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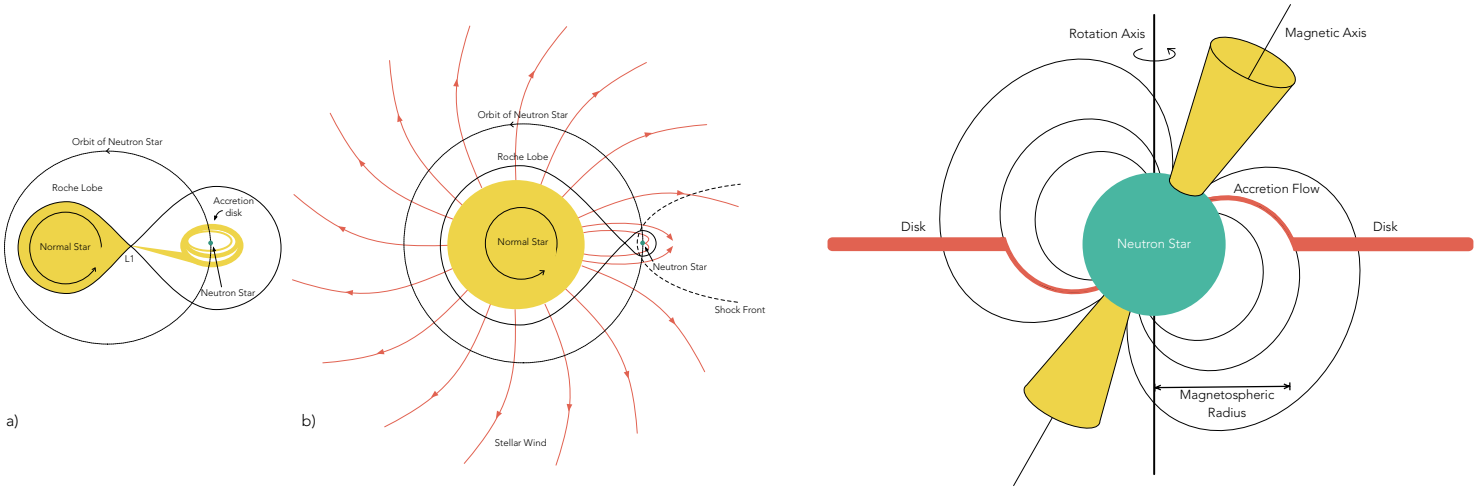


ON THE SPIN-UP/SPIN-DOWN TRANSITIONS IN ACCRETING X-RAY BINARIES

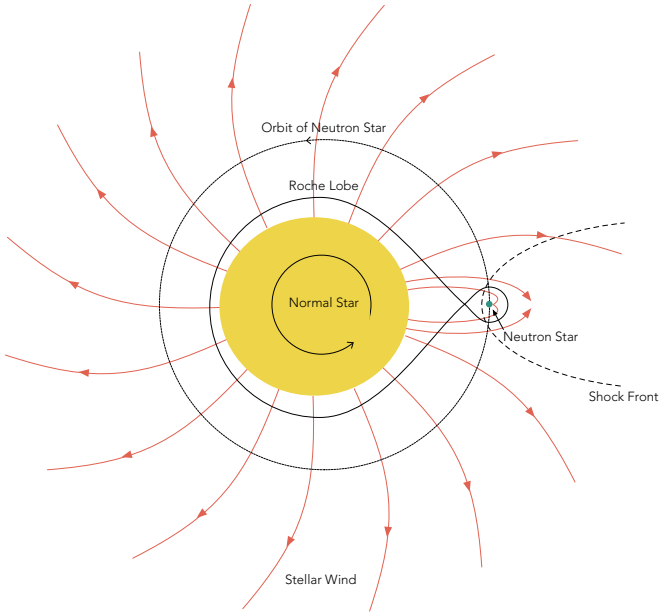
Authors:
Rosalba Perna, Enrico Bozzo, and Luigi Stella

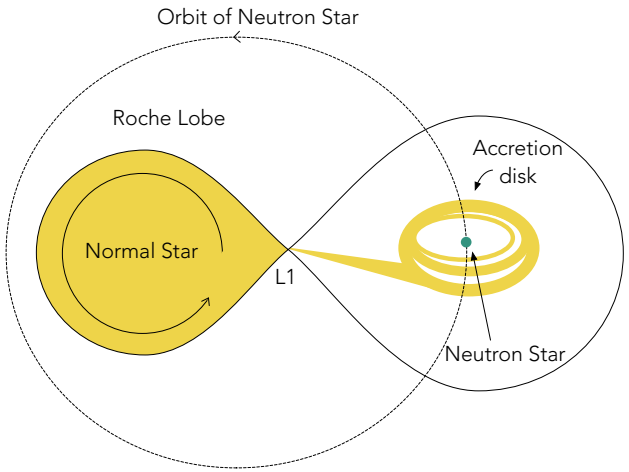
Journal Club, February 8, 2019, Inga Saathoff

Outline

Introduction
Model from Perna et al. 2006
- Inclined Rotator
- Hysteresis Limit Cycle
- Time Evolution

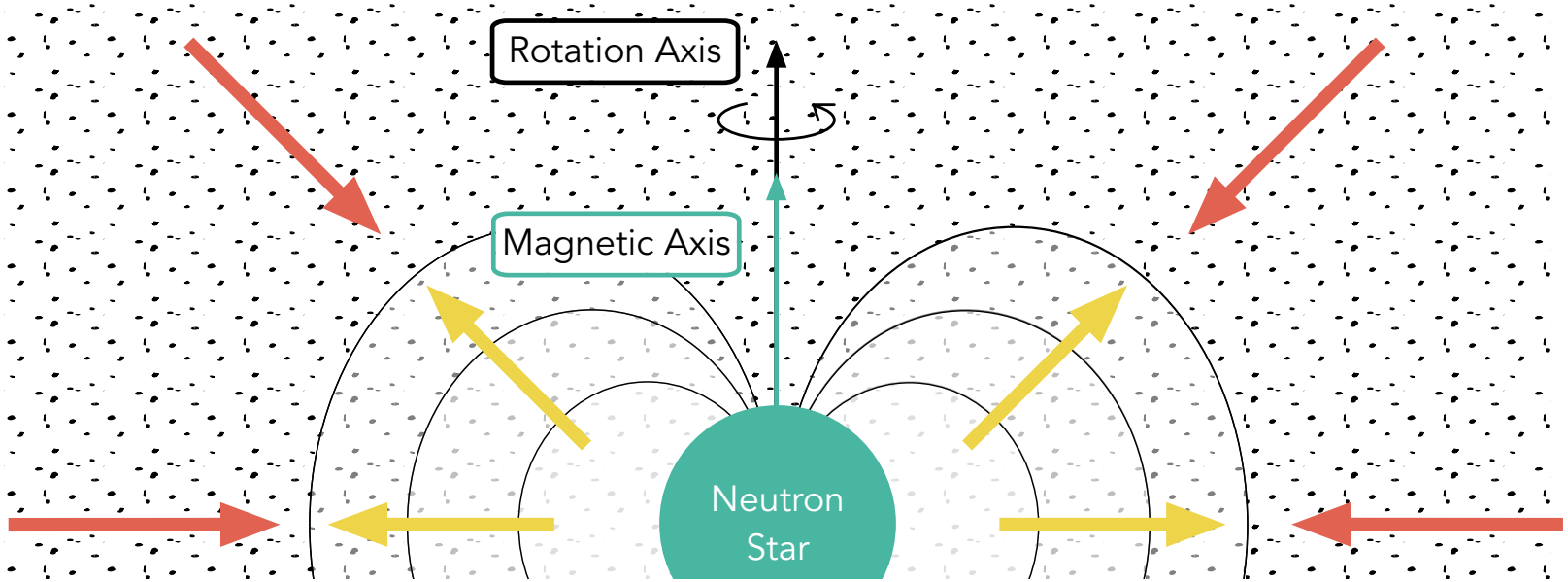
HMXB, LMXB





- High Mass X-ray Binaries (HMXB):
  - Compact star: Neutron Star, White Dwarf or Black Hole
  - Companion: Early type star (O-B) with $M > 5M_{\odot}$
  - Strong magnetic field (~ 10^{12} G)
- Low Mass X-ray Binaries (LMXB):
  - Compact star: Neutron Star, White Dwarf or Black Hole
  - Companion: Late type star (M-K) with $M < 1M_{\odot}$
  - Low magnetic field (~ 10^{9} G)

