Numerical Experiment of Mass Loss and Mass Accretion Mechanics in Massive Stars

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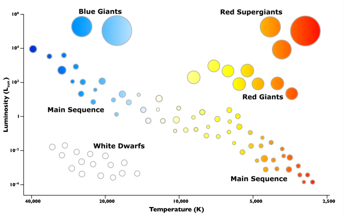
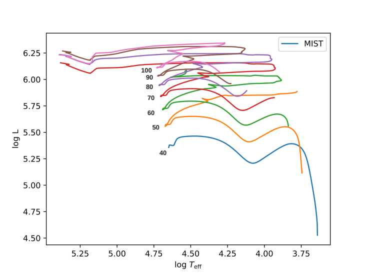
General overview

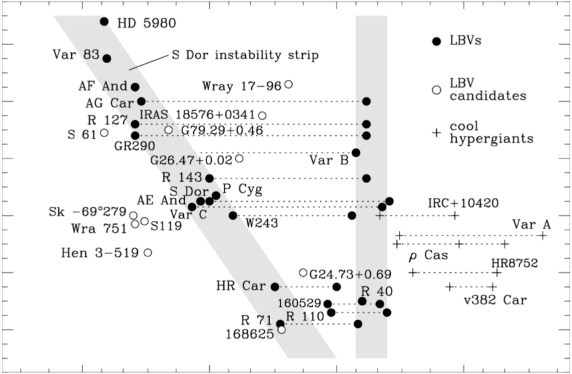
- Massive star formation
- supernova explosions
- Strong stellar winds & high mass loss rates
- Chemically homogeneous evolution
- Proximity to the Γ-parameter





Mass loss mecahniscs

- CAK-theory for the mass loss
- Vink & Grafener theory of mass loss
- Transition mass loss from O-star to WR-star
- Hertzsprung-Russell(HR) Diagram and Humphreys & Davidson (HD) limit.
- Luminous Blue Variables-



Methodology - Response to the higher mass loss

- Physical ingredients of the MESA - initial mass, metallicity, overshooting, mixing, mass-loss, time step, convection & semiconvection, and mass fraction of elements.

$$Y = Y_{prim} + (\frac{Y}{Z})/Z \quad (1)$$

$$X = 1 - Y - Z \quad (2)$$

$$D_{ov} = D_o \exp^{\frac{-2(r-r_o)}{f_{ov} H_p}} \quad (3)$$

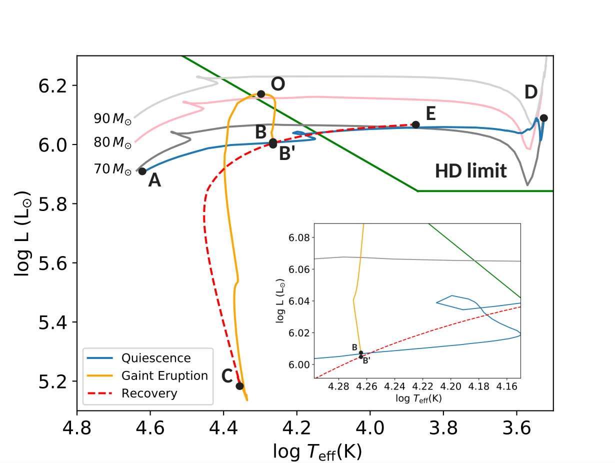
- MESA specific routine MLT++, opacity and equation of state(EOS).
- The dynamical time scale-

$$t_{dyn} = \sqrt{\frac{2R^3}{GM}} \quad (4)$$

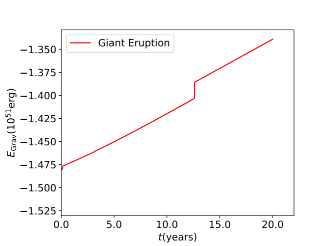
- Wind scheme: Dutch

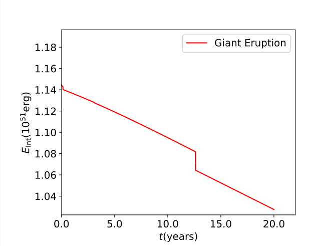
MESA evolution Results of Gaint Eruption

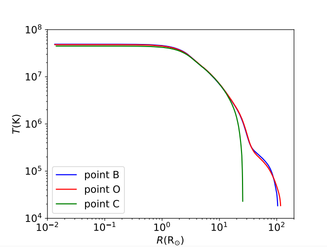
- M = 70 $M_\odot$
- Z = 0.02

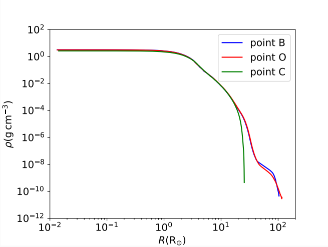


Varitaion in the stellar parameters









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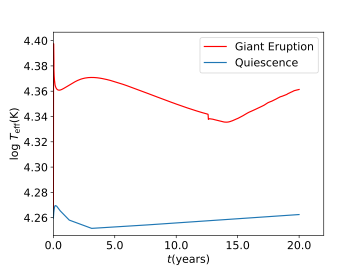
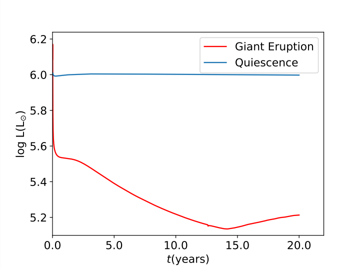
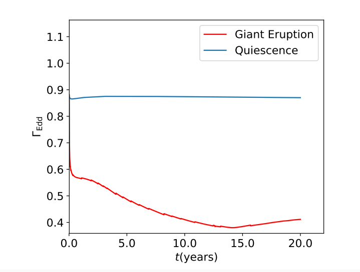
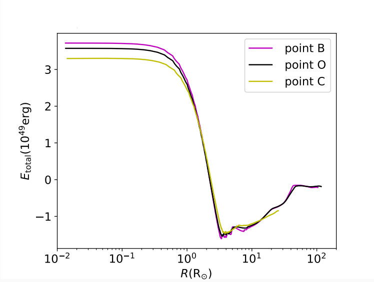


