

Circumbinary accretion disks

环双星吸积盘

Simulation results and Applications

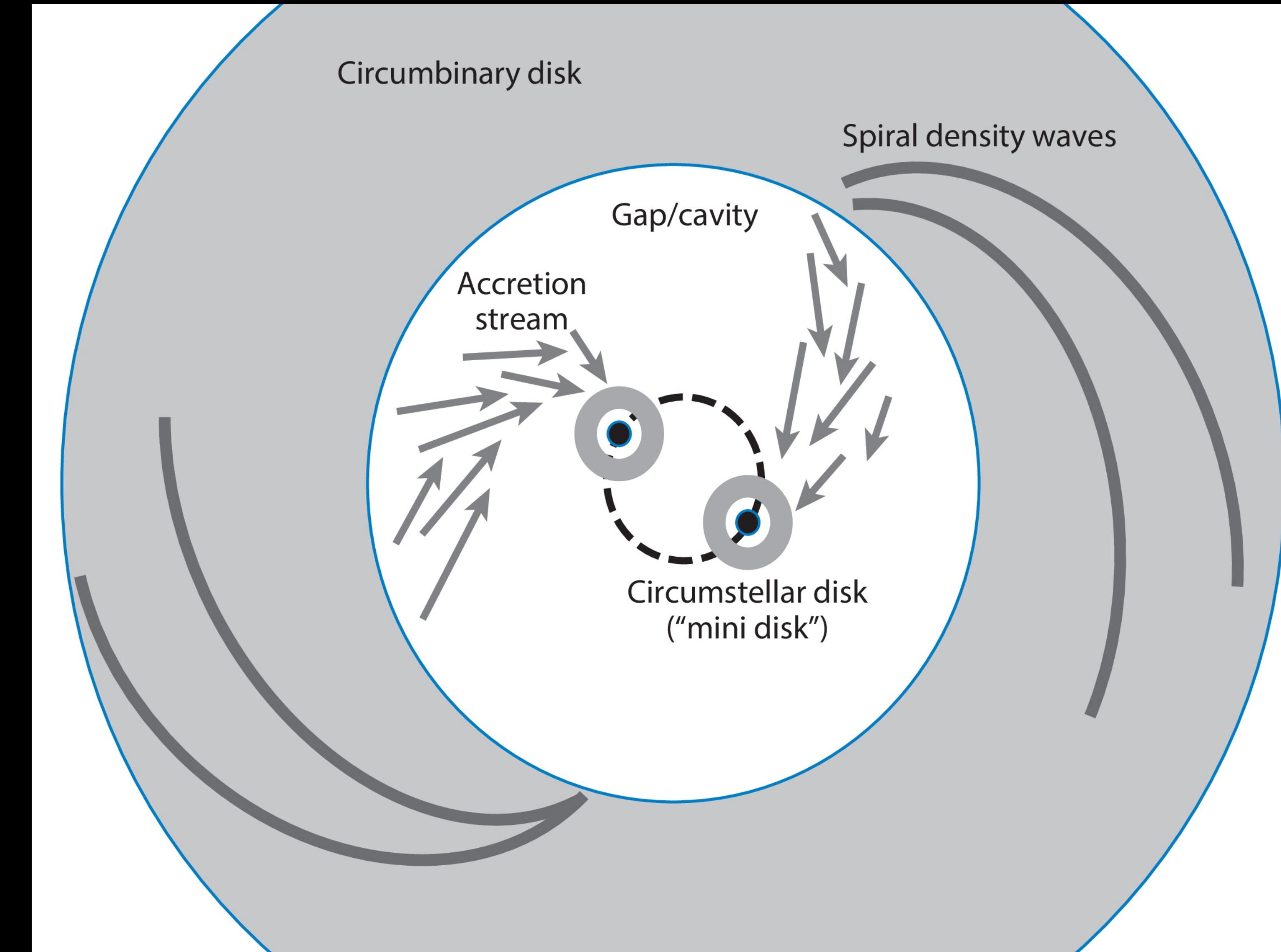
数值模拟结果及应用

杨锐祺

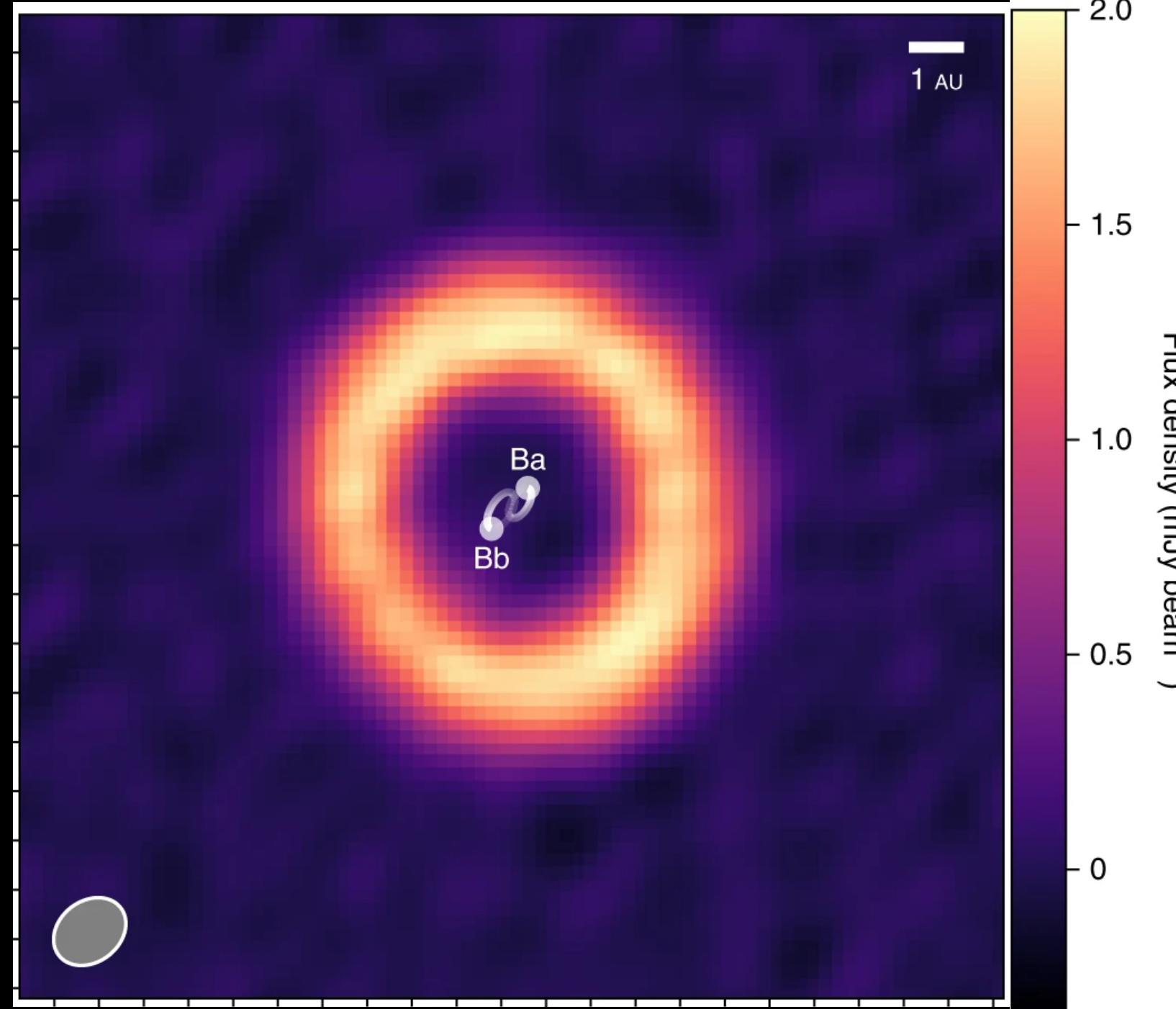
Dec 5. 2023

简介

- 基本结构 (CBD)
 - 环双星盘
 - 螺旋密度波
 - 空腔&空隙
 - 吸积流
 - 星周盘 (“迷你盘”)