Model: Aligned Rotator



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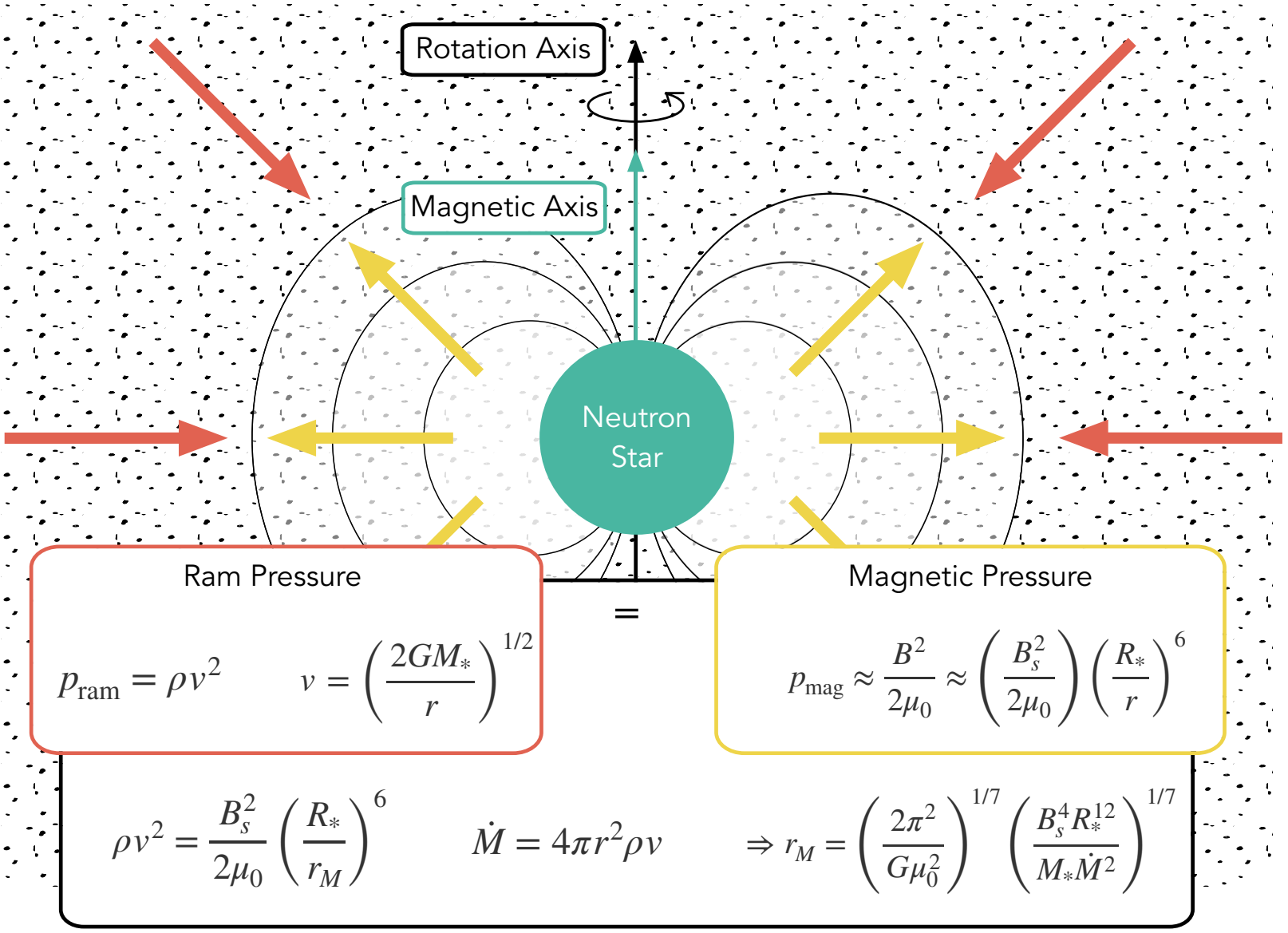


Ram Pressure

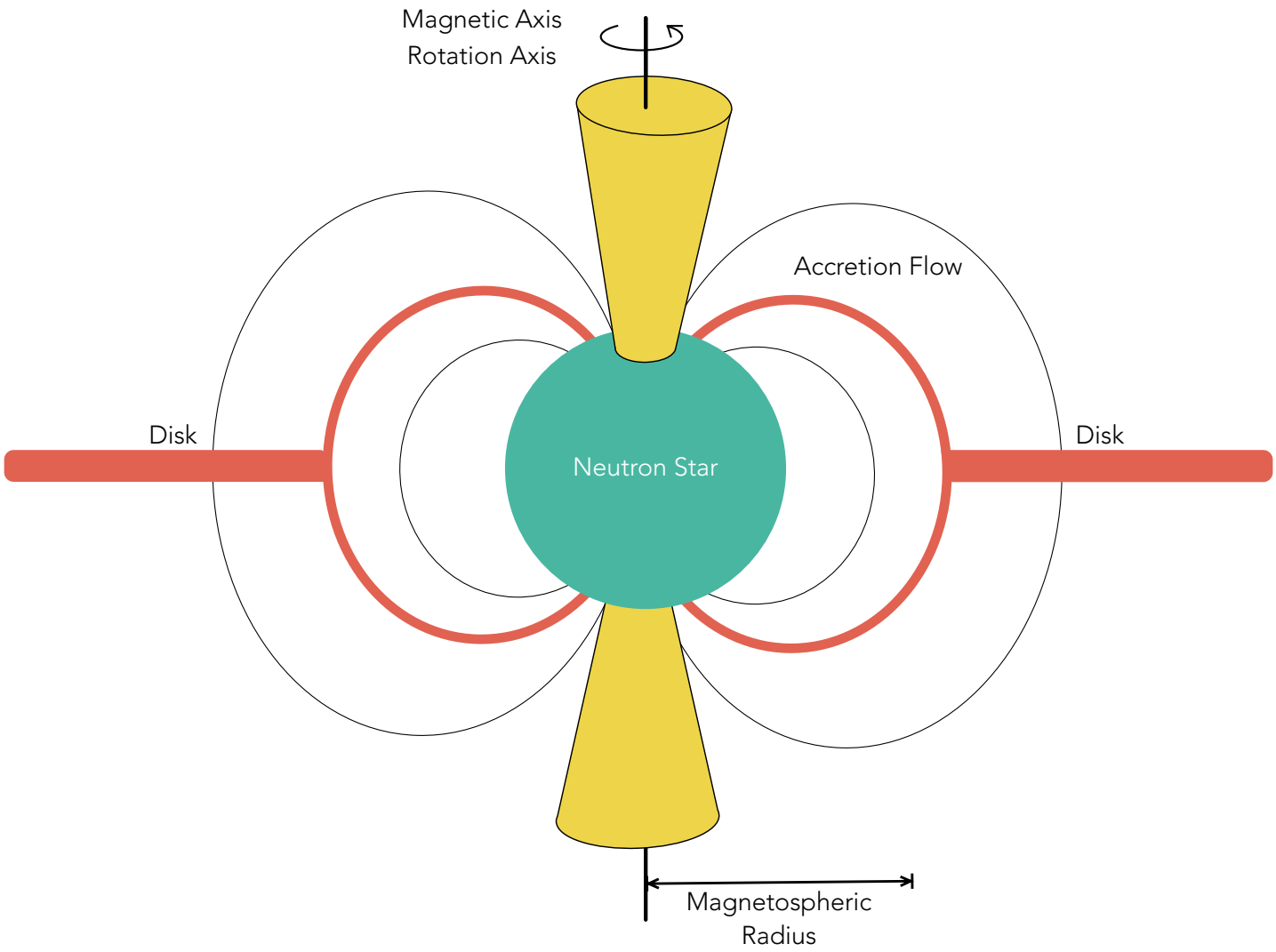
$$p_{\mathrm{ram}} = \rho v^2 \qquad v = \left(\frac{2GM_*}{r}\right)^{1/2}$$

