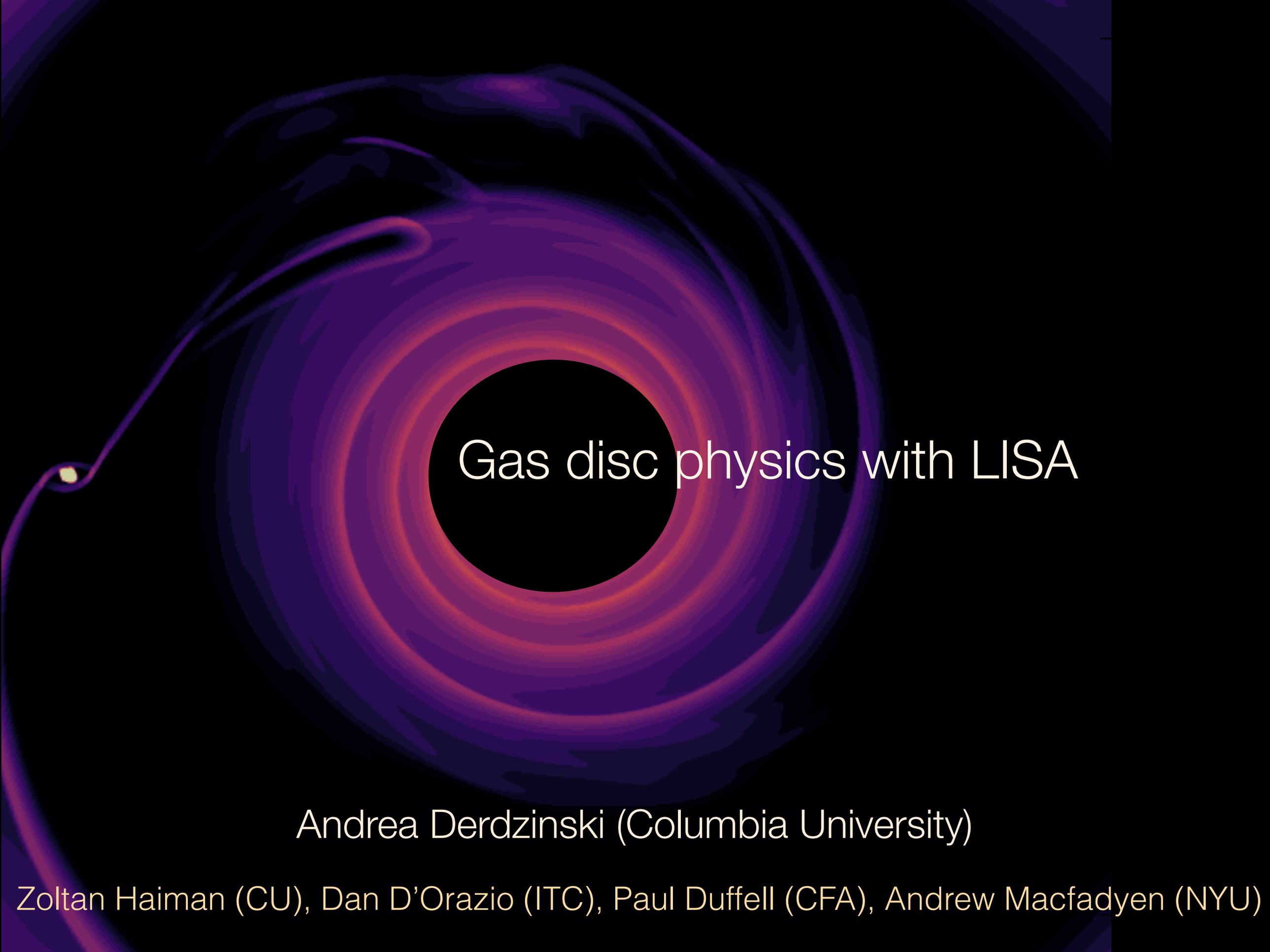
