Enhanced TDE in Post Star-Burst Galaxies

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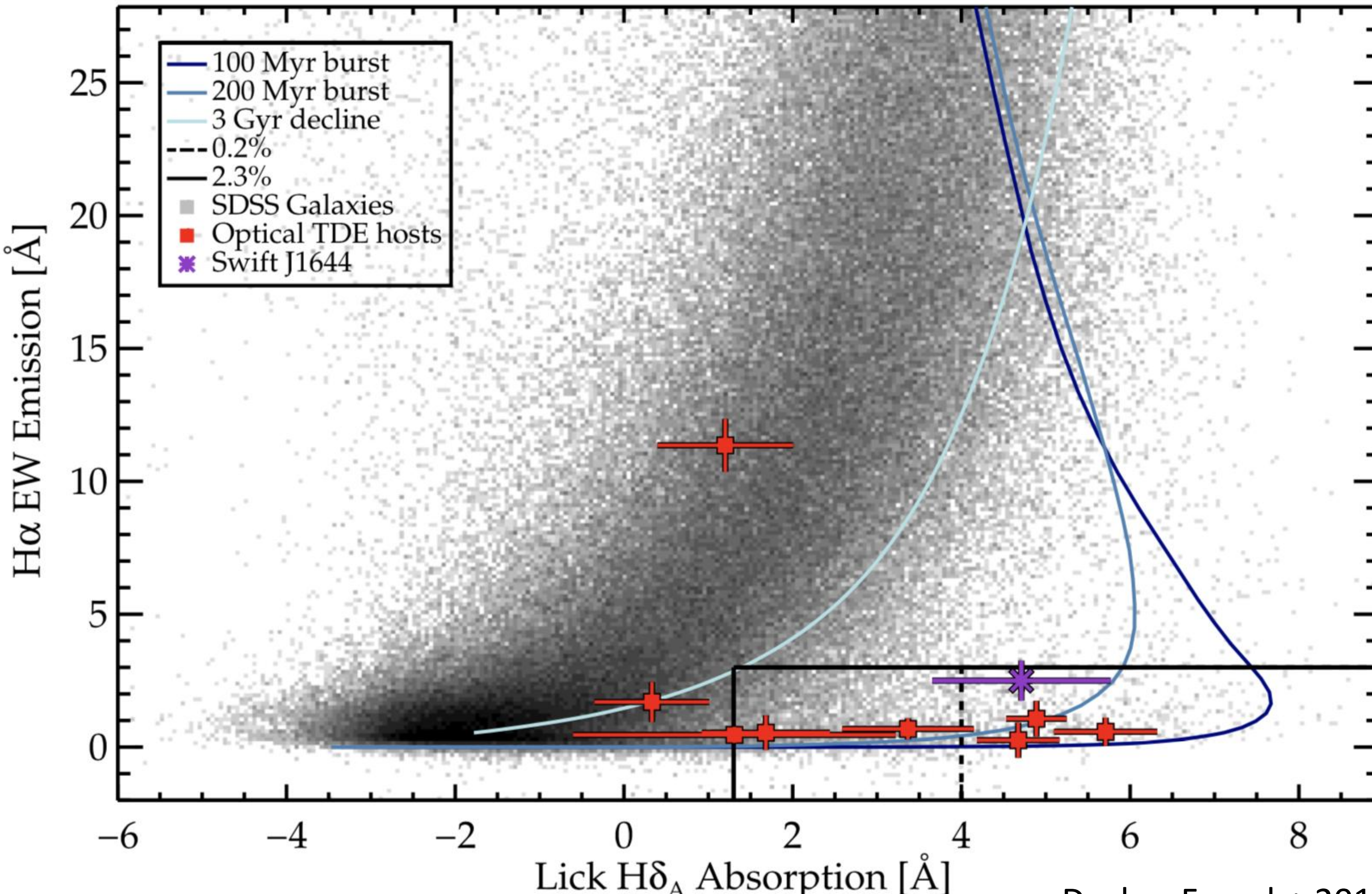
with
Xiaochen Zheng and Morgan MacLeod

