

Circumbinary accretion disks

环双星吸积盘

Simulation results and Applications
数值模拟结果及应用

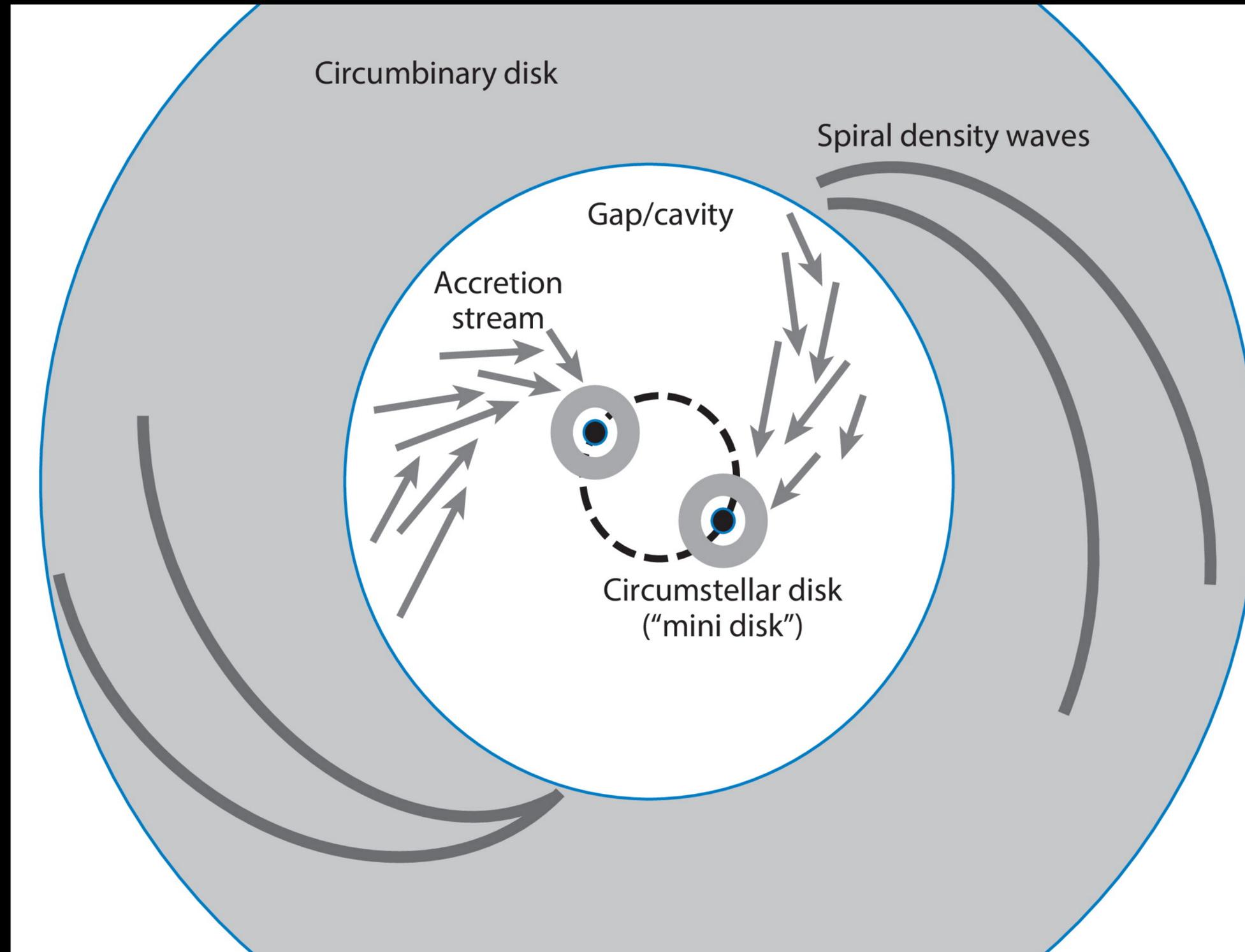
杨锐祺

Dec 5. 2023

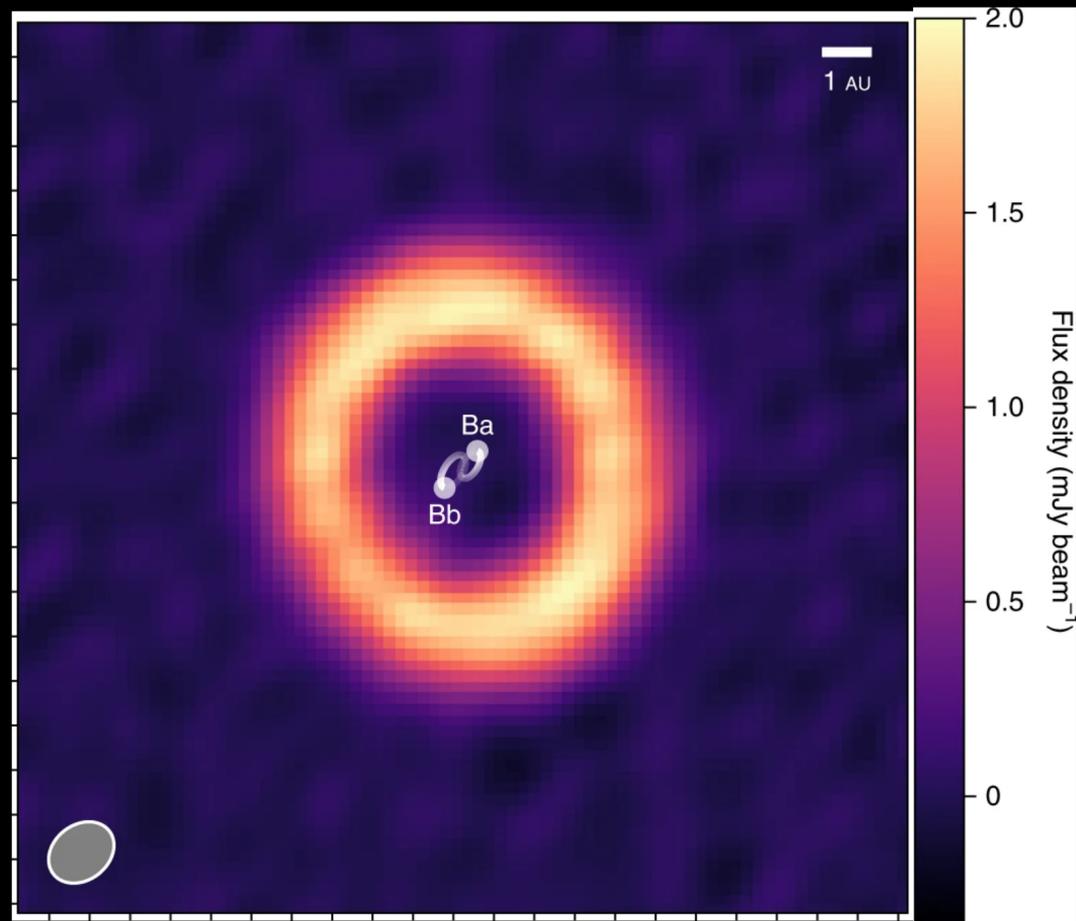
简介

- **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”)