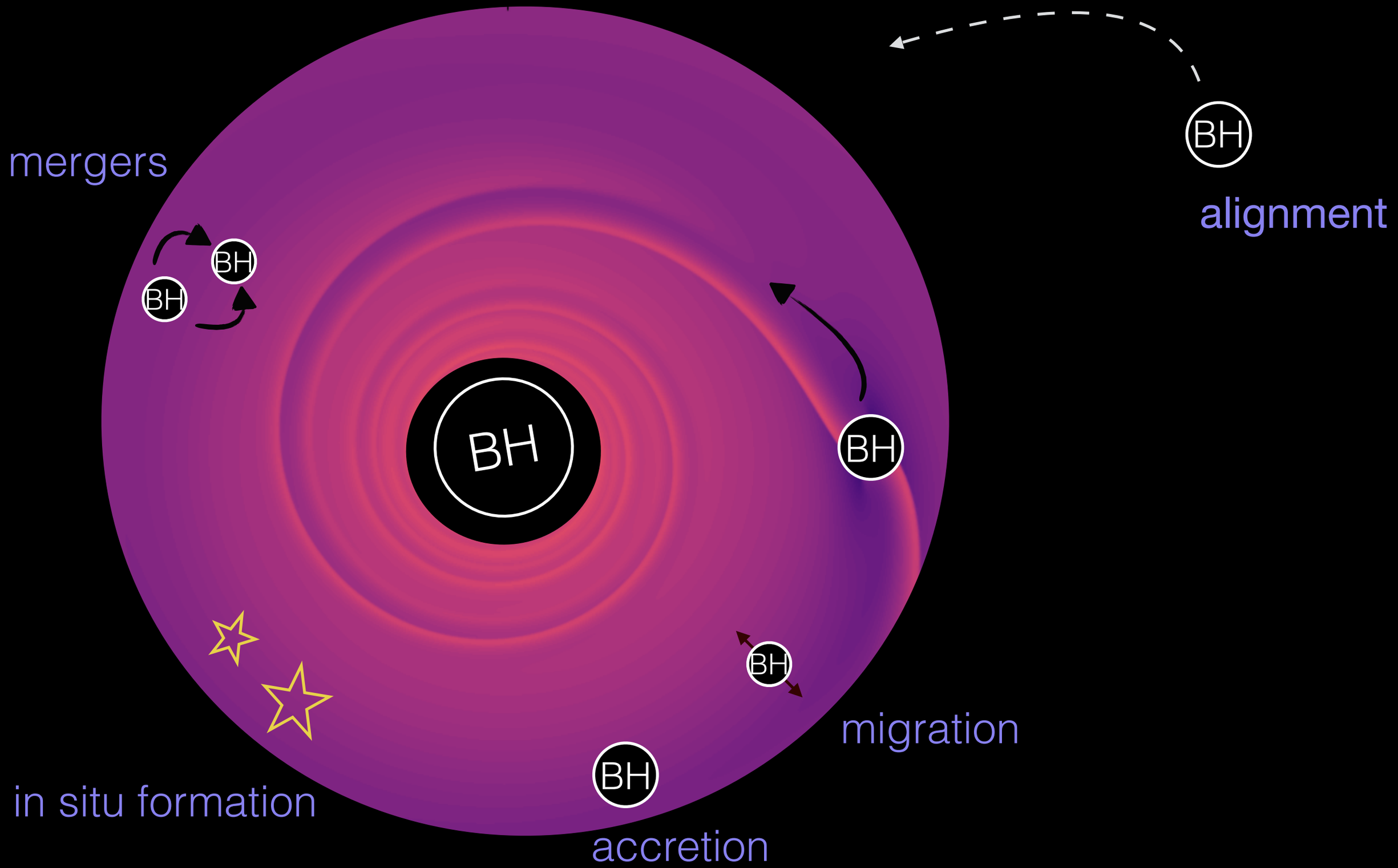