Magnetic Pressure

$$p_{\mathrm{mag}} \approx \frac{B^2}{2\mu_0} \approx \left(\frac{B_s^2}{2\mu_0}\right)\left(\frac{R_*}{r}\right)^6$$

$$\rho v^2 = \frac{B_s^2}{2\mu_0}\left(\frac{R_*}{r_M}\right)^6 \qquad \dot{M} = 4\pi r^2 \rho v \qquad \Rightarrow r_M = \left(\frac{2\pi^2}{G\mu_0^2}\right)^{1/7}\left(\frac{B_s^4 R_*^{12}}{M_* \dot{M}^2}\right)^{1/7}$$

Model: Aligned Rotator



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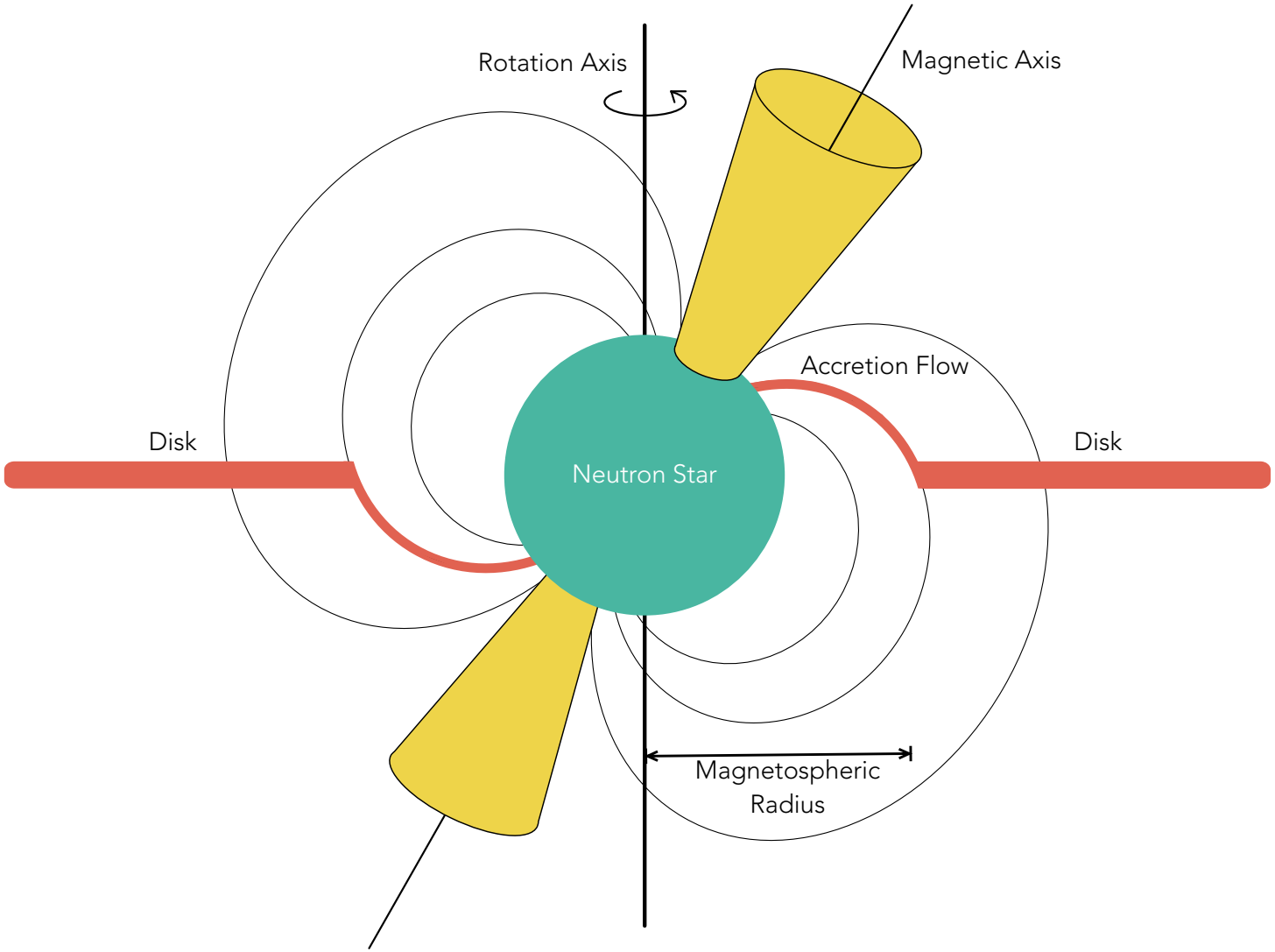
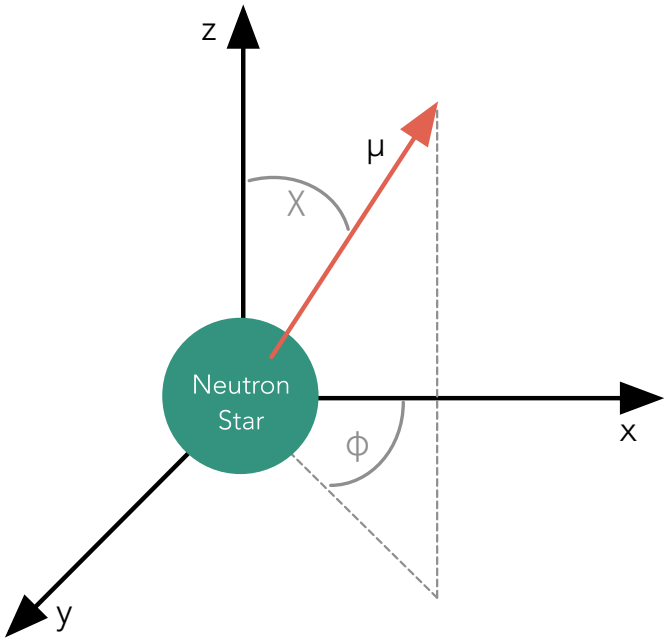
Model: Inclined Rotator