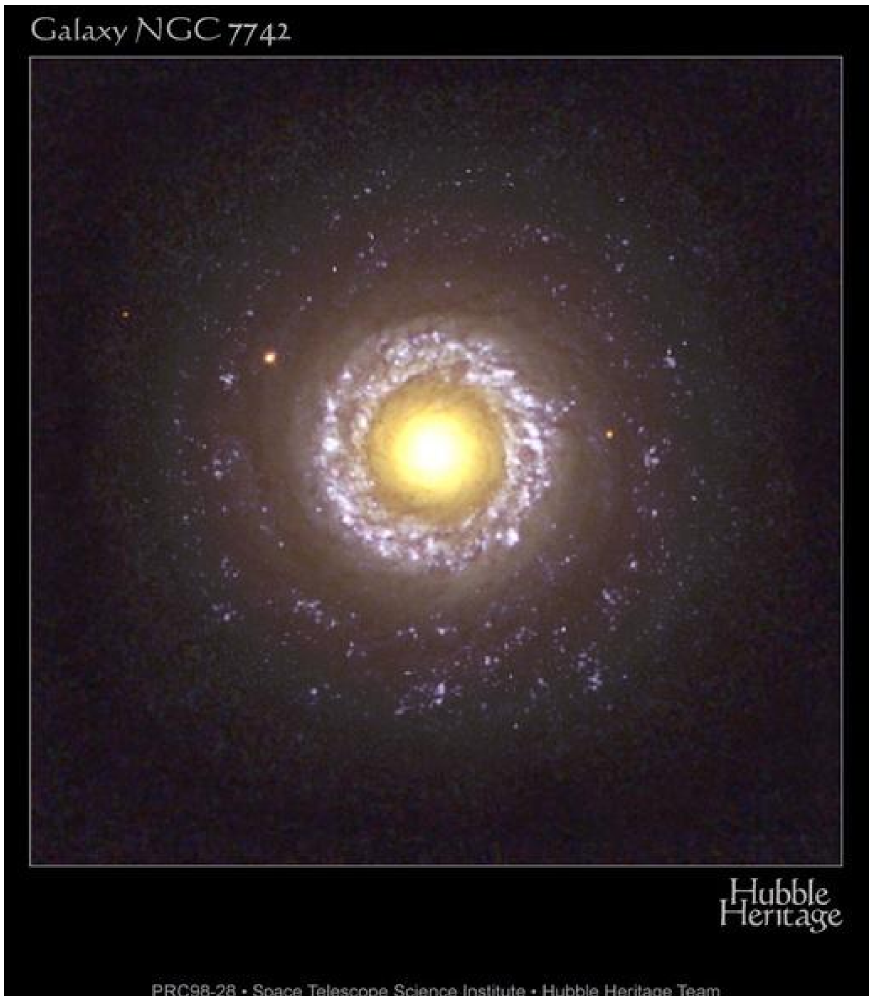
TDLI 2024.10.17

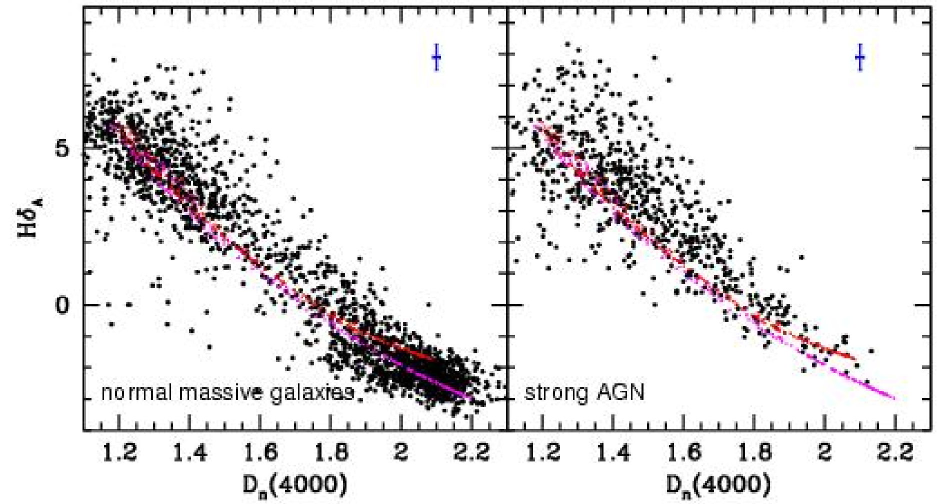
TDE-star burst connection

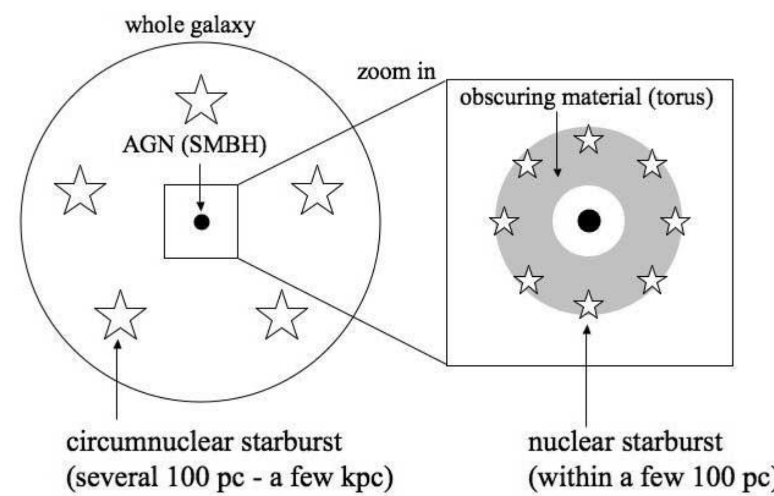


Decker-French+ 2016

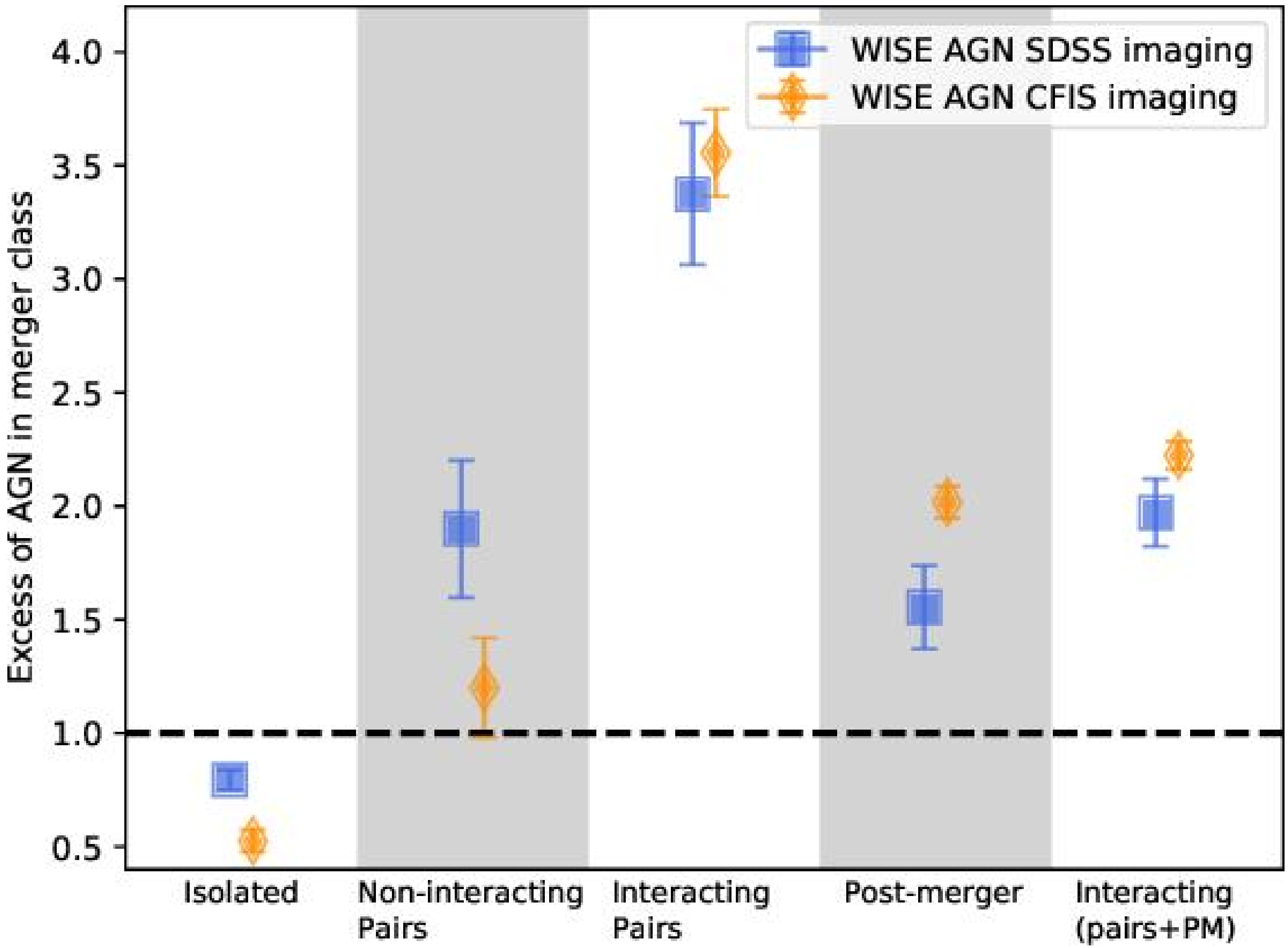
AGN-Star burst connection







AGN-merger correlation



Schematic scenario

Galaxy- mergers

Gas injection

Clusters & IMBHs

Star bursts in host galaxies

AGN with star formation in disks

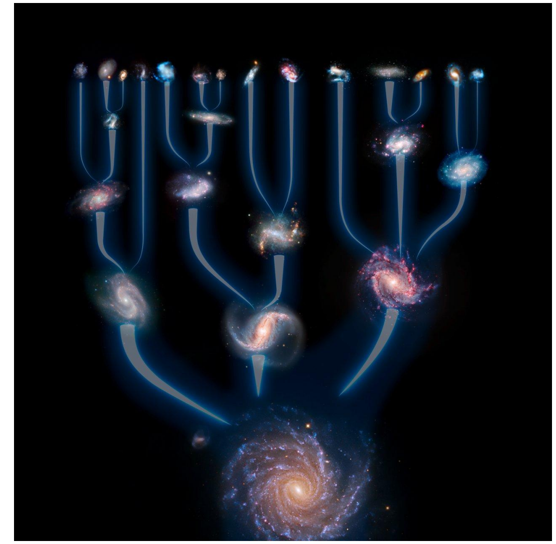
Orbital decay of companions

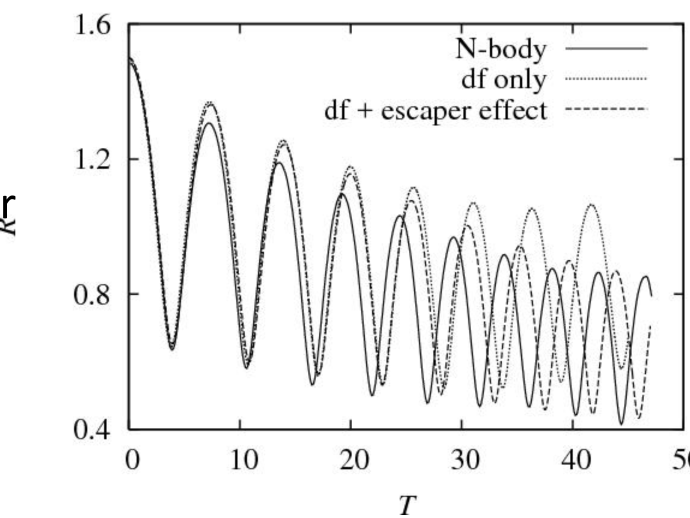
Return to quiescence

Disk depletion

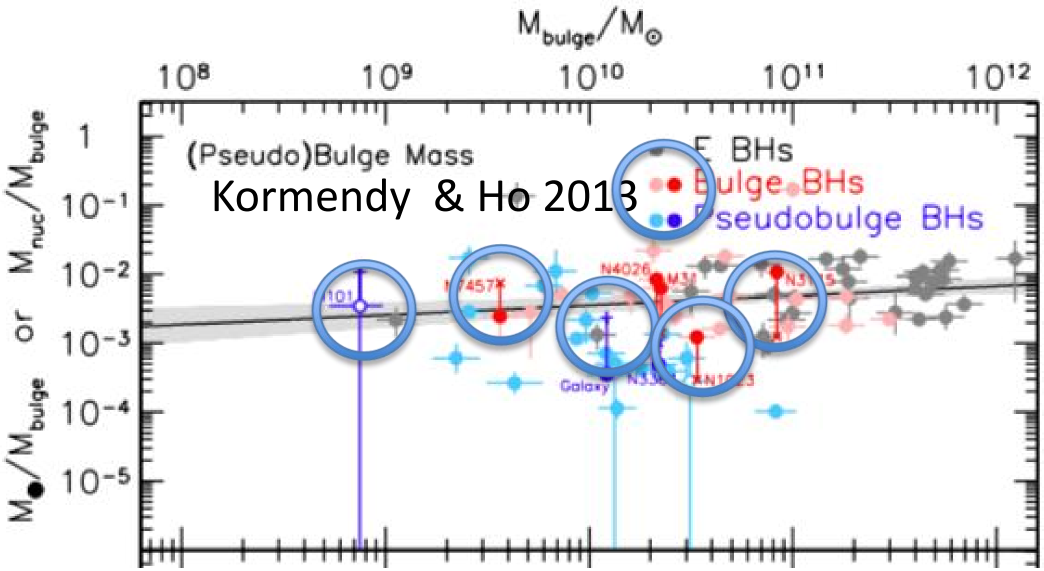
Sweeping secular resonance

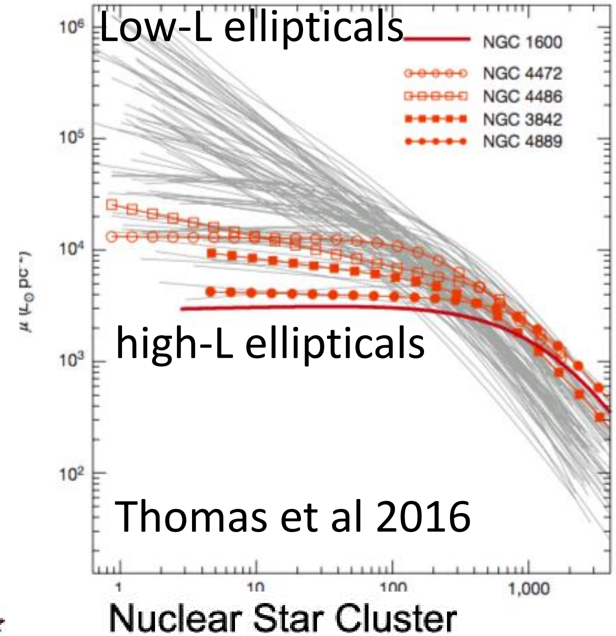
Enhanced TDEs

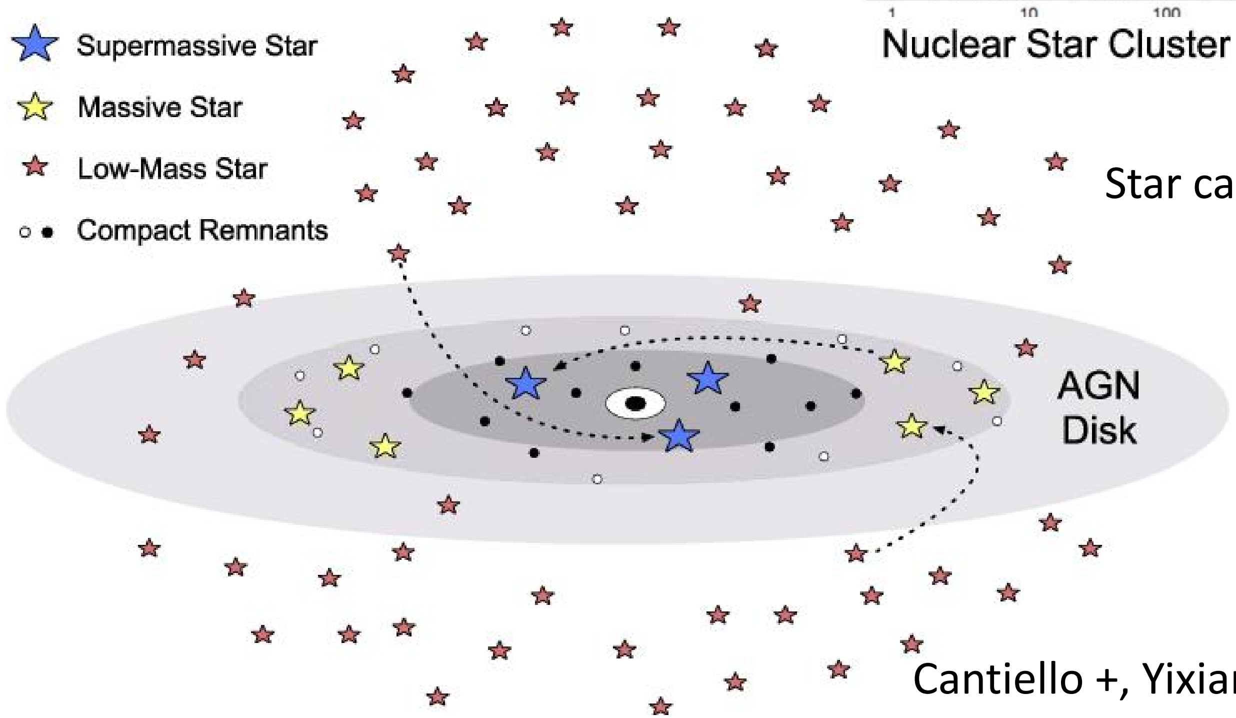




Coexistence of nuclear clusters & black holes



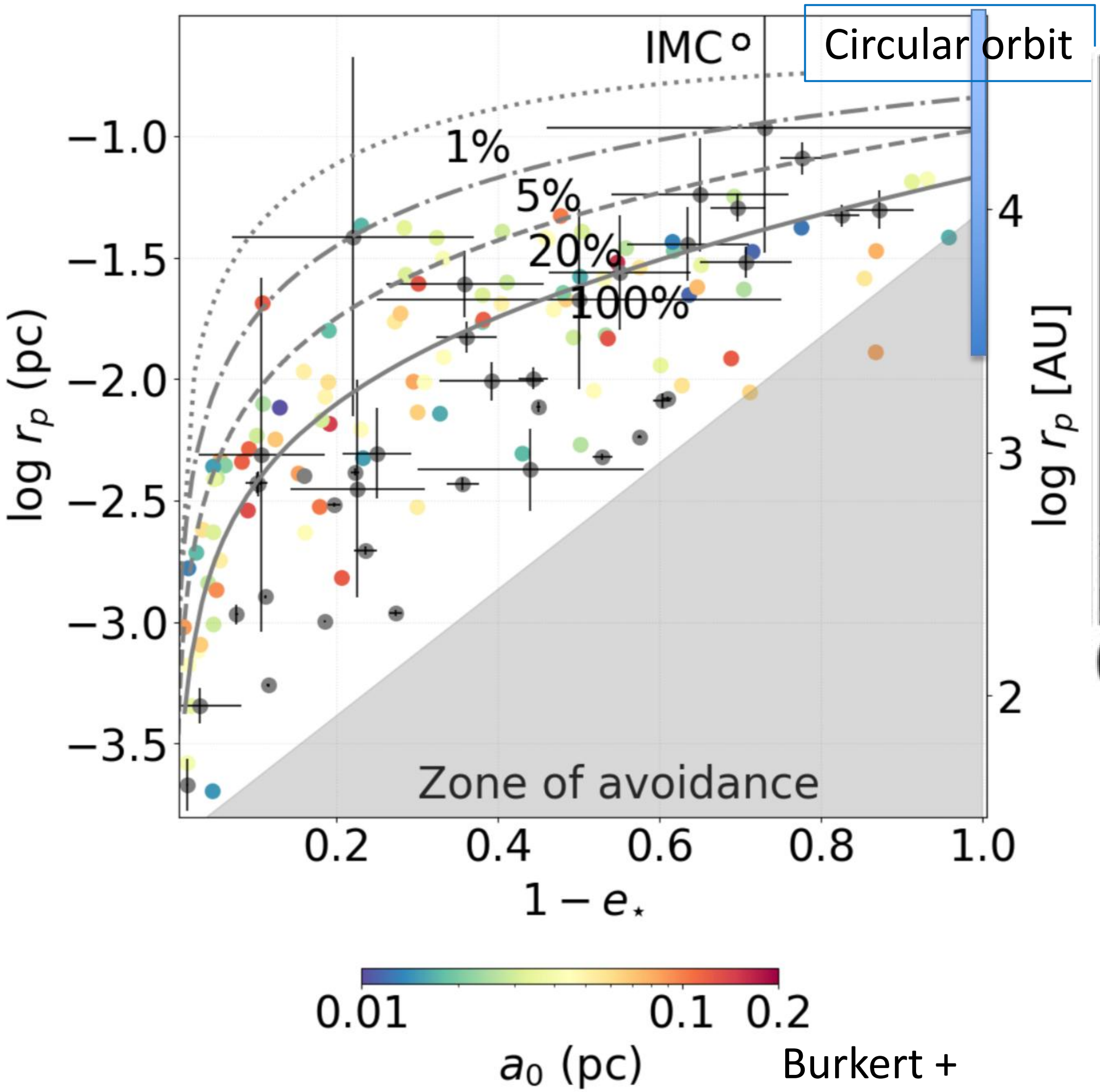




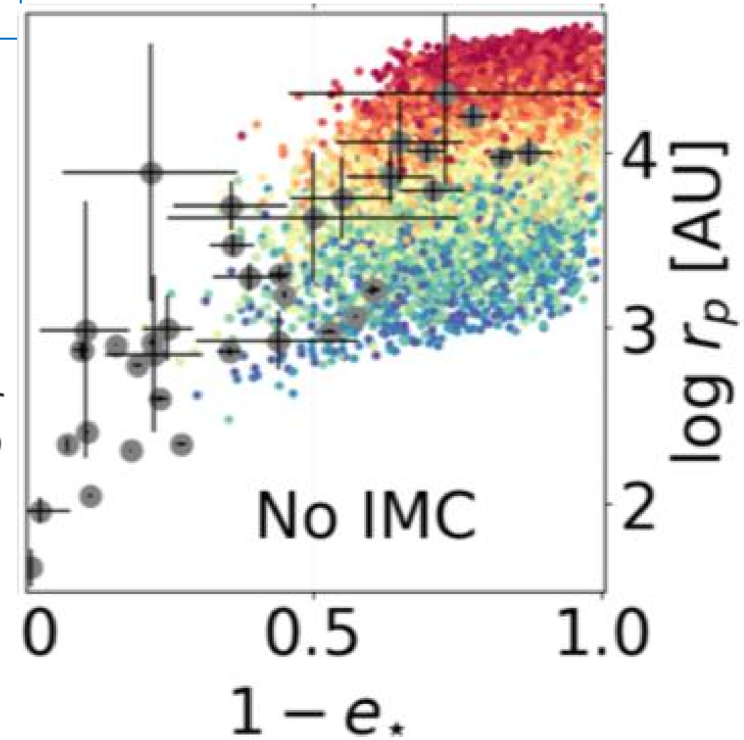
Star capture, Yihan Wang

Cantiello +, Yixian Chen, also Wu +

Sgr A* zone of avoidance

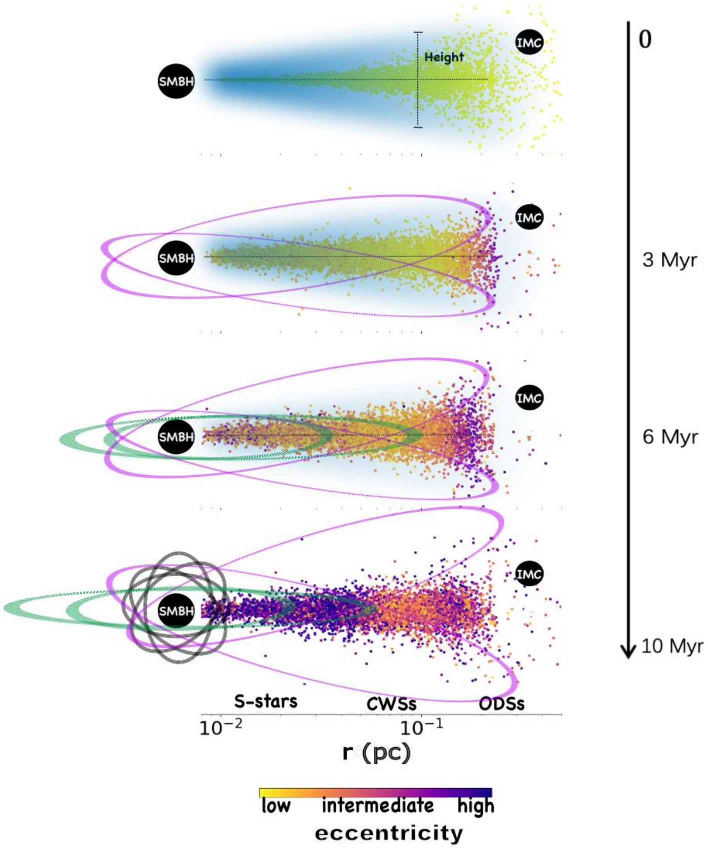


Burkert +

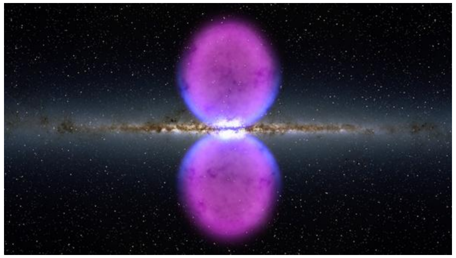


Two-body relaxation alone cannot lead to the observed distribution in <10Myr

Intermediate-mass companion (IMC) scenario

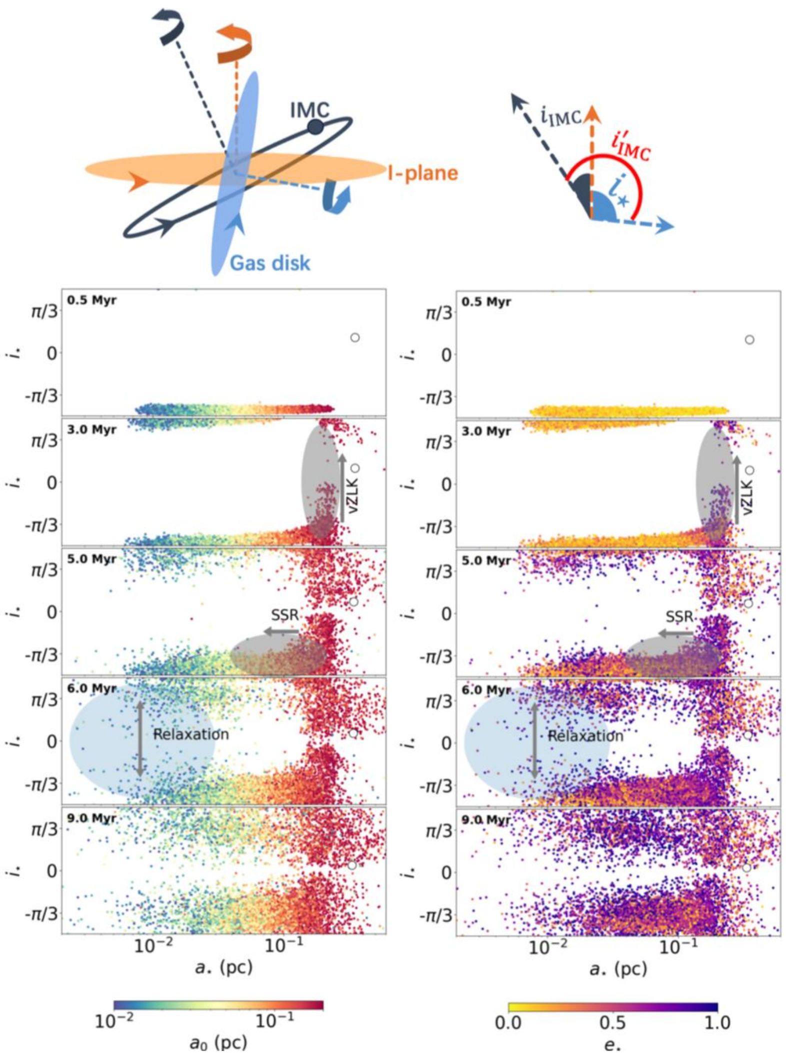


Dynamical processes:
vonZeipel-Lidov-Kozai effect+
sweeping secular resonances +
resonant relaxation