Gas disc physics with LISA

Andrea Derdzinski (Columbia University)

Zoltan Haiman (CU), Dan D’Orazio (ITC), Paul Duffell (CFA), Andrew Macfadyen (NYU)

inspirals in gas discs



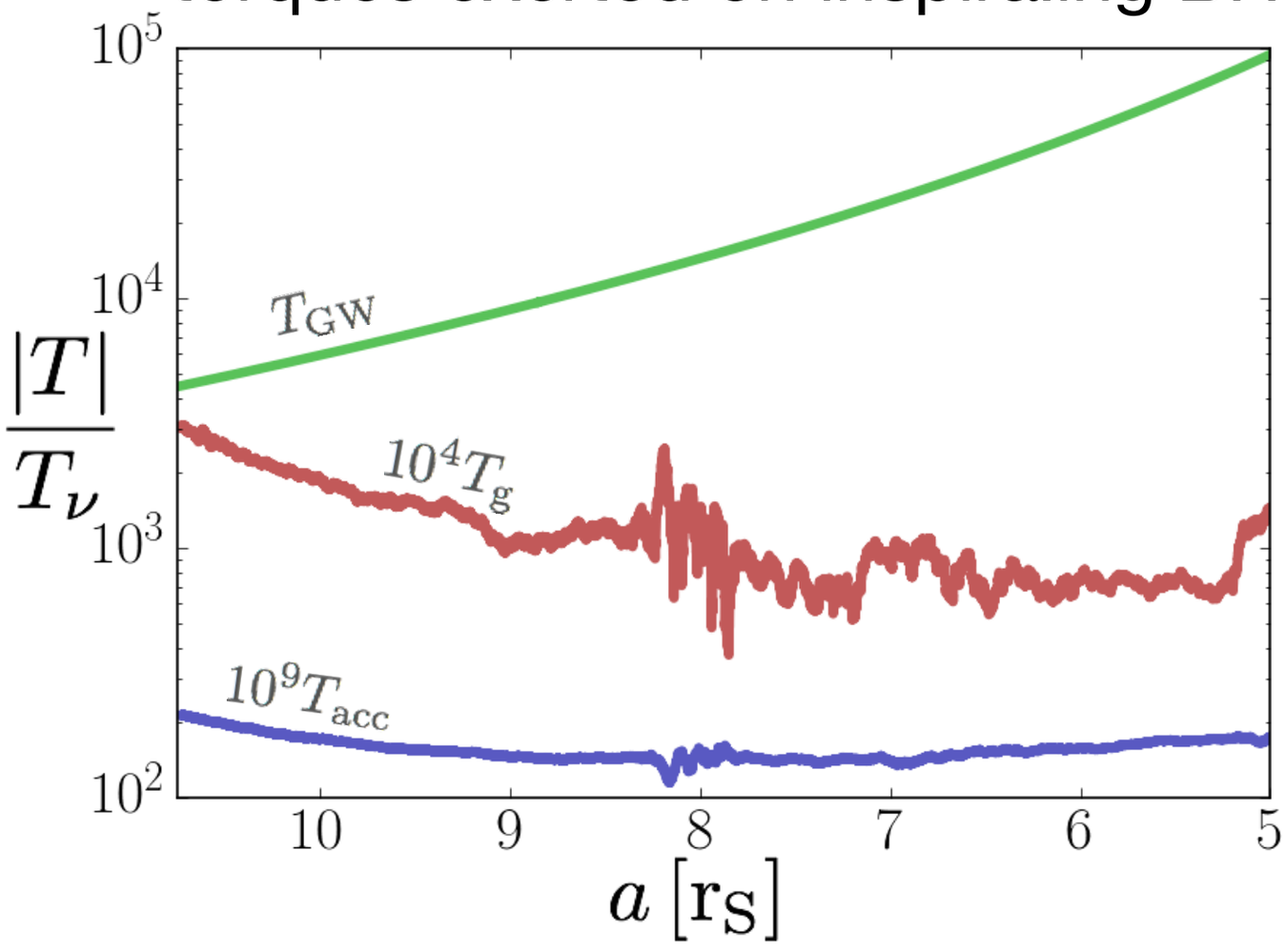
(Levin 2007, McKernan+2008, 2017, Bellovary+2016, Stone+2017, Bartos+2017)