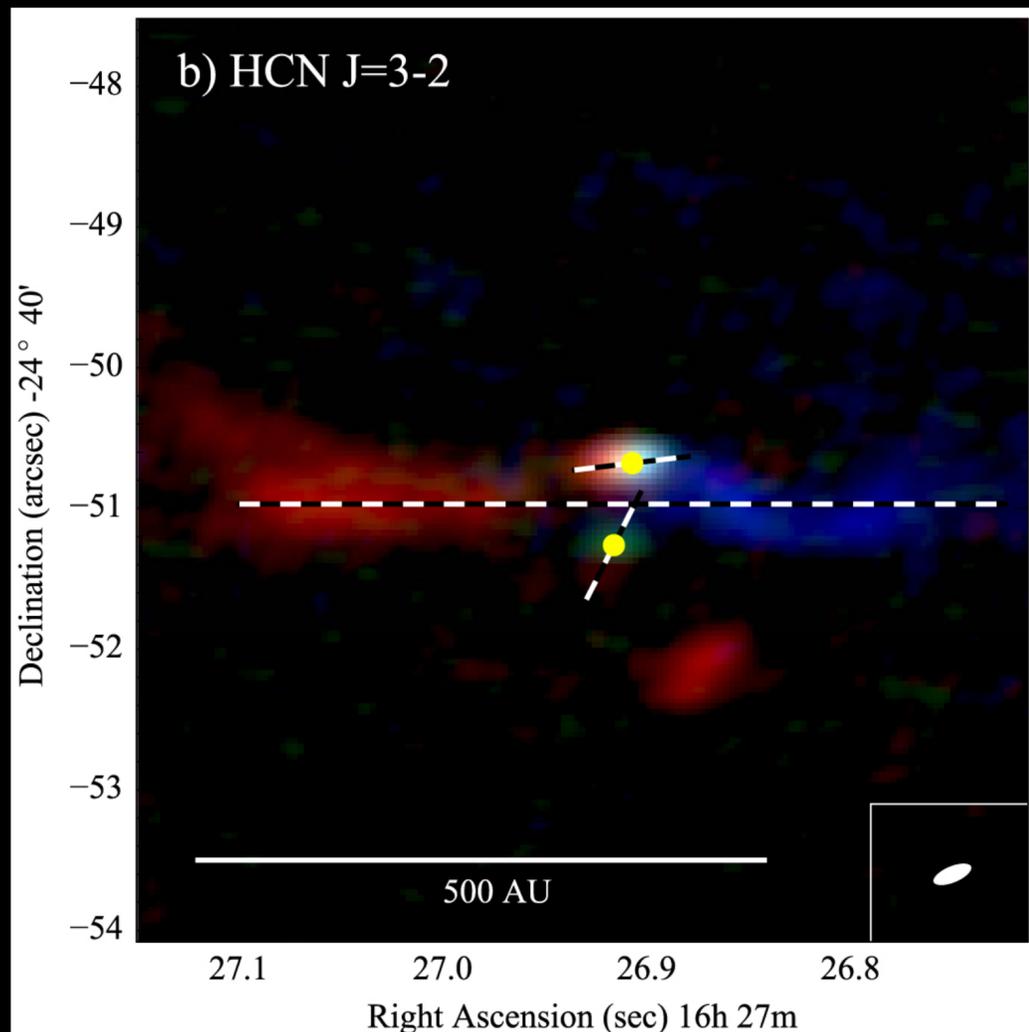
简介



原行星盘

HD 98800

Kennedy et al. 2019/ALMA



原恒星盘

IRS 43

Brinch et al. 2016/ALMA



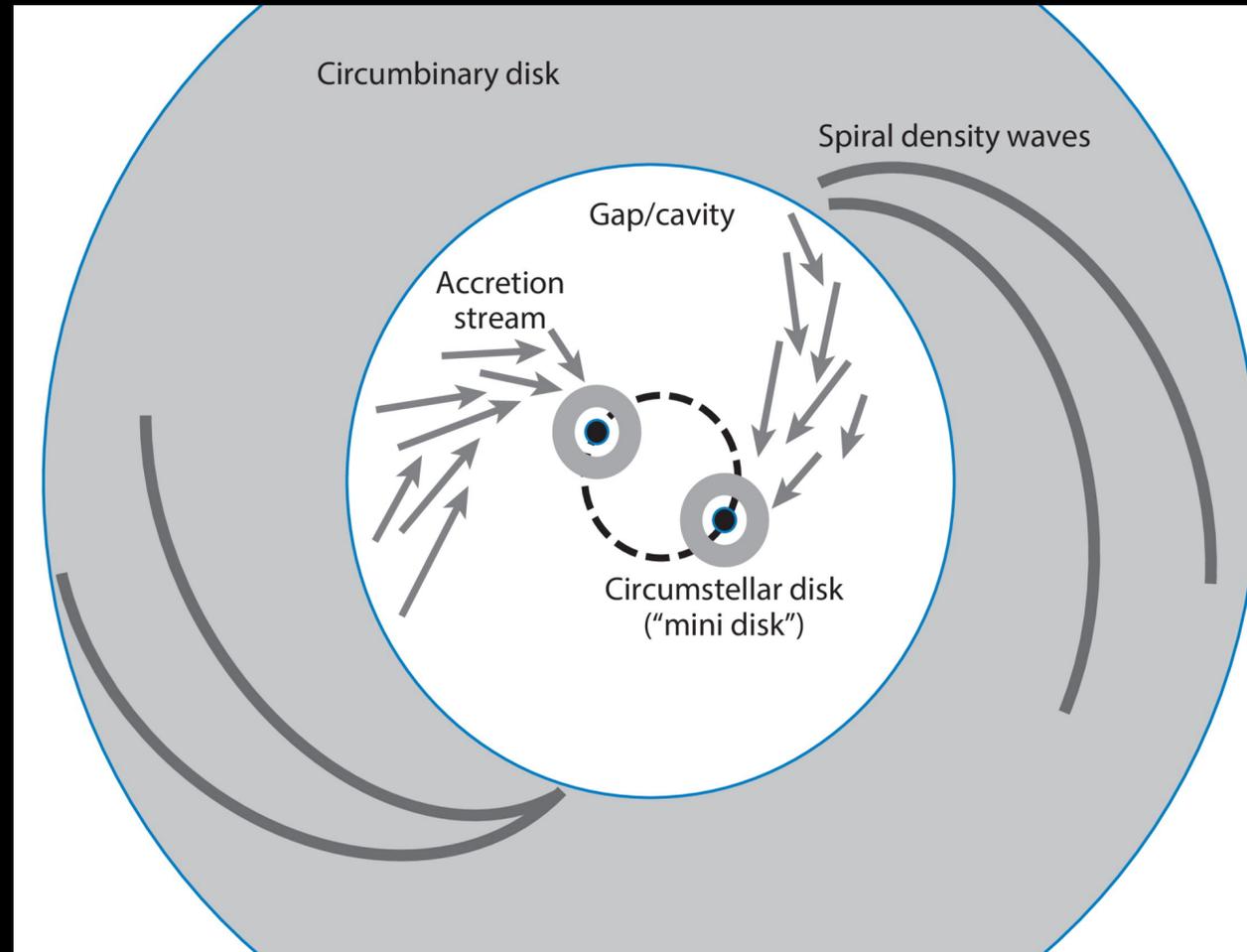
星系合并 (超) 大质量黑洞

NGC 4676

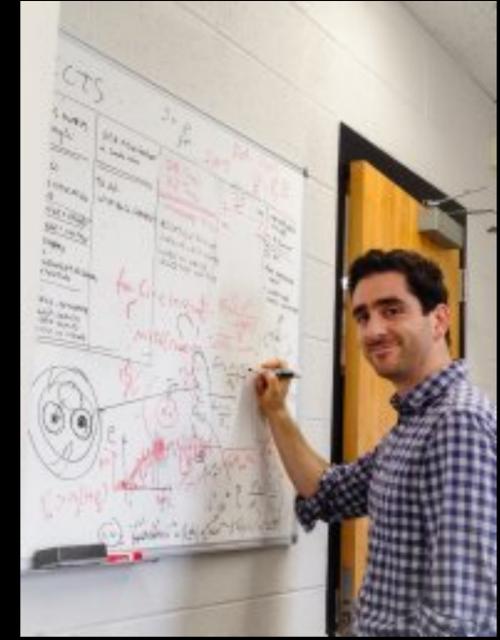
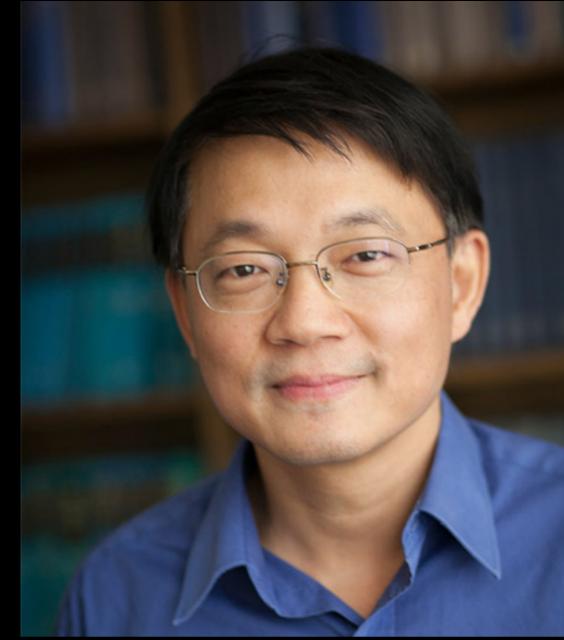
HST