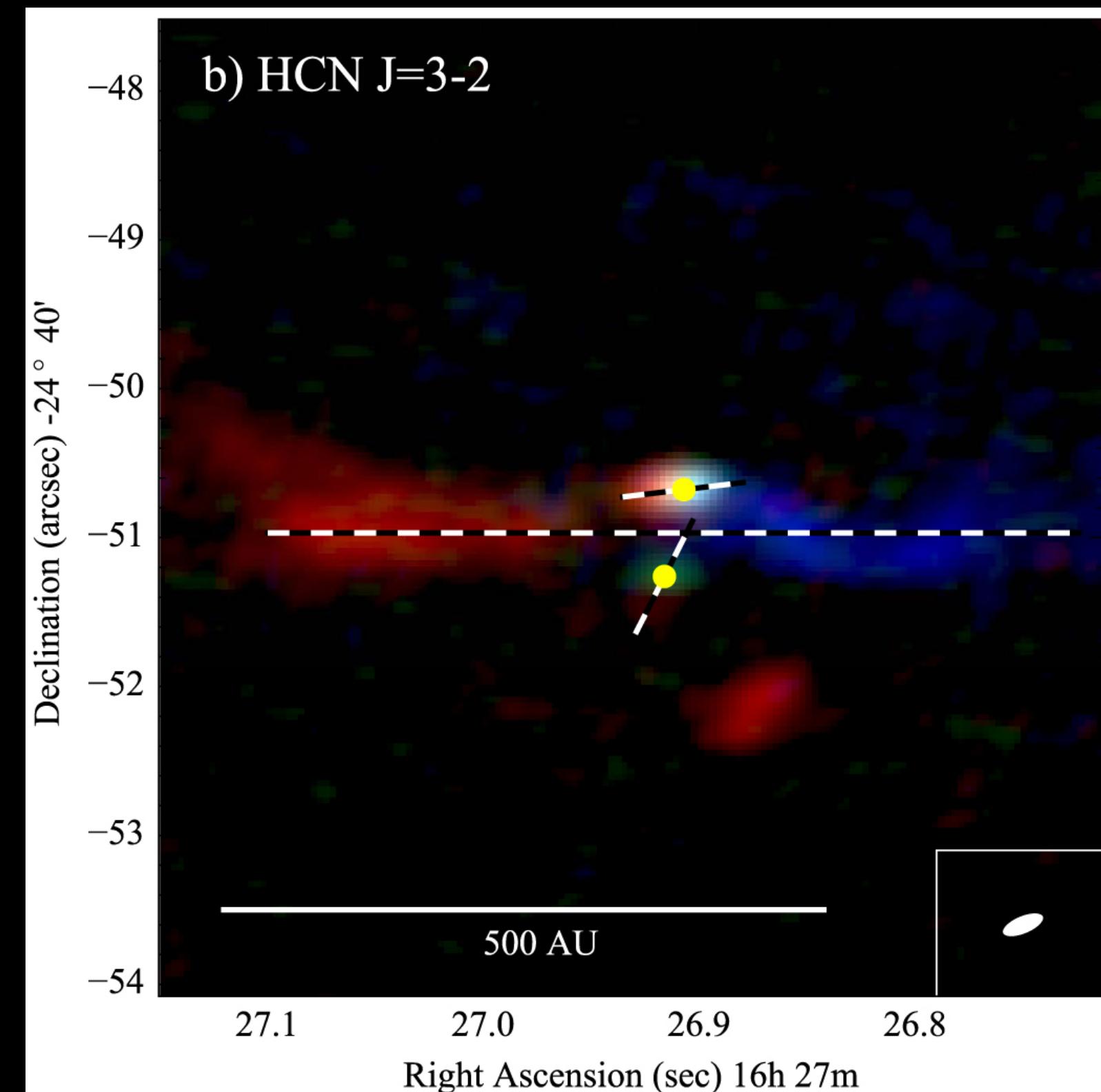
简介



原行星盘

HD 98800

Kennedy et al. 2019/ALMA



原恒星盘

IRS 43

Brinch et al. 2016/ALMA



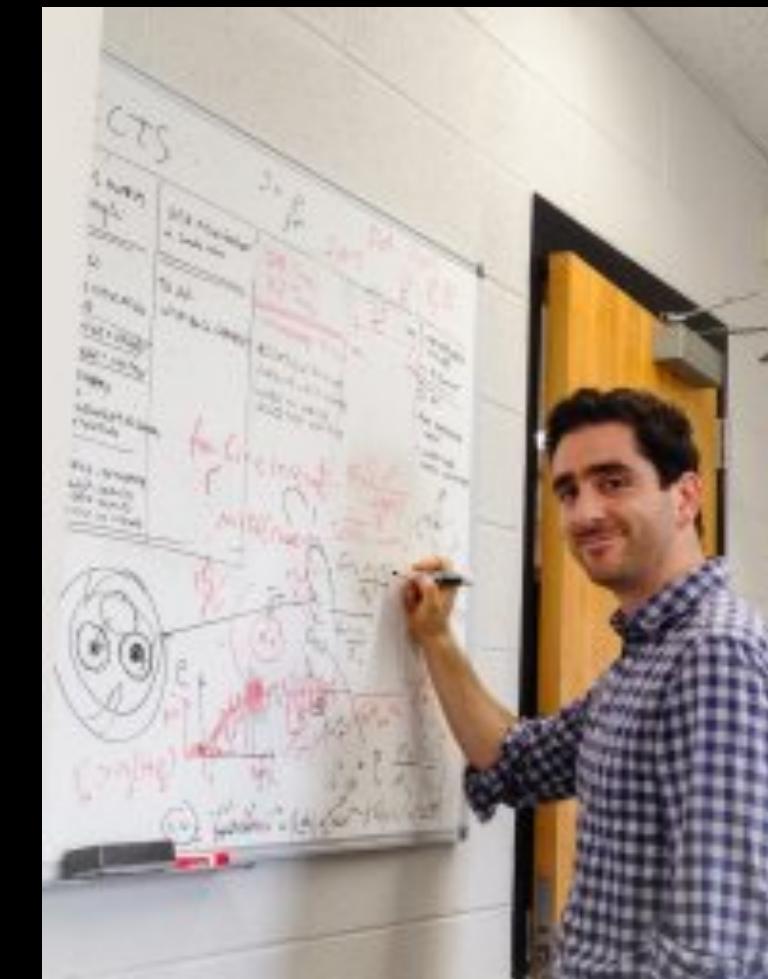
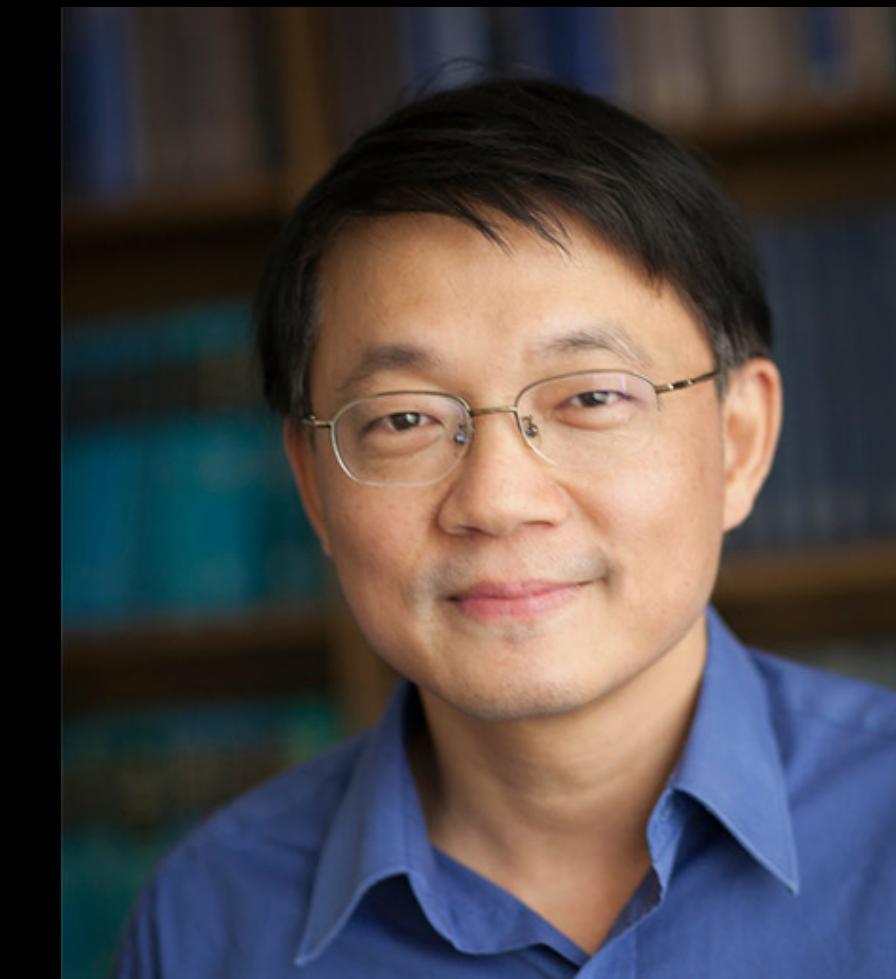
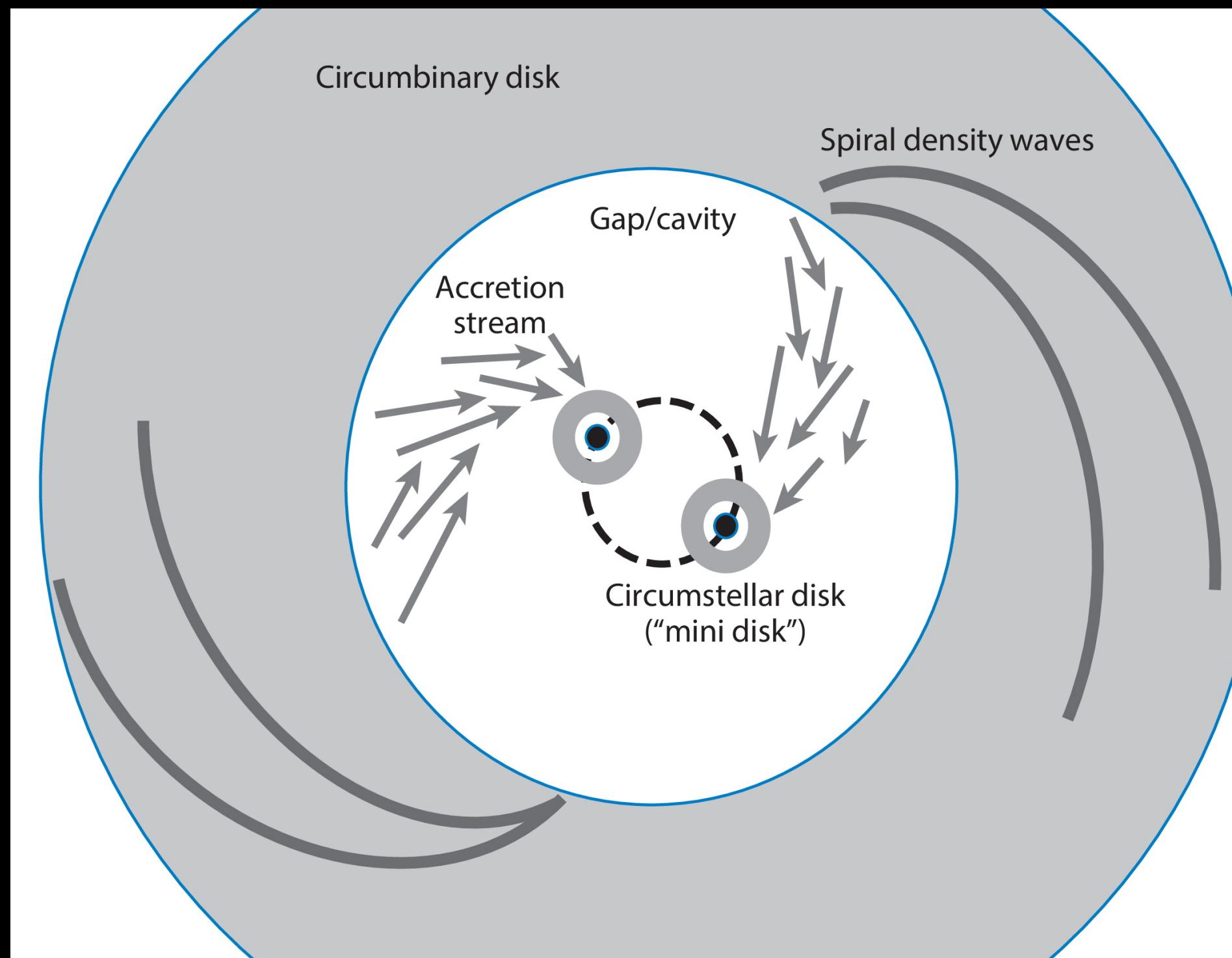
星系合并
(超) 大质量黑洞