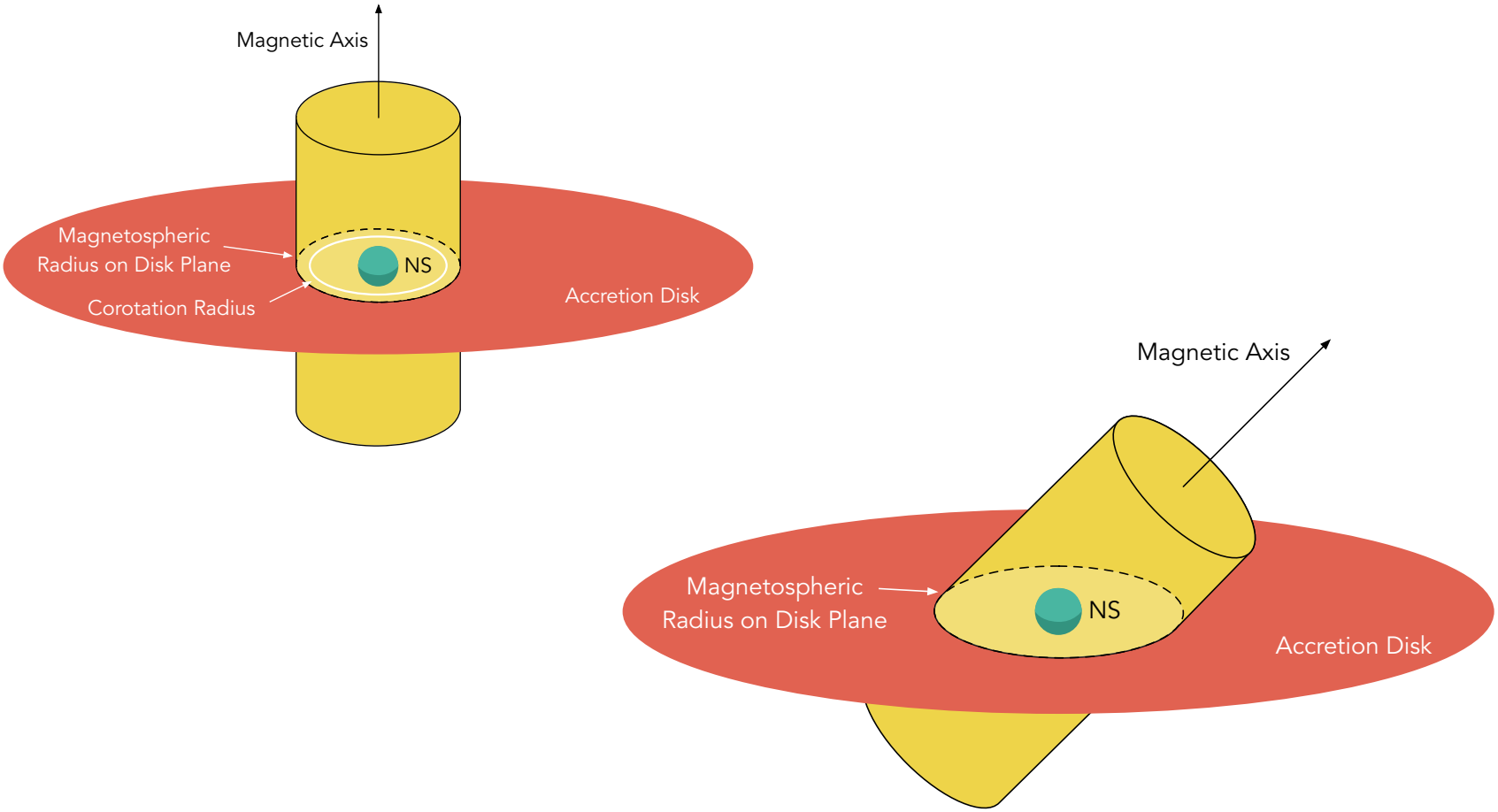


Model: Inclined Rotator

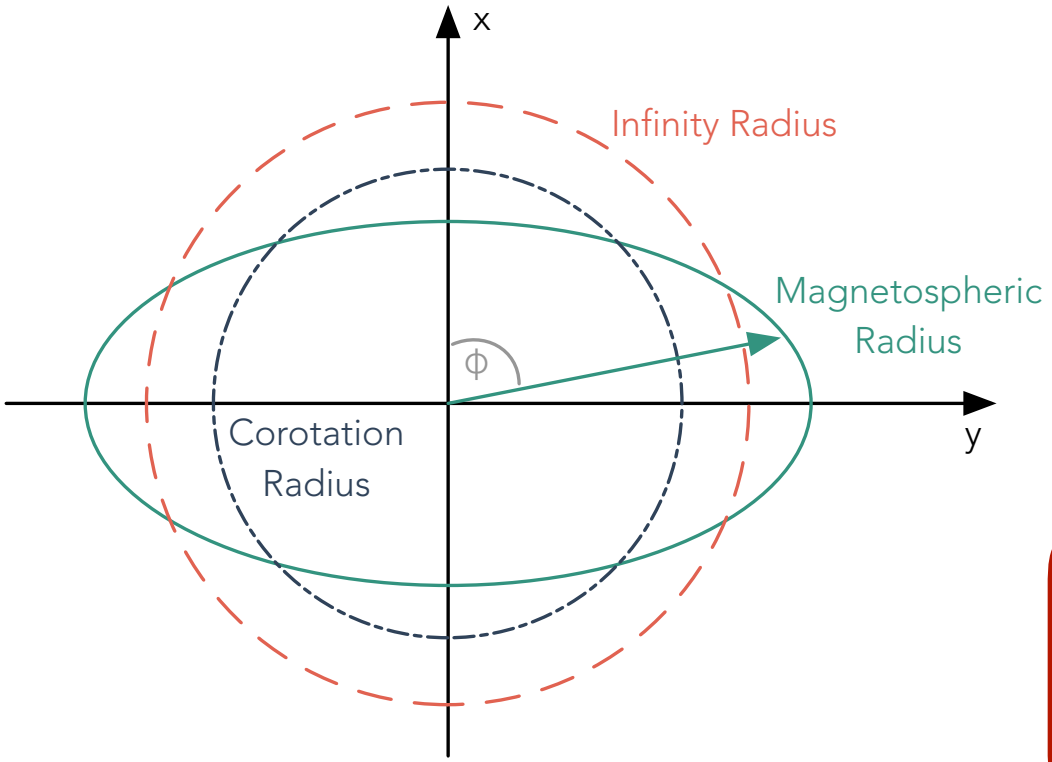


$$B^2 = \frac{\mu^2}{r^6}[1 + 3(\sin\chi \sin\phi)^2]$$

Model: Inclined Rotator



Model: Inclined Rotator



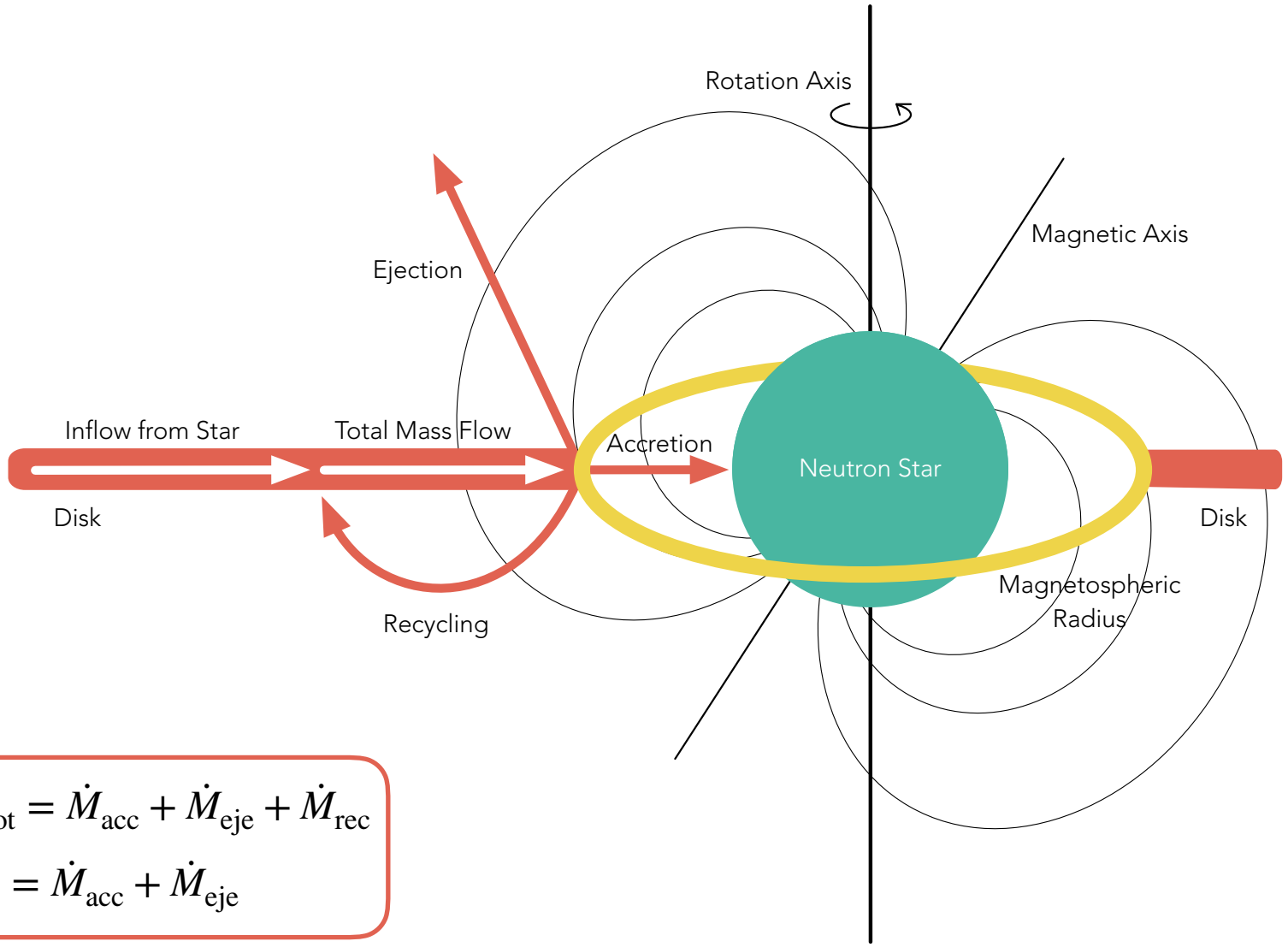
$R_M(\phi) < R_{\rm co}$: accretion

$R_{\rm co} < R_M(\phi) < R_{\rm inf}$: recycling