主要模拟结果

- 难度：空间跨度大，周期长，变化剧烈

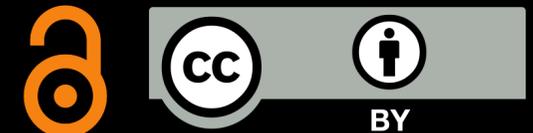


- 共面等质量双星、固定粘滞度

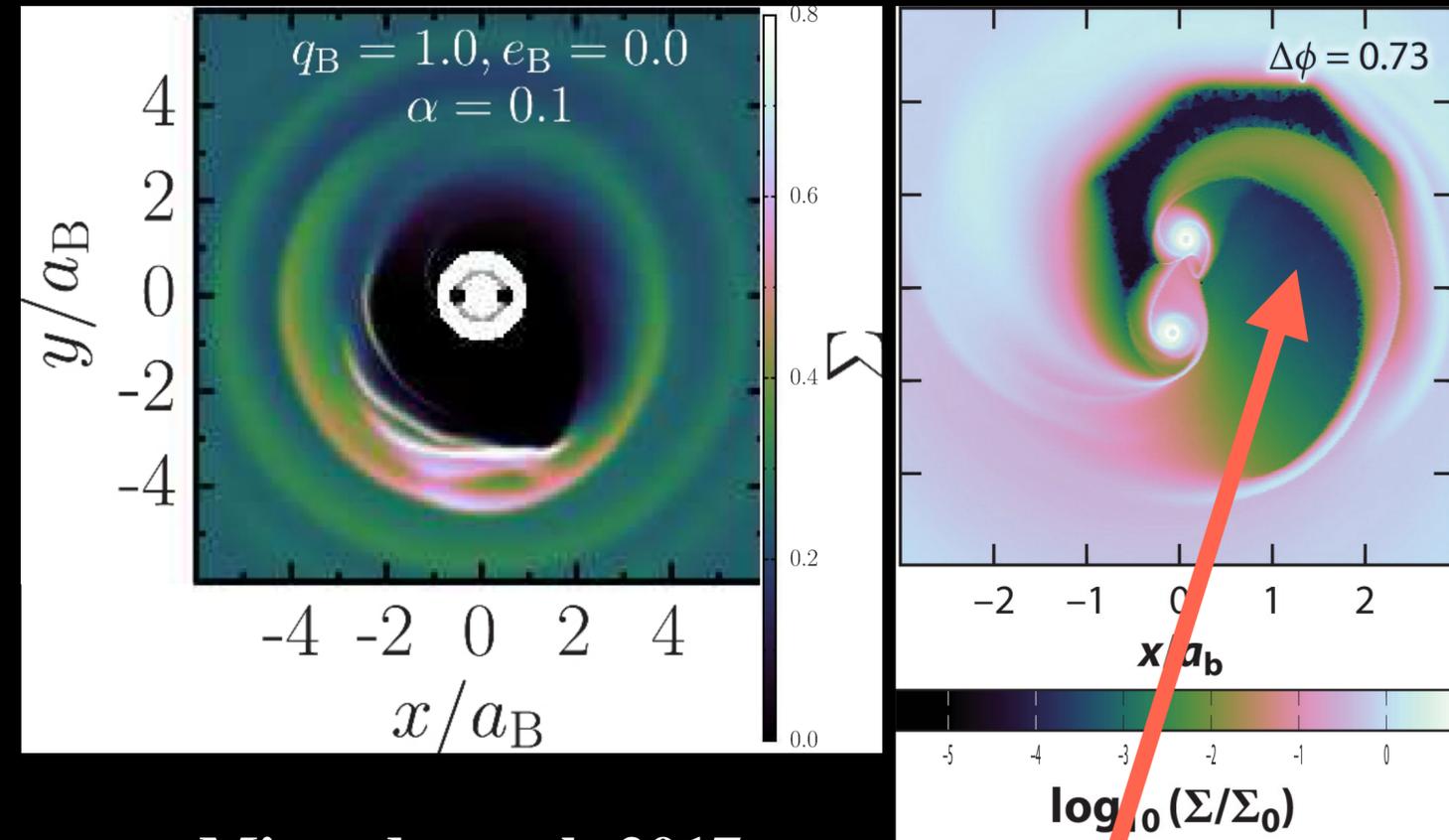


Lai, Muñoz . 2023

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



短期变化特征



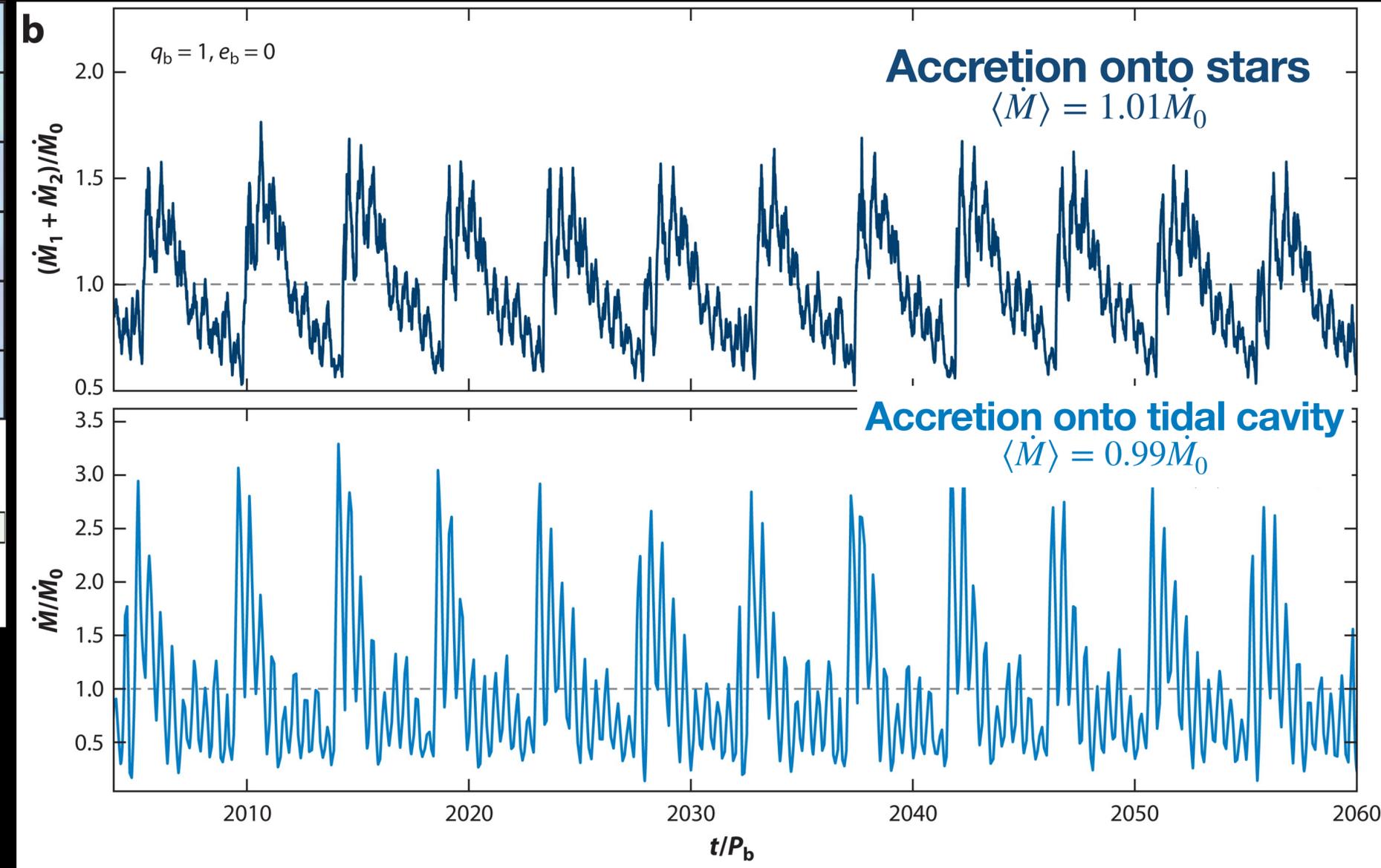