NGC 4676

HST

主要模拟结果

- 难度：空间跨度大，周期长，变化剧烈

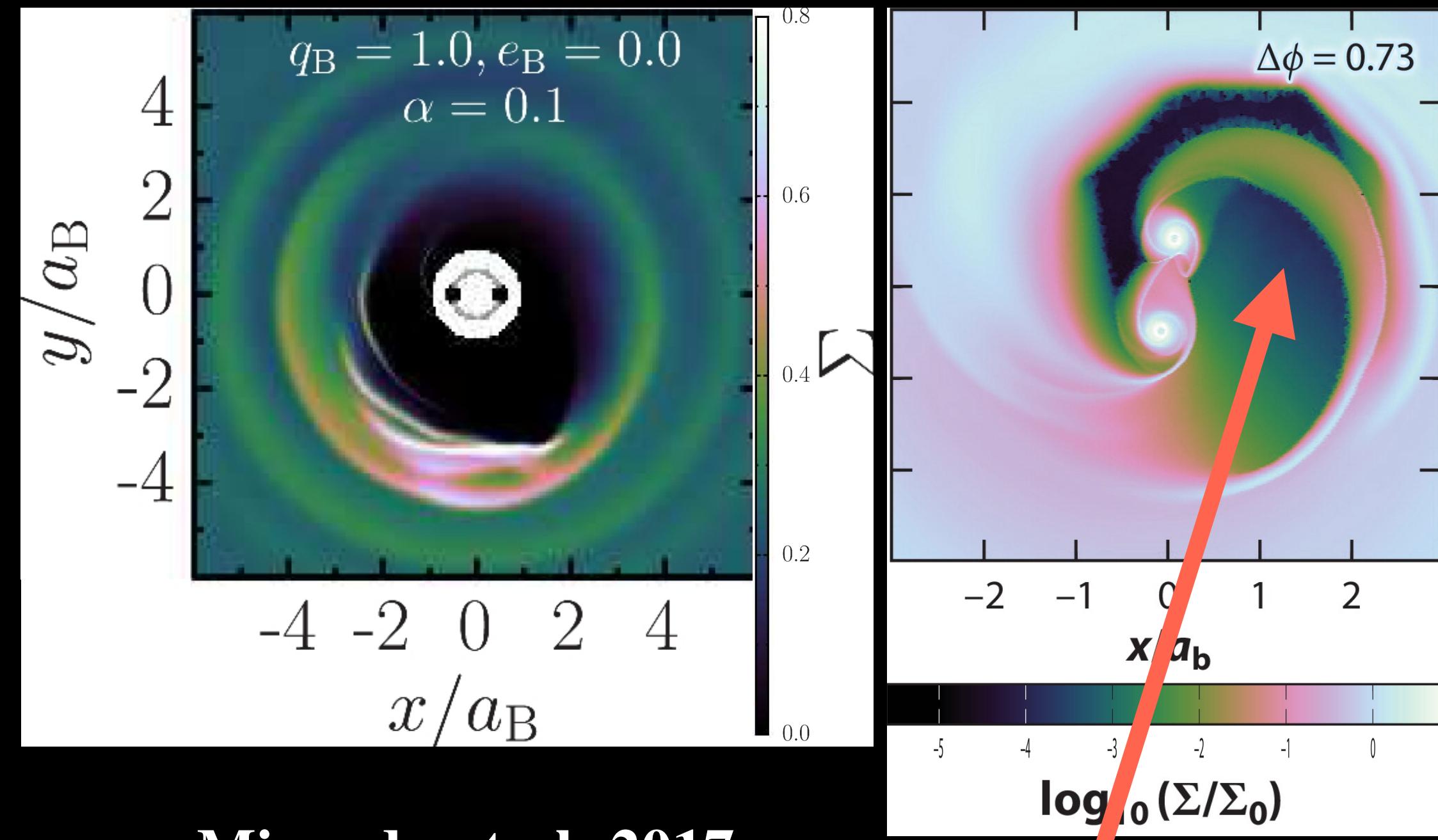


Lai, Muñoz . 2023

**Circumbinary Accretion:
From Binary Stars to
Massive Binary Black Holes**

- 共面等质量双星、固定粘滞度

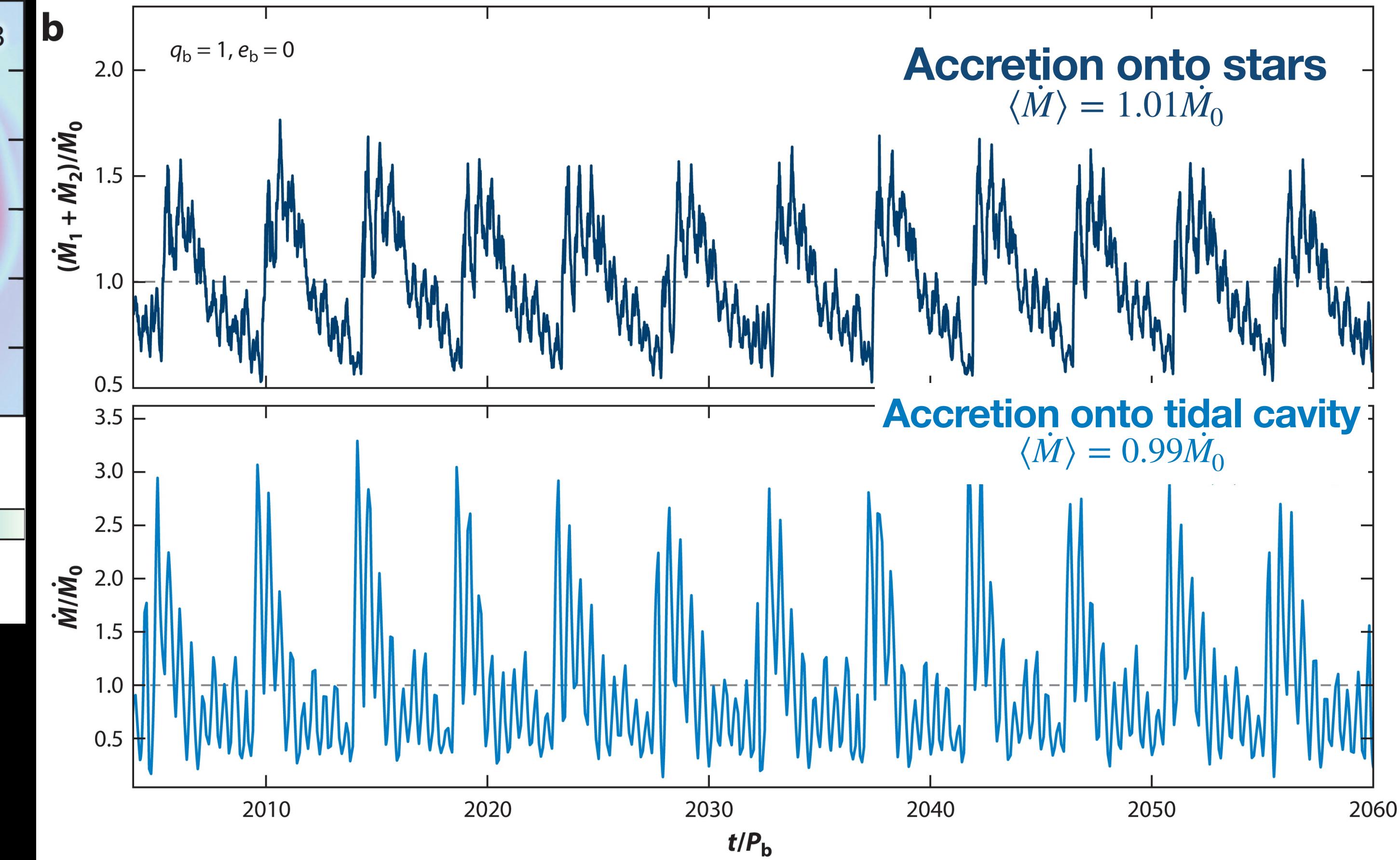
