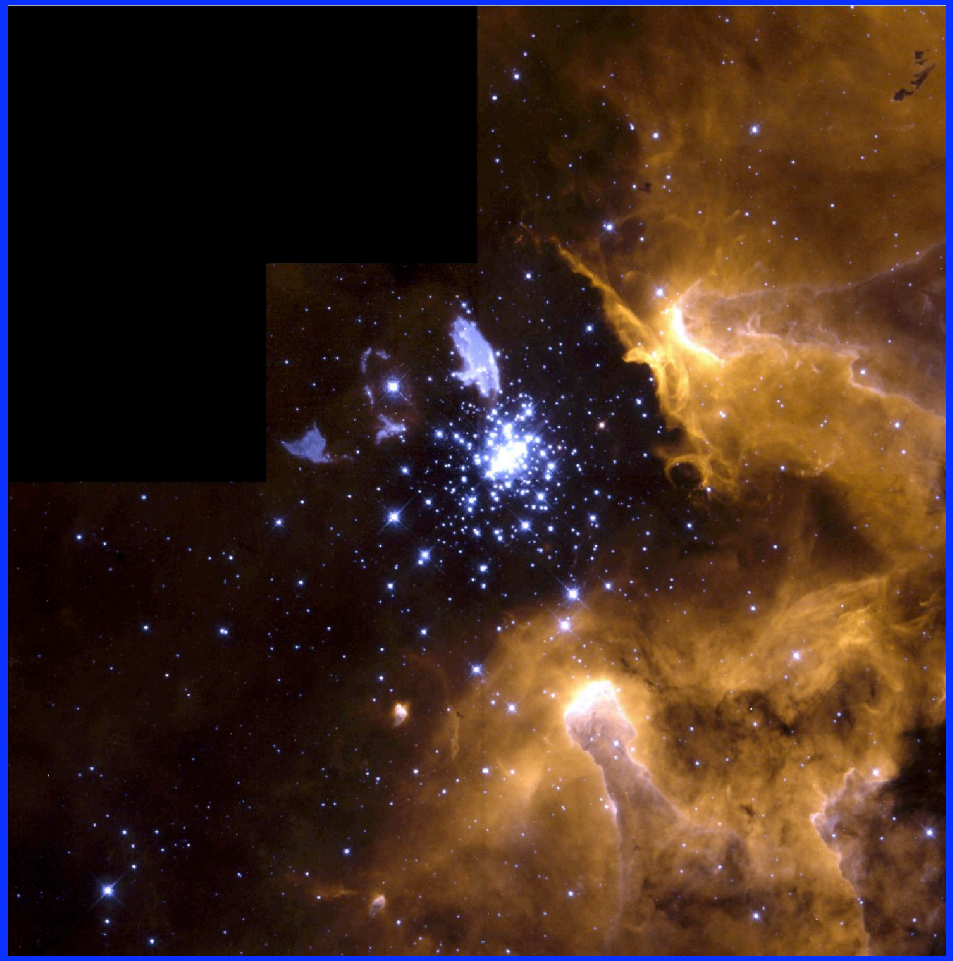
Mass loss as a function of Z



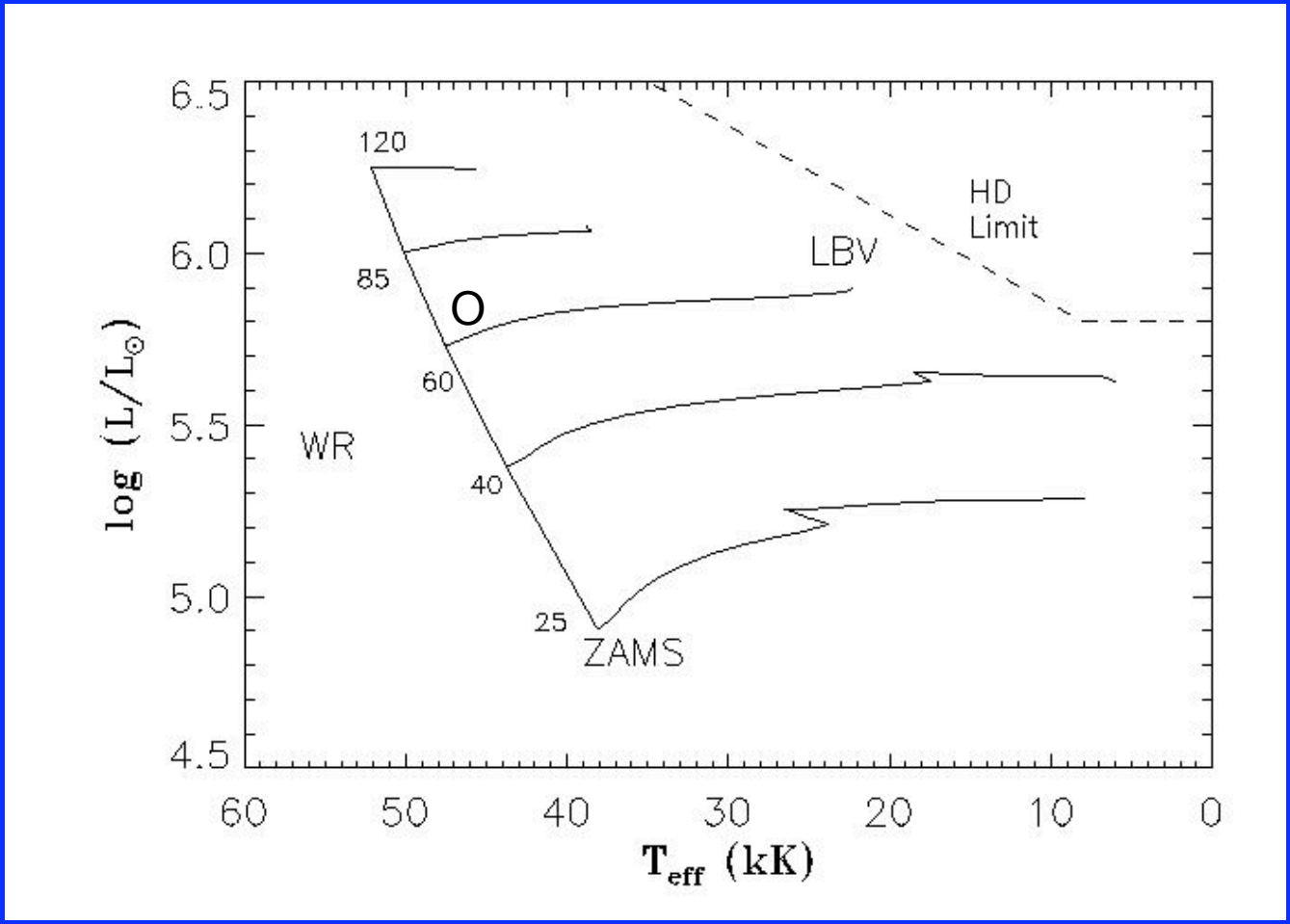
Jorick Vink (Armagh Observatory, UK/Ireland)