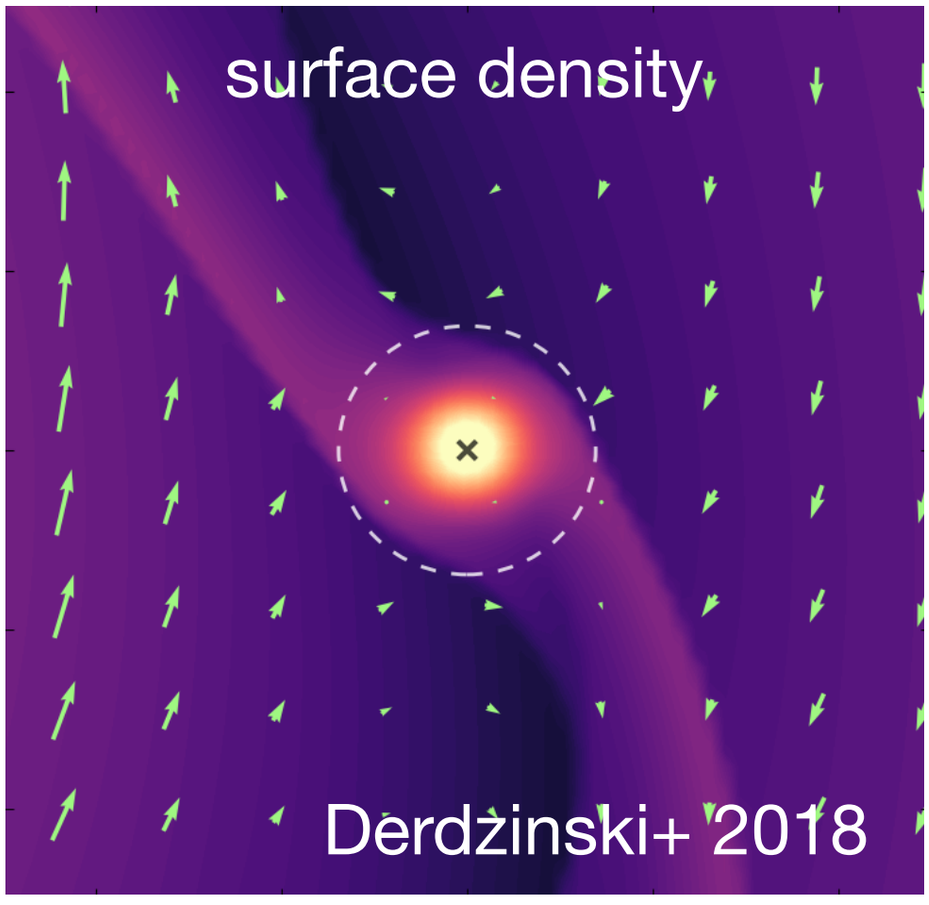
How does gas affect an inspiraling BH in the LISA band?

Simulations of a $q = 10^{-3}$ IMRI in a 2D viscous disk

gas-embedded IMRI = “g-IMRI”

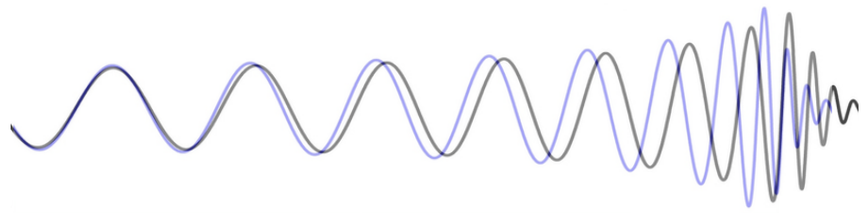
torques exerted on inspiraling BH





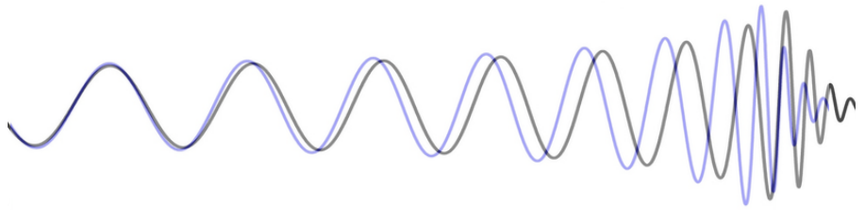
Gas torques are weaker than GWs, but they accumulate