短期变化特征



Miranda et al. 2017

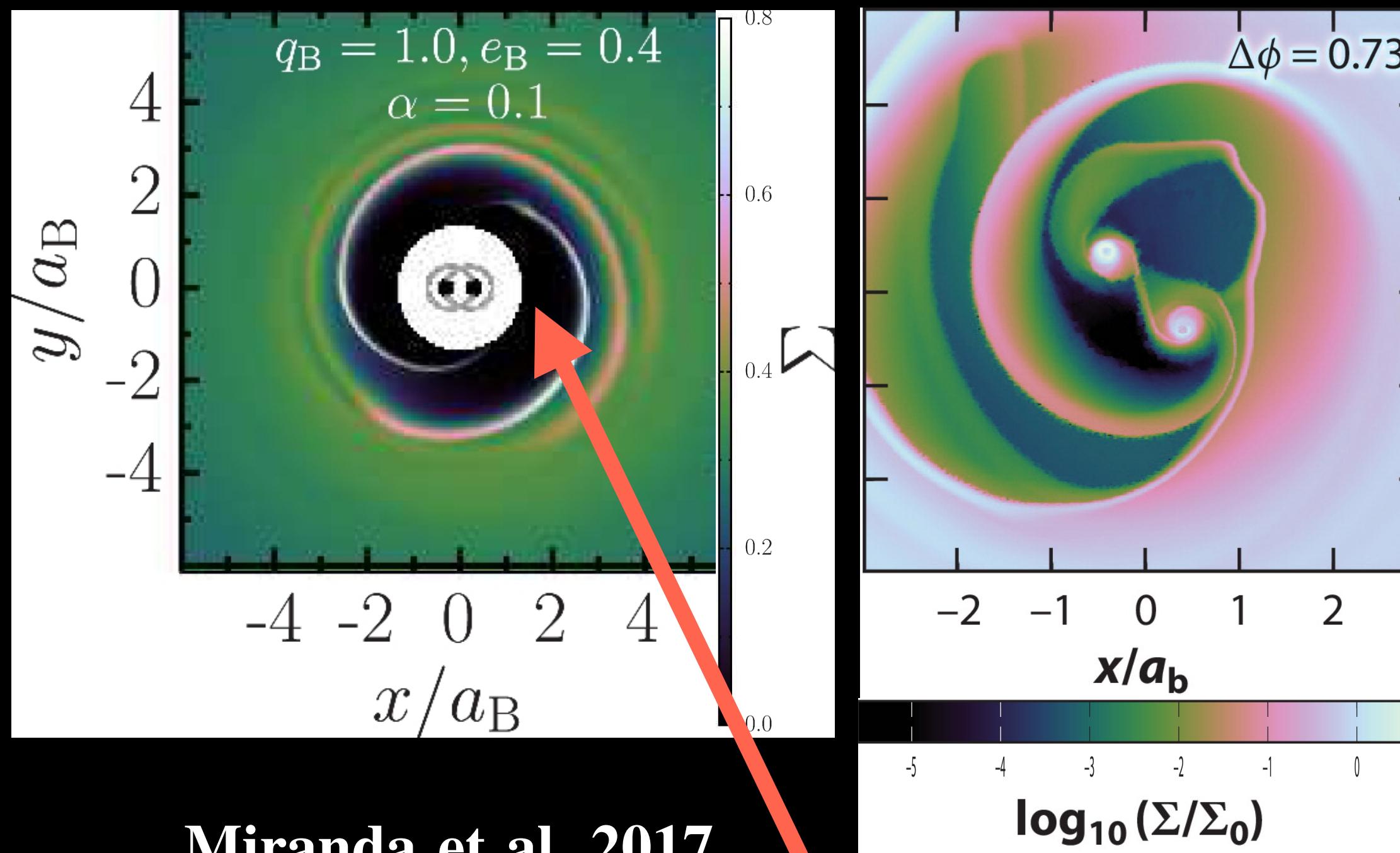
$$e_b = 0 \\ \sim 5P_b$$

$$r_{cav} \approx 3a_b$$



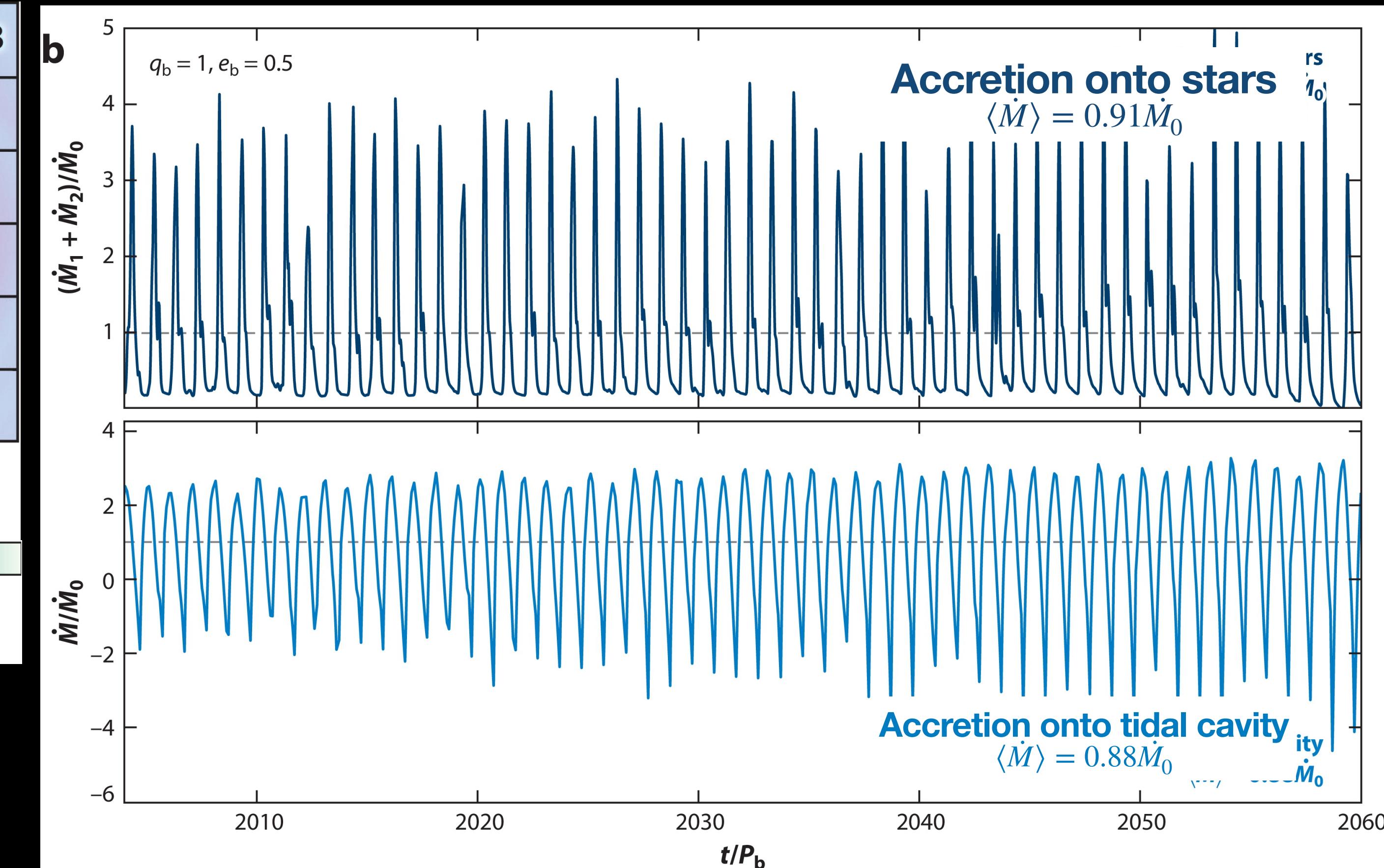
Lai, Muñoz . 2023

短期变化特征



$$e_b = 0.5 \sim P_b$$

轨道远点吸积