Miranda et al. 2017

$$e_b = 0$$

$$\sim 5P_b$$

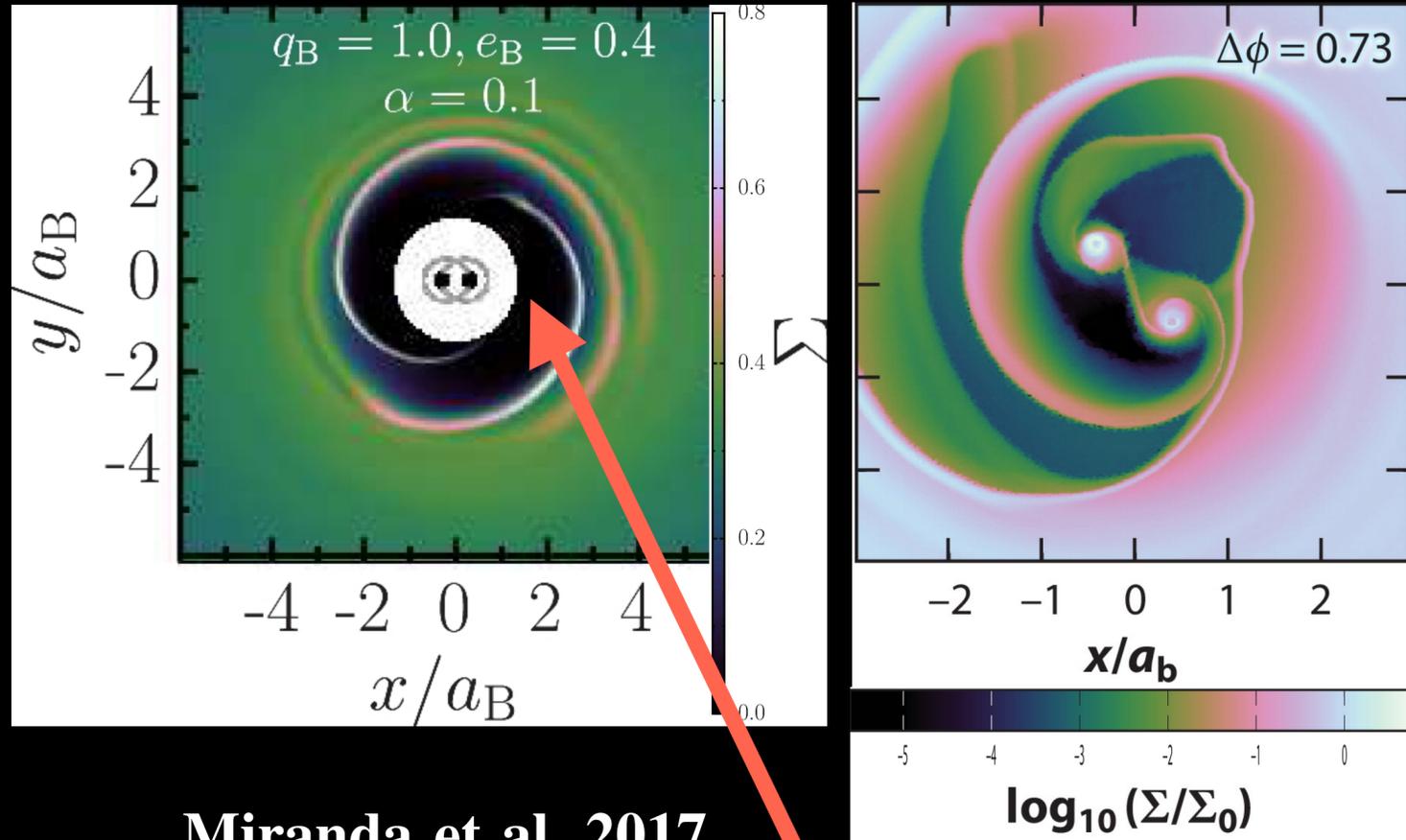
团块

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



Lai, Muñoz . 2023

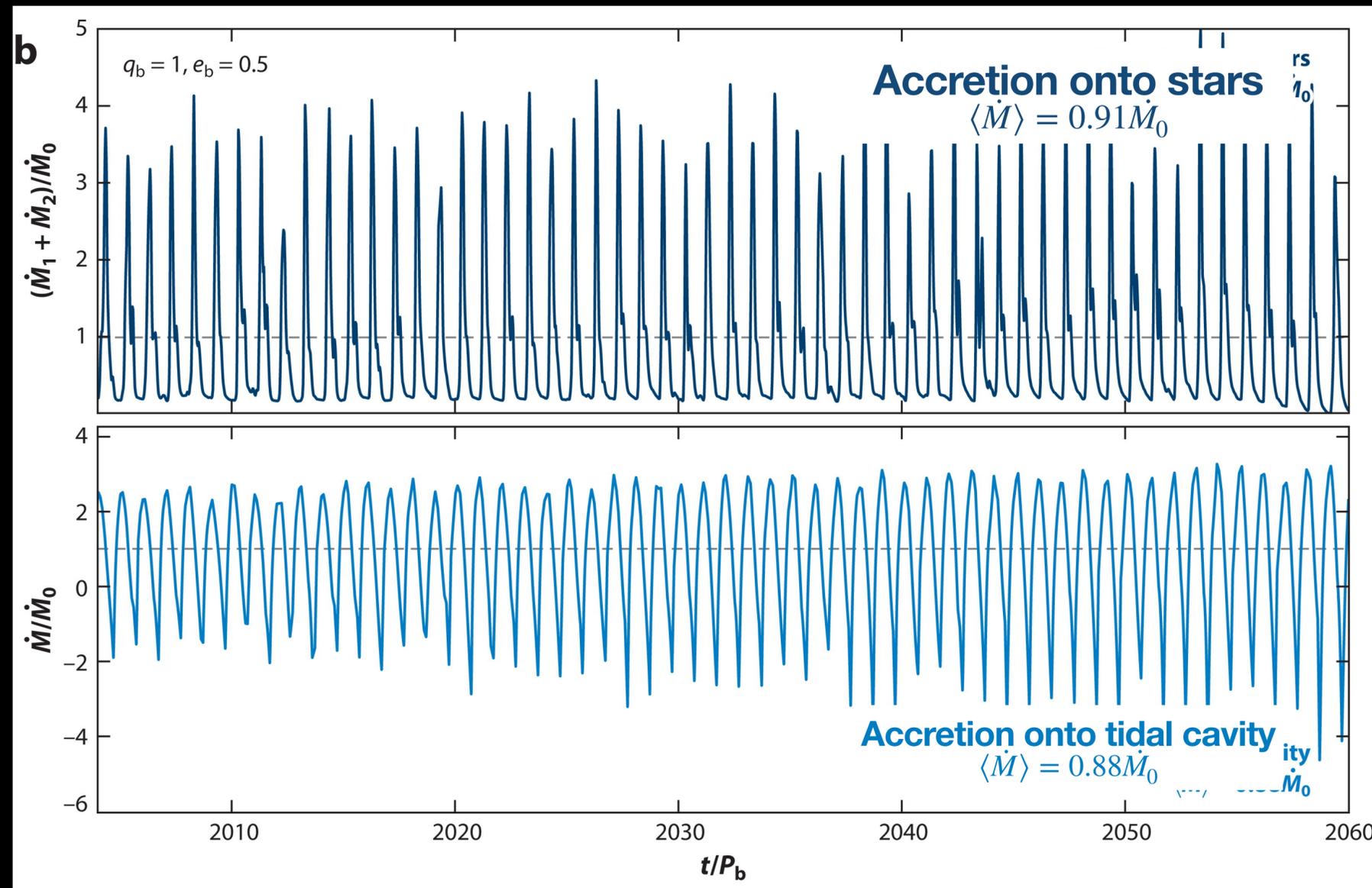
短期变化特征



Miranda et al. 2017