Migration torques lead to deviation in GW signal



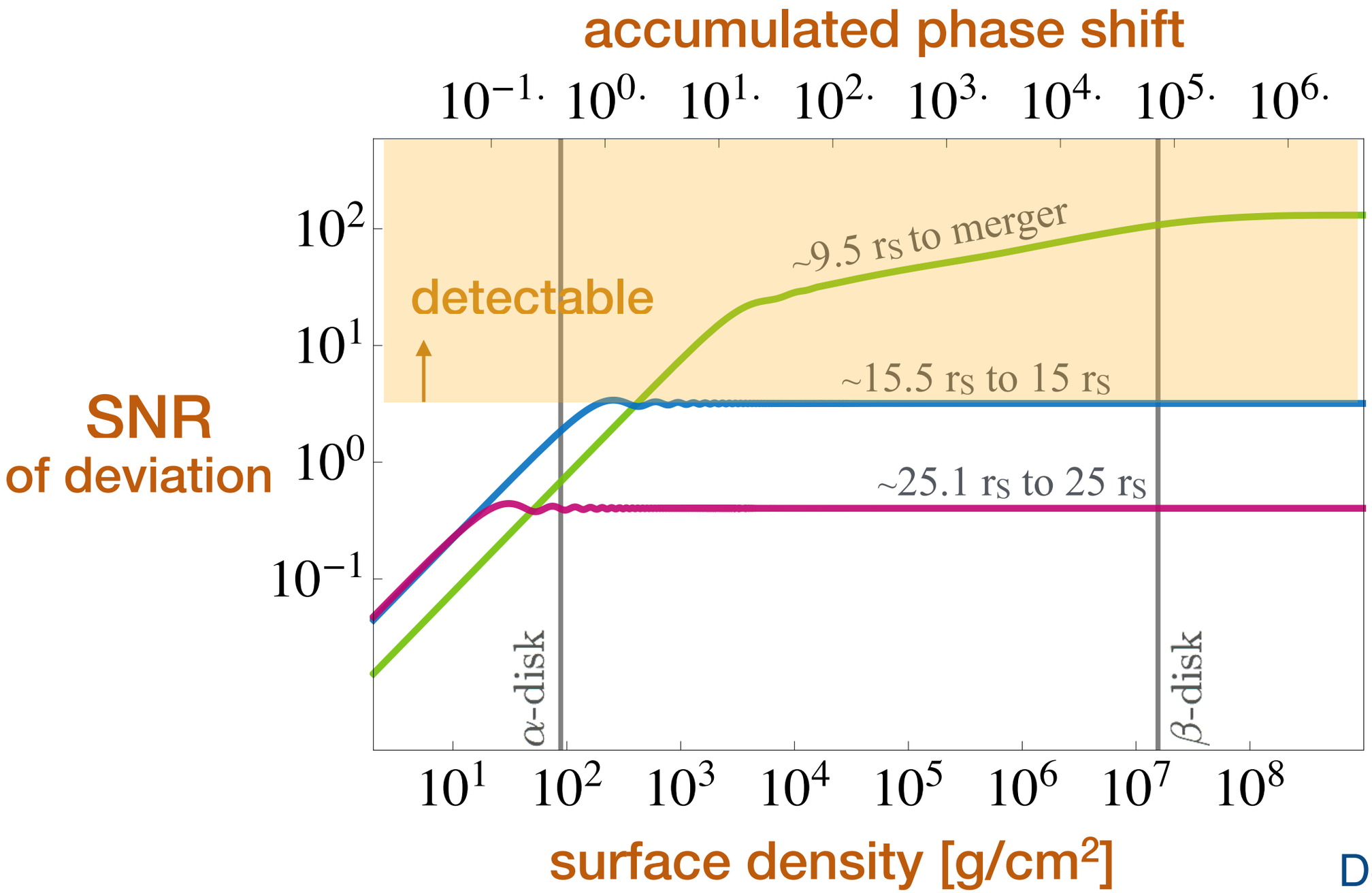
Phase shift: $\delta\phi = \phi^{\rm tot}_{\rm GW+gas} - \phi^{\rm tot}_{\rm GW}$

Migration torques lead to deviation in GW signal



detectable if gas disc is sufficiently dense

most detectable when binary is chirping (better for IMRIs)



Derdzinski+ 2018

IF LISA detects an E/IMRI in a dense disc….

imprint in GW waveform can probe the disc mass and constrain AGN disc models!