Outline

- Intro
- CAK versus Monte Carlo
- O-type winds

- Bi-stability Jump
- Angular momentum loss

Evolution of a Massive Star



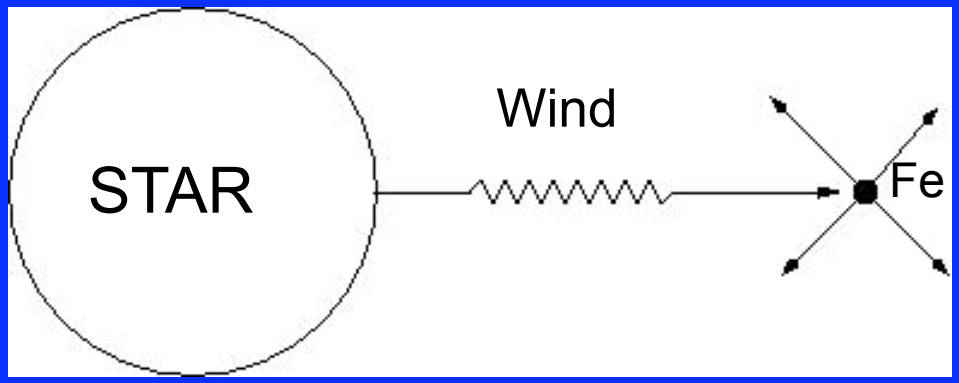
Mass Loss

- Peeling off the star
  → O → LBV → WN → WC/WO → BH
  (e.g. Conti 1976)

- Removal of angular momentum
  (e.g. Langer 1998, Maeder & Meynet 2000)

Radiation-driven wind by Lines

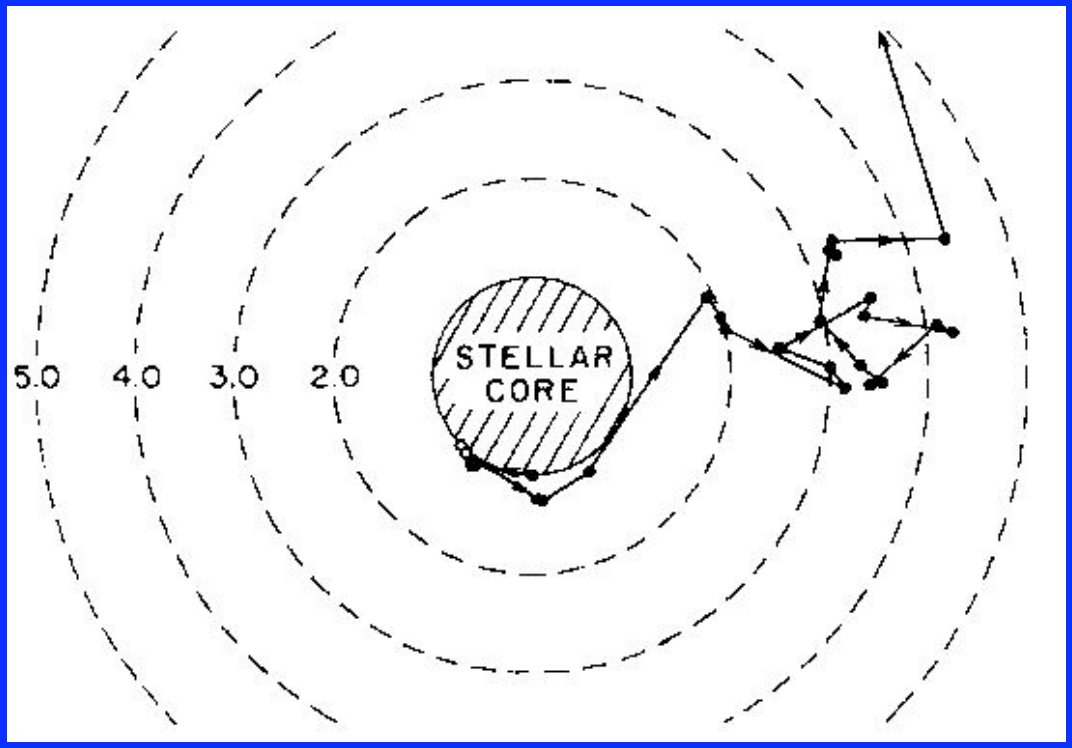
Lucy & Solomon (1970)
Castor, Abbott & Klein (1975) = CAK



$$dM/dt = f(Z, L, M, T_{eff})$$

Monte Carlo Approach

Abbott & Lucy (1985)



$$\dot{M}\, v_\infty > \frac{L_*}{c}$$

dM/dt = f (Z, L, M, Teff)