$$e_b = 0.5 \sim P_b$$

轨道远点吸积



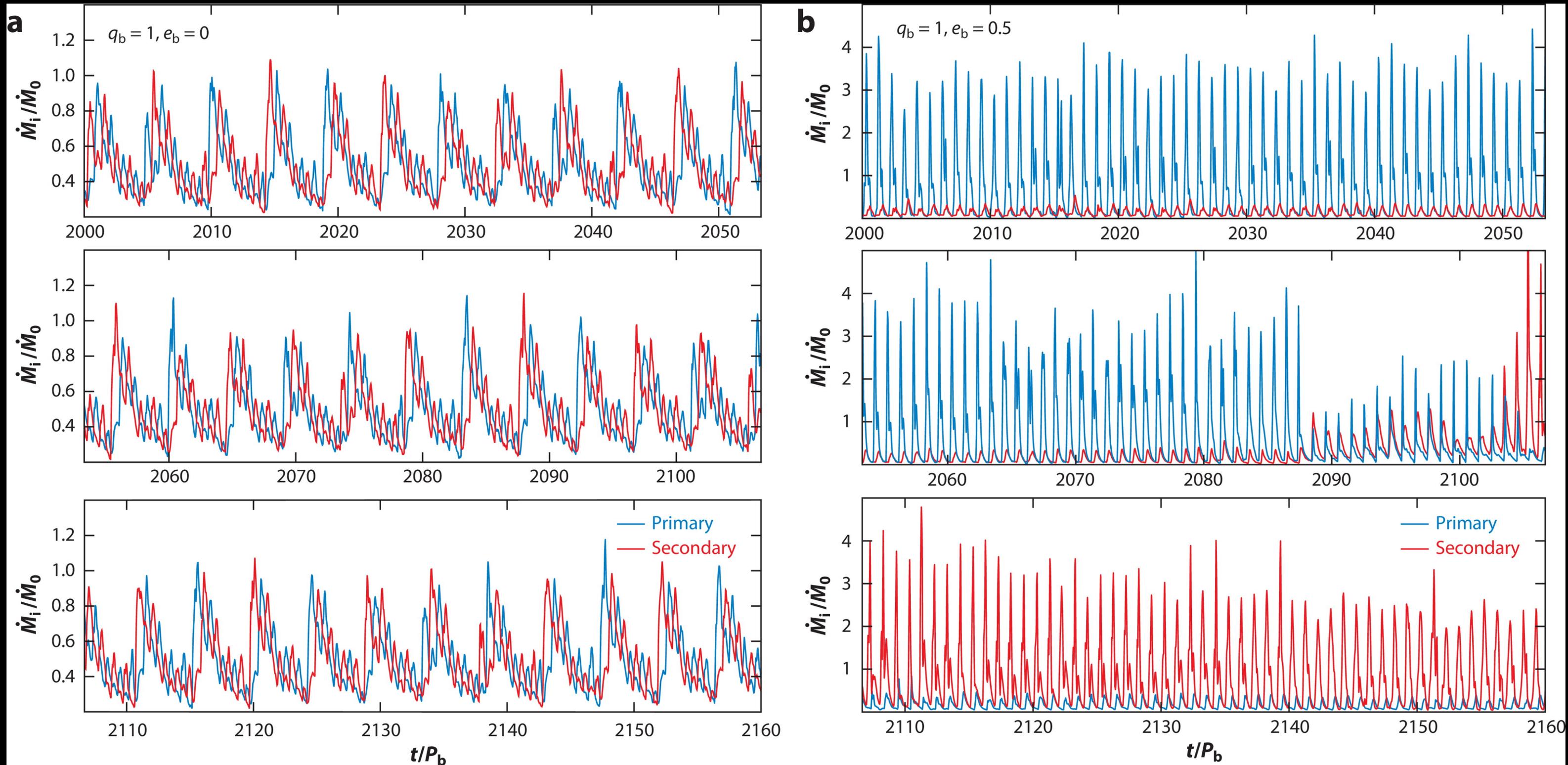
Lai, Muñoz . 2023

长期变化特征

Lai, Muñoz . 2023

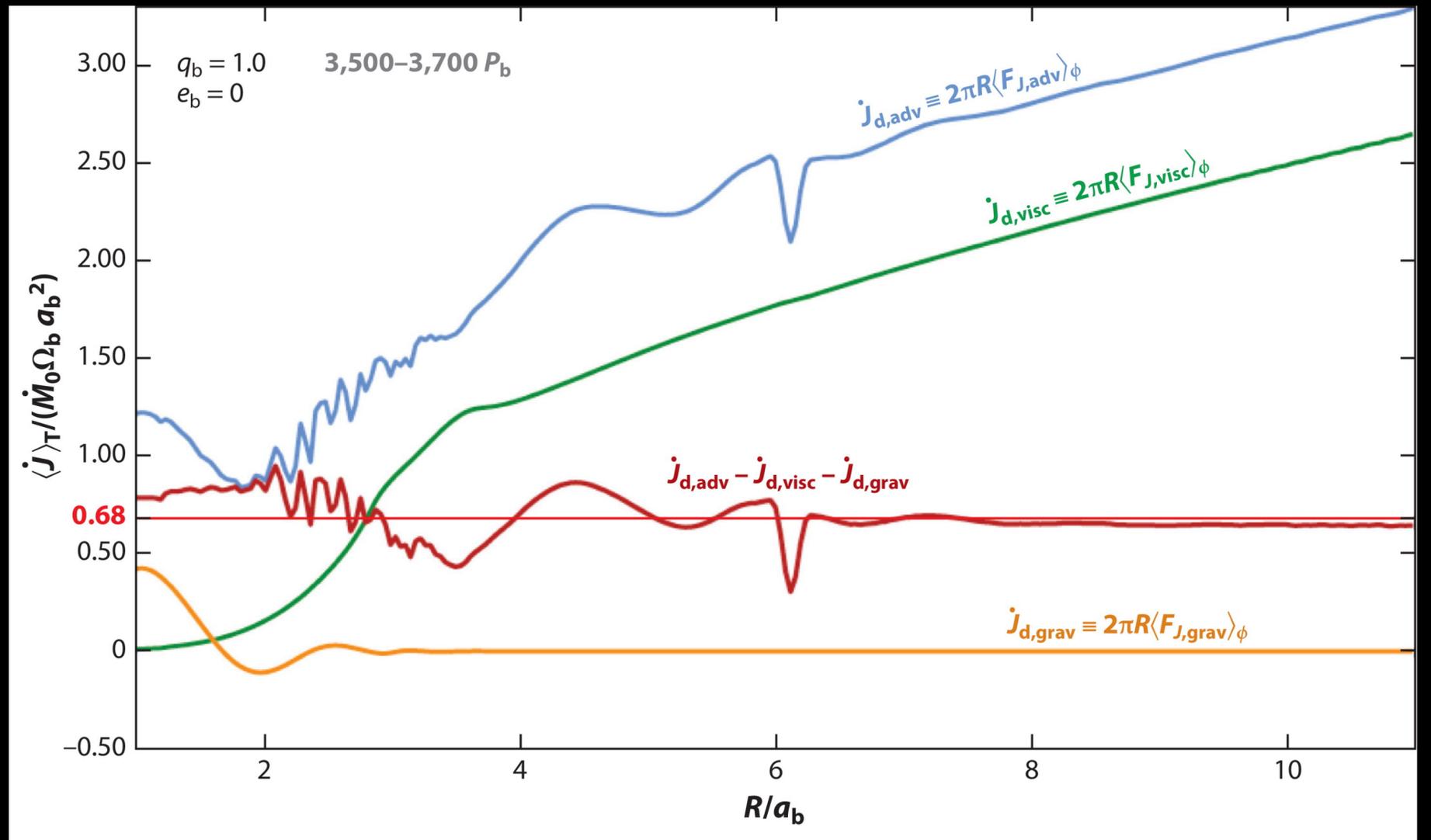
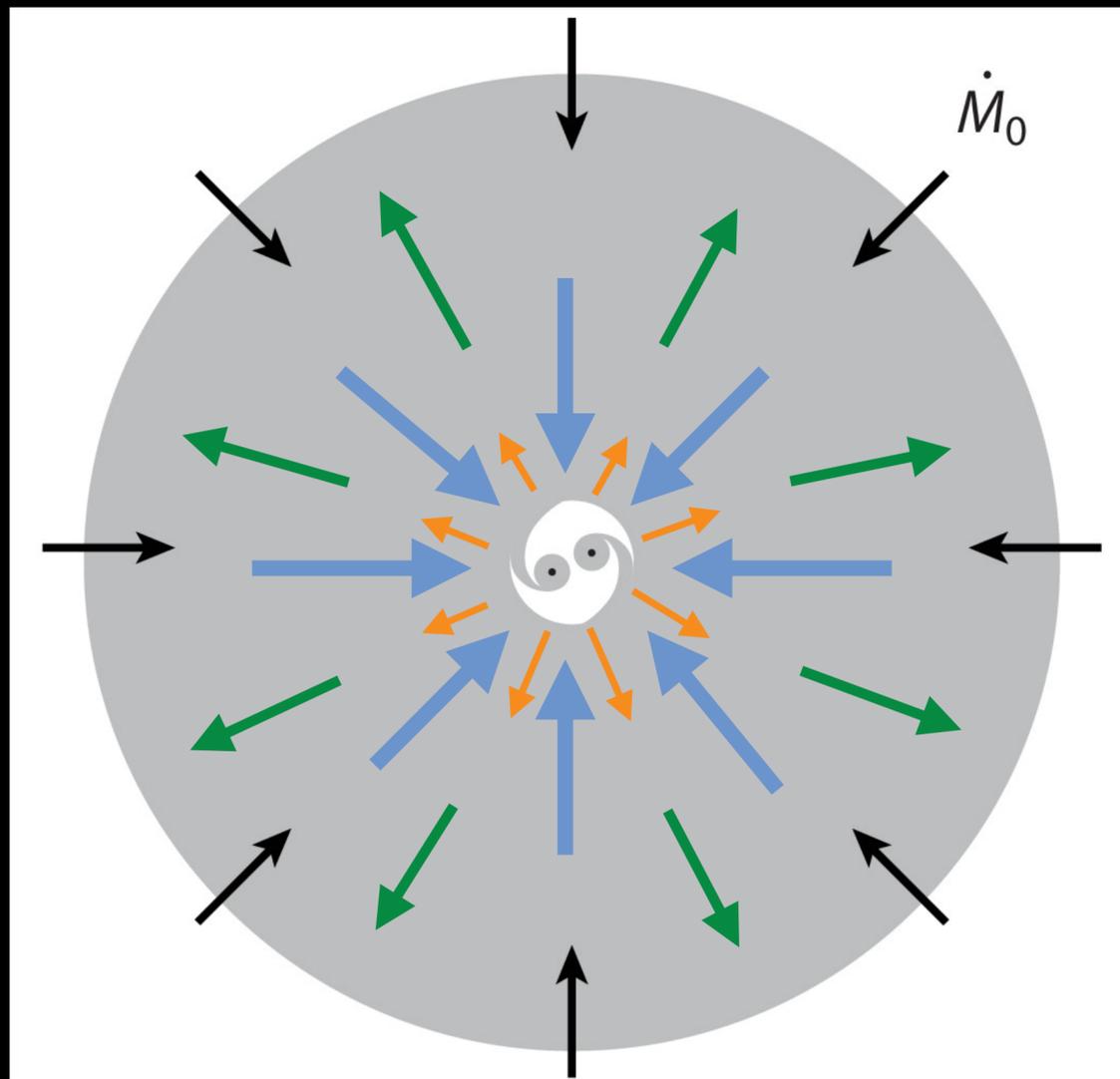
$$\dot{M}_1 \geq 20\dot{M}_2$$
$$\sim 100P_b \quad e_b = 0.5$$