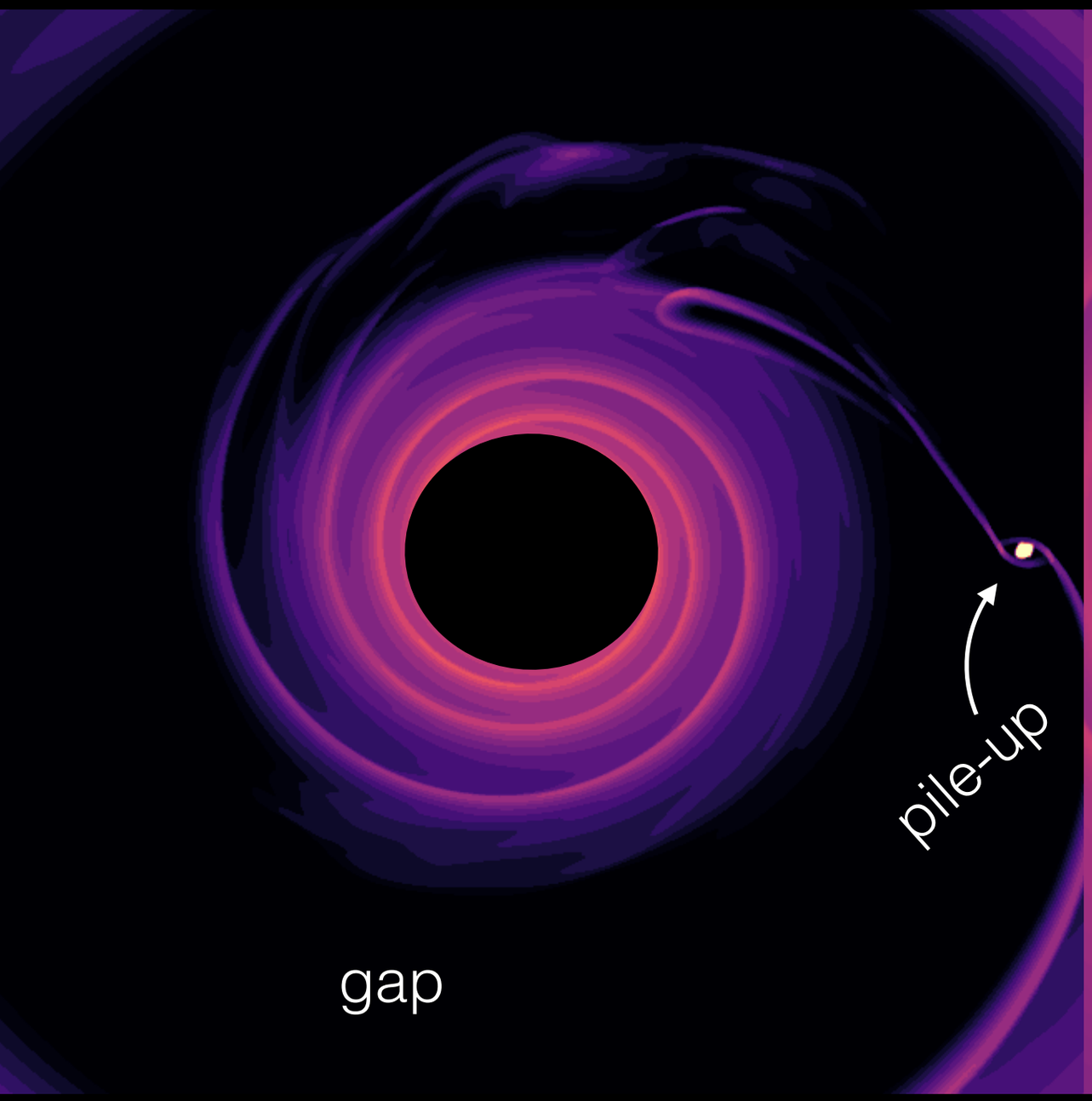
BUT

how accurately can we measure a phase drift (hello data analysts??)