Two O-star approaches

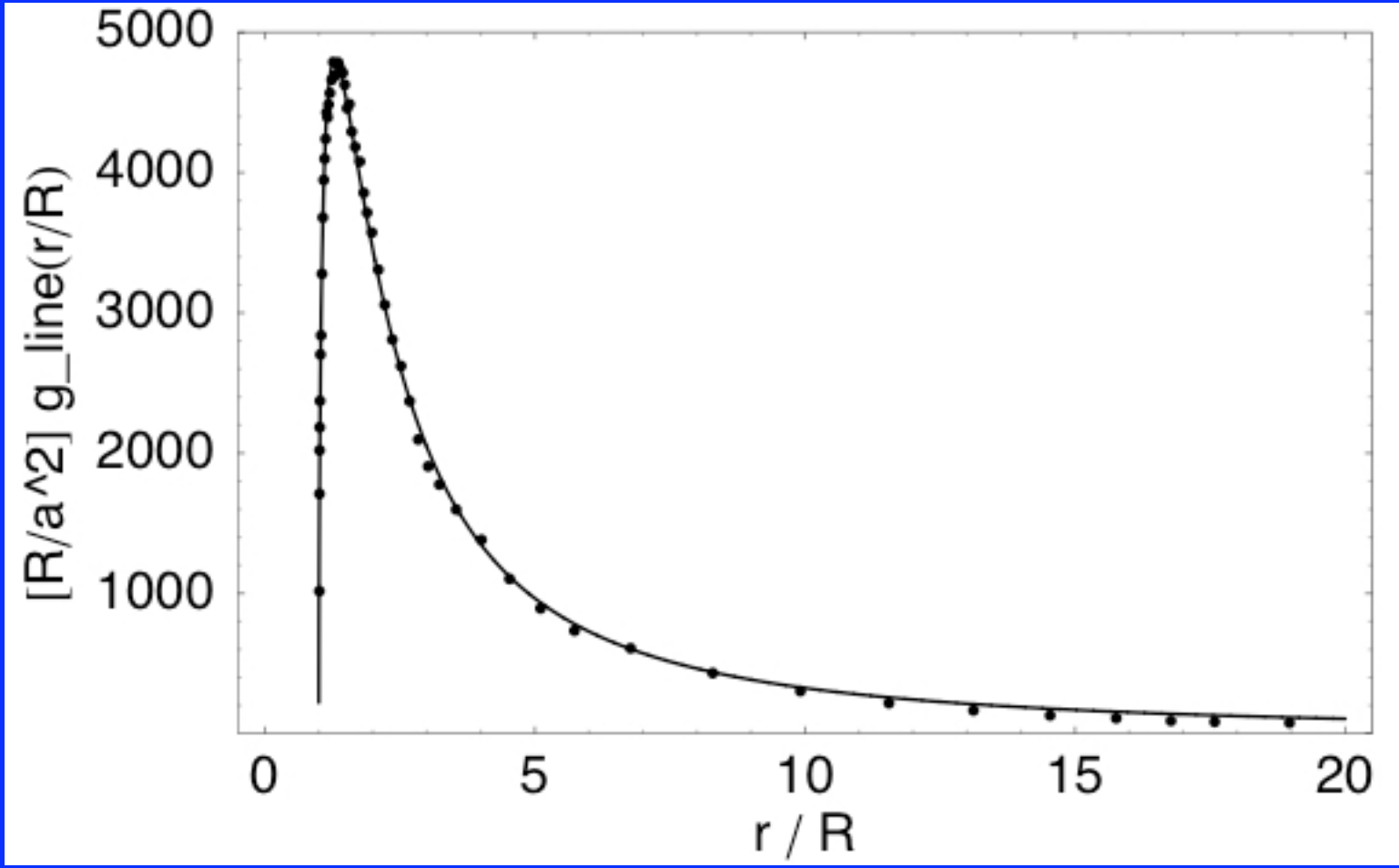
1. CAK-type
   → Line force approximated
   → v(r) predicted

   Pauldrach et al. (1986); Kudritzki (2002)

2. Monte Carlo (Abbott & Lucy)
   → V(r) adopted
   → Line force computed – for all radii
   → multiple scatterings included