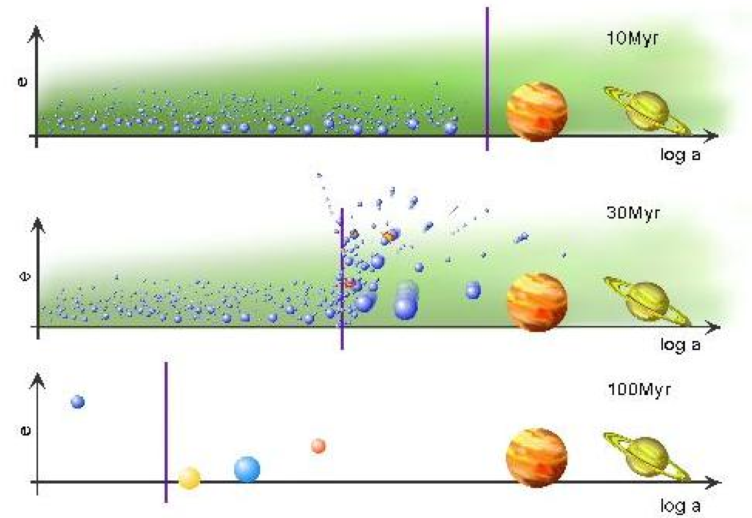


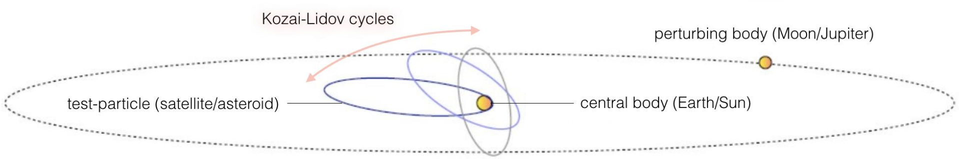
Xiaochen Zheng, Long Wang +

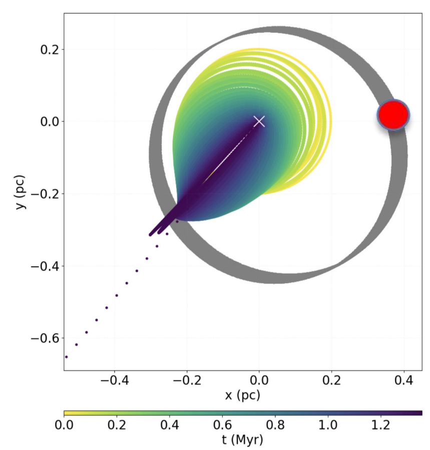
Stellar dynamics around Sgr A*



Solar system analog

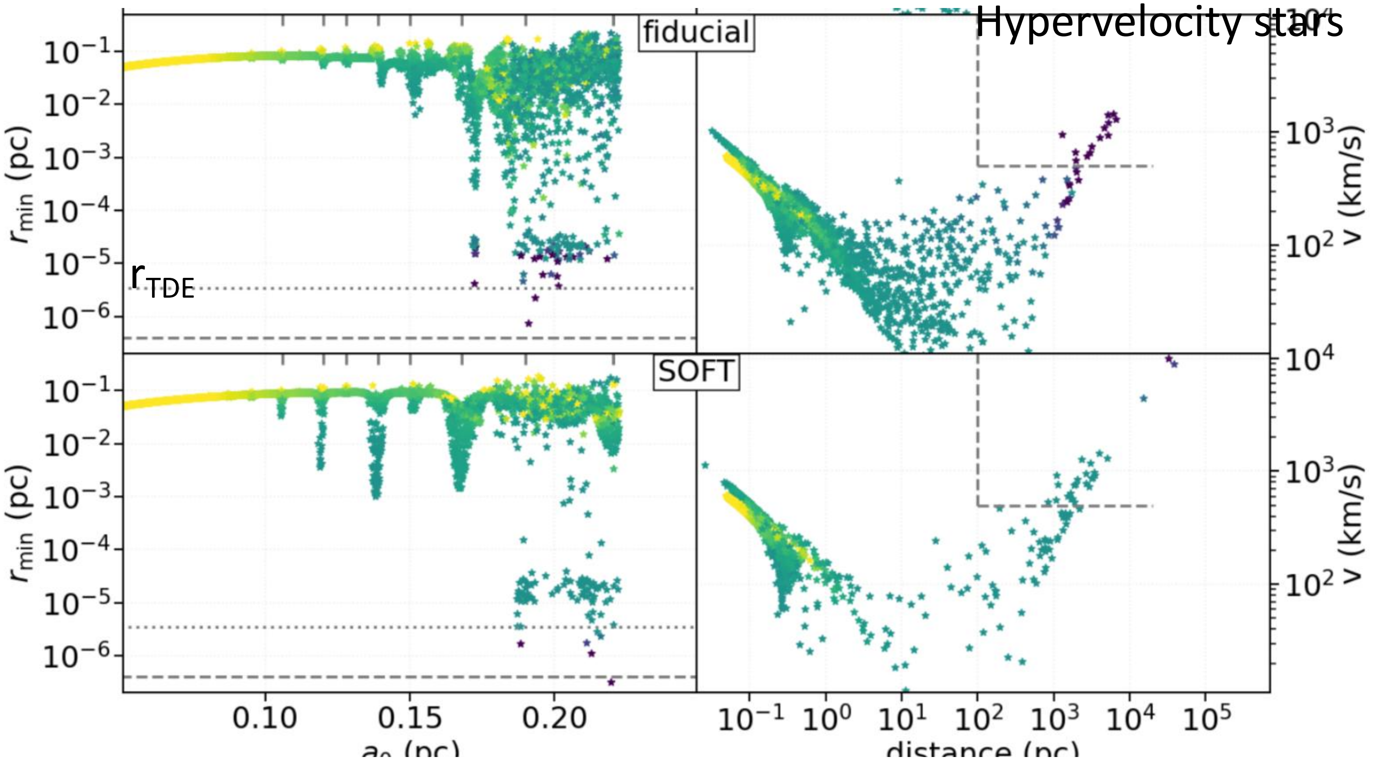


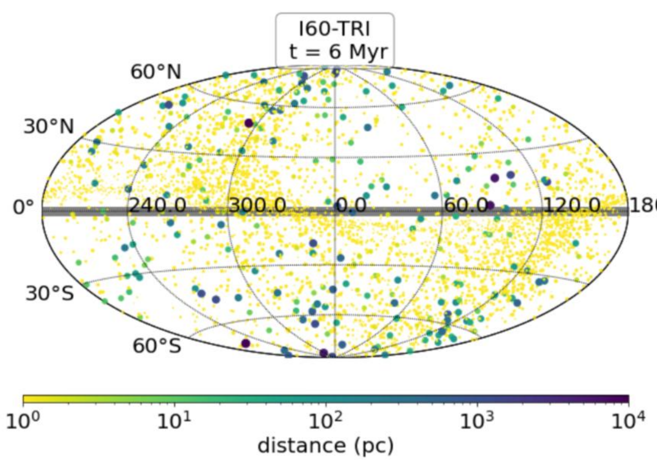




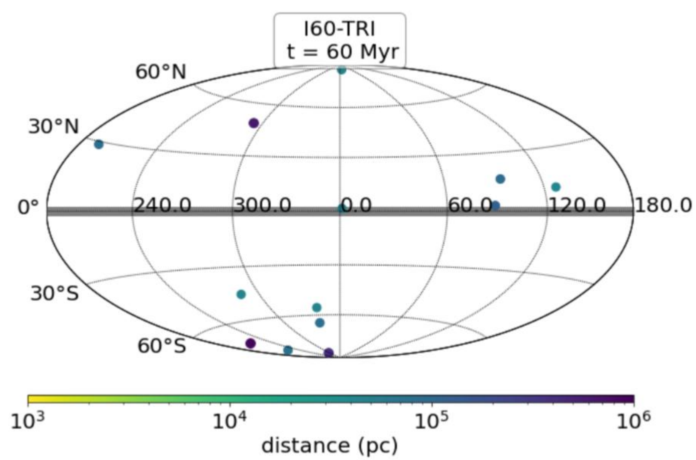
Zheng +

TDEs and HVSs





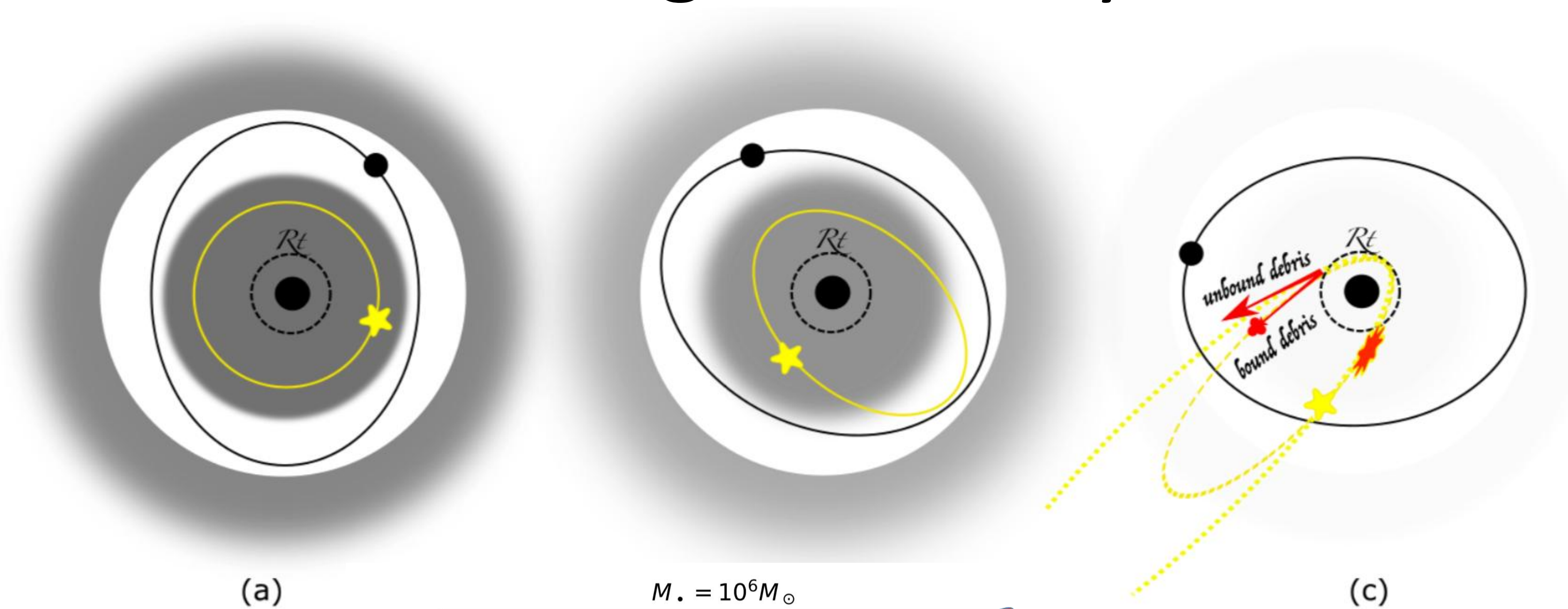
(e)



(f)

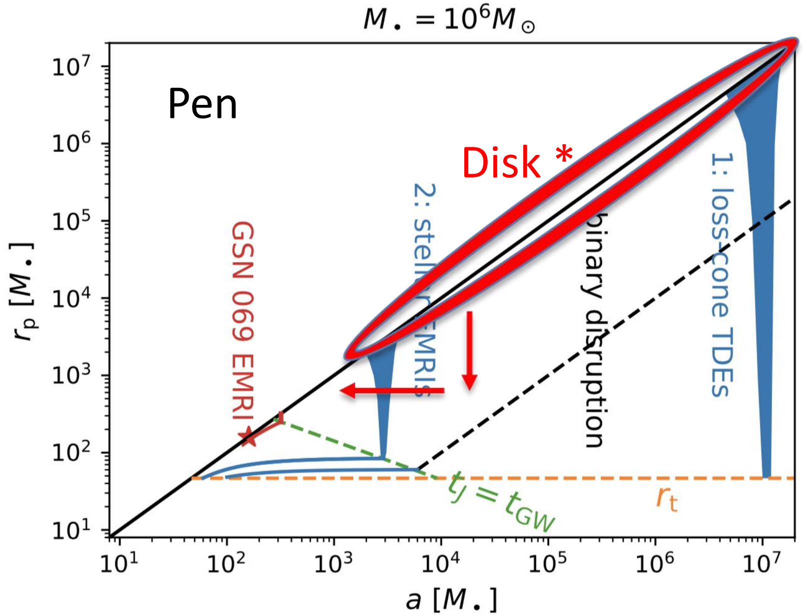
Zheng, Mao

In the green valley



(a)

(c)

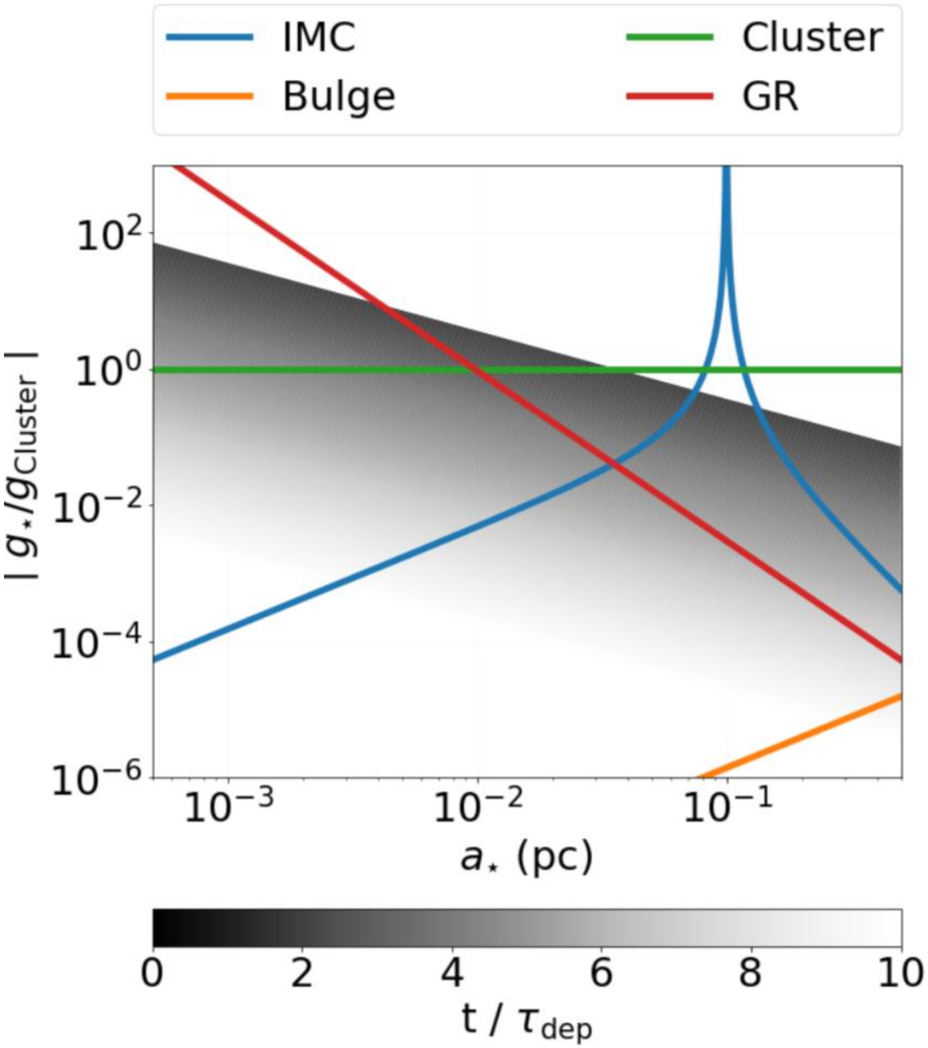


Sari , Linial

Disk+IMC =>
speed up relaxation
and in-spiral

Zhou Pen+

IMC's secular perturbation

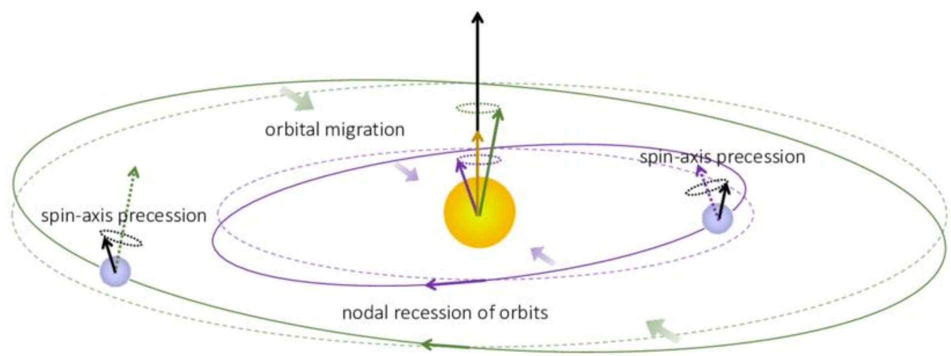


Relative precession frequencies

$$\frac{d\xi}{dt} = -\frac{q}{4} n_\star \alpha \tilde{\alpha} b_{3/2}^{(2)} \sin\,\eta,$$

$$\frac{d\eta}{dt} = \begin{cases} g_\star - g_{\rm IMC} & \text{co-orbiting case} \\ g_\star + g_{\rm IMC} & \text{counter-orbiting case} \end{cases}$$