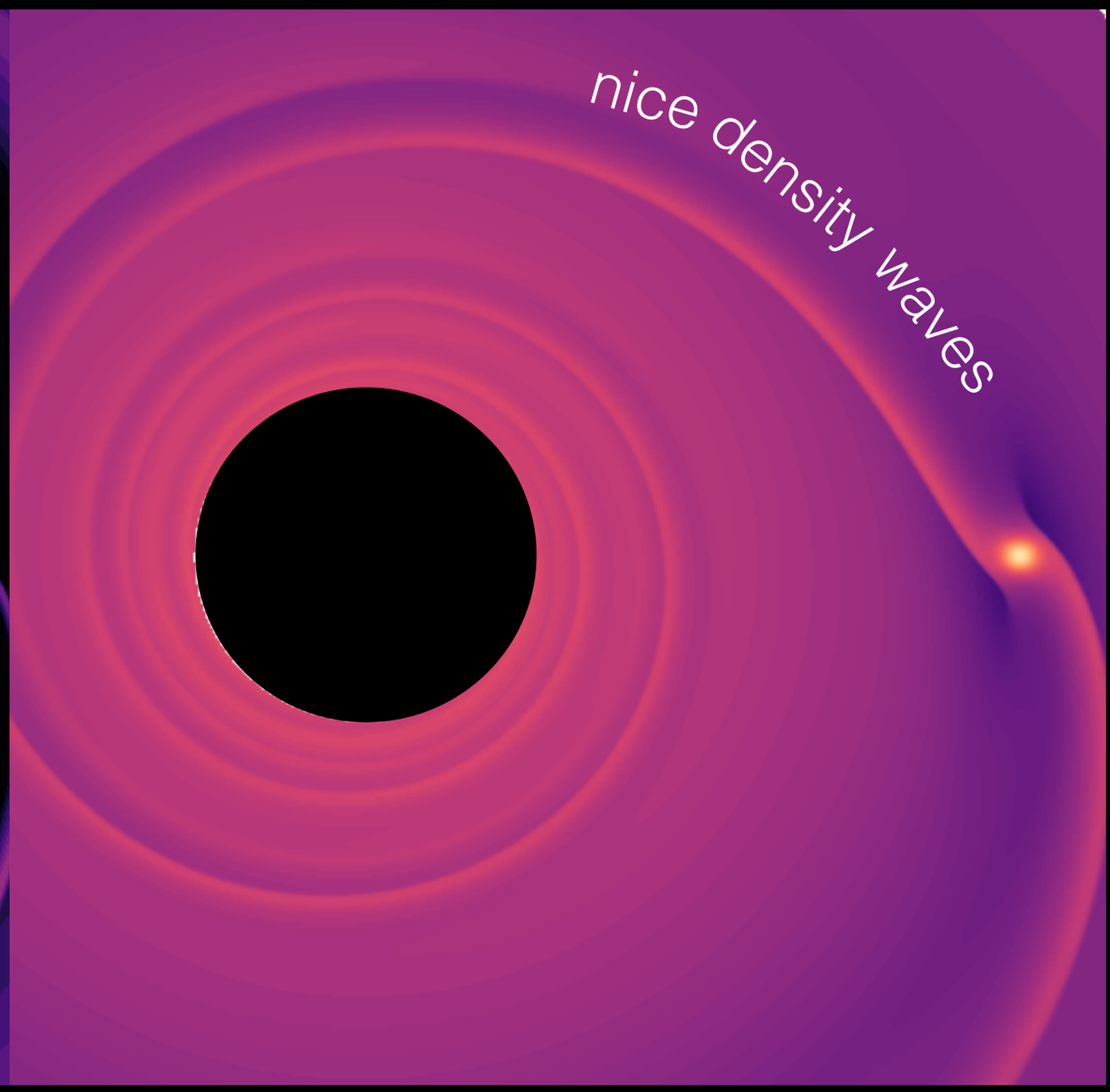
how well can we infer information about the gas?

how can we break degeneracies (with system and environmental parameters)?