$R_M(\phi) > R_{\rm inf}$: ejection

$$\Rightarrow R_M(\phi) = 3.2 \times 10^8 \, \mu_{30}^{4/7} M_1^{-1/7} \dot{M}_{17}^{-2/7} [1 + 3(\sin\chi \, \sin\phi)^2]^{2/7}$$

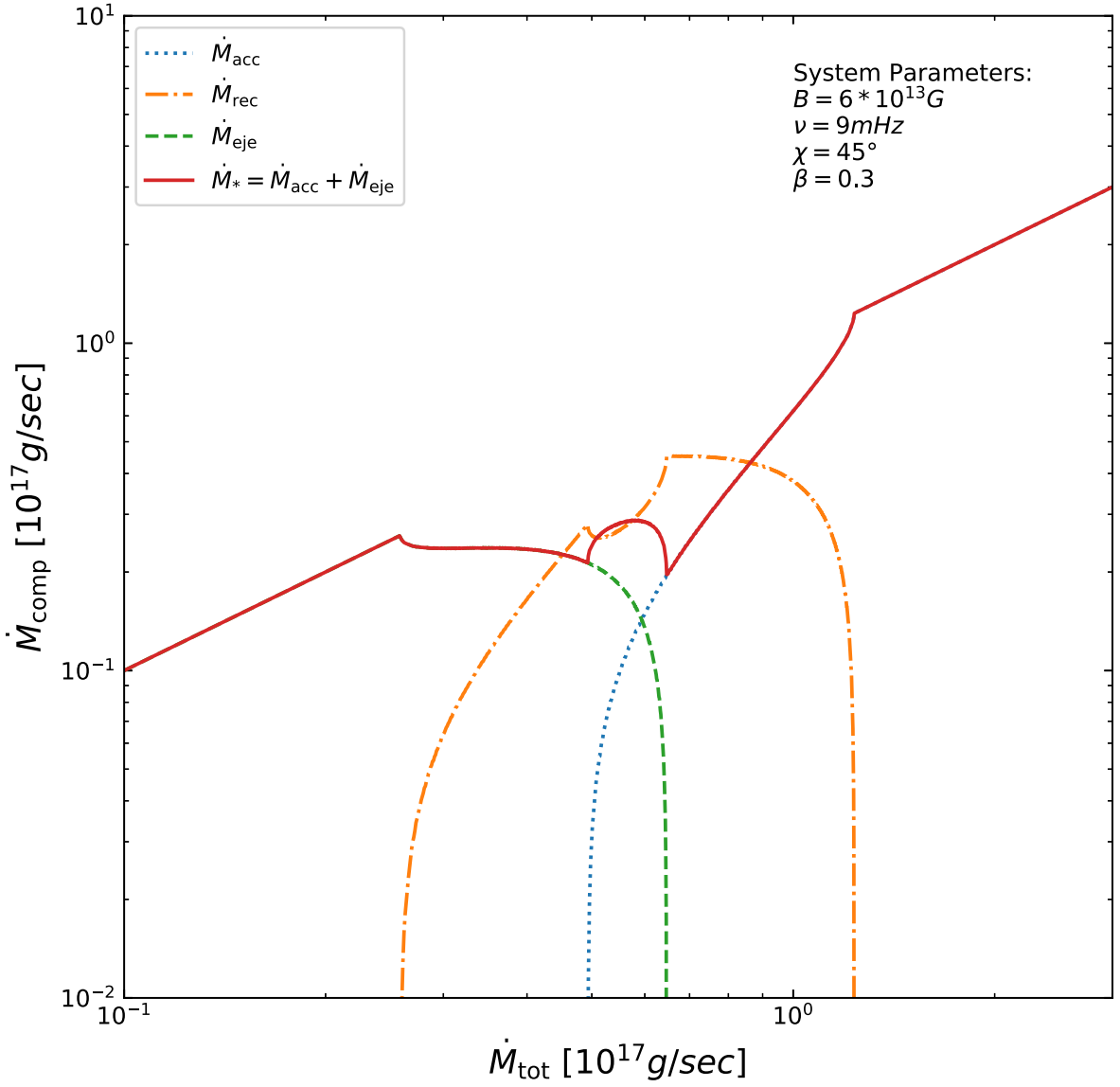
Contributions to $\dot{M}_{\rm tot}$



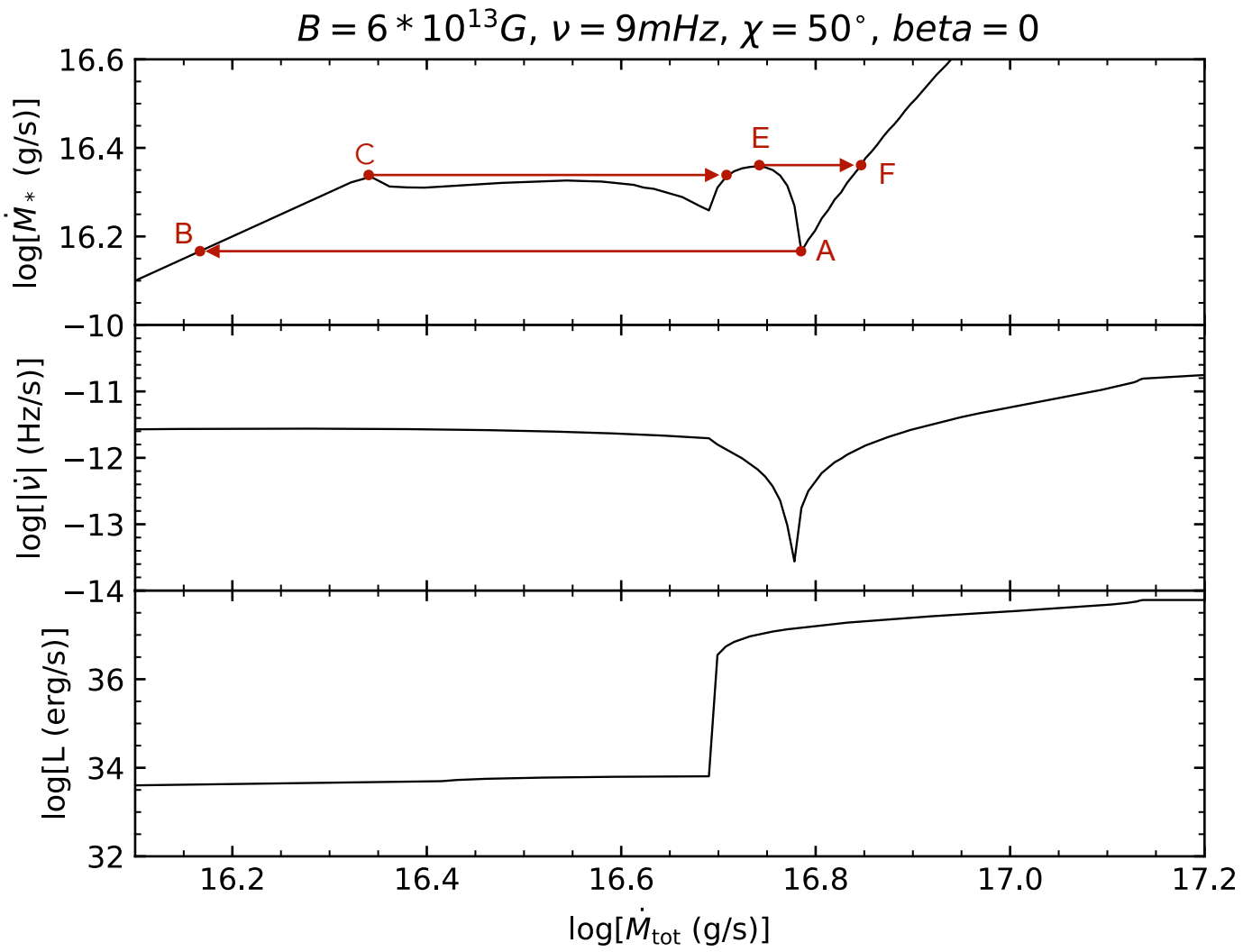
$$\dot{M}_{\rm tot} = \dot{M}_{\rm acc} + \dot{M}_{\rm eje} + \dot{M}_{\rm rec}$$