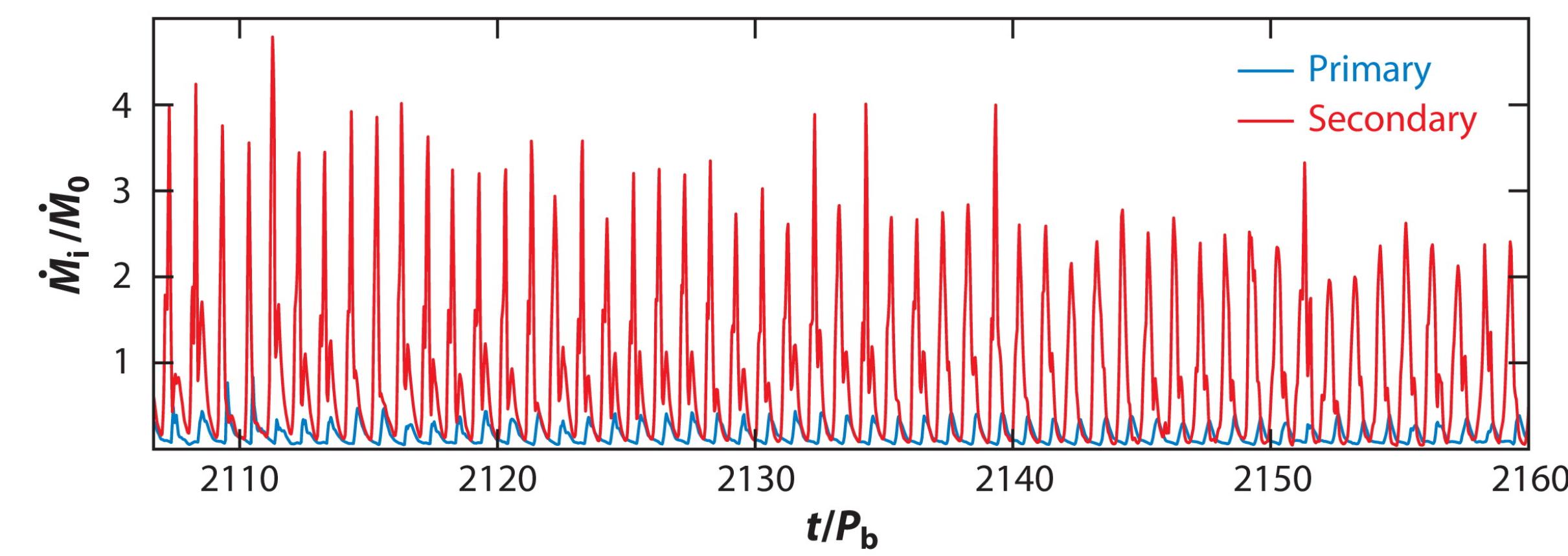
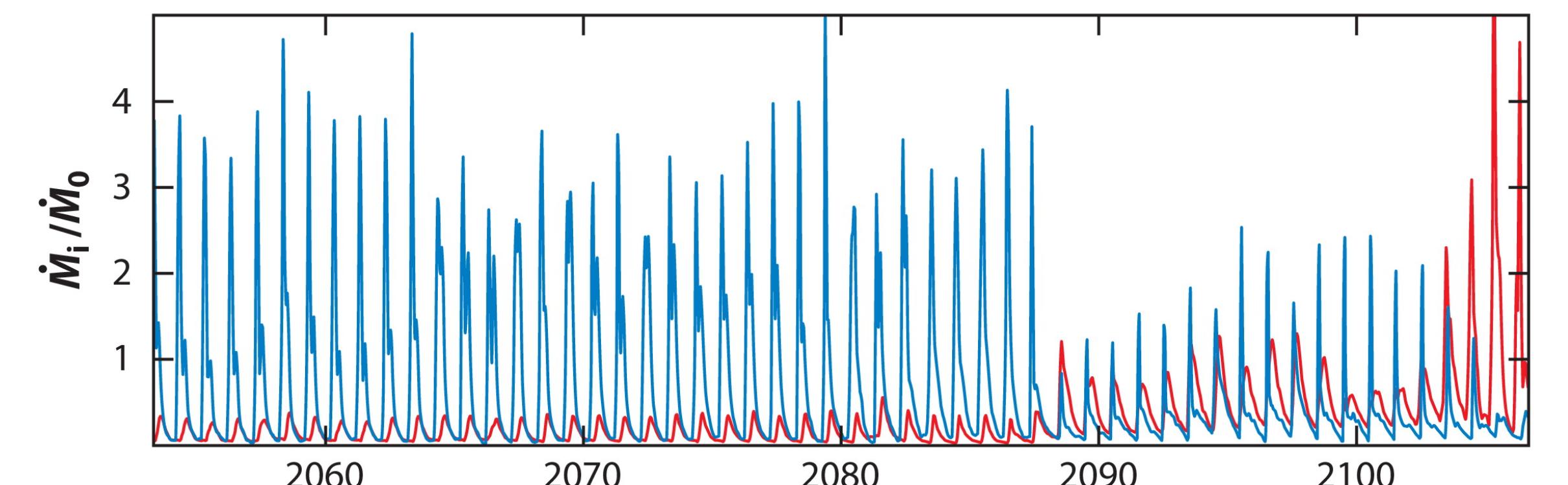
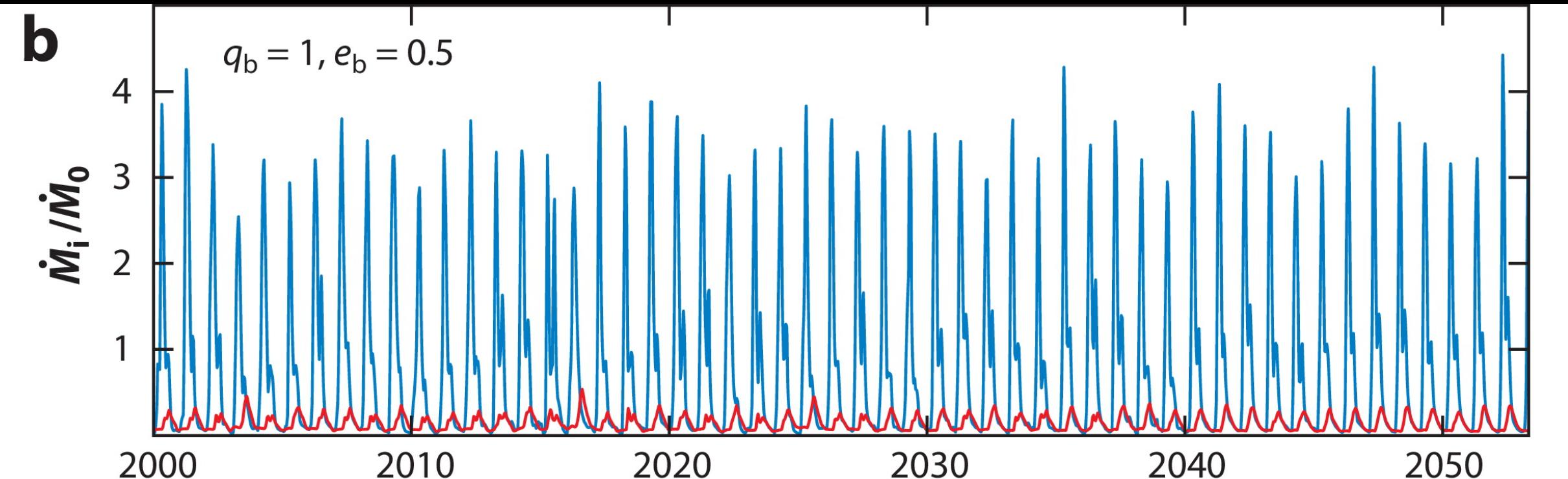
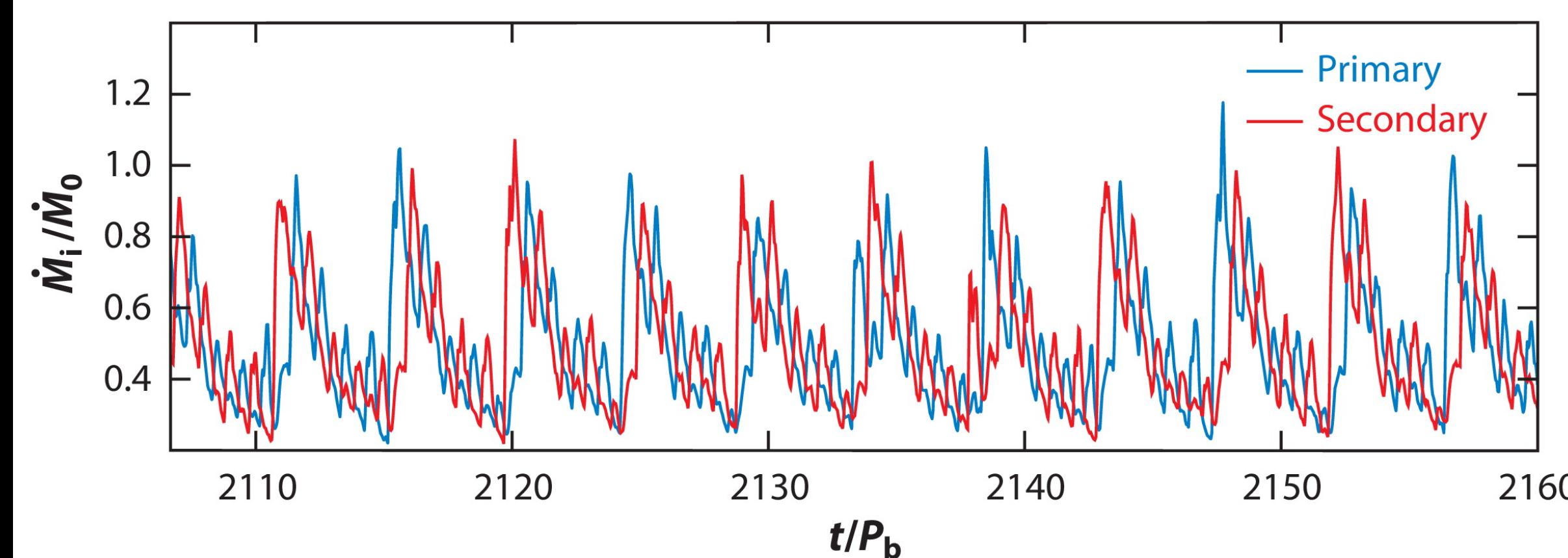
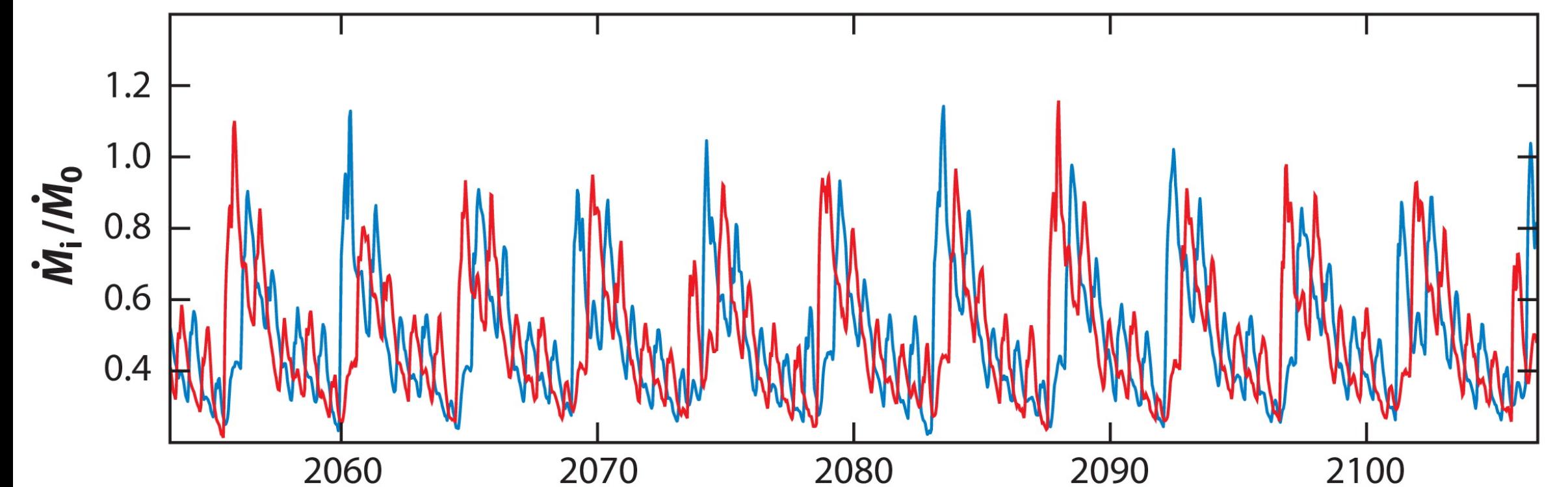
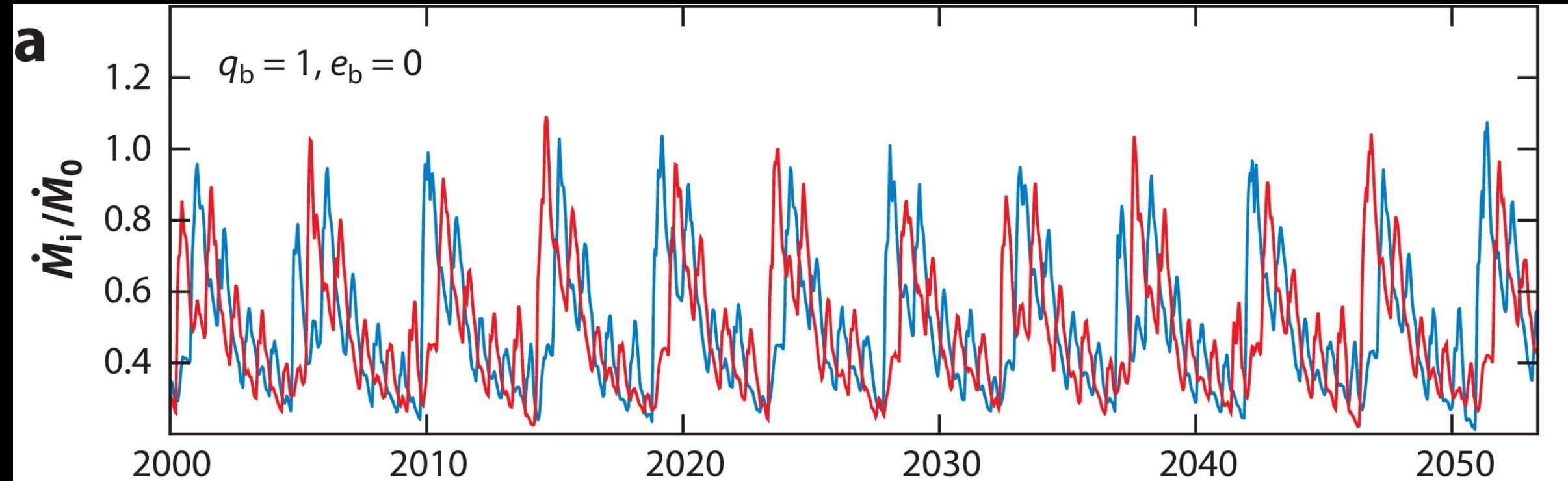
Lai, Muñoz . 2023