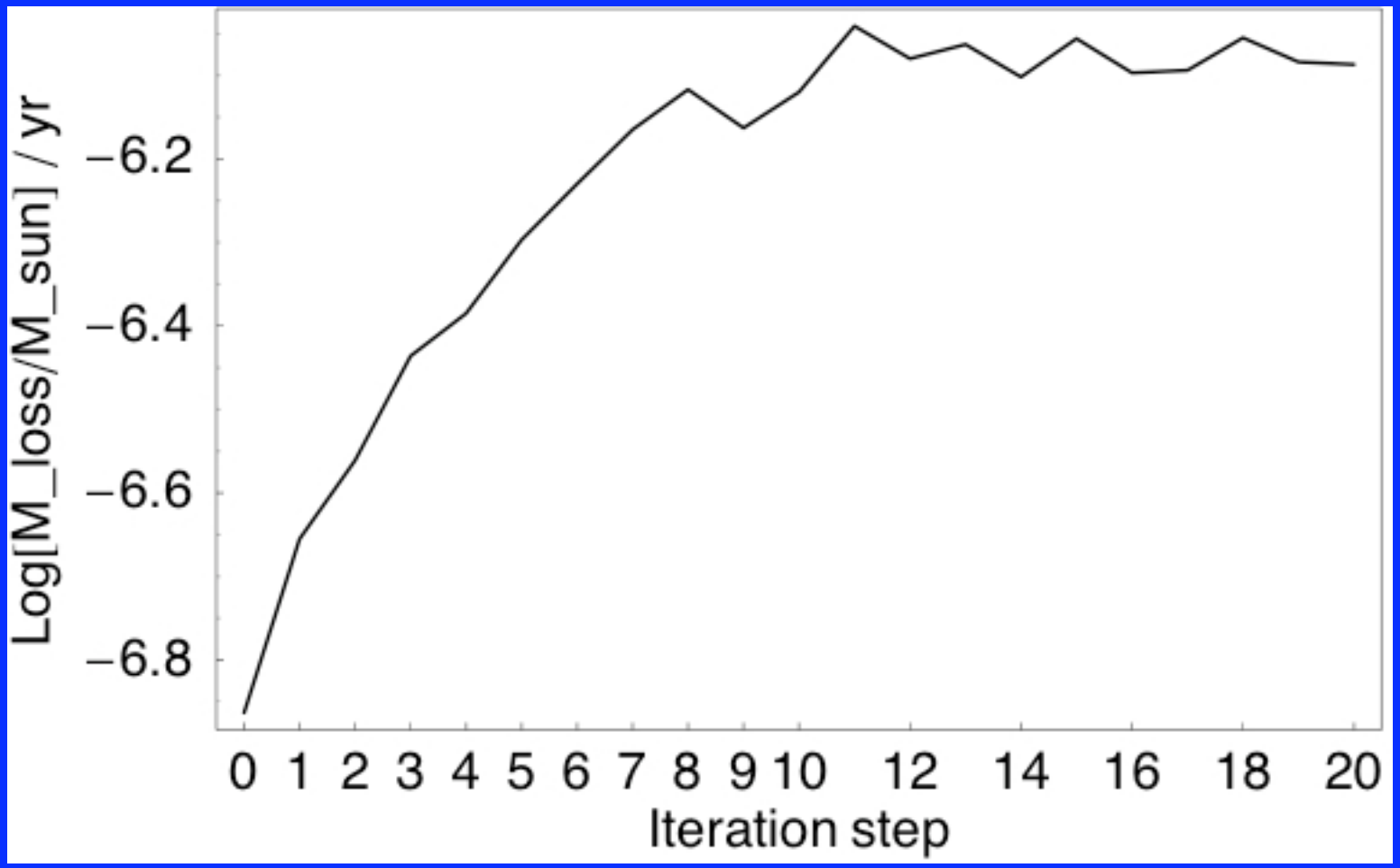
   Vink, de Koter & Lamers (2000, 2001)

Line acceleration: g(r)



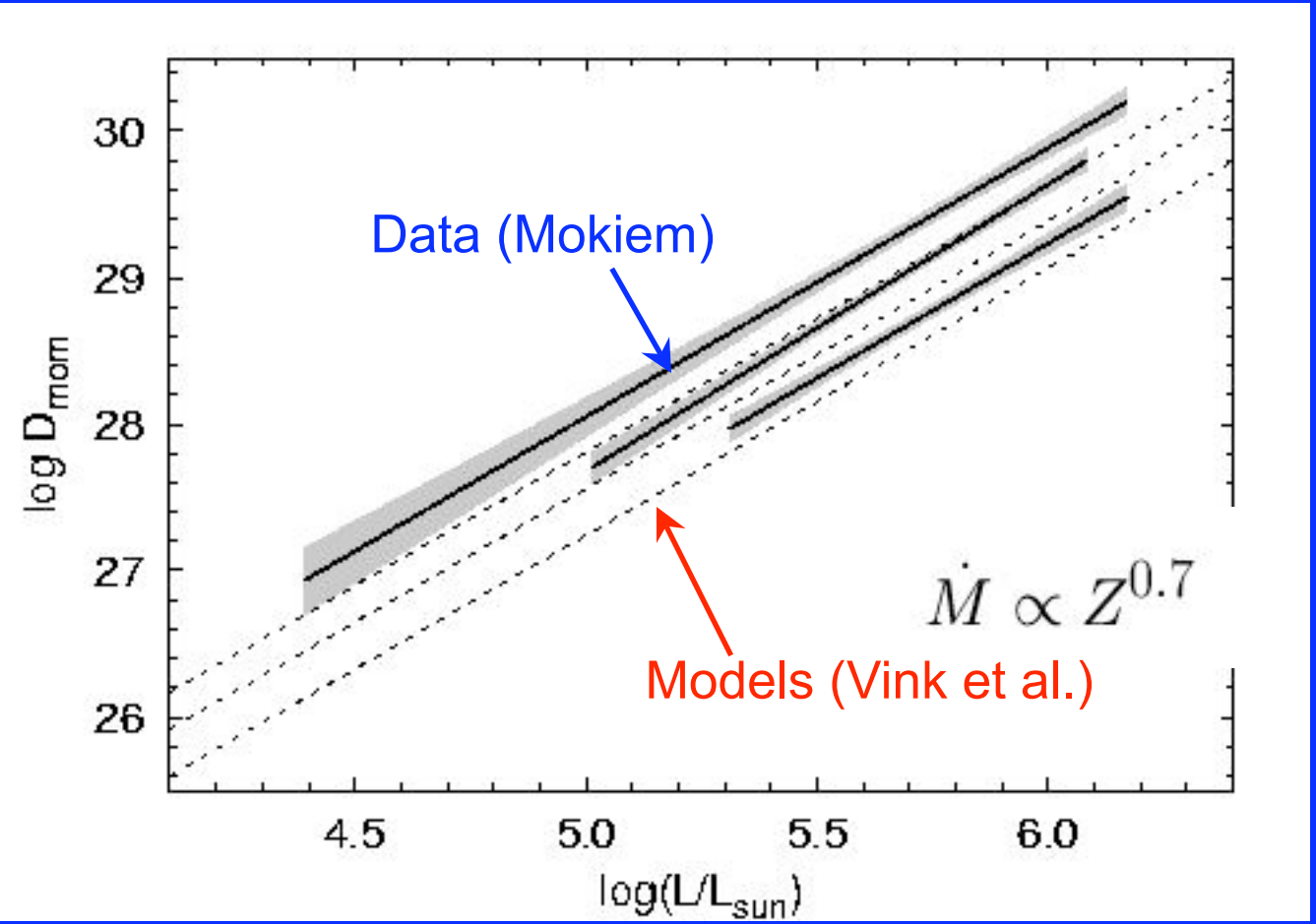
Mueller & Vink (2009)