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 $j_{d,grav}$

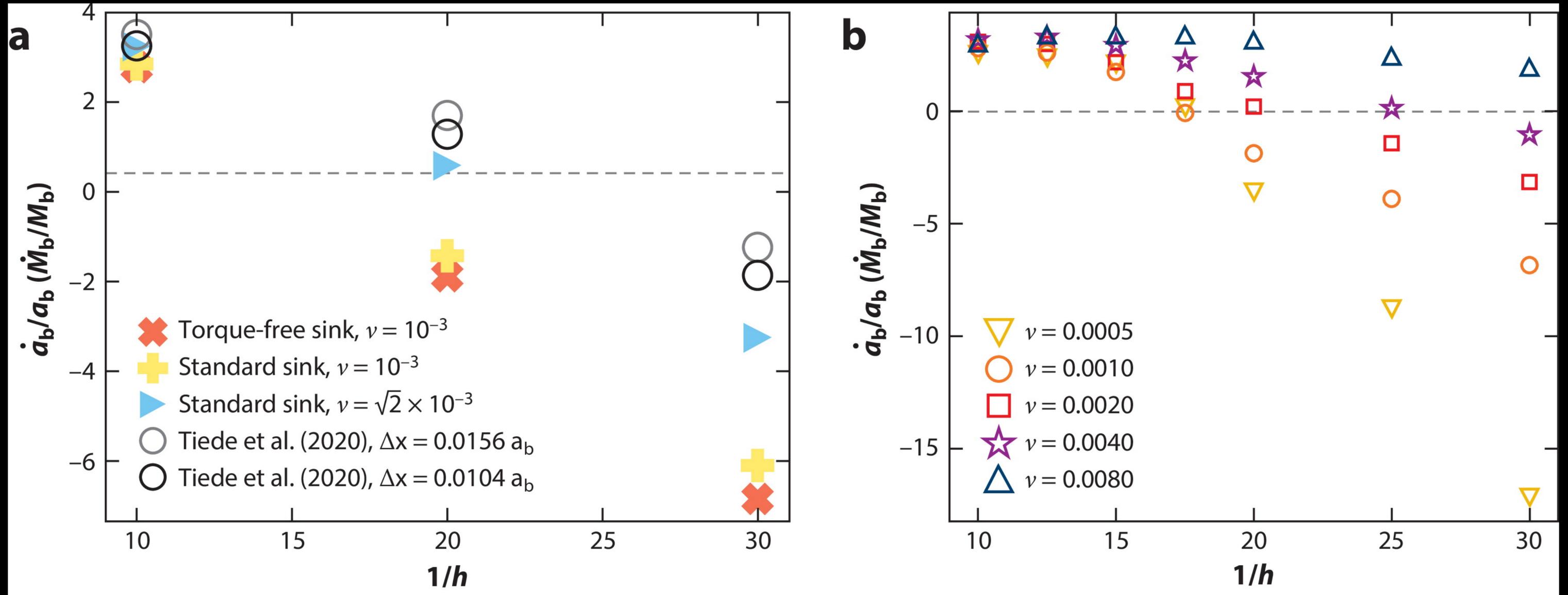
$$l_0 \equiv \frac{\langle \dot{J}_b \rangle}{\langle \dot{M}_b \rangle} = 0.68 a_b^2 \Omega_b$$