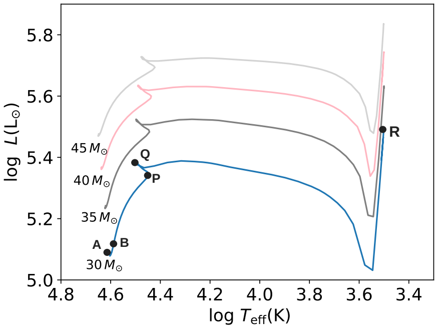




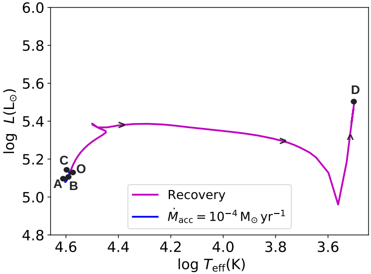


- Accretion Phenomena

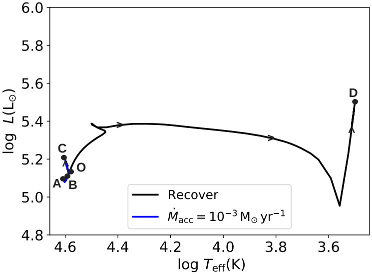
- Modelling by using MESA-
  M = 30 $M_\odot$
- We use the diffusive technique to represent the convective overshooting, using f_1 = 0.005 and f_0 = 0.001 for each convective core and shell.
- By using MESA control default-
  $\mathrm{mass\_change} = 10^{-4}, 10^{-3}, 10^{-2}, 10^{-1}$! ($\mathrm{M_\odot\ yr^{-1}}$)
  $\mathrm{t} = 20$ years



Lower accretion rates scenario

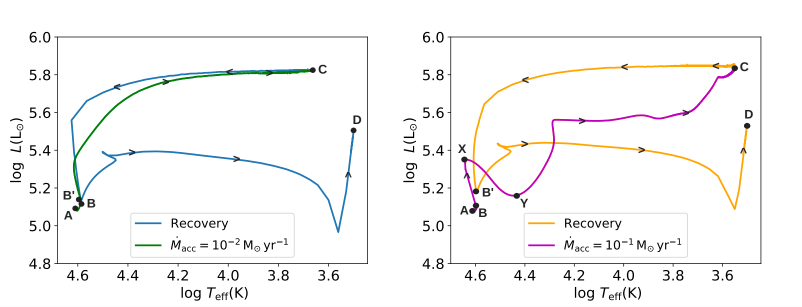


(a)

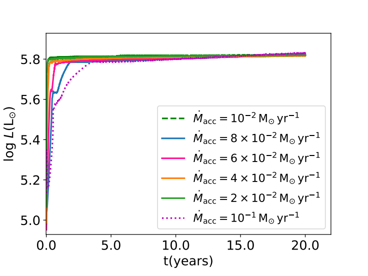


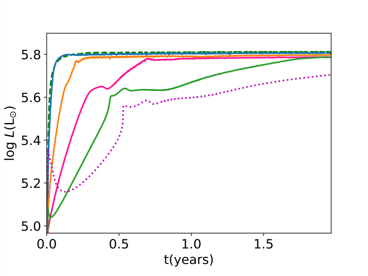
(b)

Higher accretion rate scenario



(c) (d)





$$\epsilon_{\rm grav} = -T\left(\frac{\partial S}{\partial t}\right)_q + T\,\frac{\partial \ln M(T)}{\partial t}\left(\frac{\partial S}{\partial \ln q}\right)_t \qquad (5)$$

Conclusion

- Gaint Eruption in massive star: We examined the im pact of mass loss on the stellar parameters in the aftermath of the eruption and obtained a physical transition where the evolutionary track switches from the cool side to the hot side of the HR diagram.
- We propose that at point B', the star might undergo another GE. If the system is binary, and the eruptions are induced by the gravitational force of the companion in an eccentric orbit
- Accretion Phenomena in massive star: We examined massive companion star in a binary system with a the primary star that undergoes a Giant Eruption, responds to the accretion of the arriving gas at a high rate from the primary star.
- We analyzed that the star responds differently for the lower and higher accretion rates. For the high accretion rate i.e., 10^{-2}, 10^{-1} the star becomes cooler, while for low accretion rates i.e., 10^{-3} and $10^{-4}\ \mathrm{M_{\odot}\ yr^{-1}}$ the star remains on the hotter side of the HR diagram during the accretion.
- We also find out the effect of compression in the outer layers due to the arriving material and how it changes the envelope properties of the star.

Future work

- Accretion dependency on metallicity
- Bondi-Hoyle accretion in binary sysytems
- Co-existing interval between fast and $\Omega-$ slow solution

To the listener

Thankyou