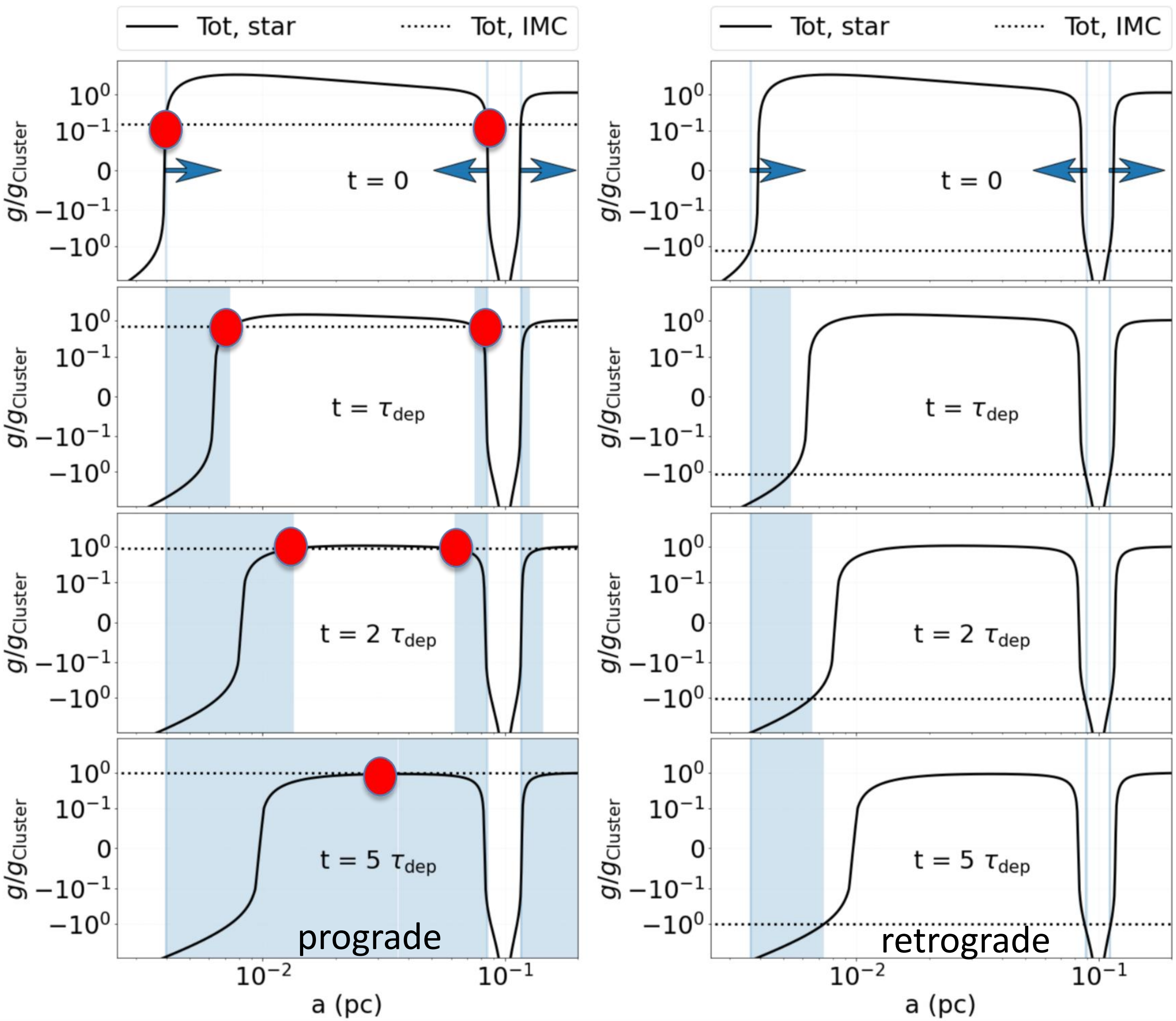
where the eccentricity ratio $\xi \equiv e_\star / e_{\rm IMC}$, the



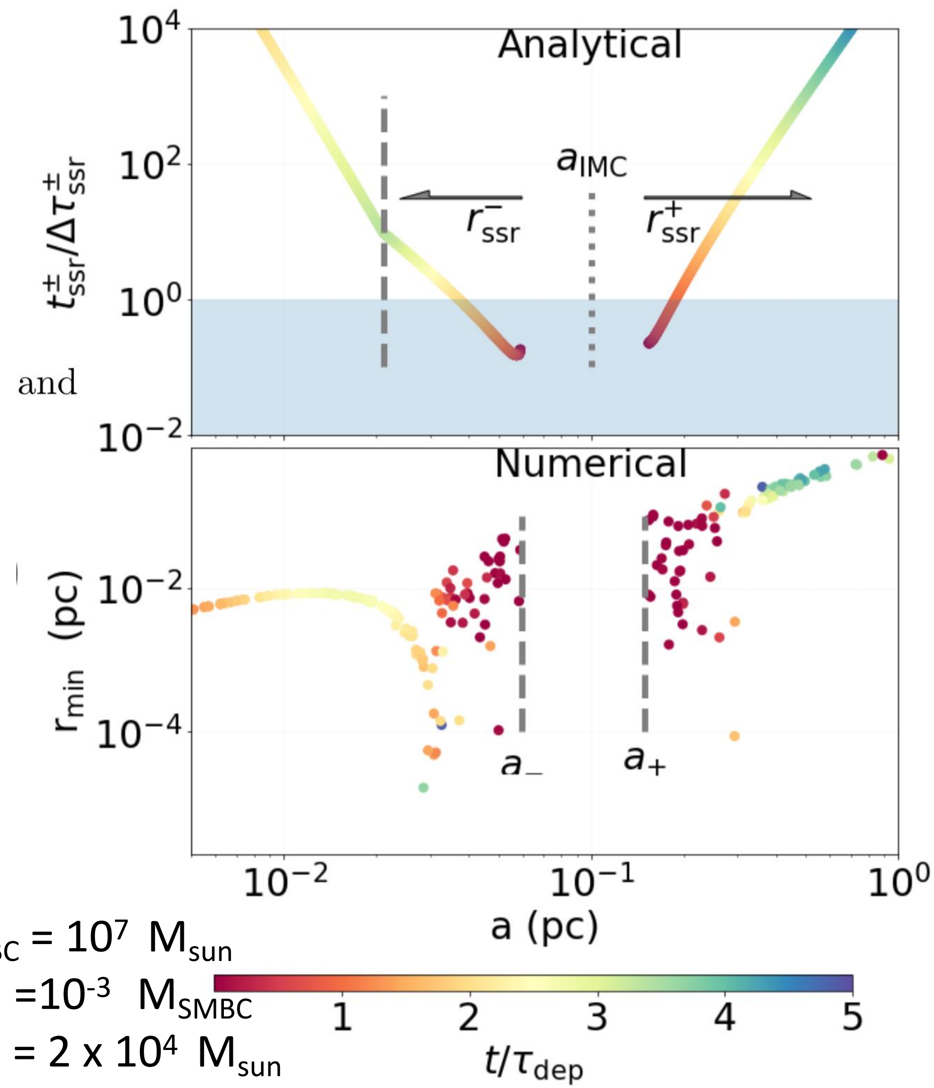
Disk contribution to the potential

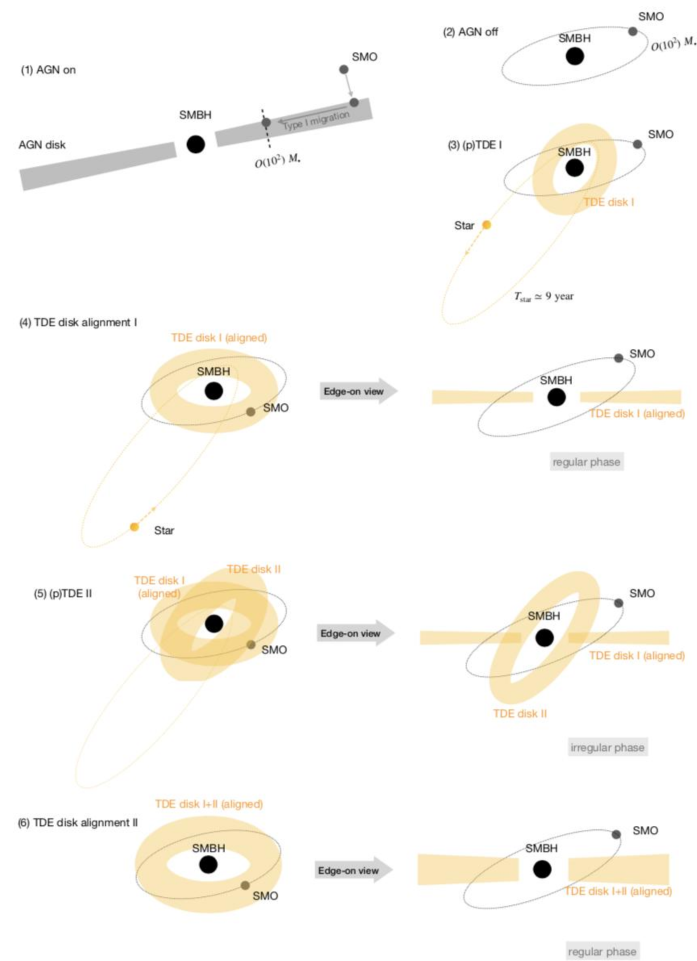
$$\Sigma = \Sigma_0 \left(\frac{r}{R_0}\right)^{-3/2} e^{-t/\tau_{\rm dep}}\ \mathrm{g/cm^2}$$