Varying perturber mass, or viscosity…



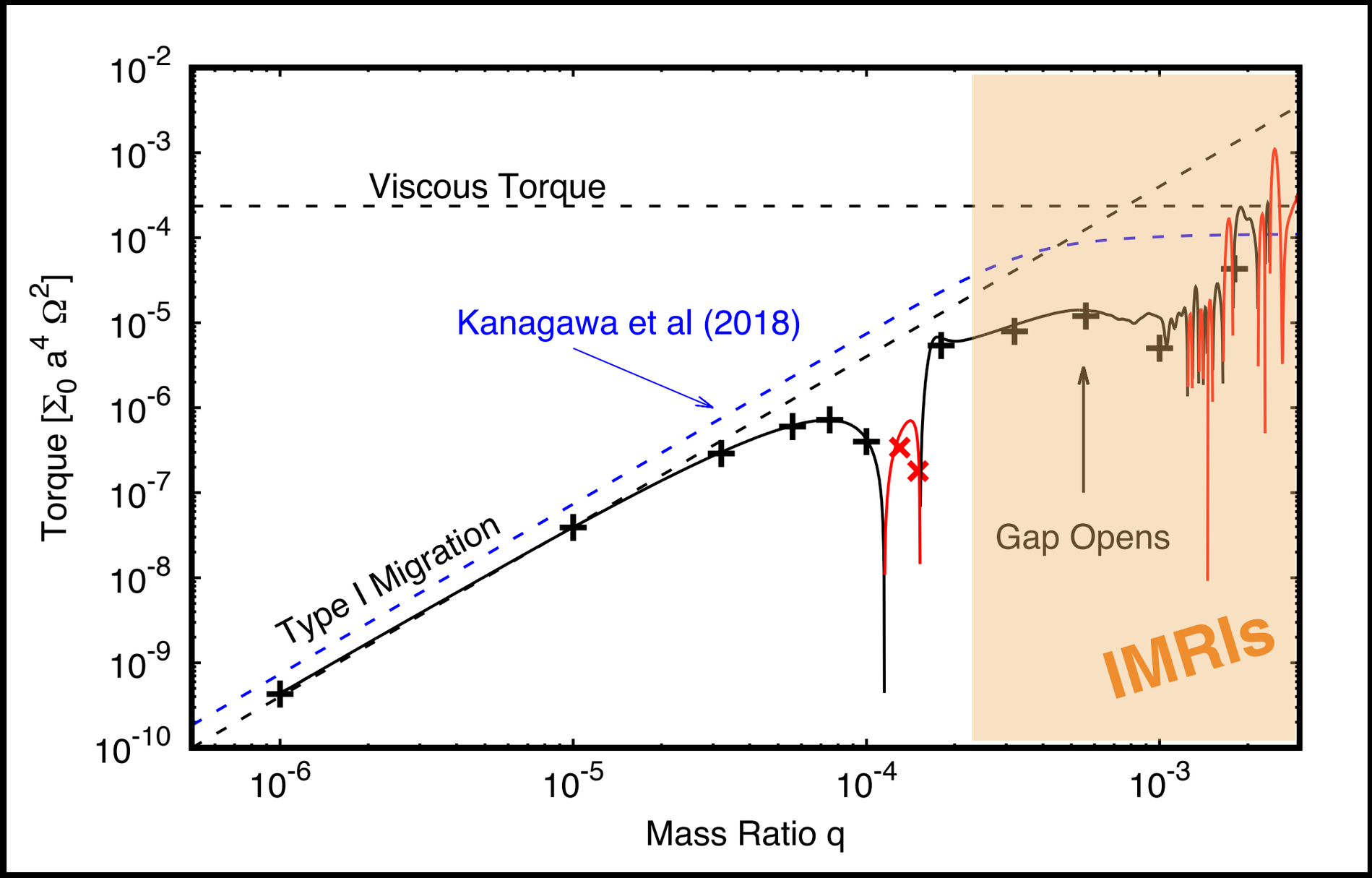
higher q



smaller q

Strength and direction of torque varies with mass ratio (and viscosity)

Torque vs. Mass ratio



Duffell, AD, Haiman et al. (in prep)

LISA can teach us about BH environments

Migration is complicated, but g-EMRIs can probe it

GOALS

- understand how gas effects vary with system parameters e.g. BH mass, viscosity, accretion rate (i’m trying)
- connect with other constraints (eccentricity, spin, EM counterpart?) to build a more complete picture