单位吸积质量传递角动量

厚度和粘度

h & α

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

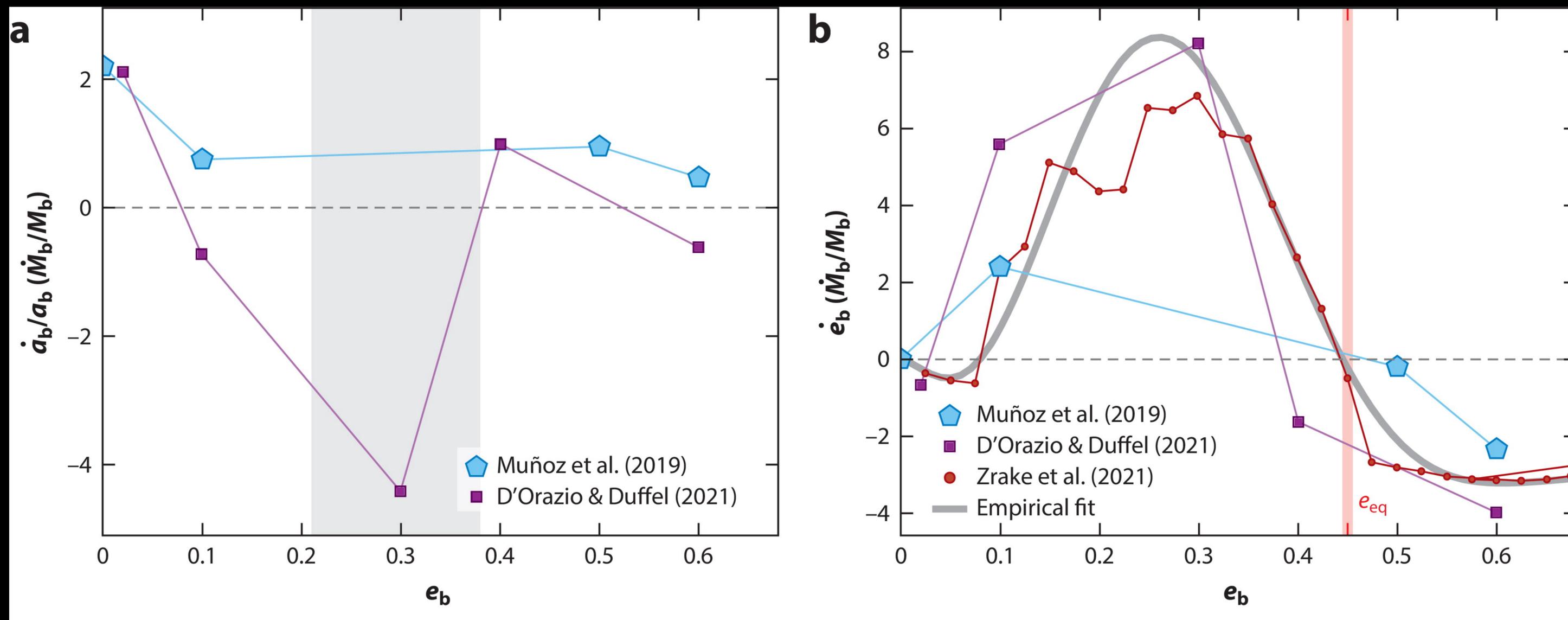


Tiede et al. 2020

Dittmann, Ryan. 2022

Lai, Muñoz. 2023

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

$$e_b = 0.568$$

$$q_b = 0.936$$

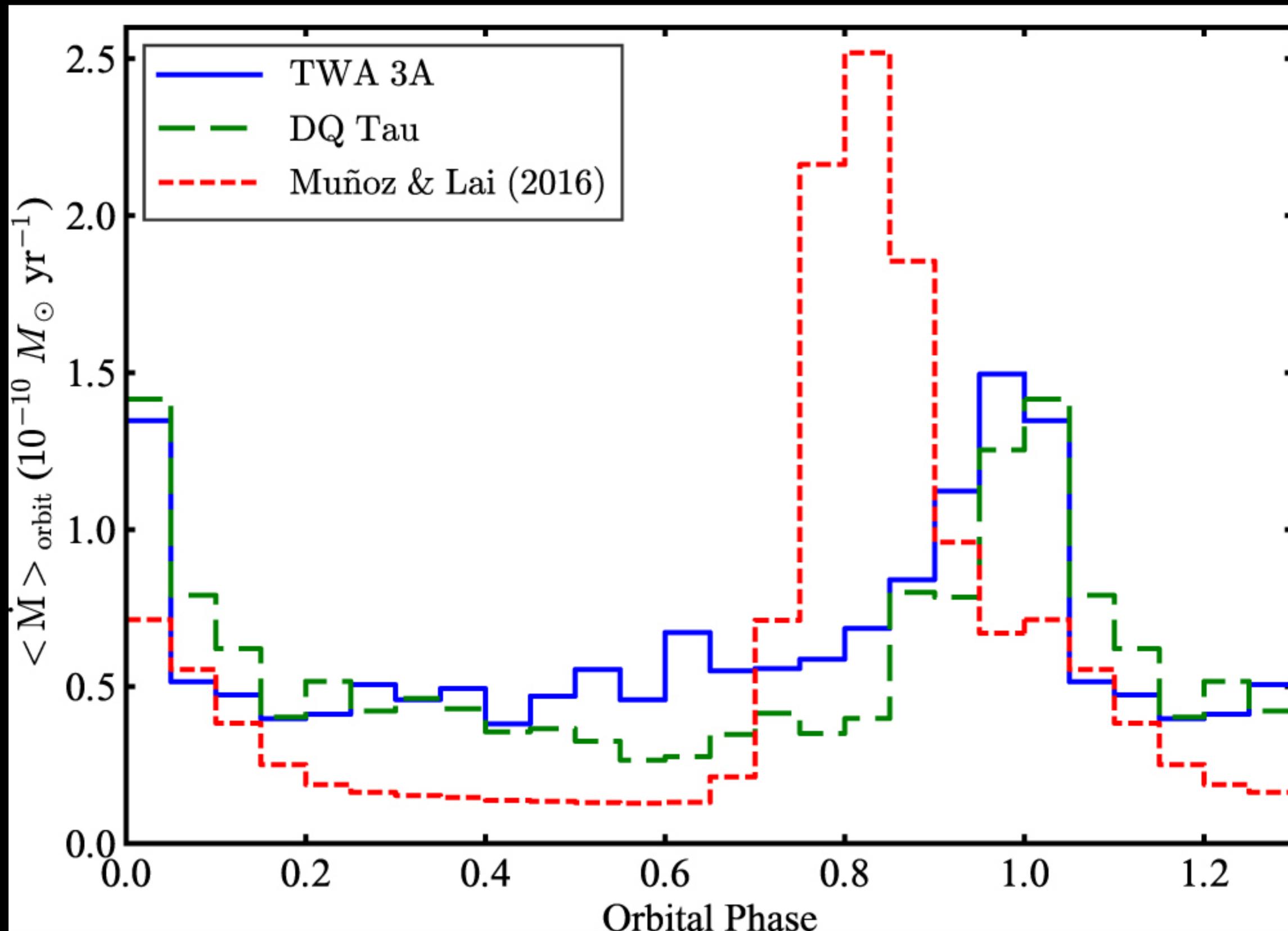
TWA 3A

$$e_b = 0.6280$$