Sweeping secular resonance



Eccentricity excitation during disk depletion





$M_{SMBC} = 10^7\ M_{sun}$

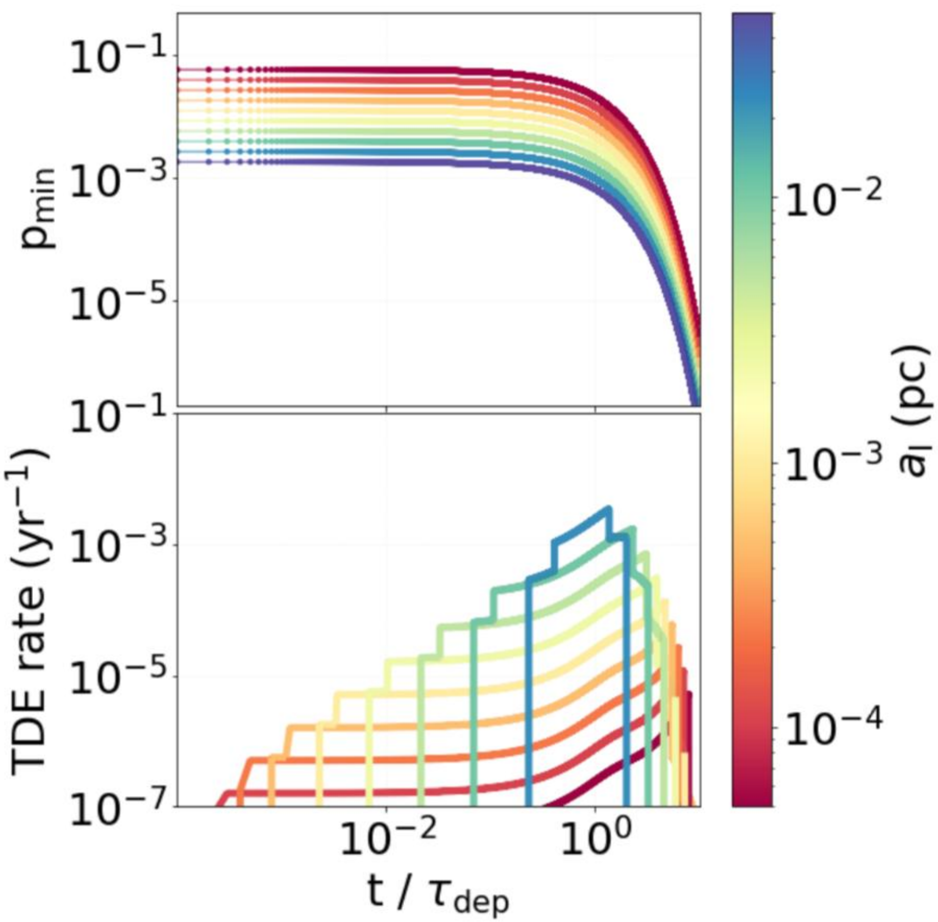
$M_{IMC} = 10^{-3}\ M_{SMBC}$

$M_{disk} = 2 \times 10^4\ M_{sun}$

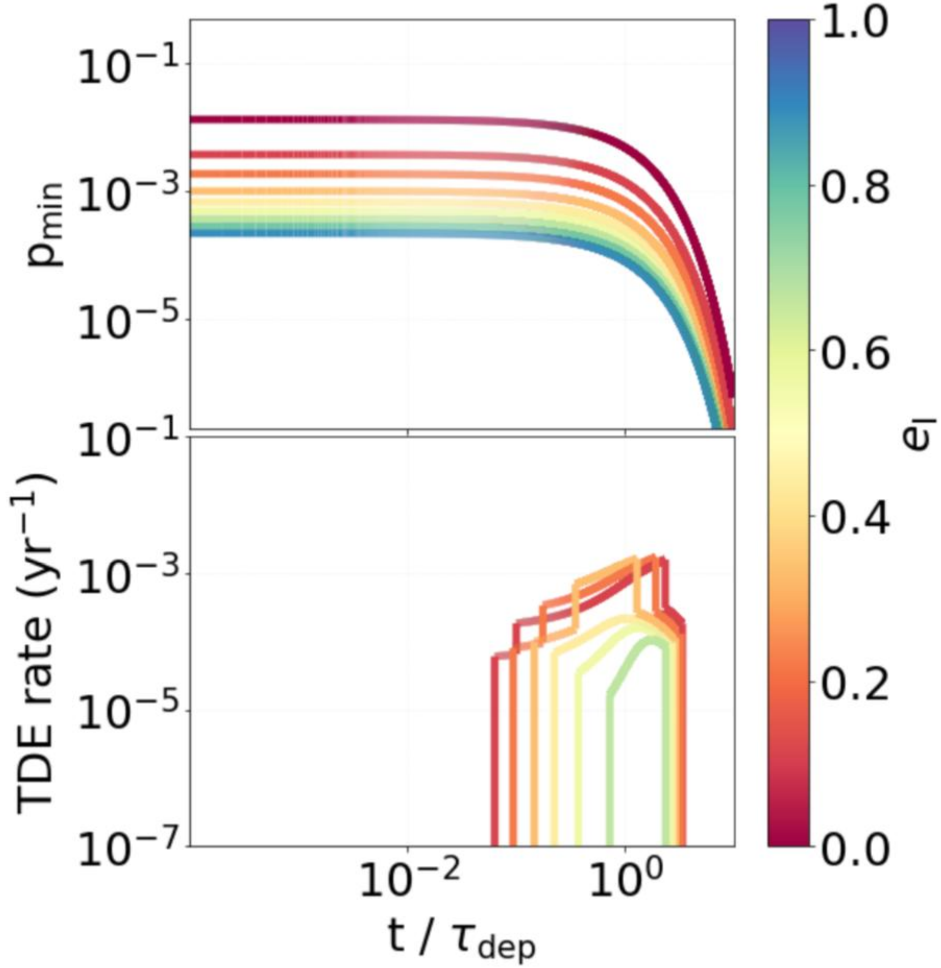
$a_{IMC} = 0.1$pc, $e_{IMC} = 0.1$

Zhou, Pen +

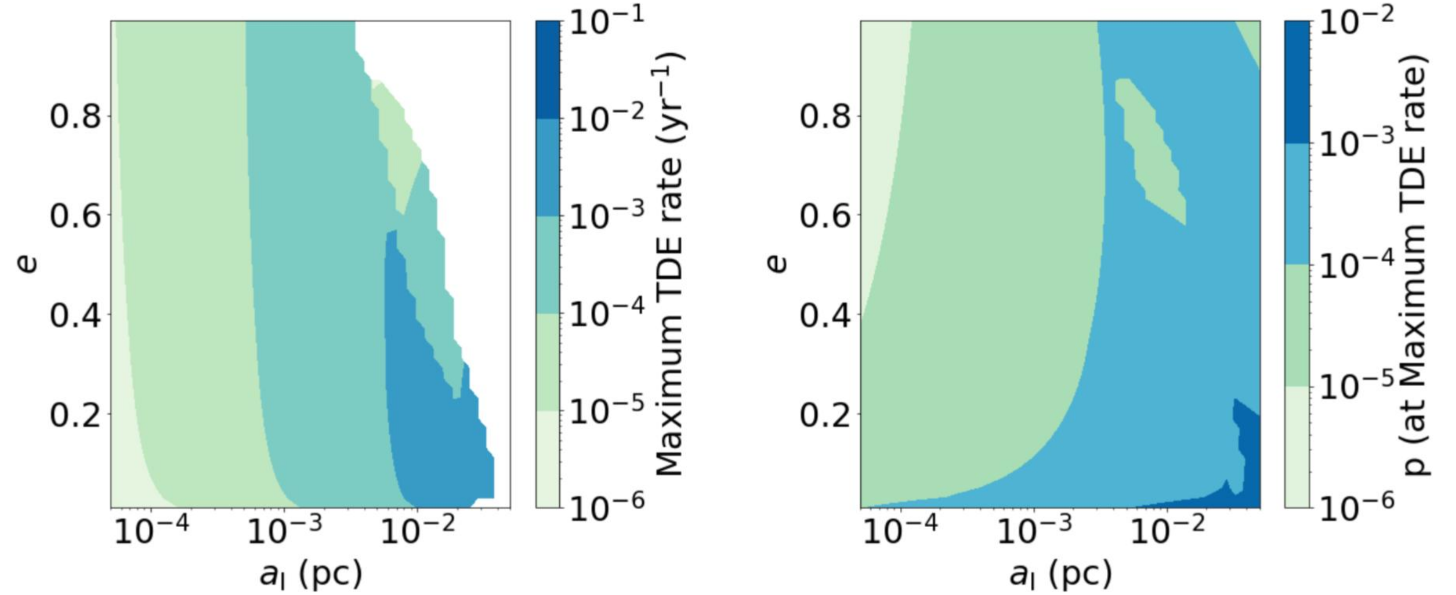
TDEs’ occurrence rate



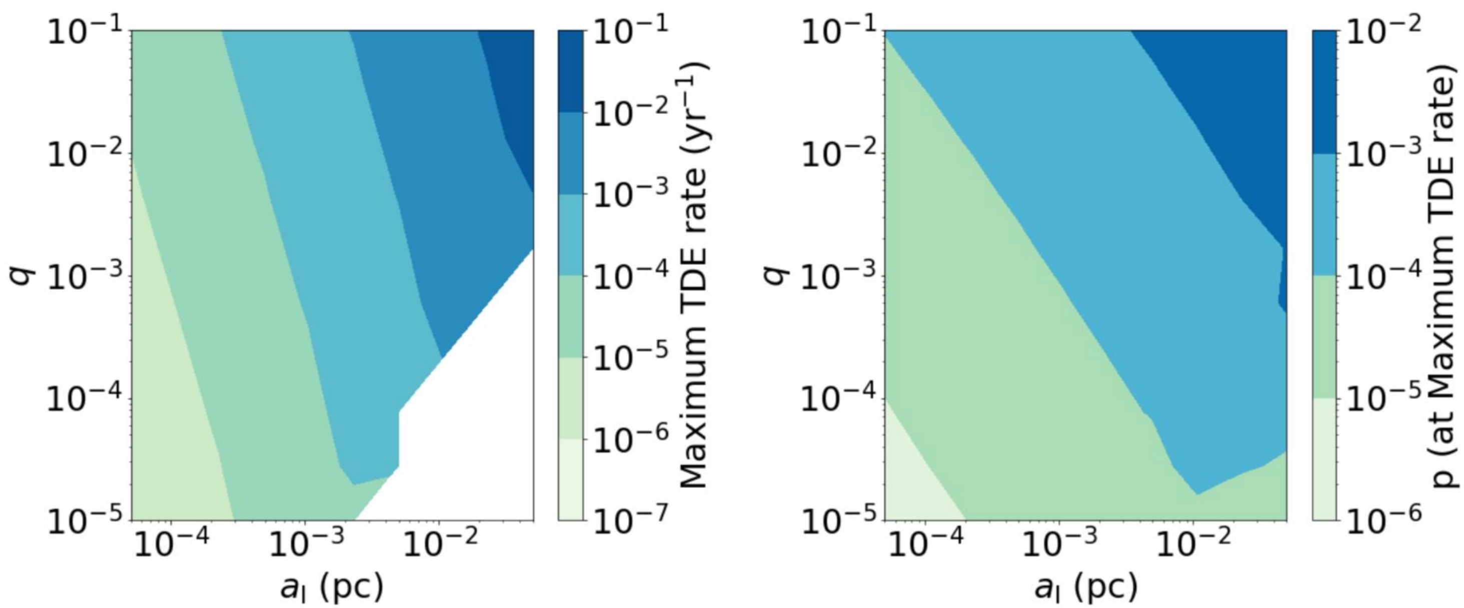
Semi-major axis of the IMC dependence



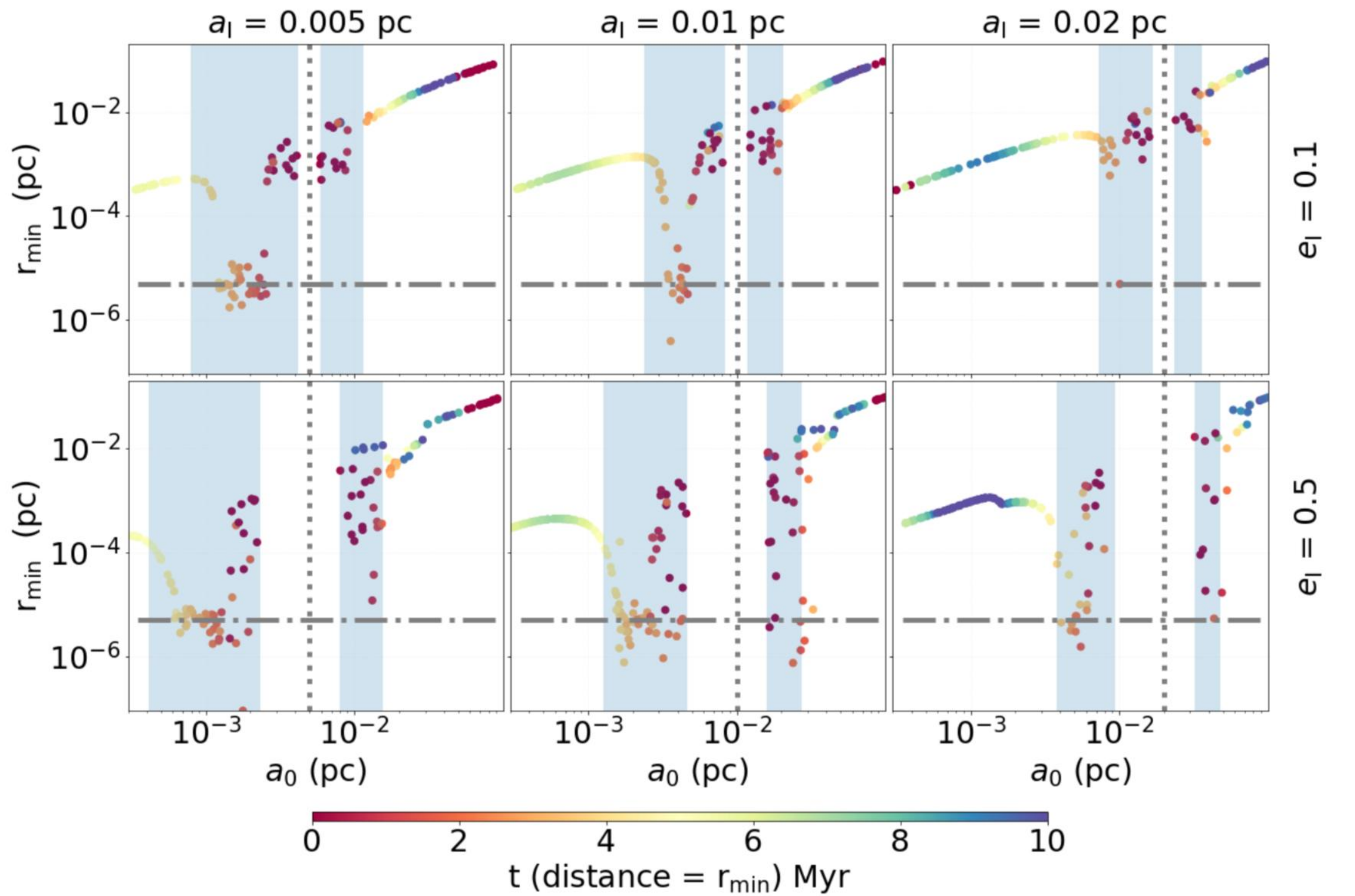
Eccentricity of the IMC dependence



$\tau_{\mathrm{dep}} = 1$ Myr, $q = 10^{-3}$



$\tau_{\mathrm{dep}} = 1$ Myr, $e_{\mathrm{I}} = 0.1$

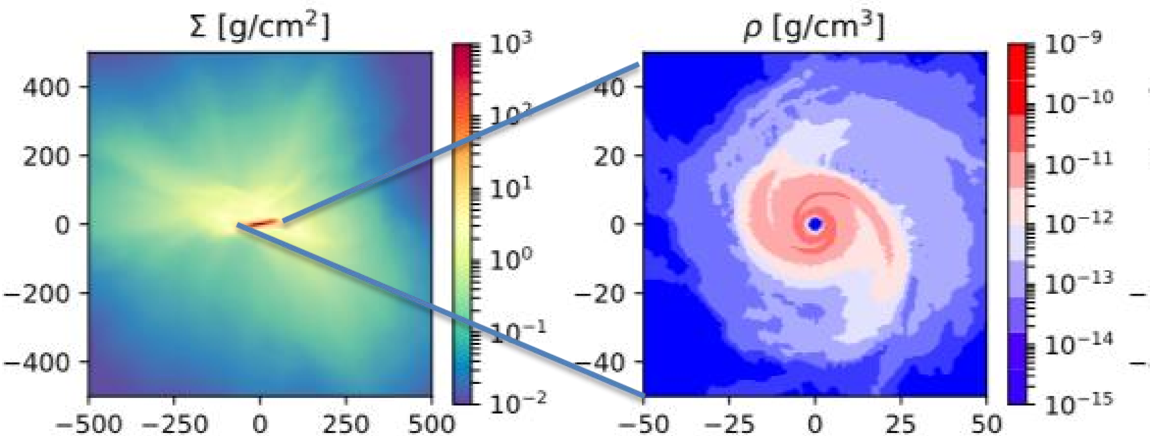


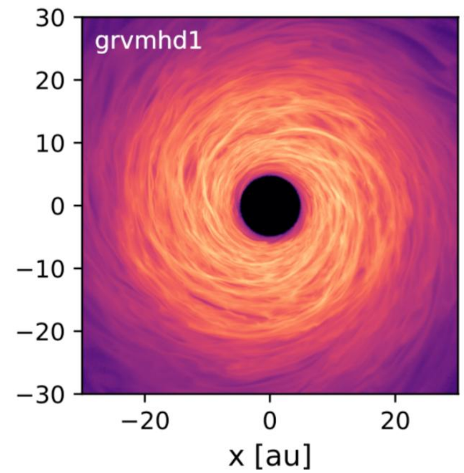
a_l = 0.005 pc
a_l = 0.01 pc
a_l = 0.02 pc
e_l = 0.1
e_l = 0.5
r_{min} (pc)
10^{-2}
10^{-4}
10^{-6}
10^{-3}
a_0 (pc)
0
2
4
6
8
10
t (distance = r_{min}) Myr

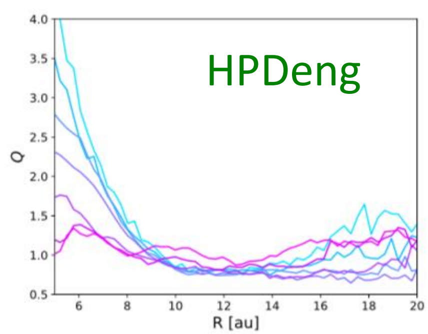
IMC synopsis:

- IMC’s secular perturbation can lead to rapid eccentricity excitation
- IMC’s proper motion and internal structure are measurable
- Stars’ correlated longitudes of periapsis and nodes are measurable
- Non GR precession are measurable
- Potential TDEs and hyper velocity stars
- IMC’s secular perturbation during disk depletion can enhance the TDE rates in the green Valley
- Possible channels of QPE in Dorman galactic nuclei.
- Remarkable similarity with Solar System dynamics

Gravitational stability & angular momentum transport







L-Pringle, Rees; Rafikov Rice; Riols, Latter, Deng

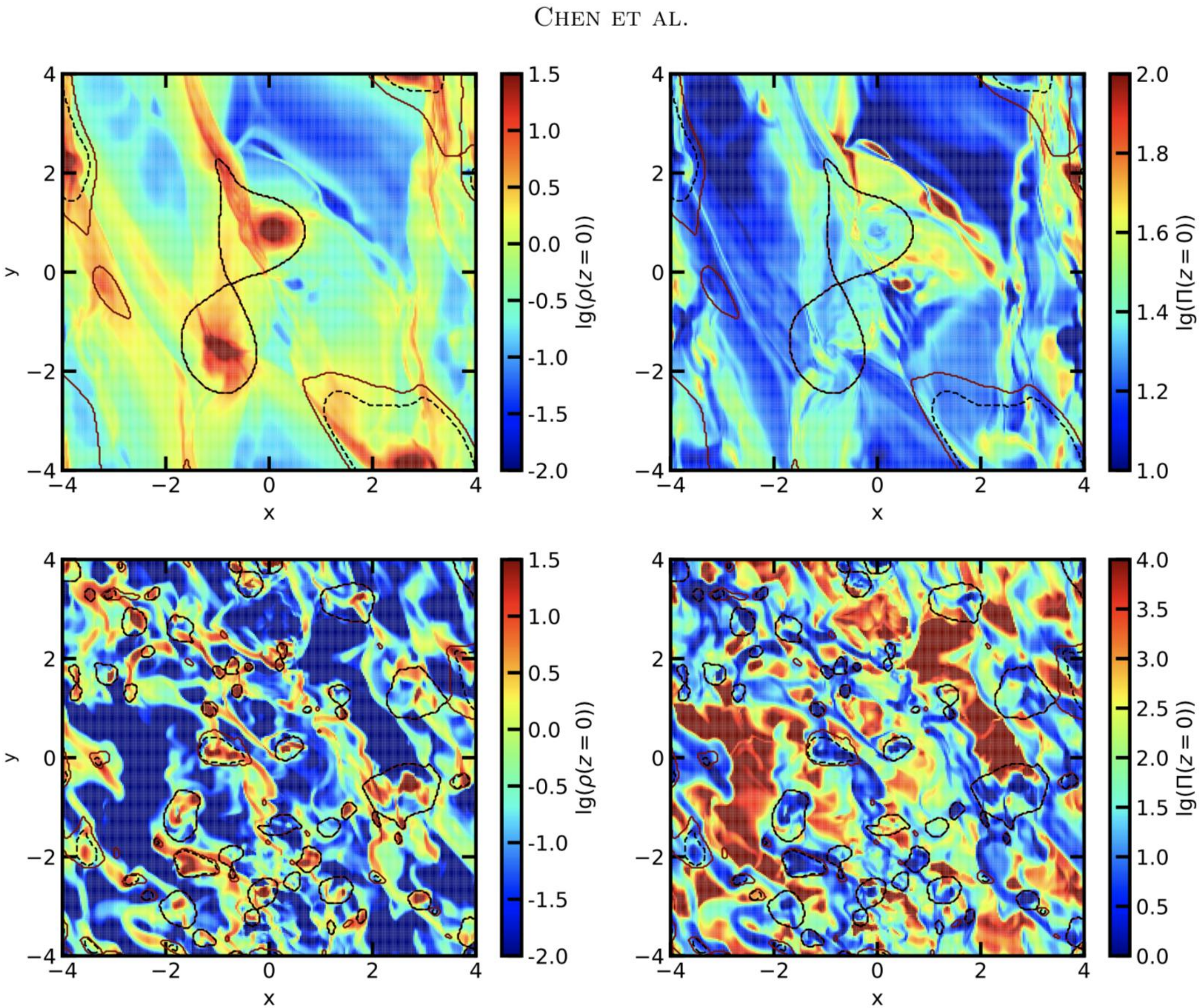
$$\alpha = \psi\alpha^{\rm R}_{\rm gt}(r, \Sigma) + \alpha_m \quad (2)$$

At $R_{pc}>10^{-2}$, $Q\sim$**1**-10, $\alpha\sim0.1$-**1**, $h \sim$ **0.03** $m_8^{-1/6}R_{pc}^{1/2}$, **(3)**

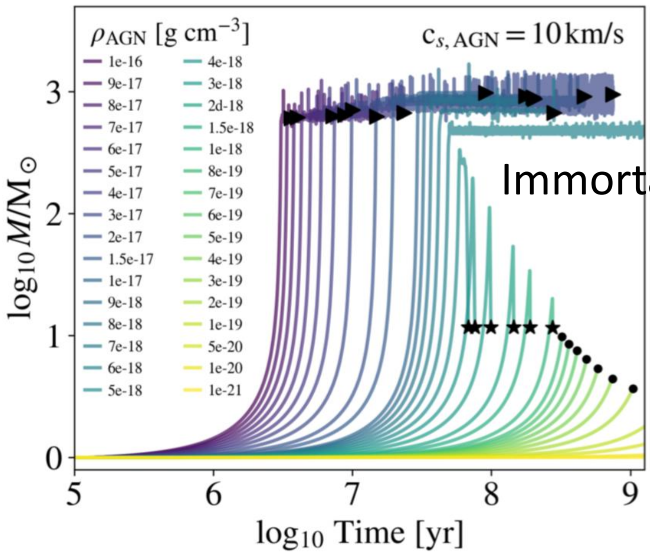
$\tau_{disk} > 20\ m_8^{5/6}R_{pc}^{-3/2}$ (optical depth)