Mass-loss iteration



Mueller & Vink (2009) - astro-ph 0810.1901

Wind momenta at low Z

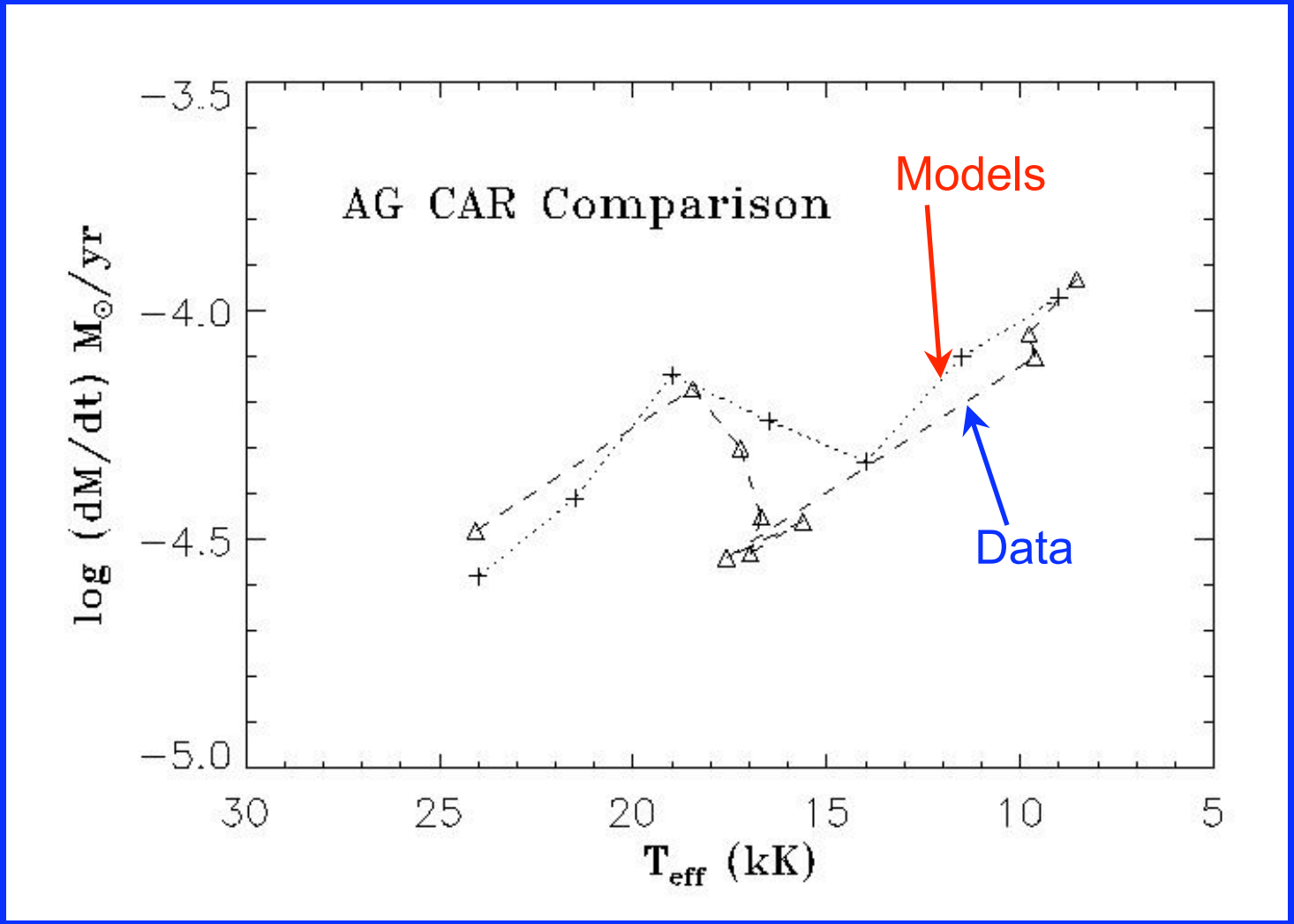


Mokiem et al. (2007b)