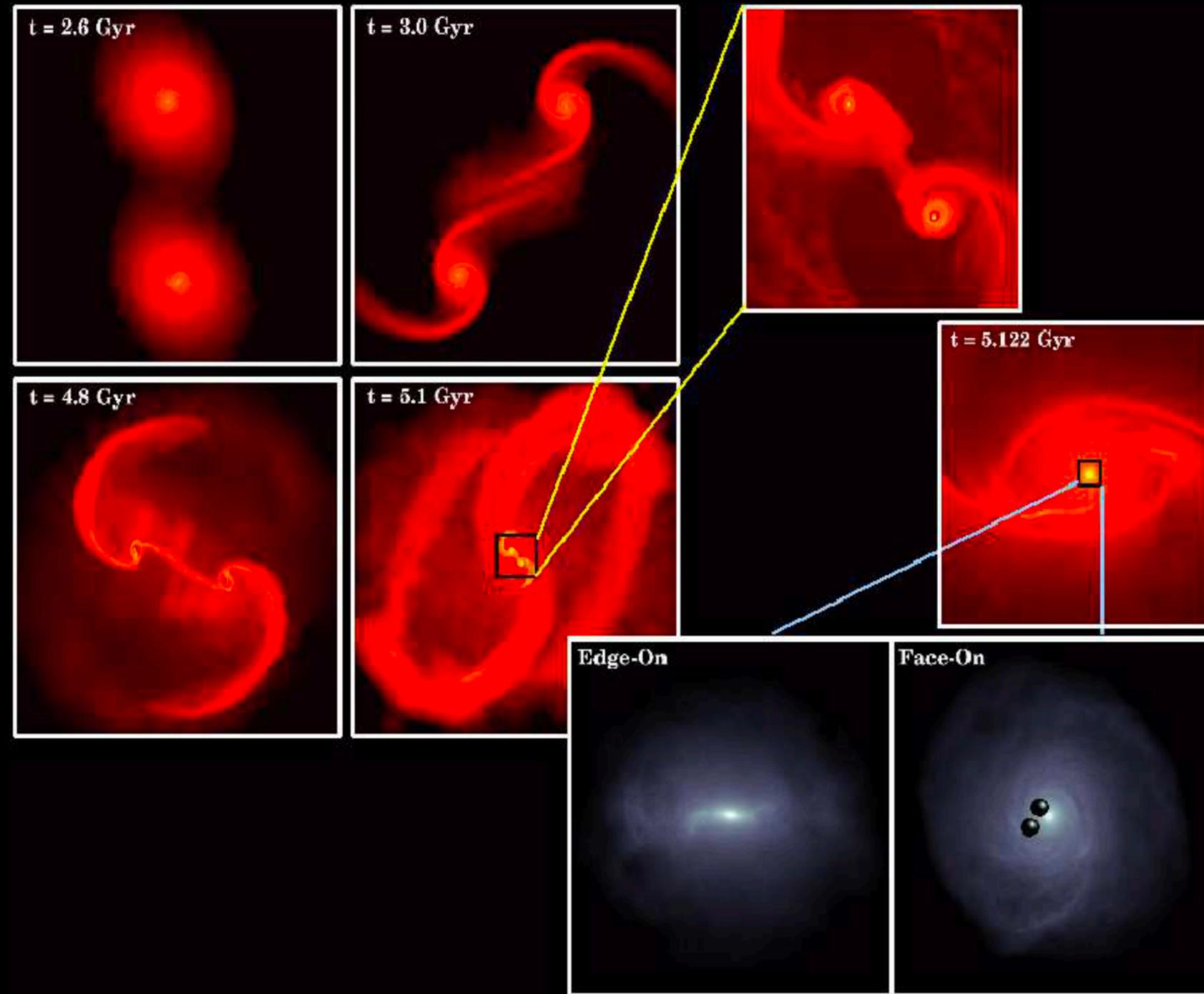
$$q_b = 0.841$$

Tofflemire et al. 2017

Lai & Muñoz. 2016



Final-parsec problem

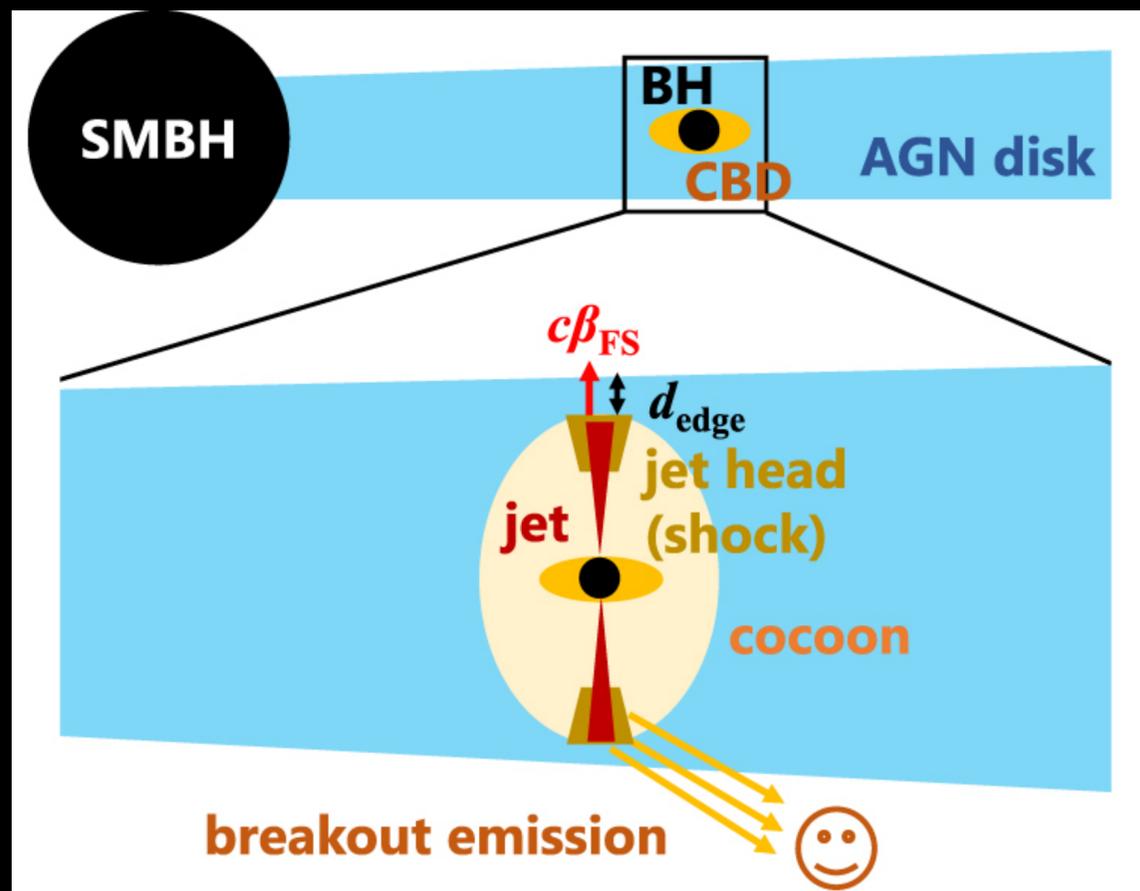


轨道是否会
衰减并最终
合并?

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

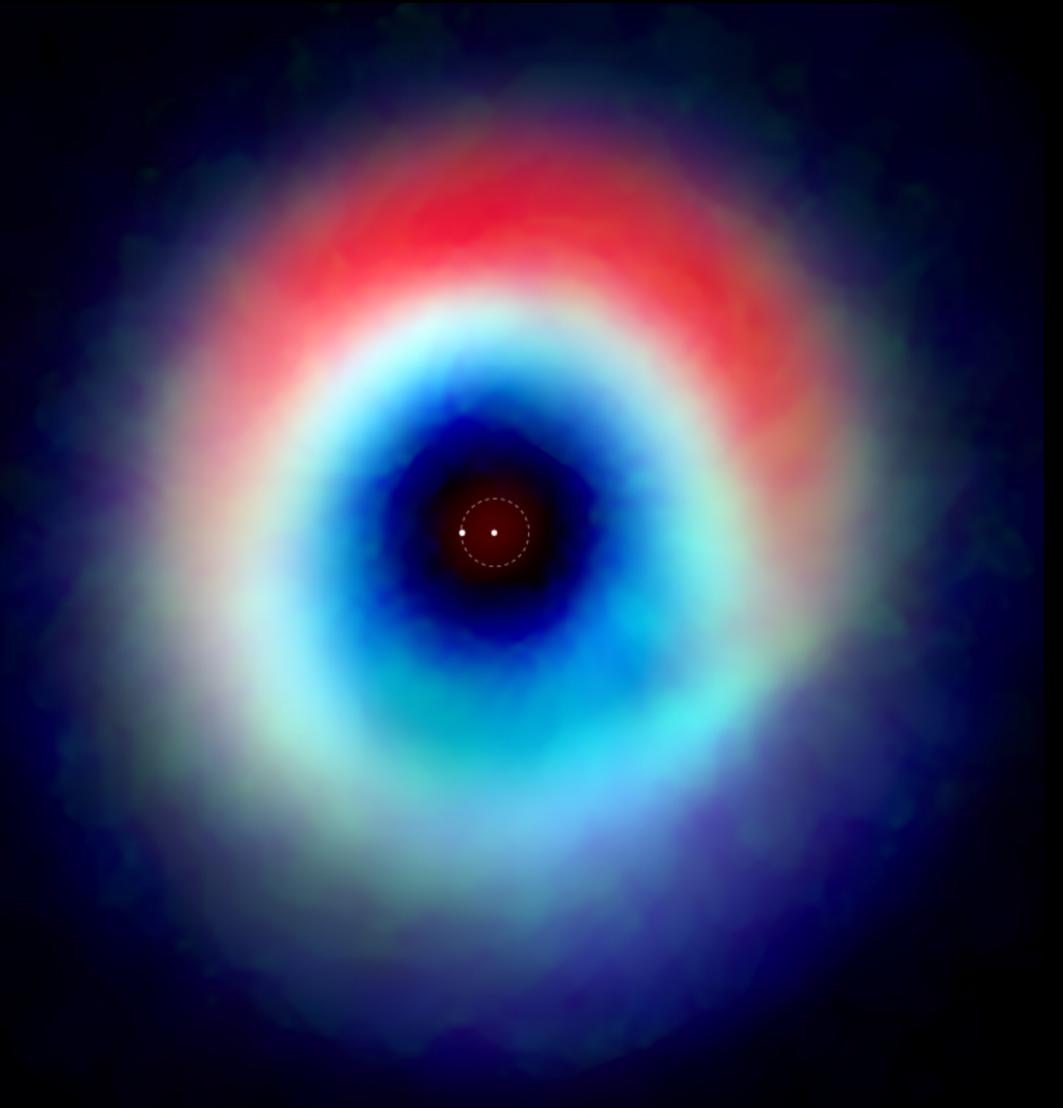
应用

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