长期变化特征

Lai, Muñoz . 2023

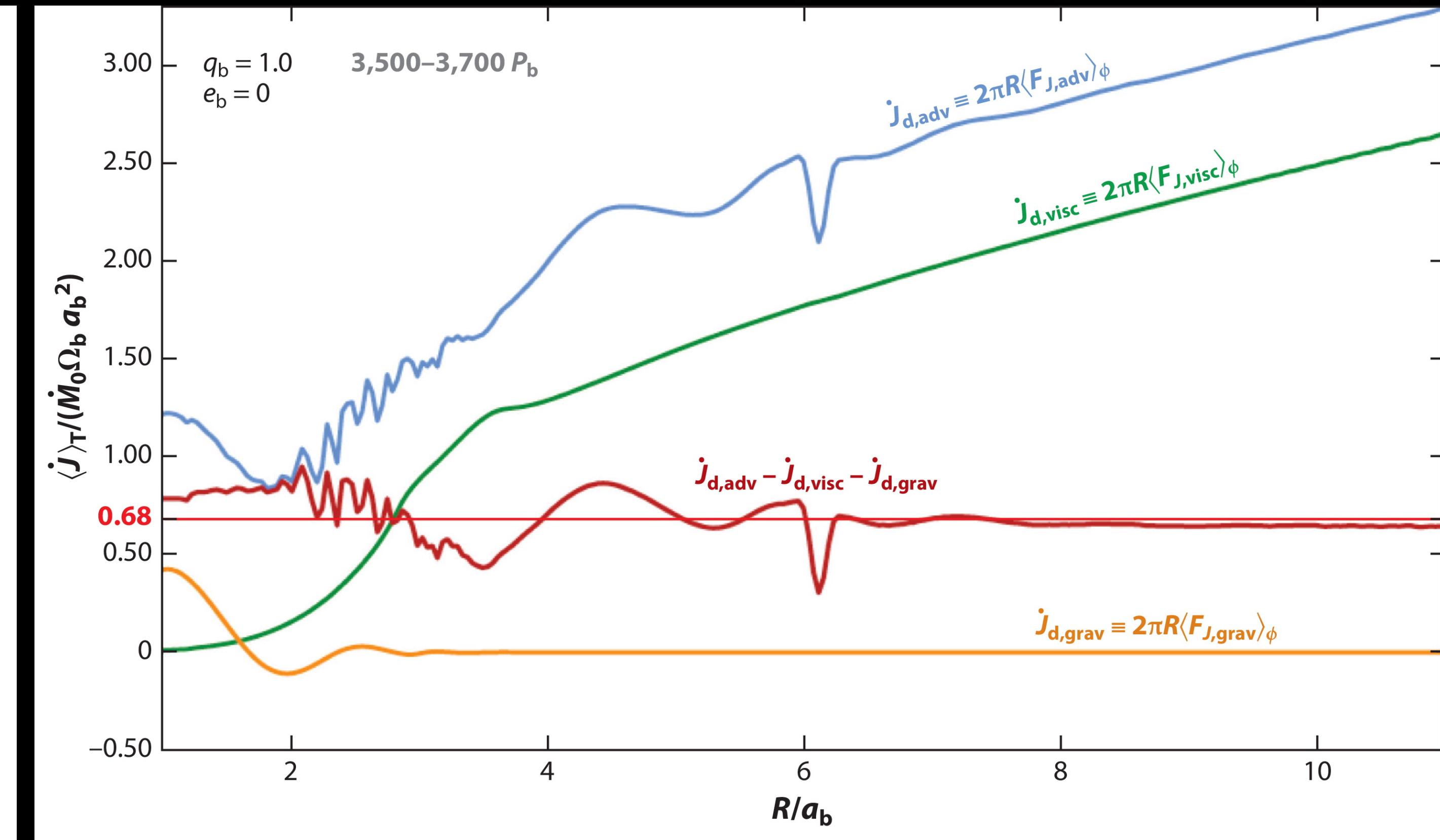
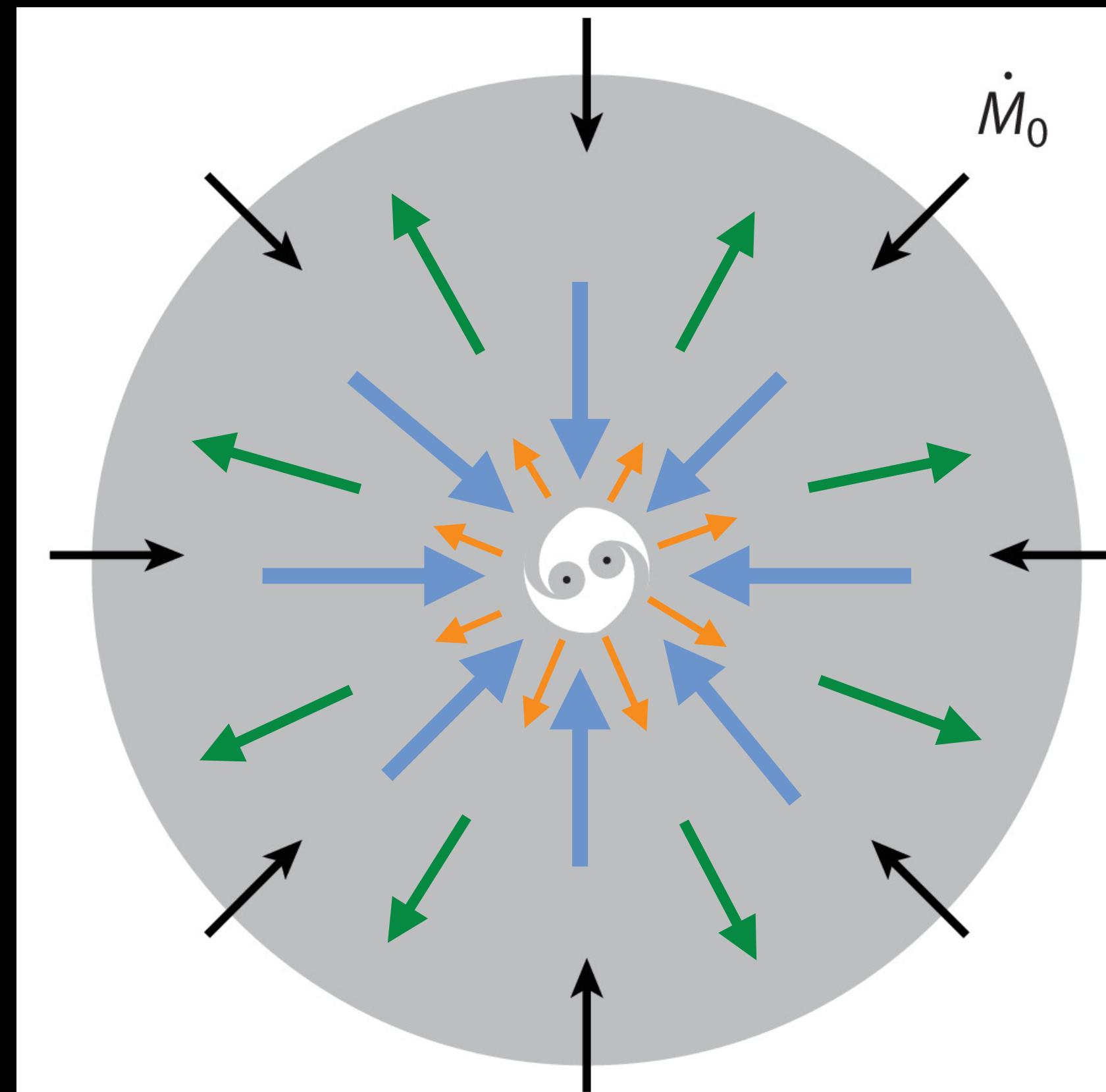
$$\dot{M}_1 \geq 20\dot{M}_2 \\ \sim 100P_b \quad e_b = 0.5$$