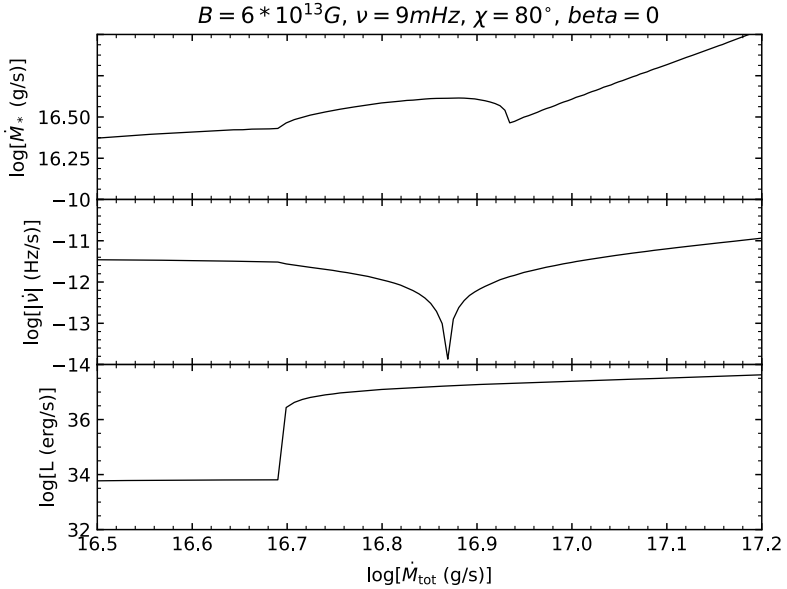
$$\dot{M}_{*} = \dot{M}_{\rm acc} + \dot{M}_{\rm eje}$$

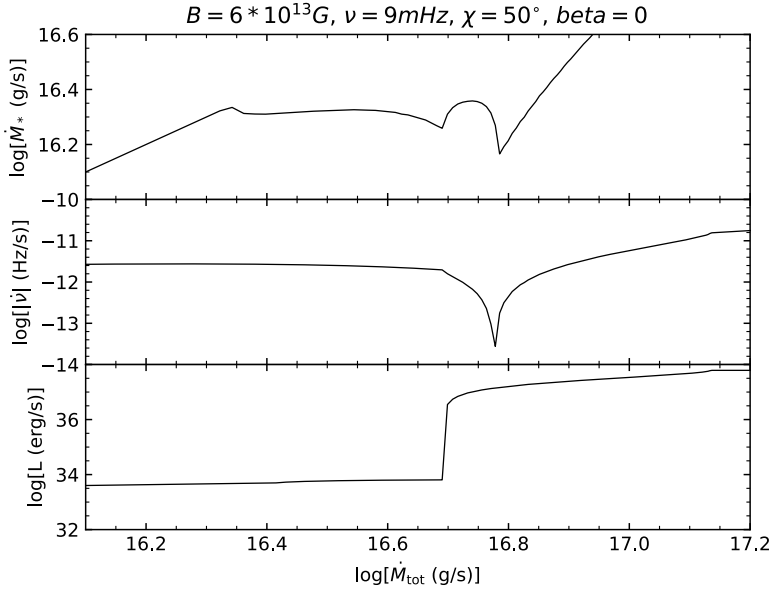
Contributions to $\dot{M}_{\mathrm{tot}}$