The Bi-stability Jump

HOT O supergiants	COOL B supergiants
dM/dt	dM/dt x 5
fast wind	slow wind
Fe IV	Fe III

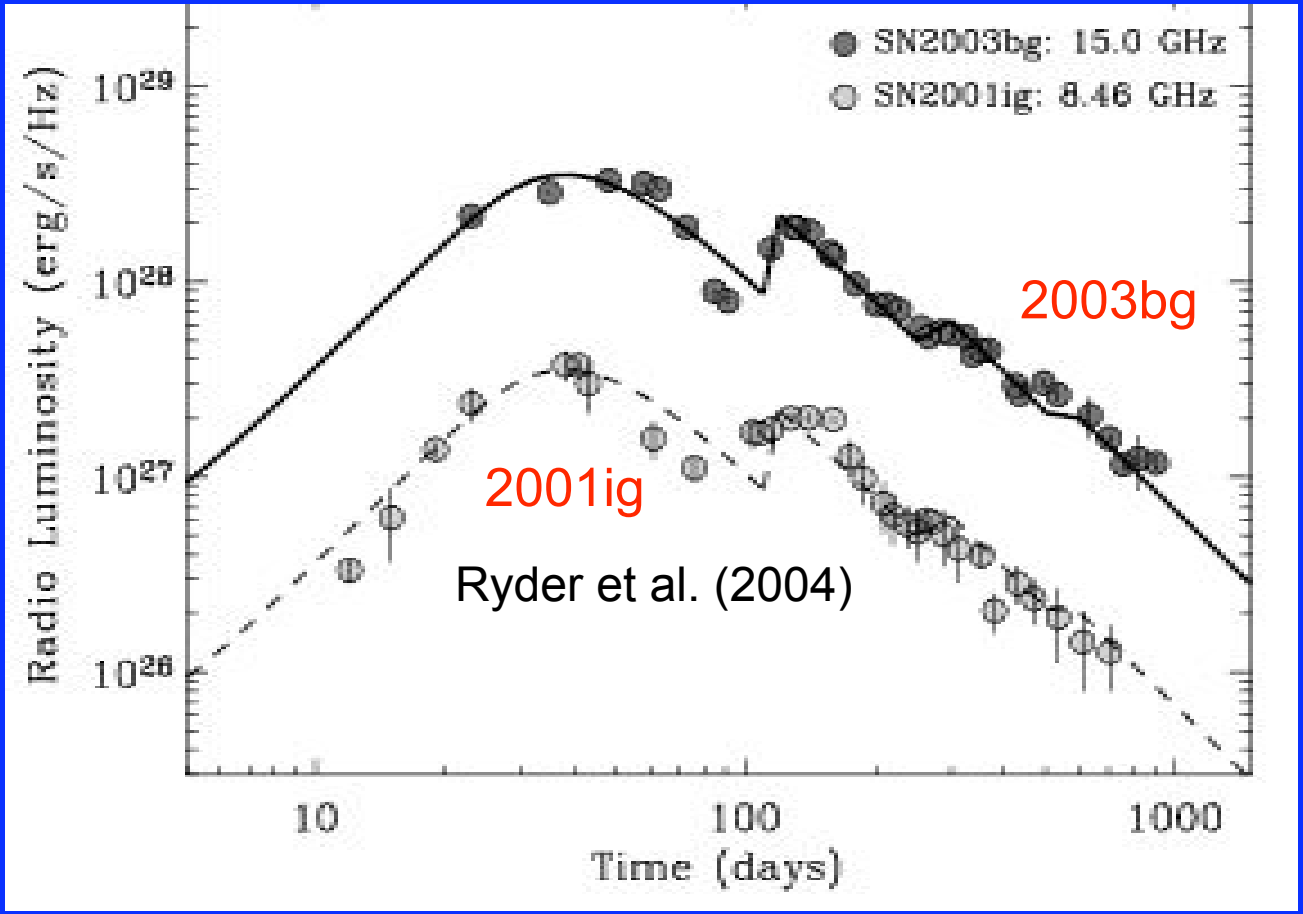
Variable mass loss of LBVs



Stahl et al. (2001)

Vink & de Koter (2002)