Disk parameters are specified for a set of M_8 & R_{pc}

Fragmentation and star formation

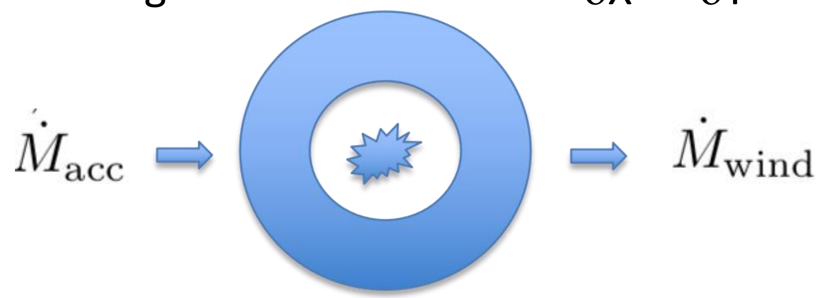


Fuel replenishment: equilibrium mass



Immortal stars

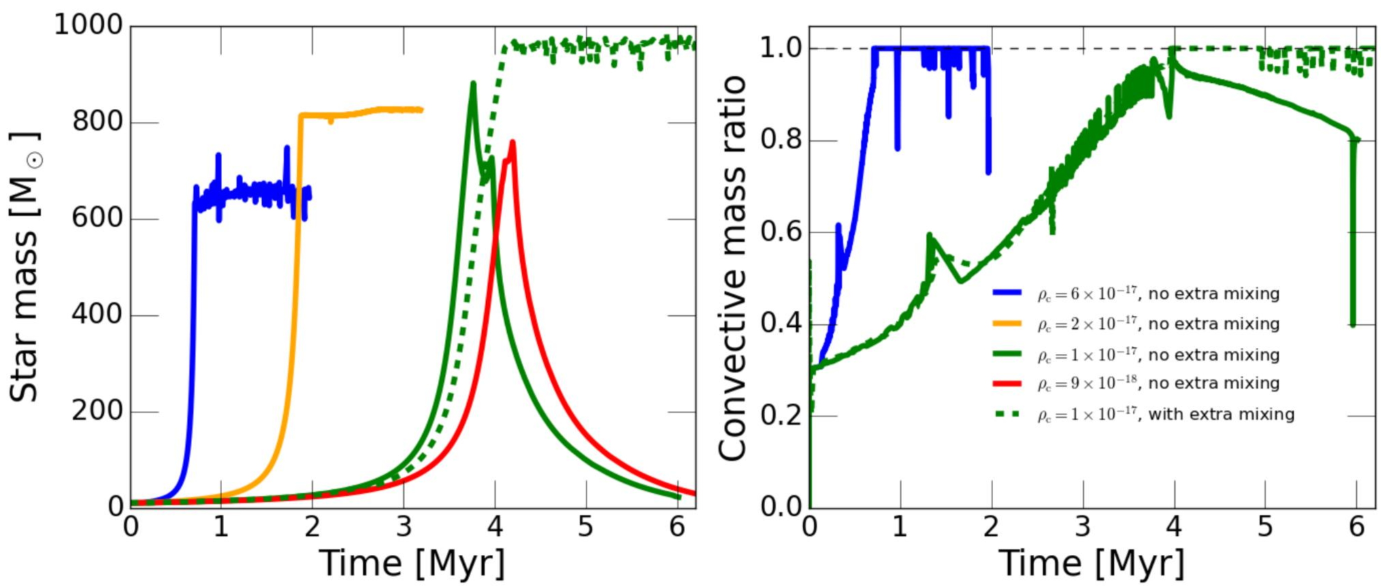
CNO burning on the MS – $\delta X = \delta Y$



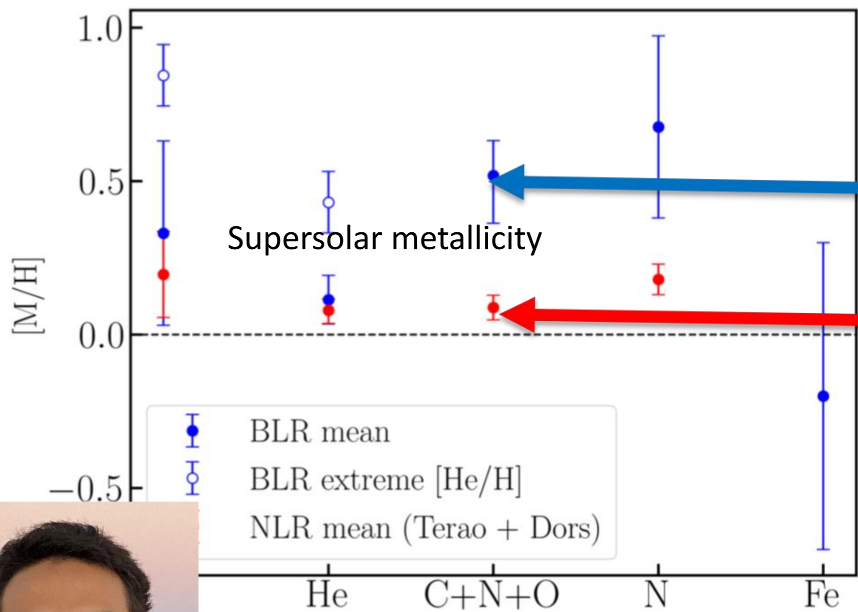
Secondary O+C -> N conversion

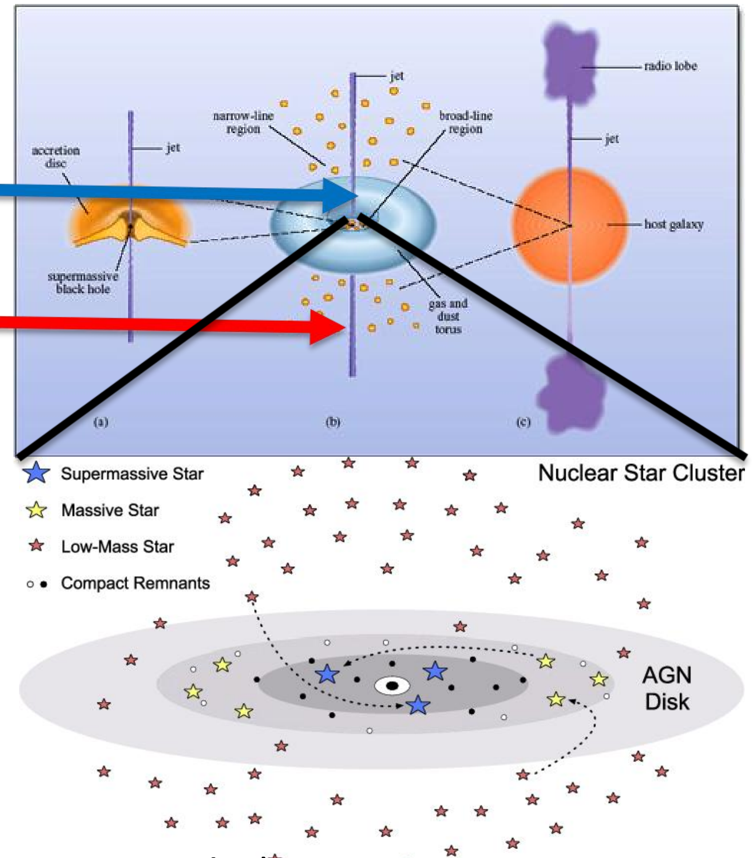
metamorphic stars

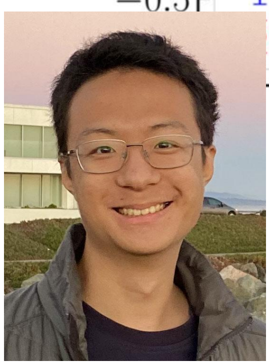
Ali-Dib, Fryer, Xu +



AGNs' supersolar heavy element contents







Jiamu Huang +

Auxiliary Power from H-to-He conversion (1.5 times solar)

In situ pollution (NLR vs BLR)

Post main sequence evolution (He burning)

Stellar **E**volution and **P**ollution in **A**GN **D**isks (SEPAD) rather than Immortal stars

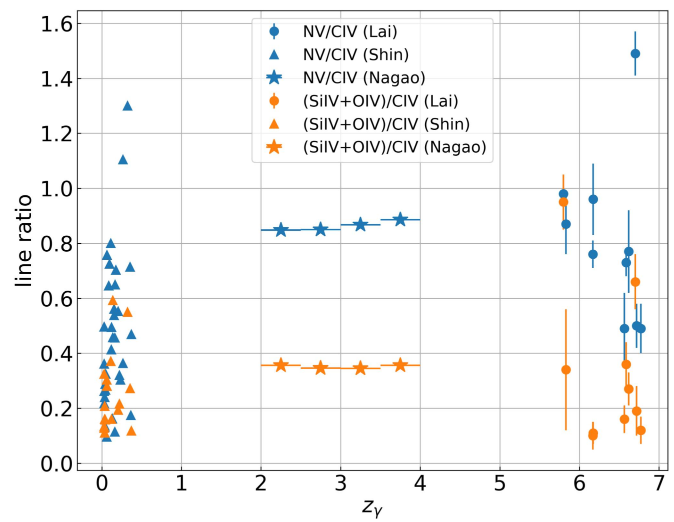
Multiple generation of stars [N/(C+O)] => $\tau_{AGN} > 10^8$ yr

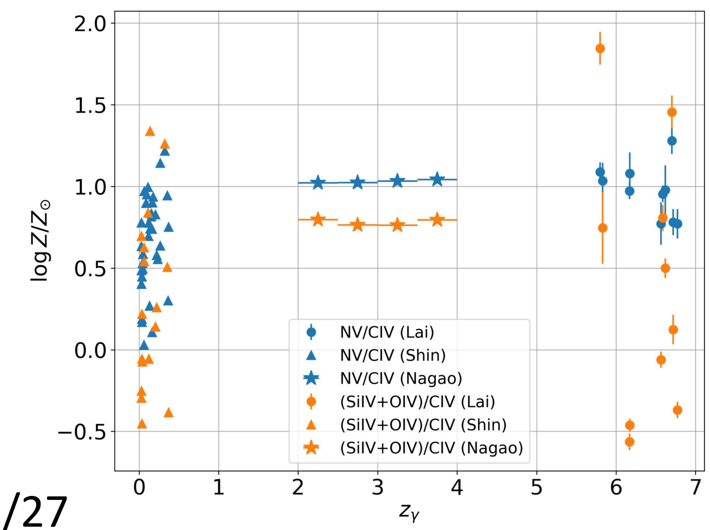
α elements

Measured line ratios:
Possible causes:
emission line physics or
abundance variations

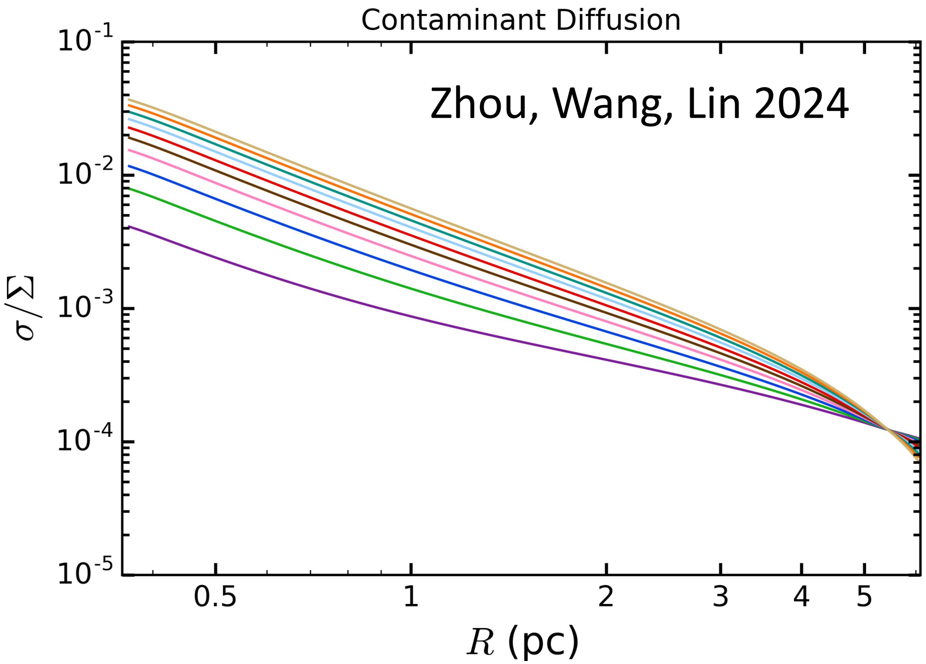
After detailed analysis
with cloudy models:
α element abundance as
a function of redshift
Huang, Shields

No redshift dependence:
No accumulation. Self-regulated
pollution in accretion-disk flow.





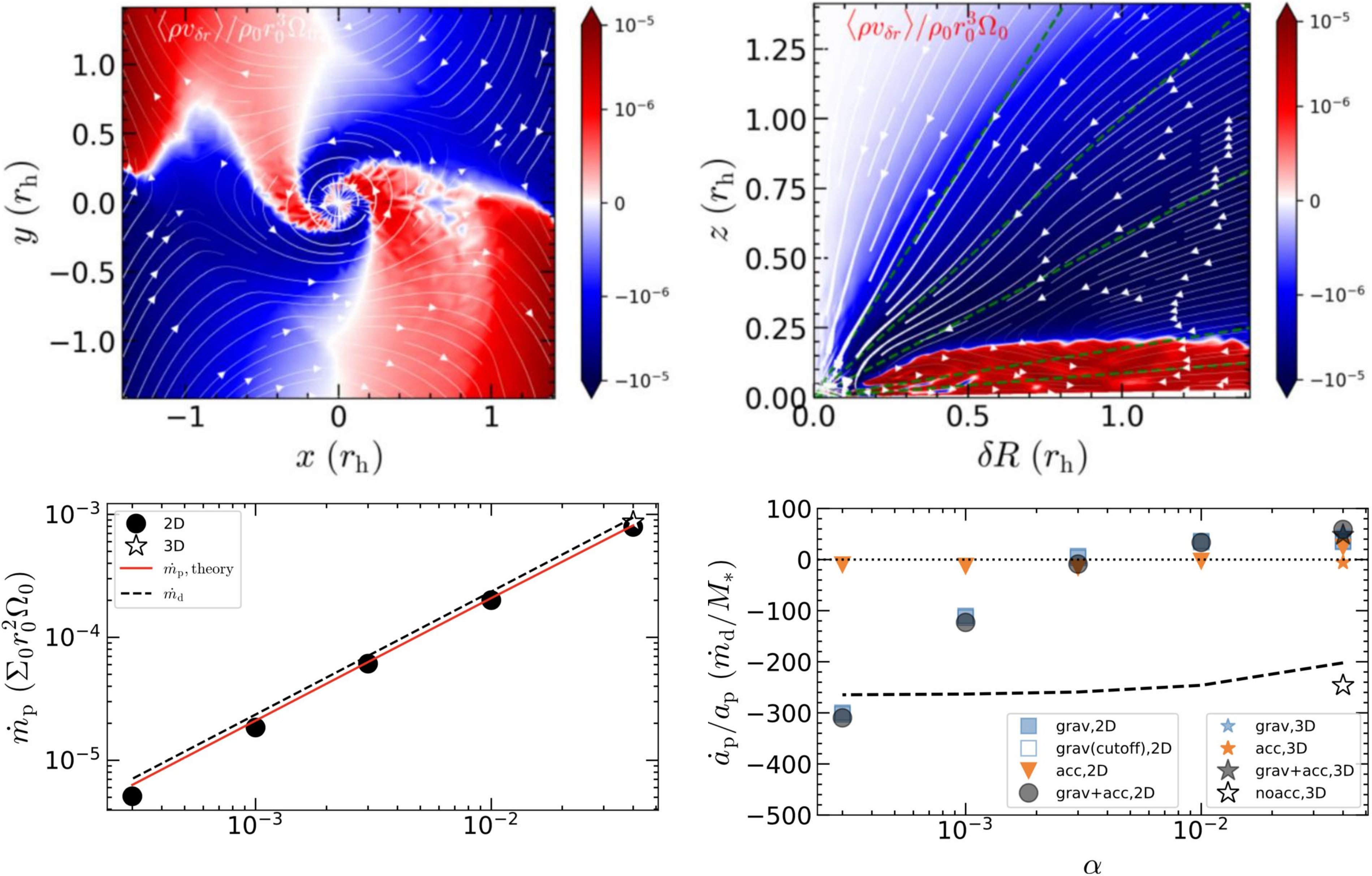
Observations: redshift independent super solar α (C+N+O) elements



$$\Sigma \frac{\partial C}{\partial t} + \Sigma U_r \frac{\partial C}{\partial R} = \frac{1}{R} \frac{\partial}{\partial R} \left(R \kappa \Sigma \frac{\partial C}{\partial R} \right) + \dot{\Sigma}_Z$$