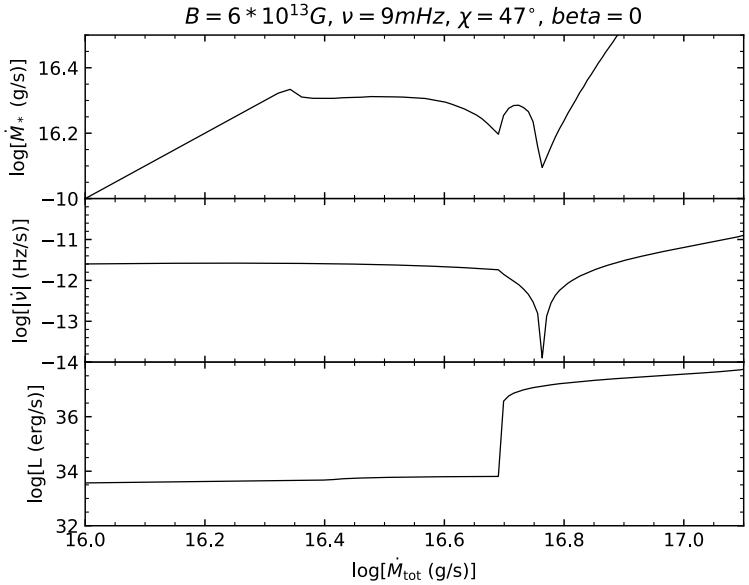


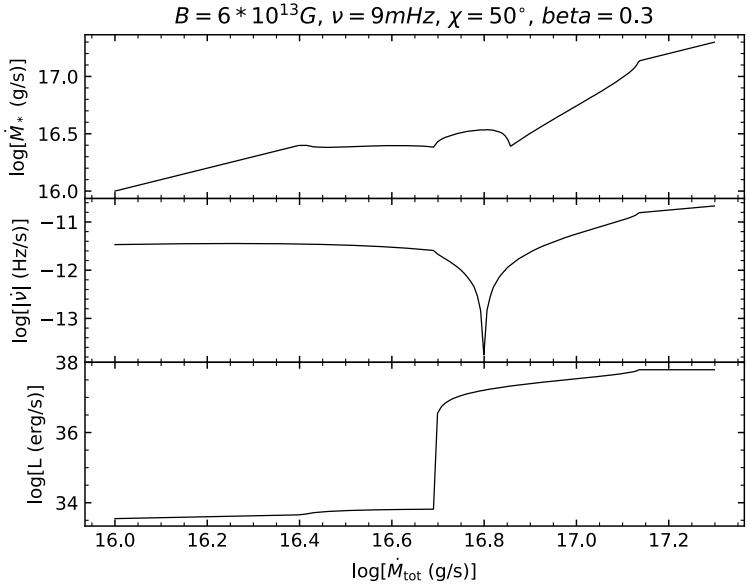
Hysteresis Limit Cycle





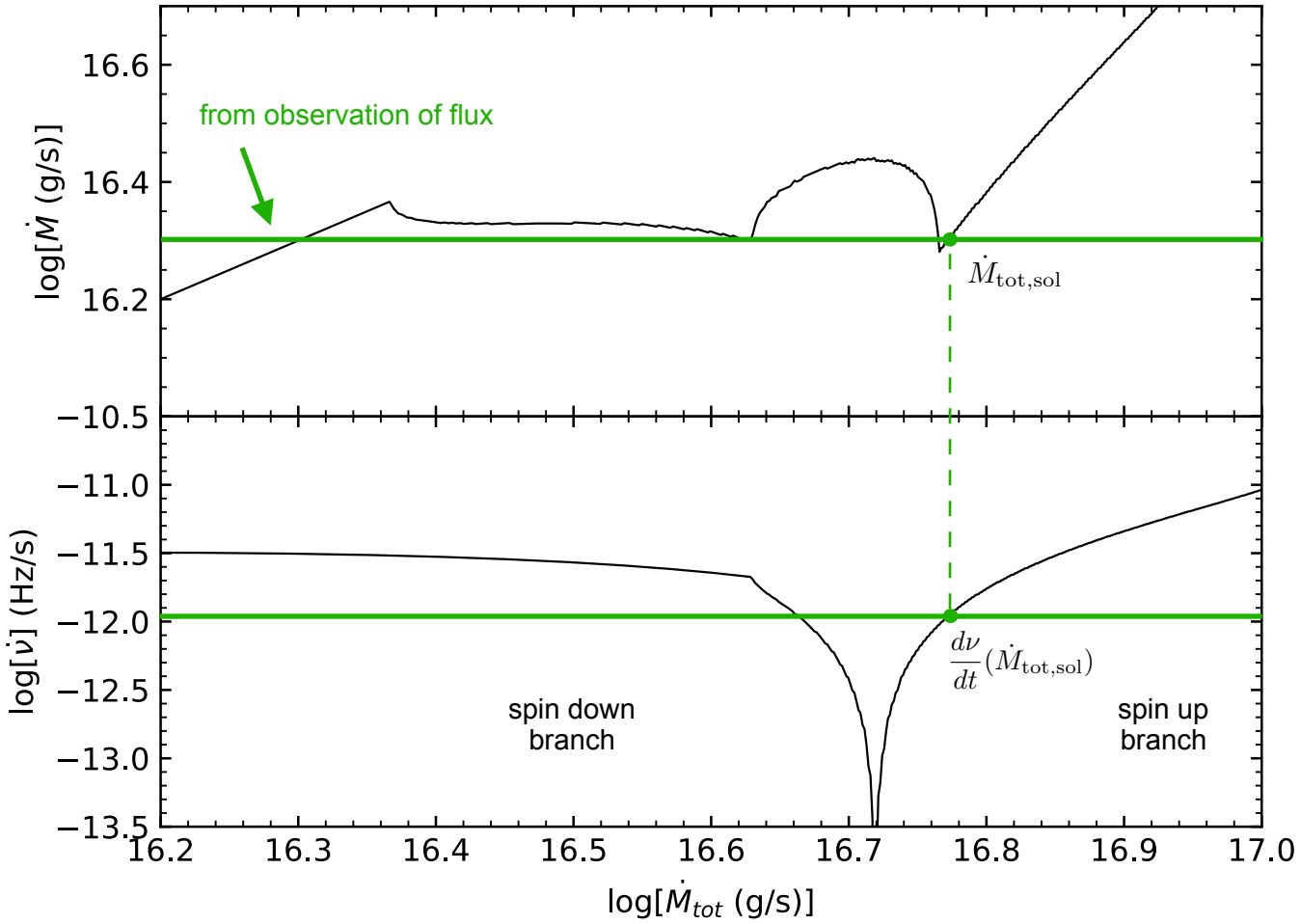


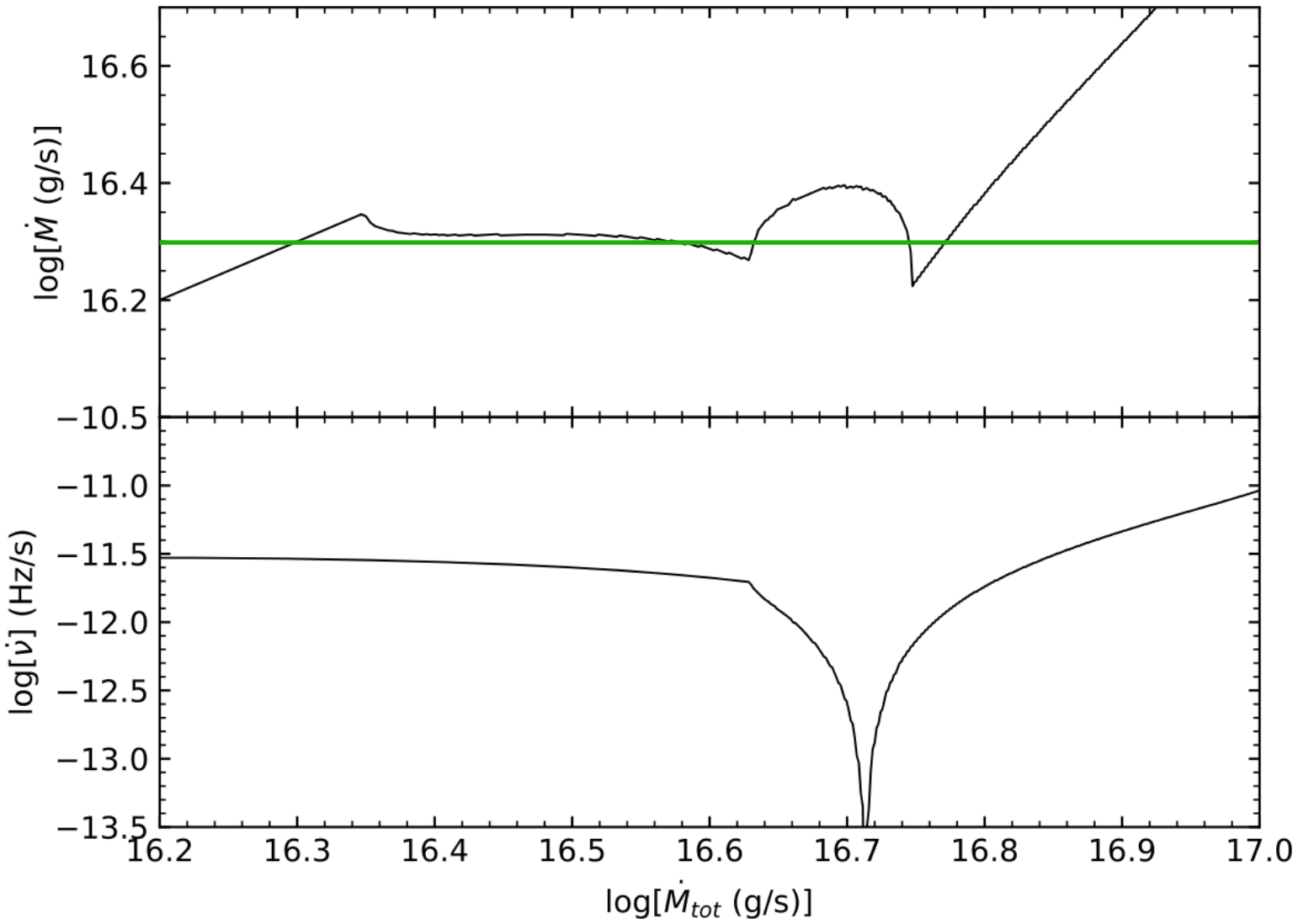




Time Evolution

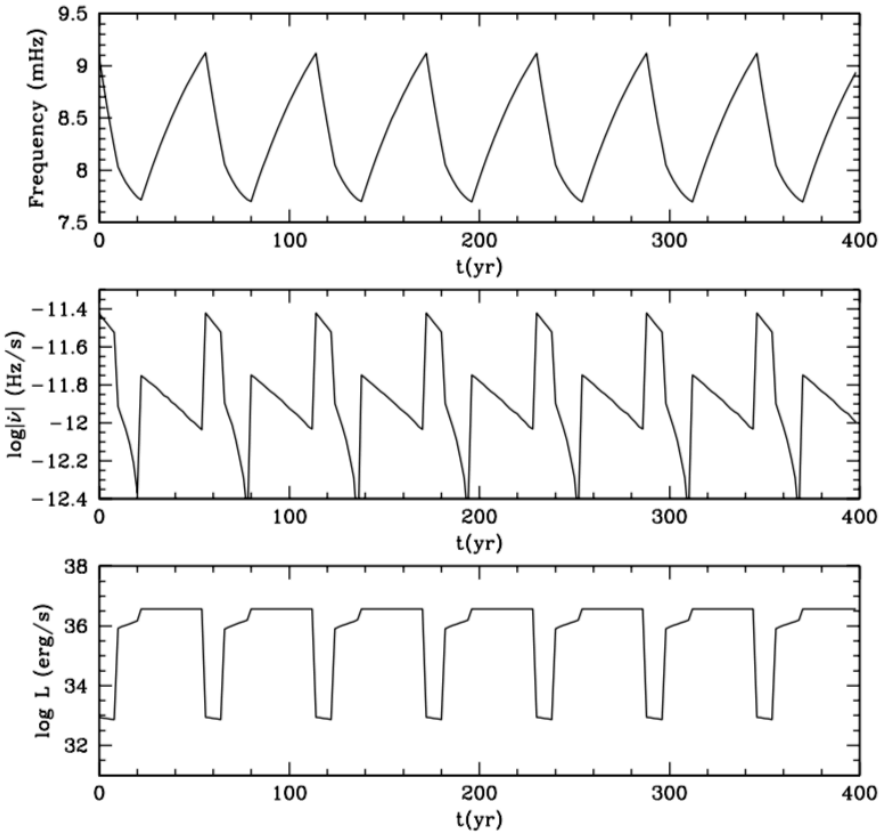