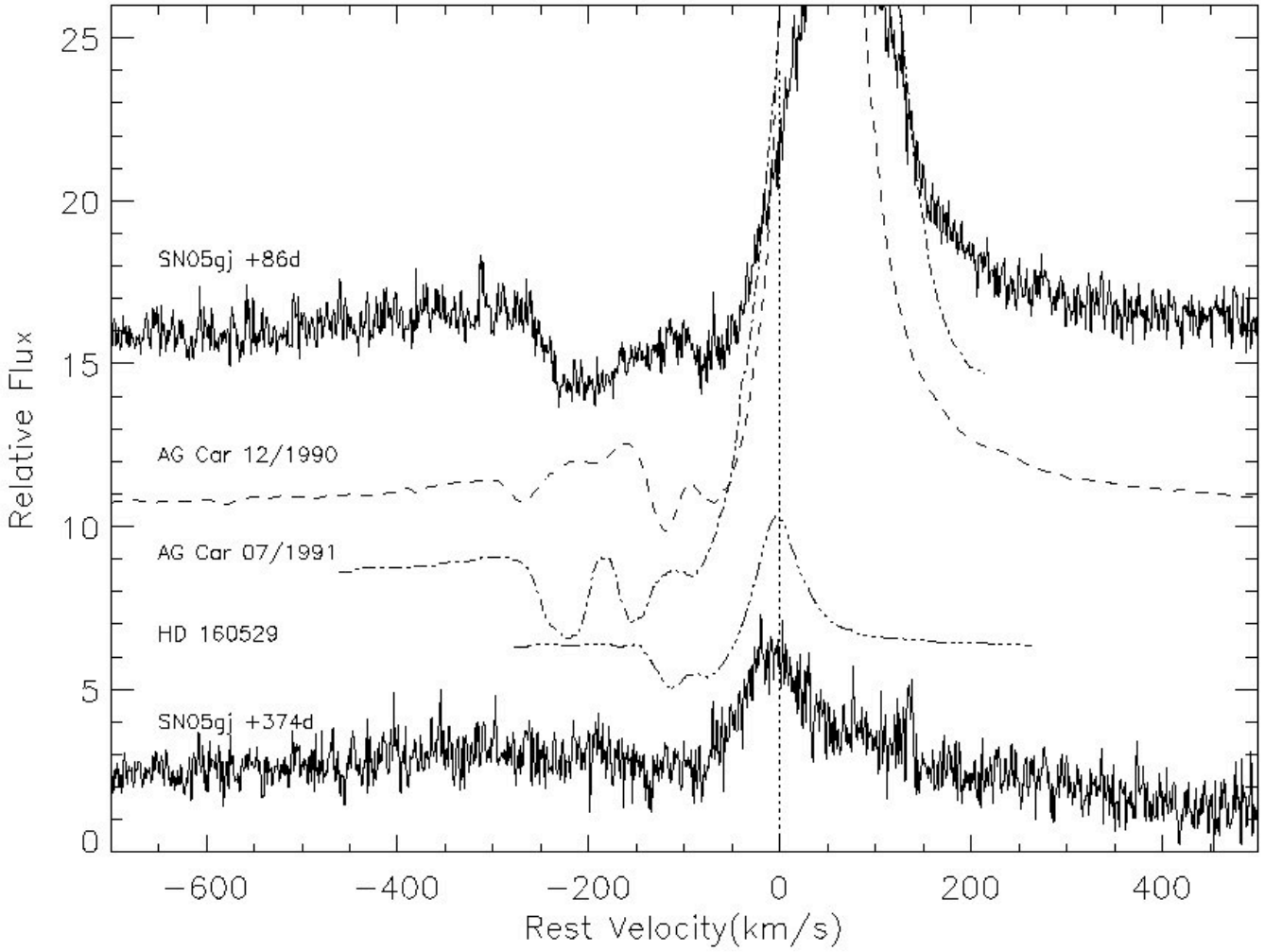
Radio supernova lightcurves



Soderberg et al. (2006)

Kotak & Vink (2006): LBV

Do LBVs explode?

