# ASTR 531 - Stellar Interiors and Evolution

Problem Set 3

Tom Wagg

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### *12.2 - Early Radii and Timescales*

*Part a - Radii Estimations*

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Let's use a couple of different relations from the textbook to get the radii at different times. A protostar becomes ionised and stars the Hayashi concentration phase when it's radius is on the order of

$$R_{\text{Hayashi,start}} \approx 100\,\text{R}_\odot \left(\frac{M}{\text{M}_\odot}\right) \tag{1}$$

We find the radius of the protostar once the Hayashi concentration phase comes to an end is approximately a factor of 50 lower (based on assumptions of the temperature and opacity) such that

$$R_{\text{Hayashi,end}} \approx 2\,\text{R}_\odot \left(\frac{M}{\text{M}_\odot}\right) \tag{2}$$

The radius at the start of the PMS phase will be the same as the end of the Hayashi concentration phase.

$$R_{\text{PMS,start}} = R_{\text{Hayashi,end}} \tag{3}$$

Finally, the radius at the end of the PMS phase is the same as the radius at ZAMS and so we can write that

$$R_{\text{PMS,end}} = R_{\text{ZAMS}} = \text{R}_\odot \left(\frac{M}{\text{M}_\odot}\right)^{0.7} \tag{4}$$

So now we can plug in numbers for the different masses of stars that we considered

| $M/\,\text{M}_\odot$ | $R_{\text{Hayashi,start}}/\,\text{R}_\odot$ | $R_{\text{Hayashi,end}}/\,\text{R}_\odot$ | $R_{\text{PMS,start}}/\,\text{R}_\odot$ | $R_{\text{PMS,end}}/\,\text{R}_\odot$ |
|---|---|---|---|---|
| 0.3 | 30 | 0.6 | 0.6 | 0.43 |
| 3 | 300 | 6 | 6 | 2.16 |
| 30 | 3000 | 60 | 60 | 10.8 |

### *15.4 - Metallicity and Mass Loss Rates*

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### *16.1 - RGB Radii*

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### *17.1 - Helium Flash Duration*

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