$$\nu(t+dt) = \nu(t) + \frac{d\nu}{dt}(\dot{M}_{\mathrm{tot,sol}})$$





Time Evolution

GX 1+4



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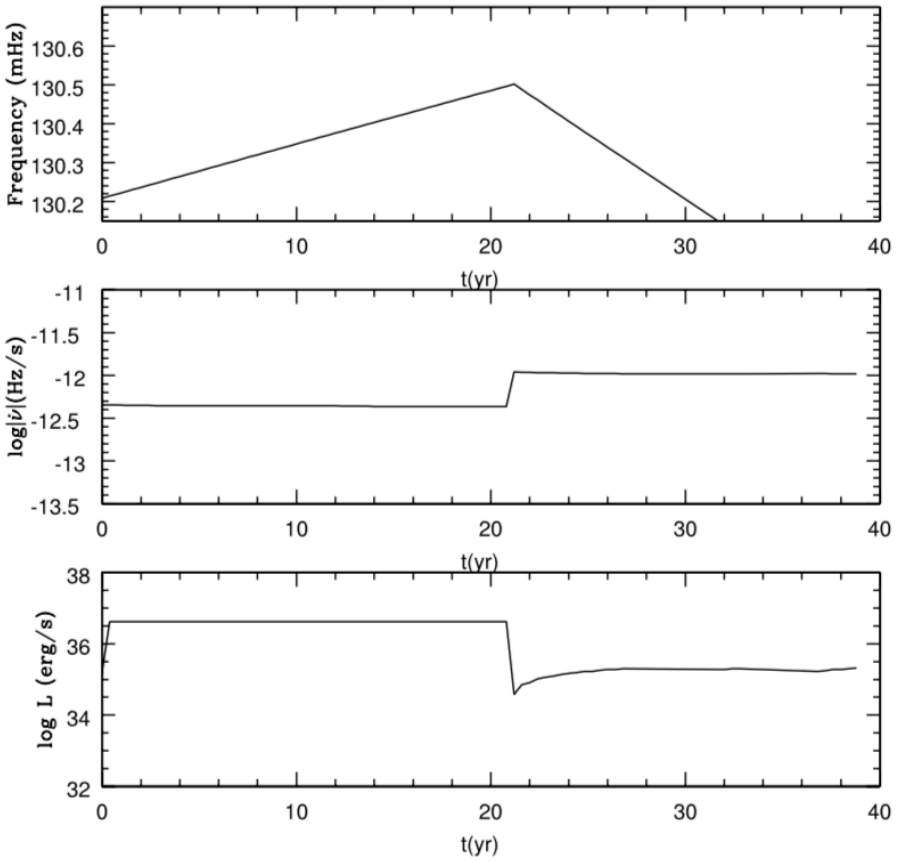
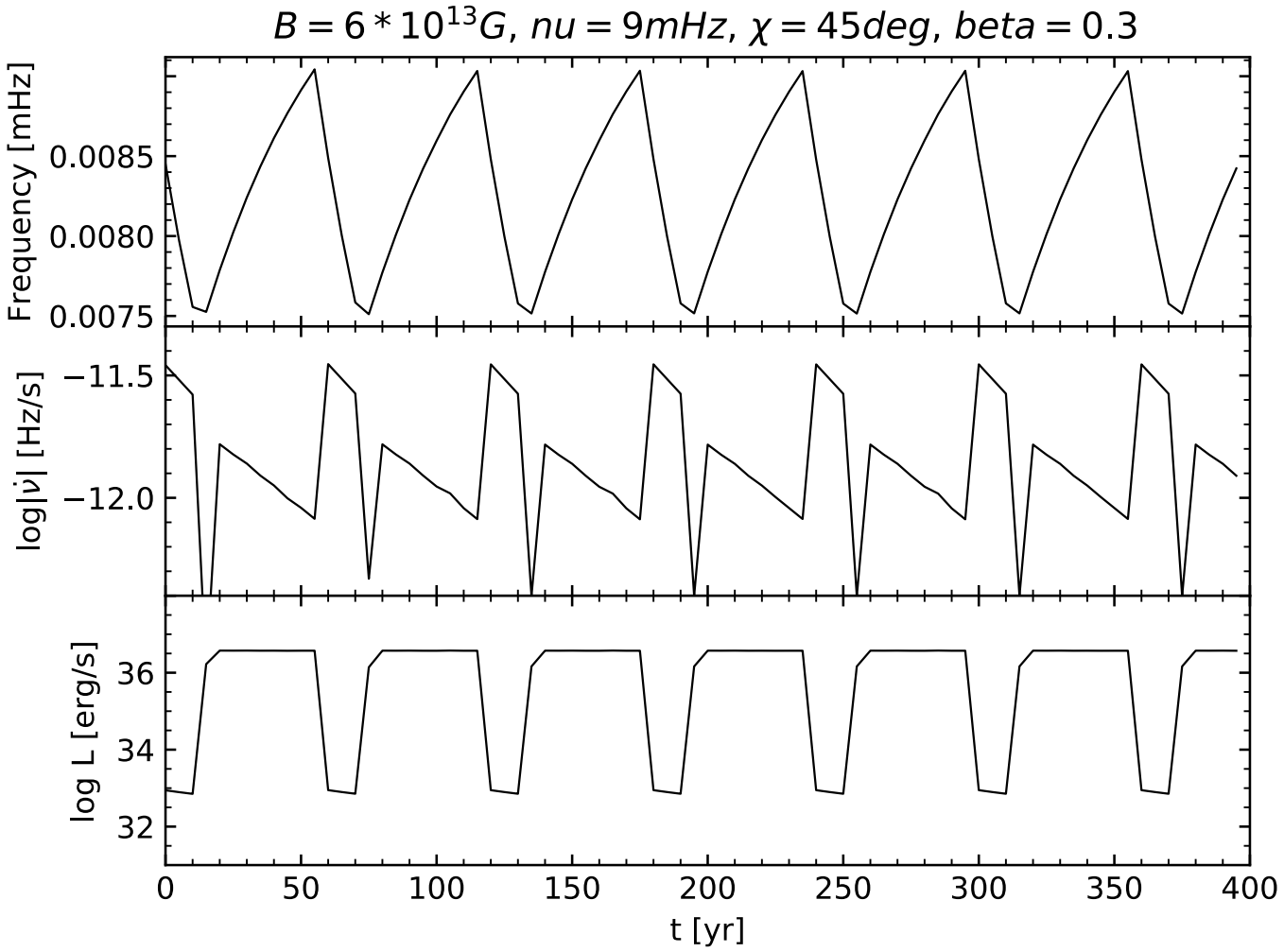


GX 1+4



Thank you.

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