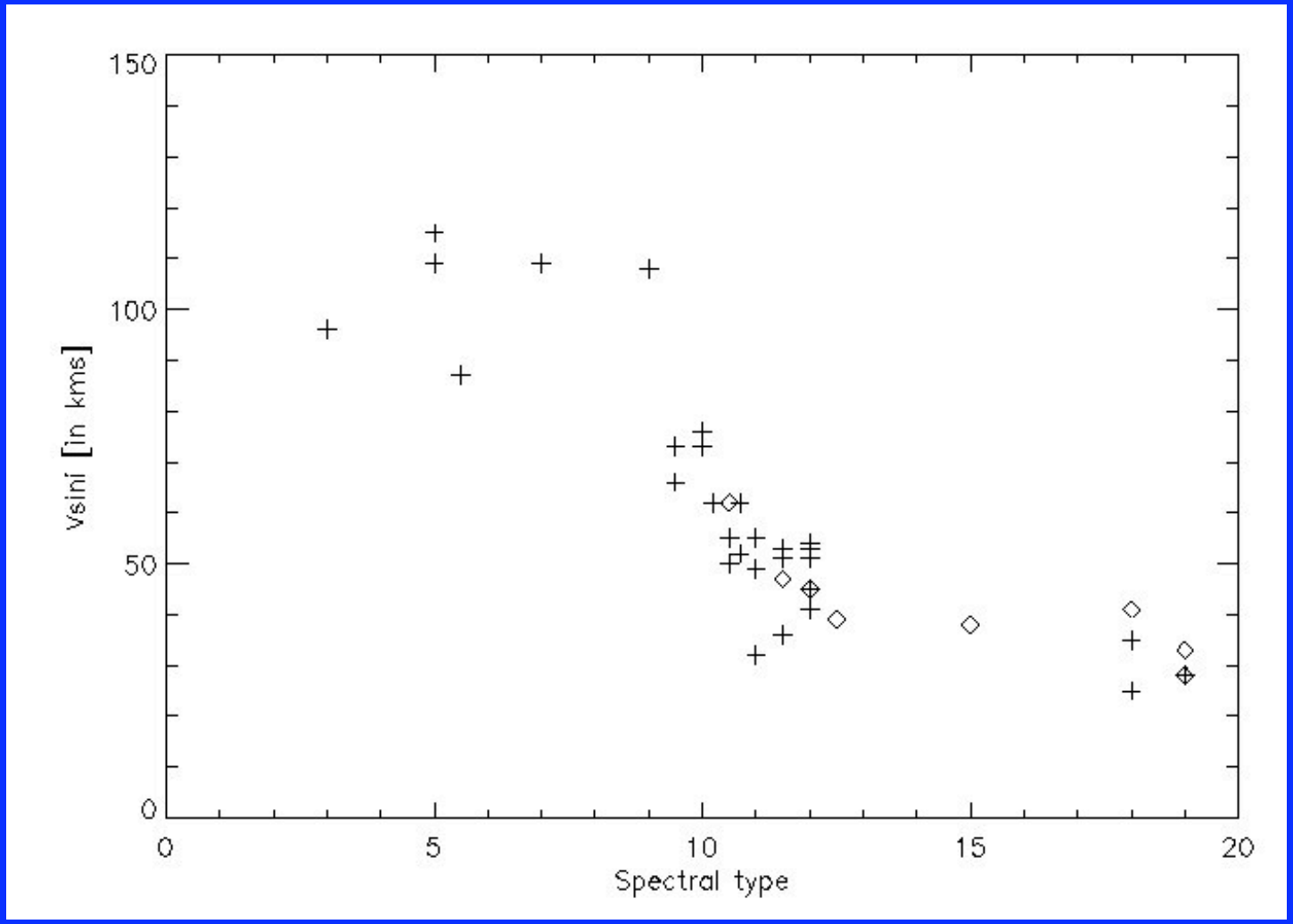


Trundle, Kotak et al. (2008)

Are the LBV winds changing the evolutionary paradigm?

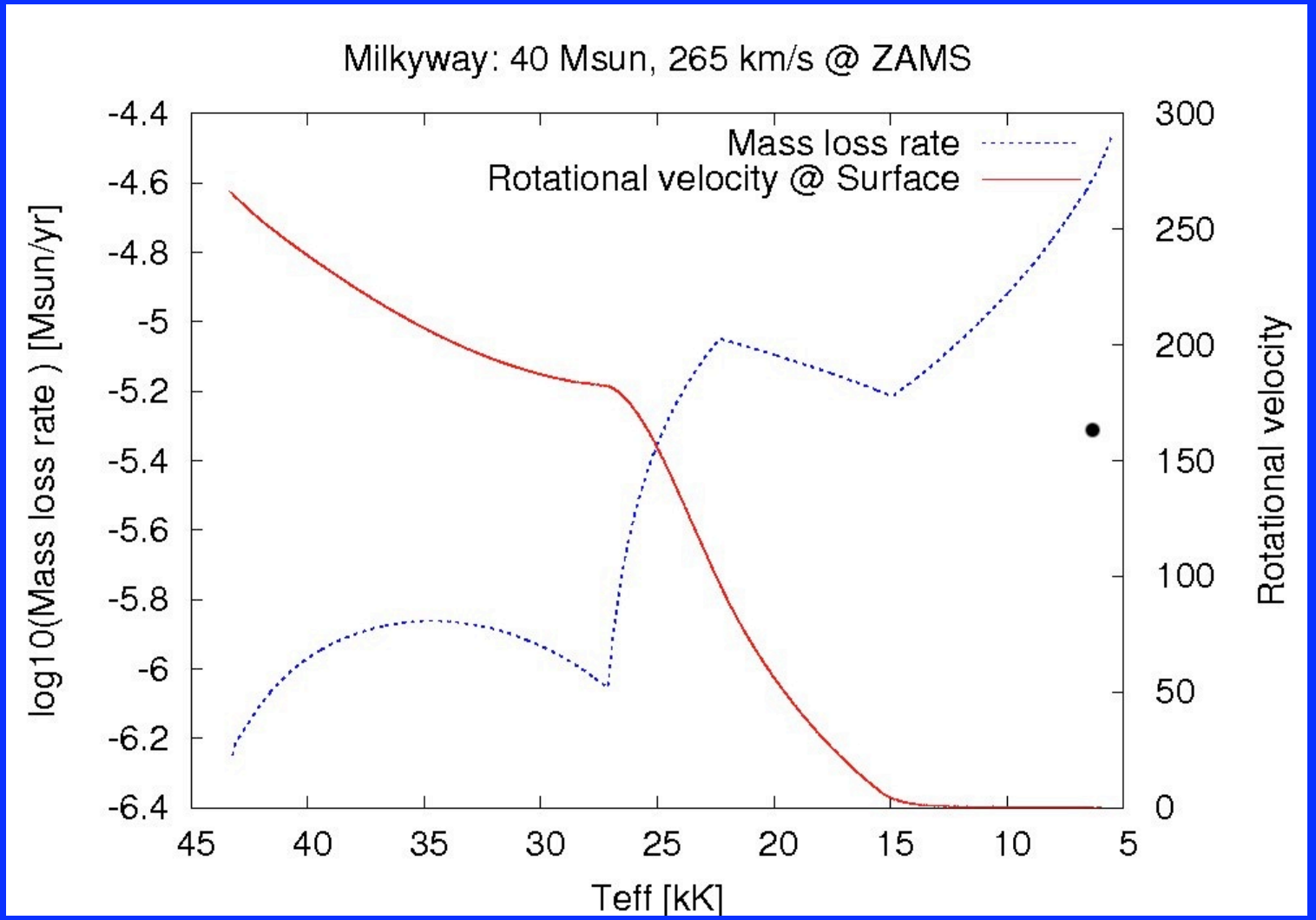
- canonical: O → LBV → WR → SN
- suggested: O → LBV → SN

OB rotation rates



Markova & Puls (2008)

Bi-stability braking?



Brott, Langer

Vink (2008) - astro-ph 0809.4789

Summary

- Mdot scalings with L & Z
- Monte Carlo + dynamics: v(r) + Mdot

Bi-Stability Jump:

- LBV variations (SN progenitors?)
- Rotation rates between O and B