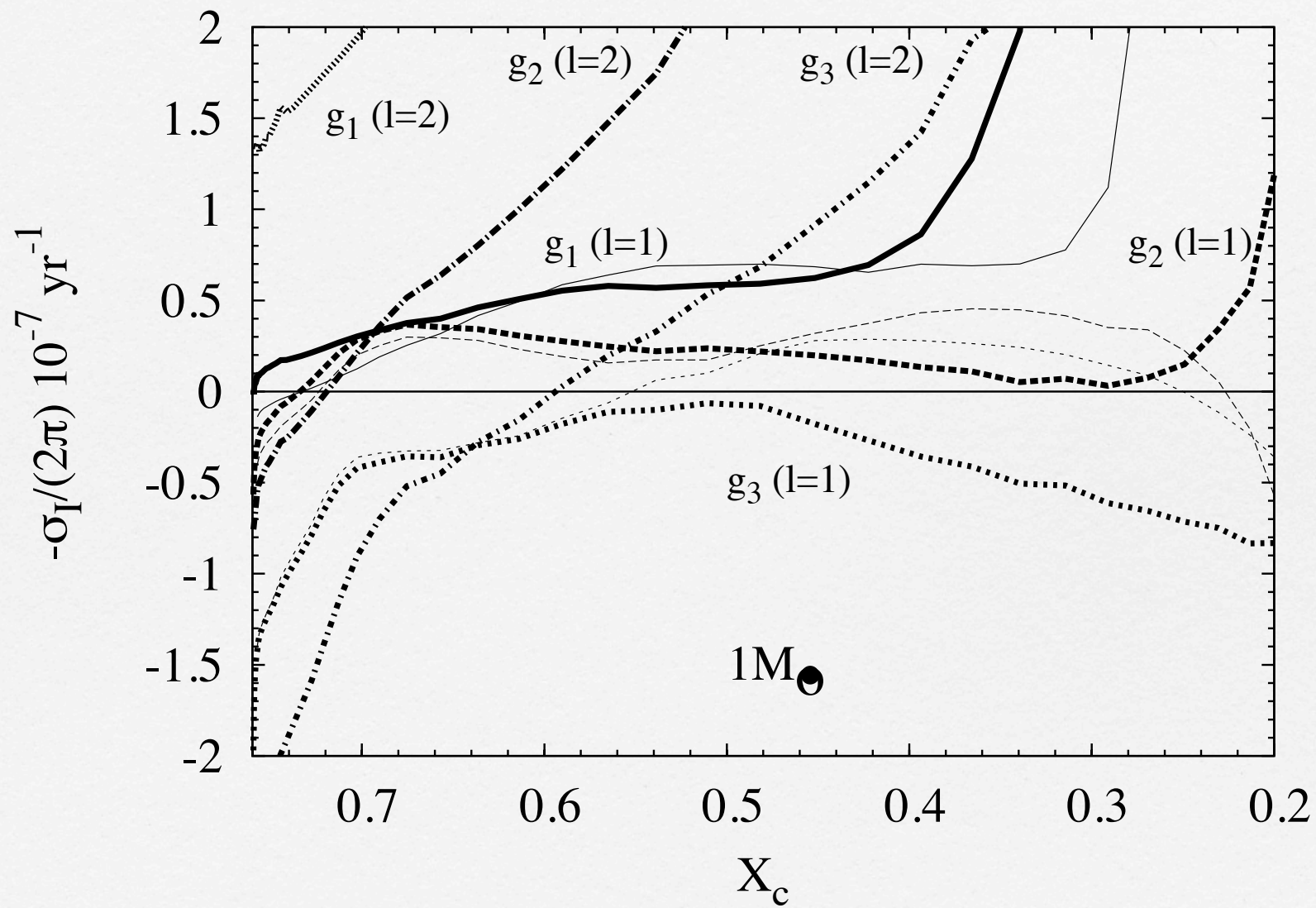












summary

- **pop-III stars are different in structure and evolution from pop-I stars, and their oscillatory properties are as well.**
- **low-degree, low-order g-modes are excited by the epsilon mechanism.**
- **next issue: nonlinear evolution**

references

- **Sonoi, T. & Shibahashi, H. 2011, PASJ, 63, 95**
- **Sonoi, T. & Shibahashi, H. 2011, submitted to PASJ**