观测



角动量传递

Lai, Muñoz . 2023



粘滞、向外 $j_{d,visc}$ 向内 $j_{d,adv}$

双星、向外 $j_{d,grav}$

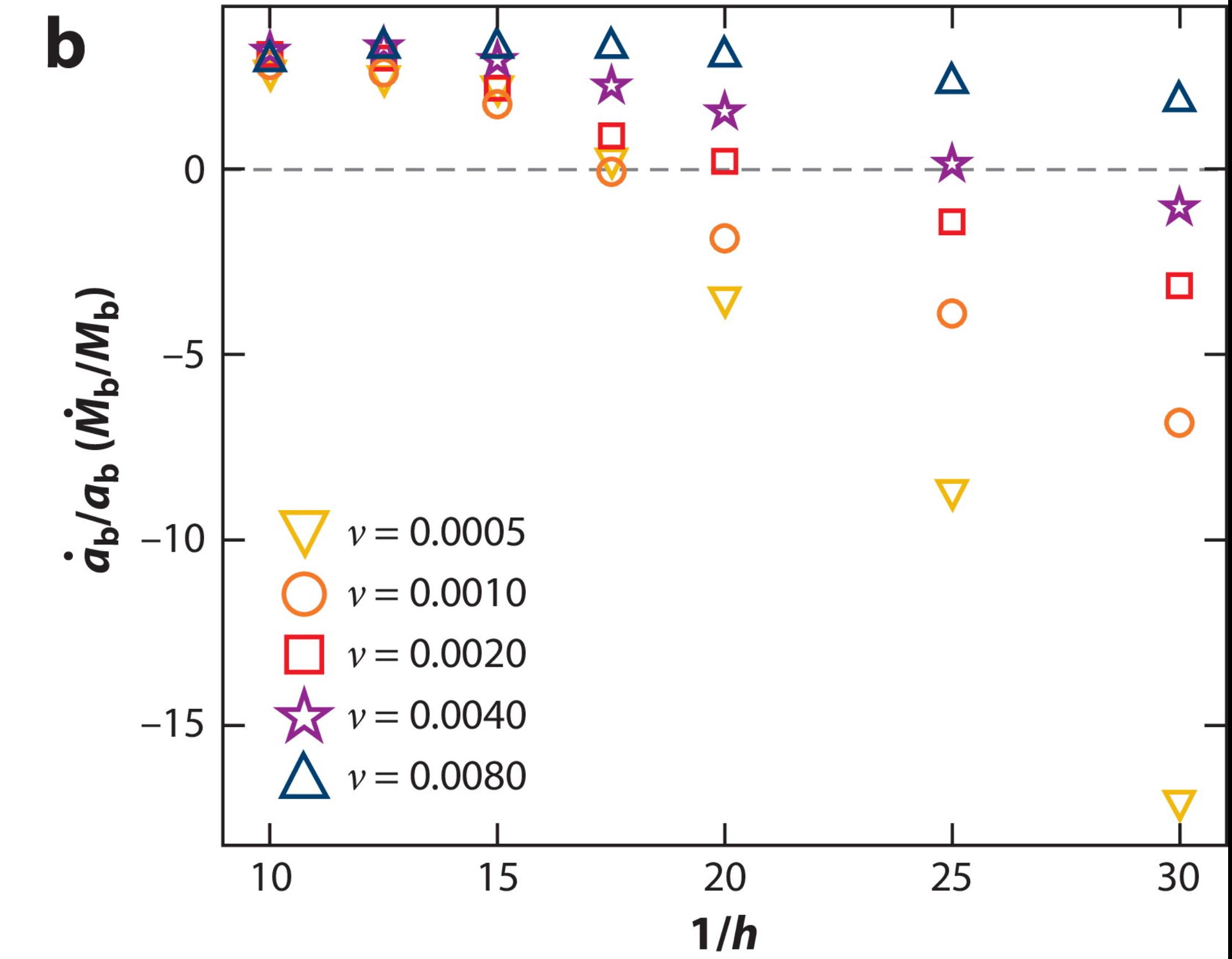
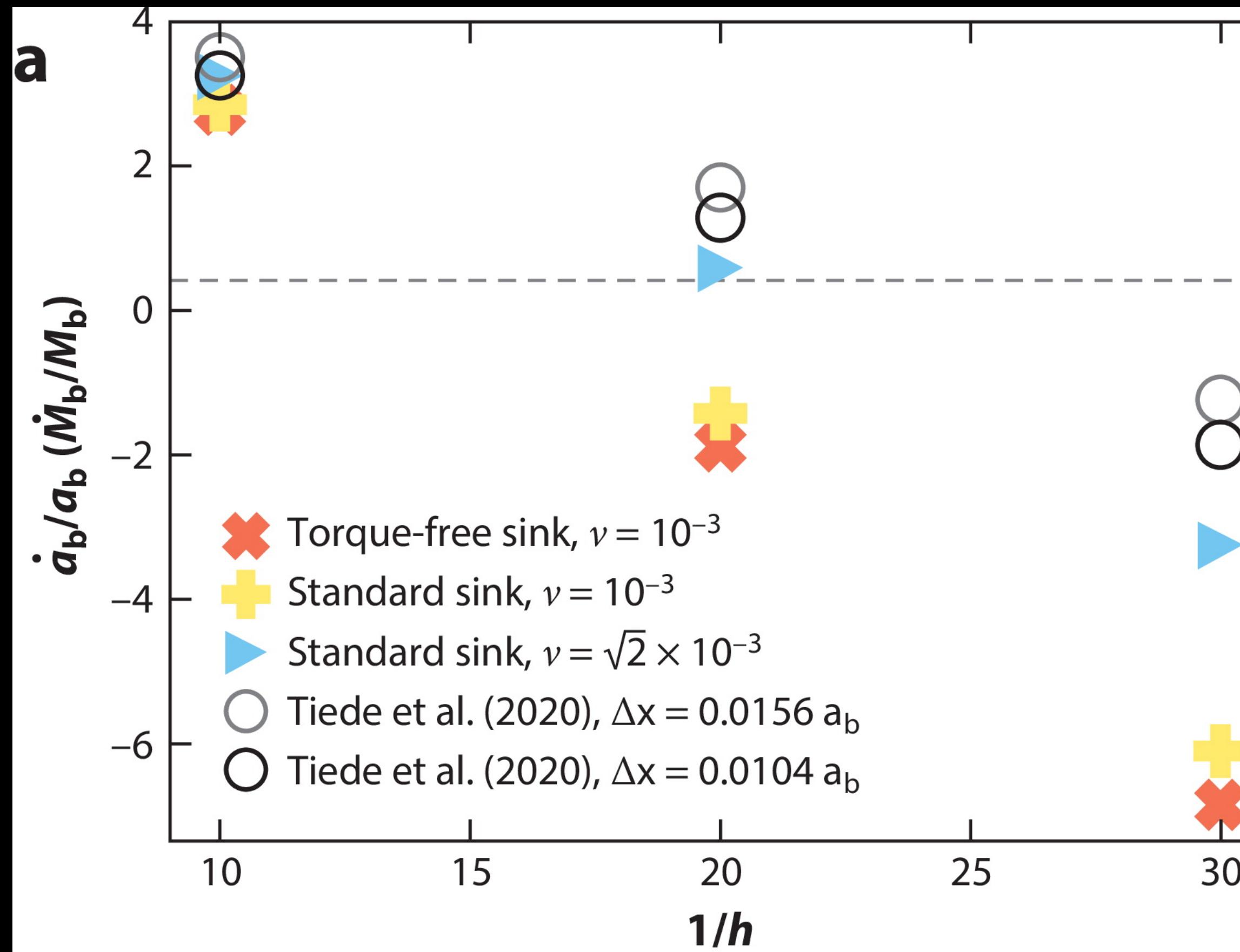
$$l_0 \equiv \frac{\langle \dot{J}_b \rangle}{\langle \dot{M}_b \rangle} = 0.68 a_b^2 \Omega_b$$