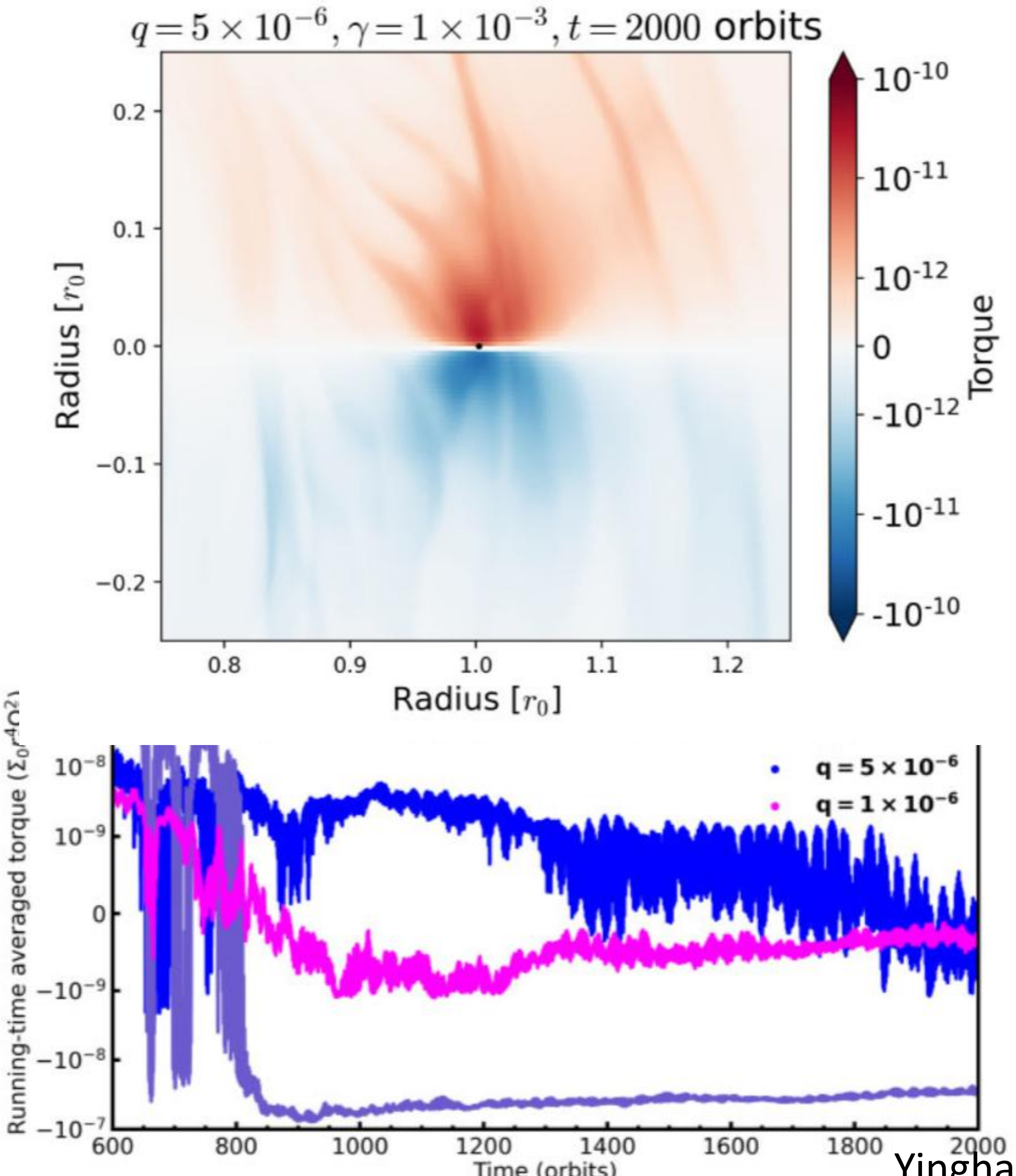
MS-to-PostMS transition in AGN disks => impermanence
self cleaning (z independent) => accretion onto SMBH

Concurrent migration & accretion



Yaping Li, Yixian Chen

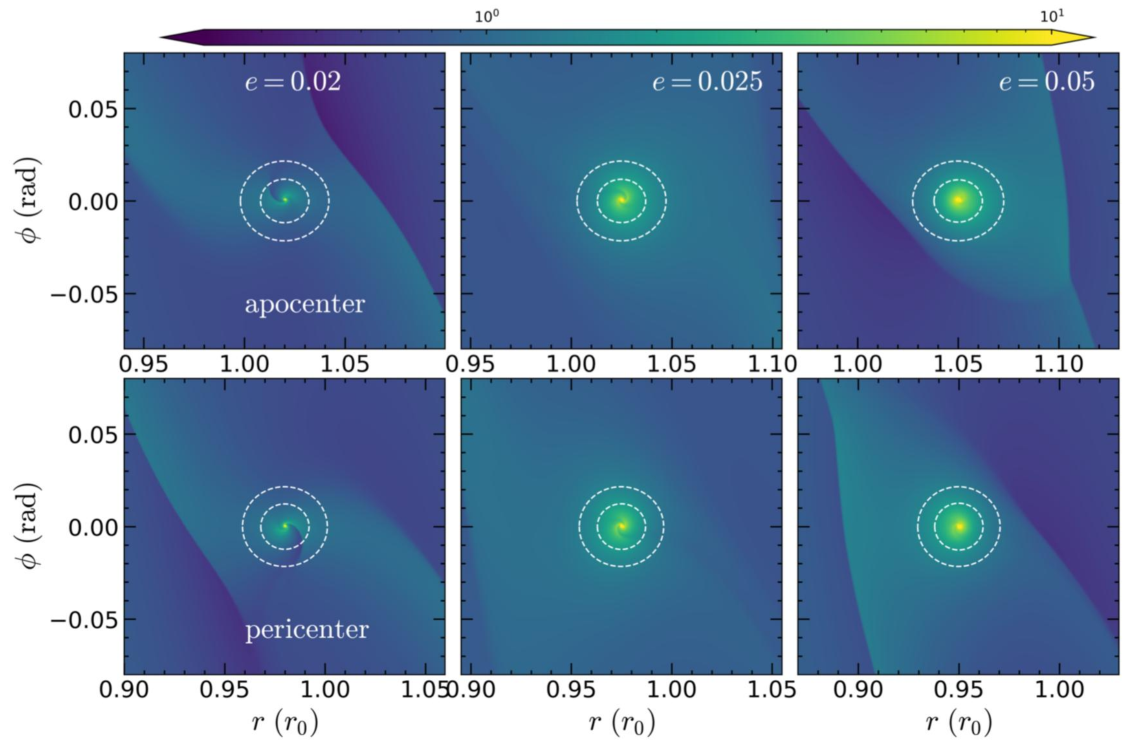
Stochastic migration

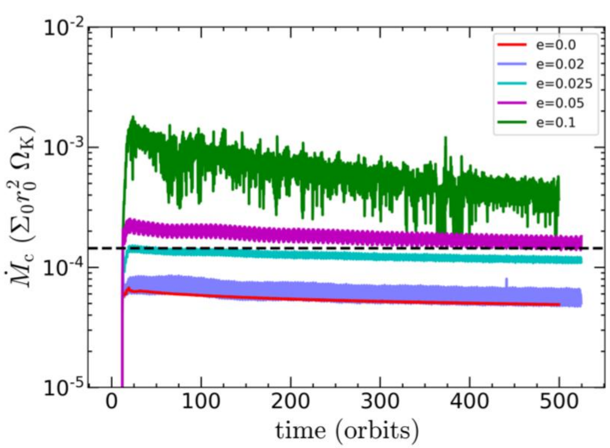


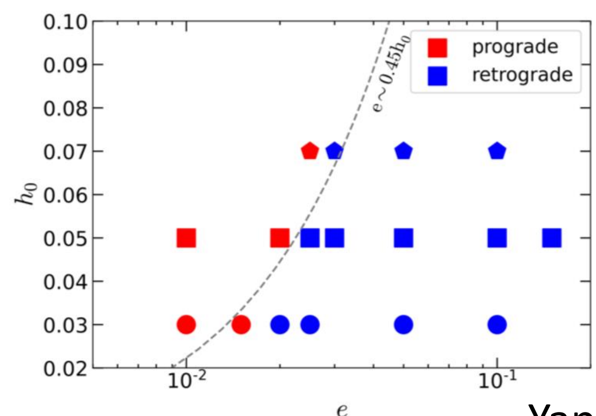
Yinghao Wu, Yixian Chen

Accretion onto eccentric stars

Li et al.