单位吸积质量传递角动量

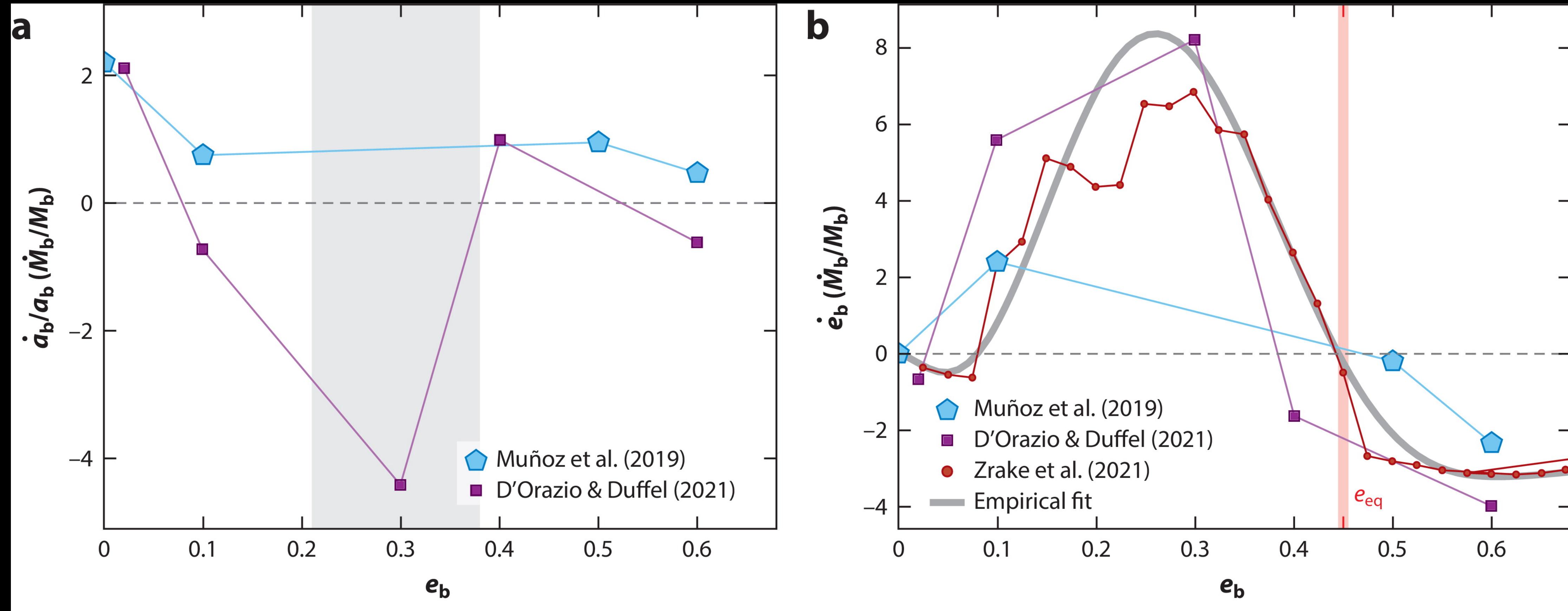
厚度和粘度

h & α

Protostellar disk $h \sim 1$
 MBHBs $h \lesssim 0.01$



长期偏心轨道演化



Zrake et al. 2021

Dittmann, Ryan . 2022

Lai, Muñoz . 2023

应用

观测 双星形成

DQ Tau

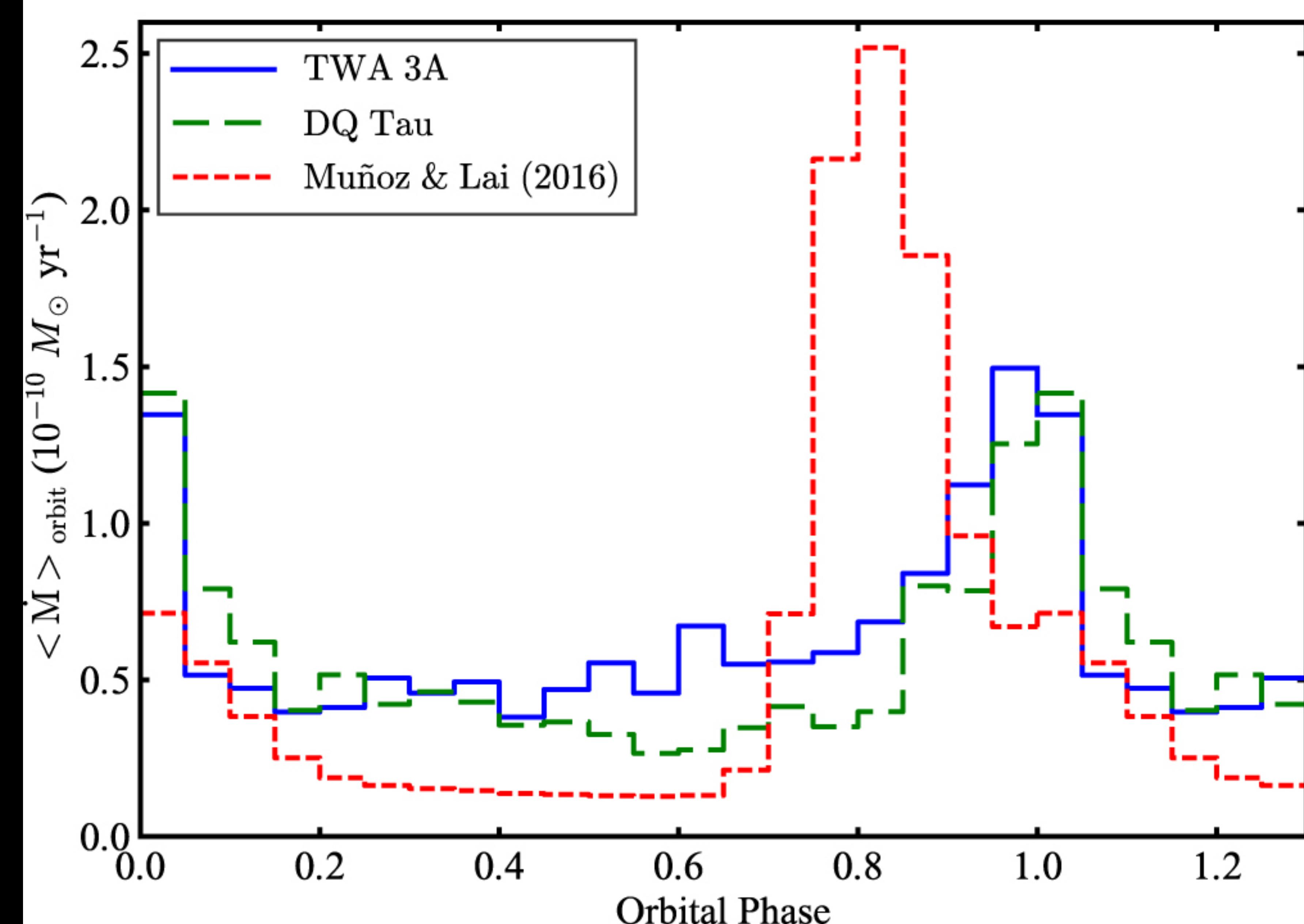
$e_b = 0.568$
 $q_b = 0.936$

TWA 3A

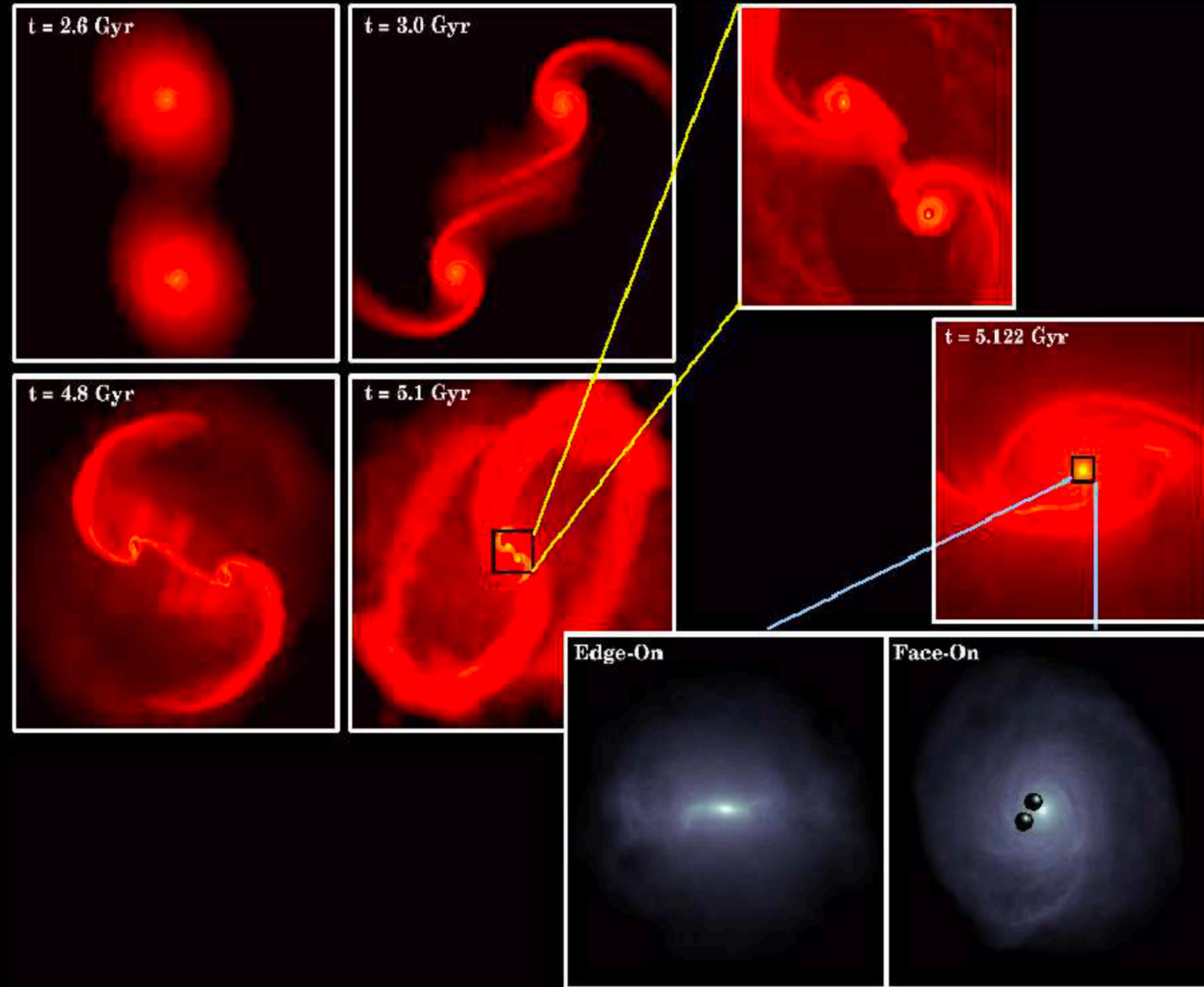
$e_b = 0.6280$
 $q_b = 0.841$

Tofflemire et al. 2017

Lai & Muñoz . 2016



Final-parsec problem

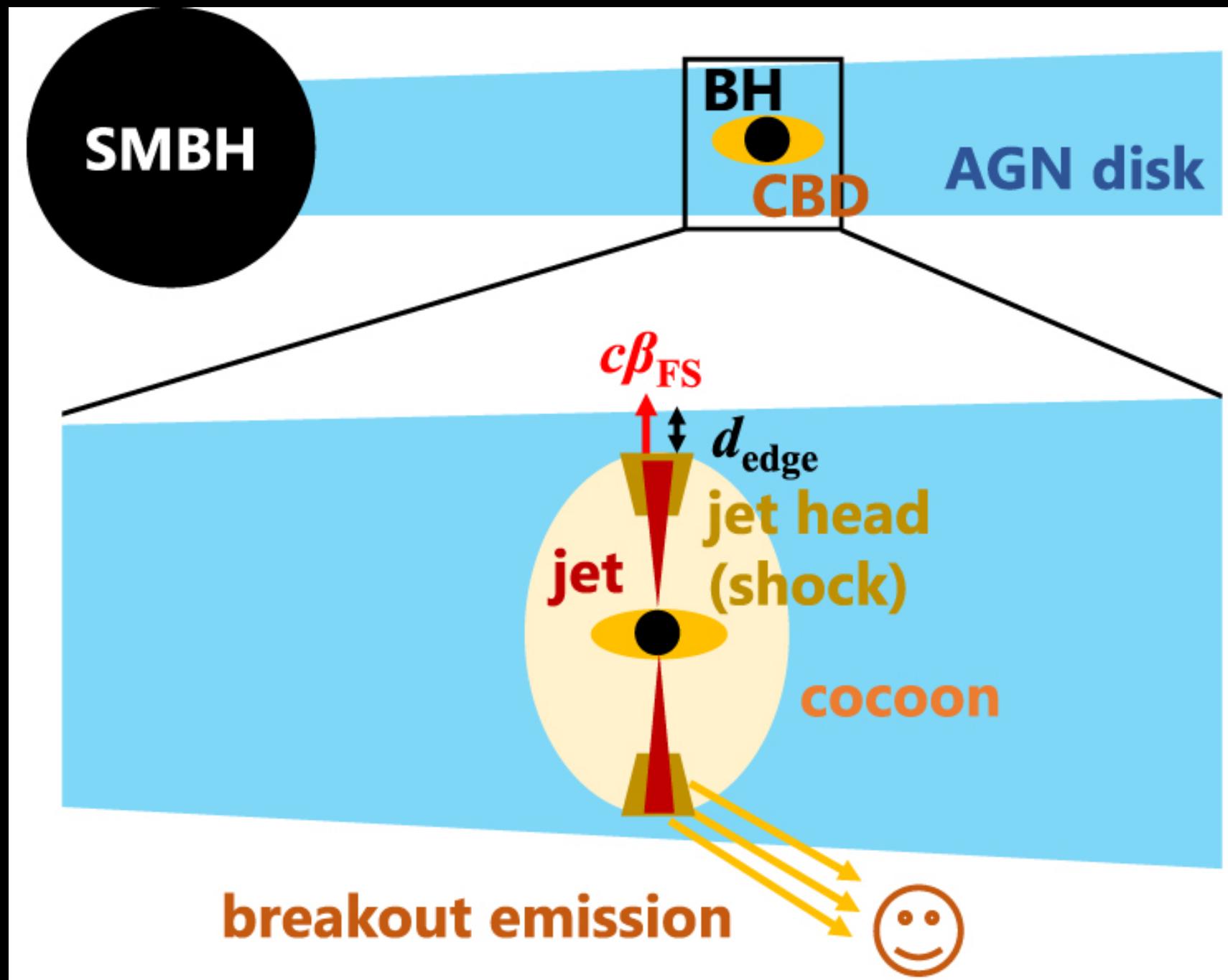


轨道是否会
衰减并最终
合并？

LIGO LISA
TianQin Taiji

应用

活动星系核(AGN)中的小质量黑洞双星



Tagawa et al. 2023

小范围（双星内）和大
范围流体动力学之间的
复杂耦合

双星低频引力波探测

限制 MBH 的演化历史
环双星吸积

应用

环双星行星 Circumbinary planets(CBPs)

- 已观测系统特征
 - 行星大小:
 - $0.3R_J \sim 1R_J$
 - 轨道:
 - 亚天文单位、共面
 - 许多参量都在系统不稳定边界附近
- 原因:
 - 行星迁移?
 - 势场、盘的密度不均匀性
 - 气体阻力

展望

- 更真实的物理模型
 - 盘的自引力效应.....
 - 辐射, Outflow, 湍流.....
 - 非共面、非等质量、非圆轨.....
- 观测和模拟计算能力 (3D、MHD、GRMHD)



HD 142527

A . Isella/ ALMA

Thanks!

Appendix