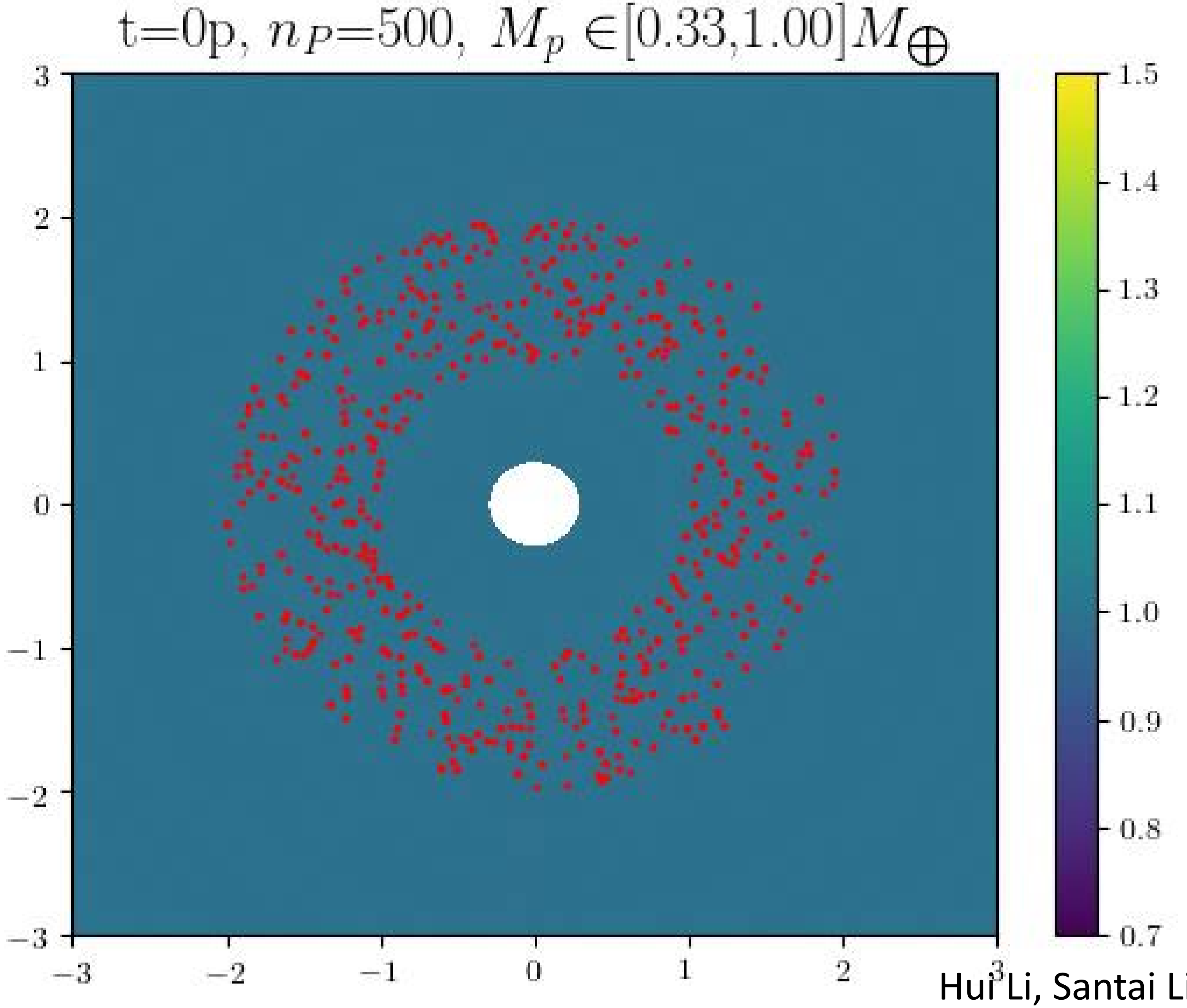






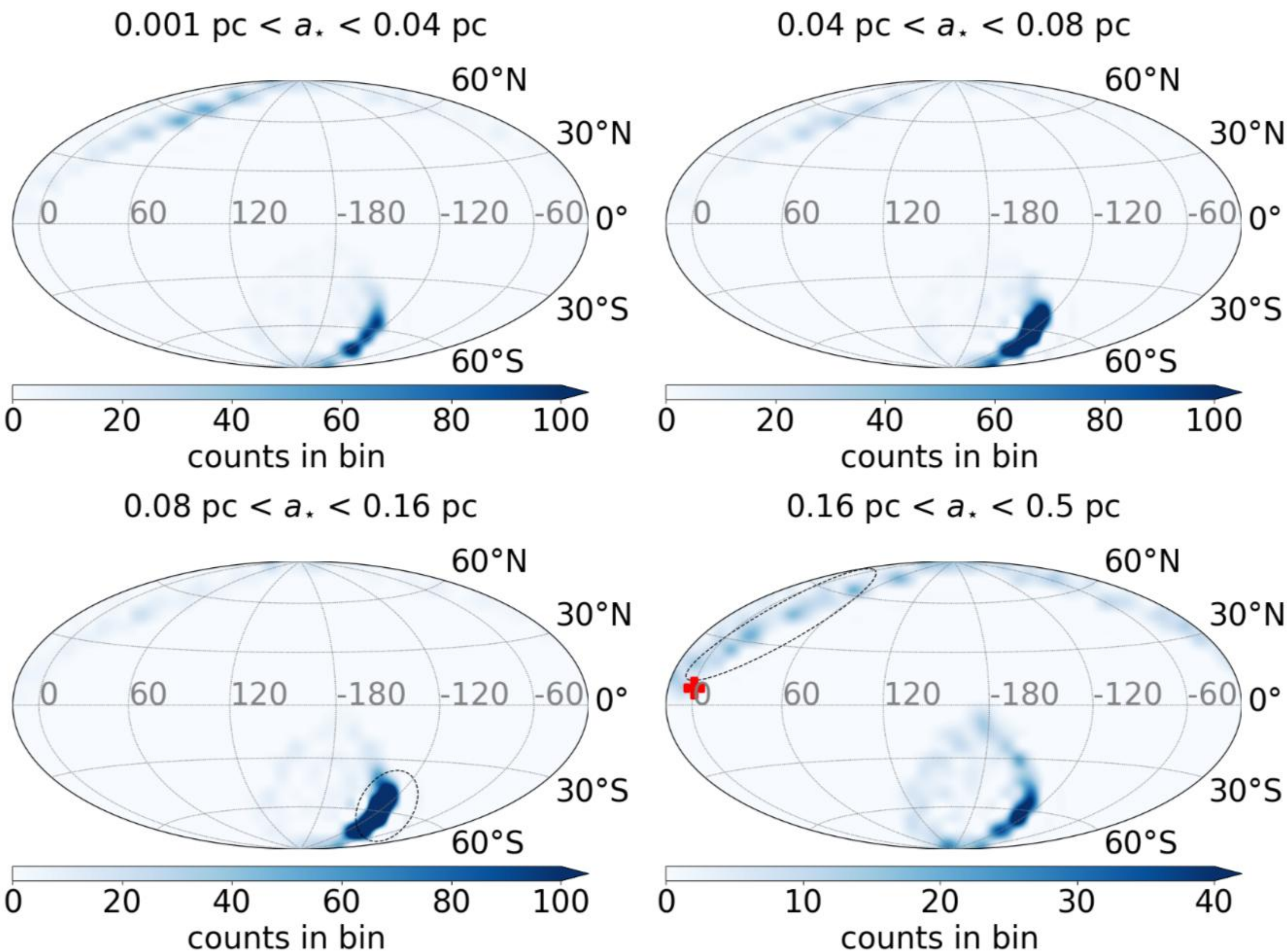
Yaping Li, Yixian Chen

Multiple capture and merger

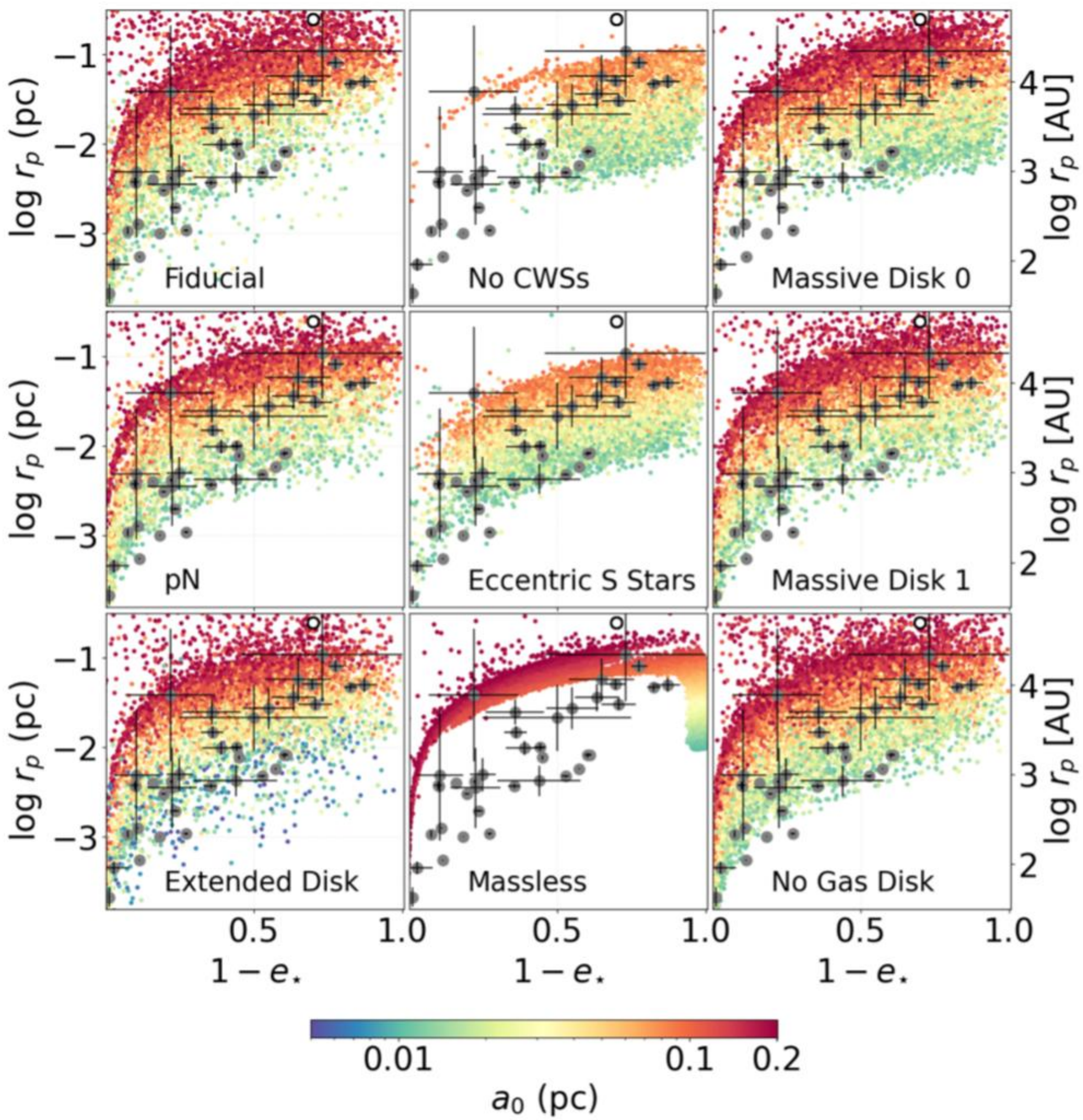


Hui Li, Santai Li,

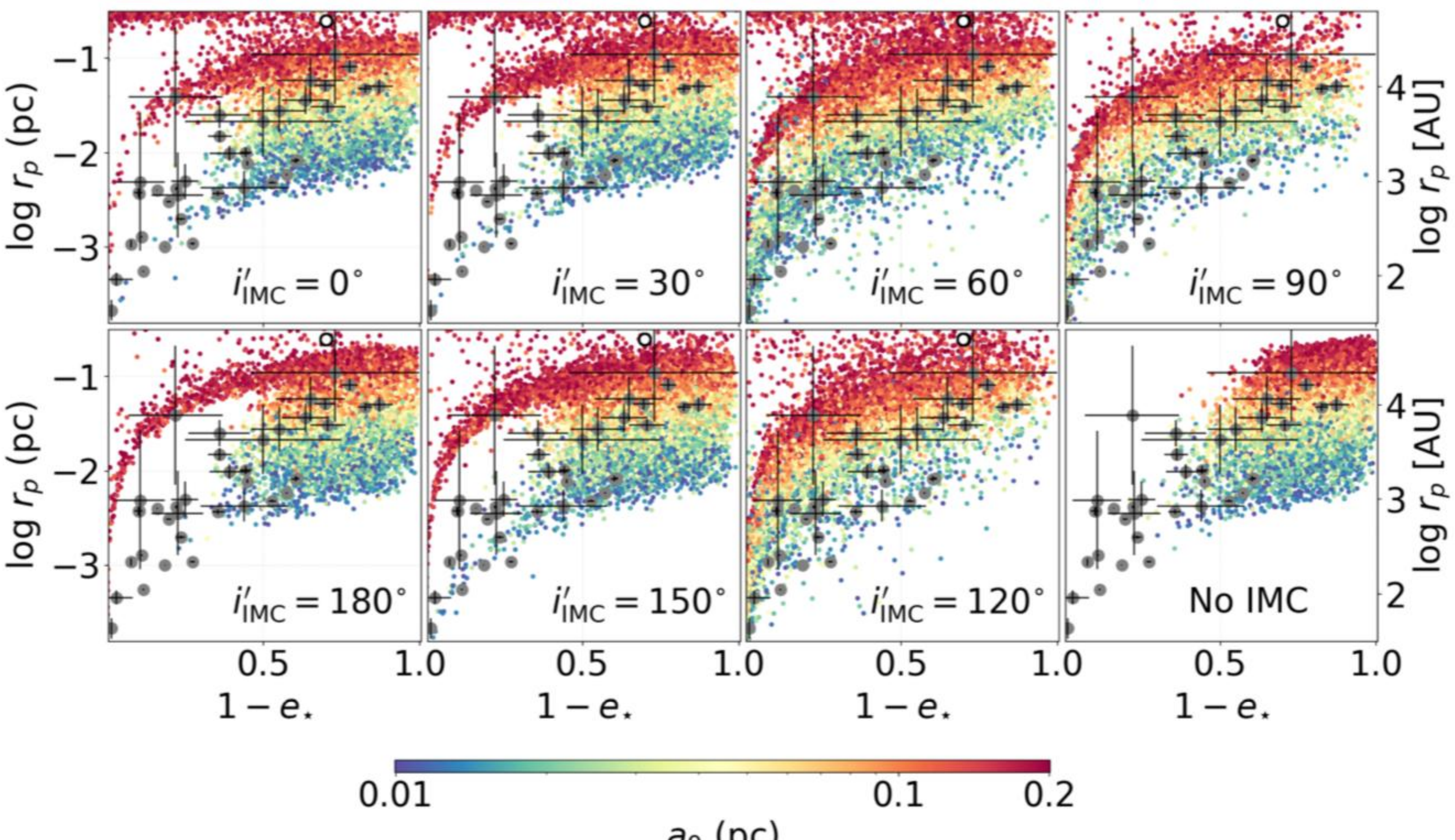
Orbital angular momentum vector



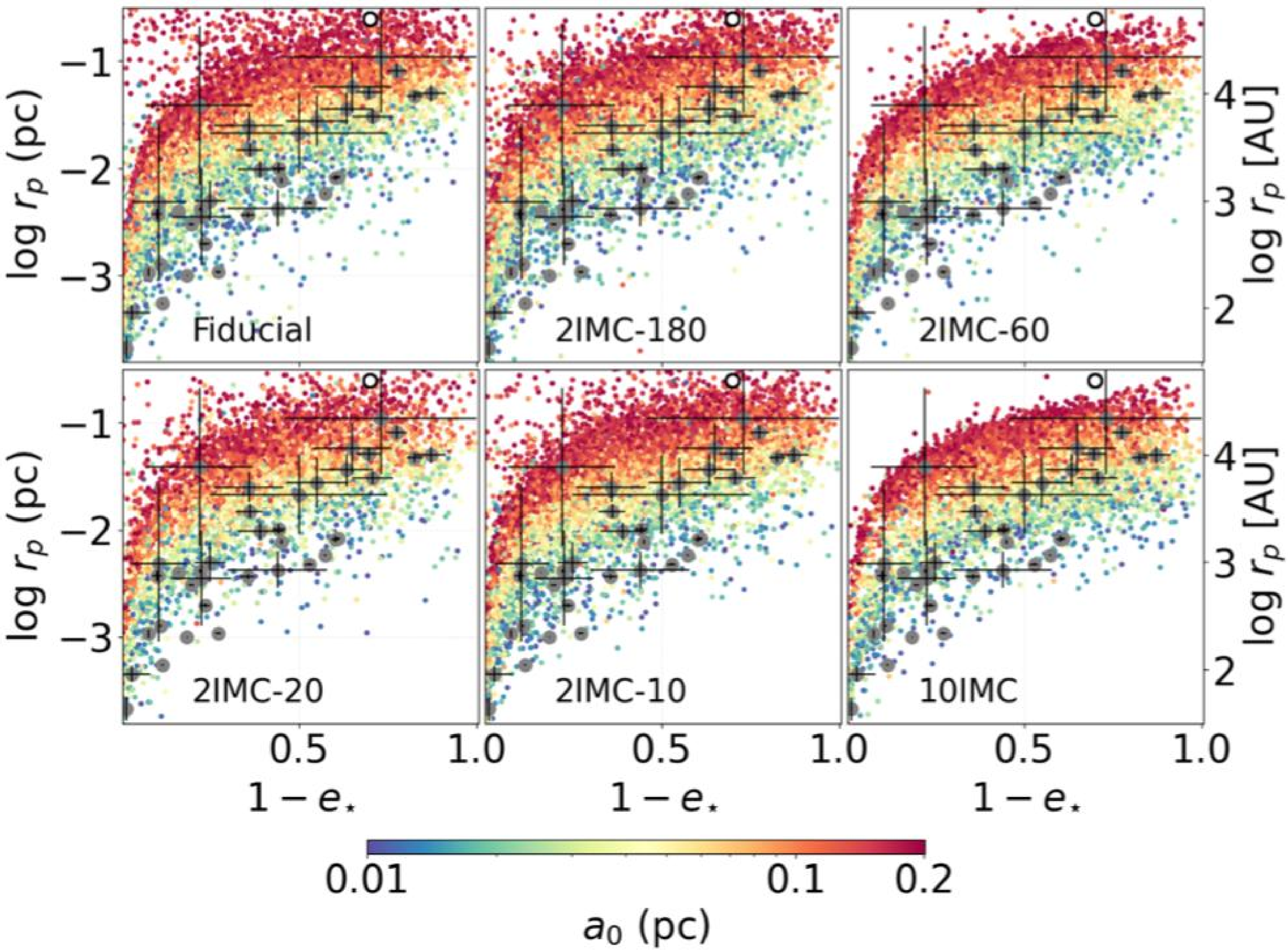
Complementary relaxation processes



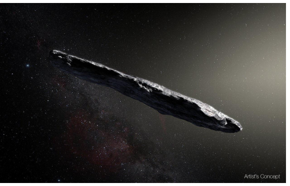
Dependence on obliquity



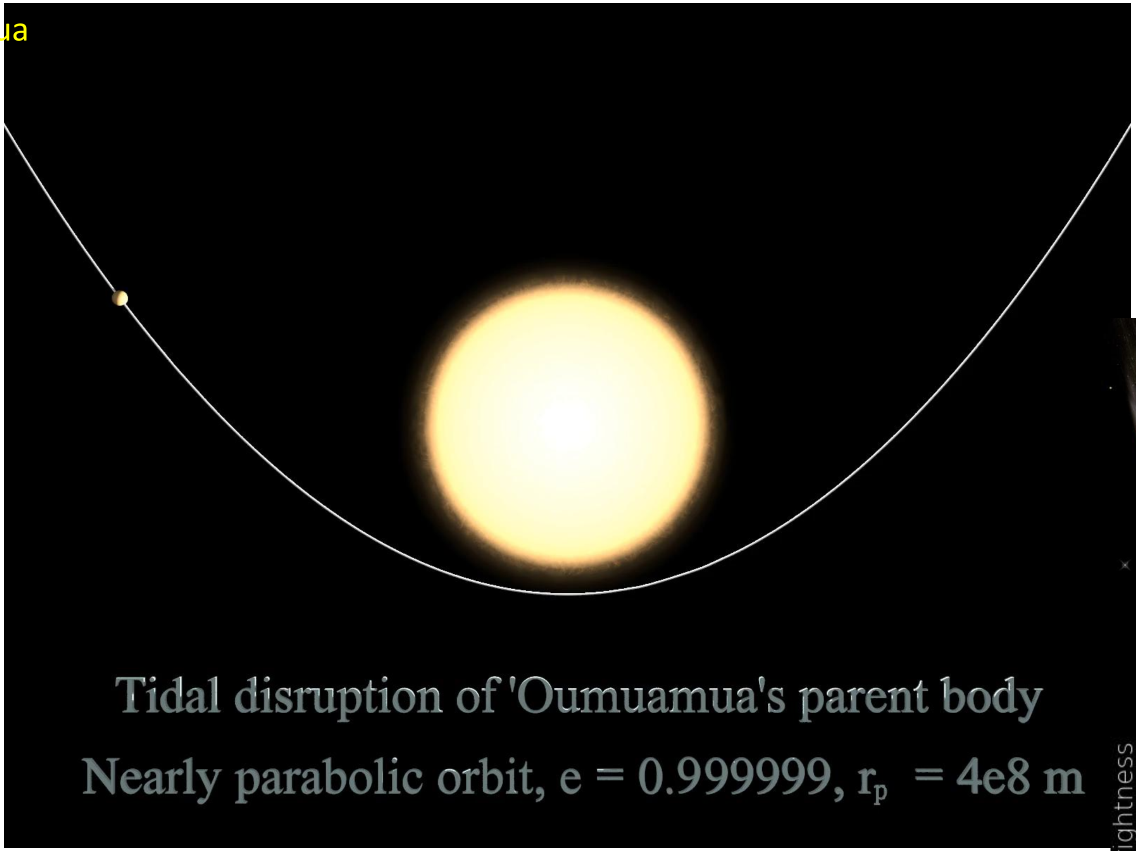
Multiple IMCs (disrupted clusters)

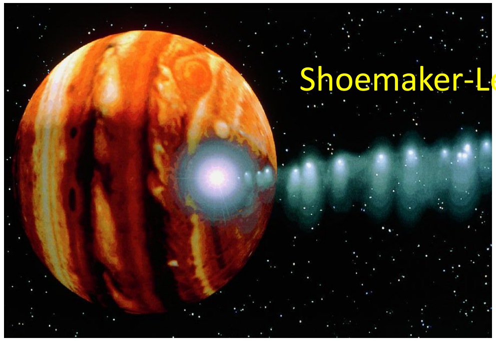


Tidal downsizing: material strength

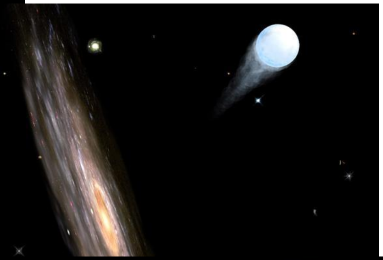


Oumuamua

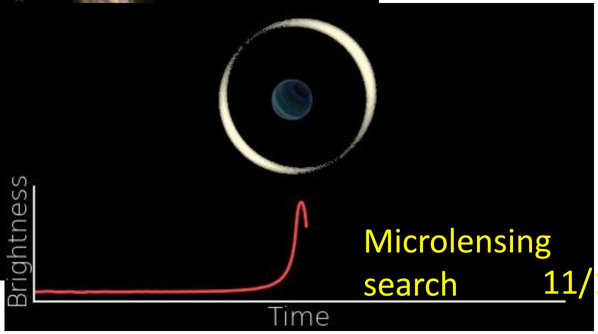




Shoemaker-Levy 9



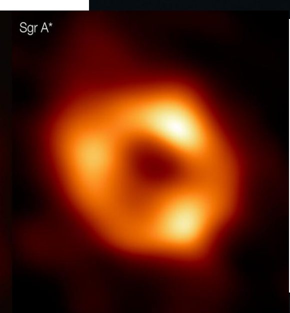
Hyper-velocity rogue planets

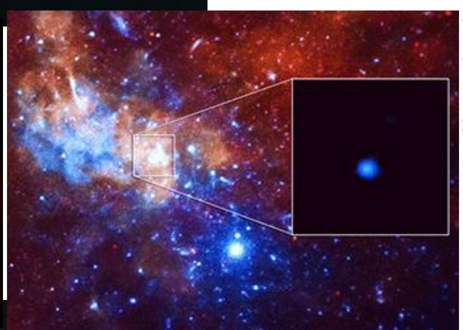


Yun Zhang

Drag heating and fireball explosion

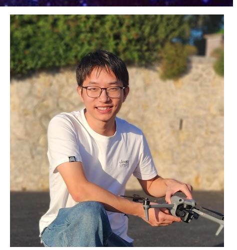
Sgr A* x-ray flares





gas near Sgr A*

Meteor explosion



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