

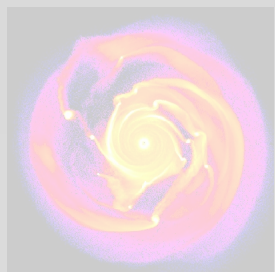
Investigating the gas flow around small protoplanets

– consequences for protoplanetary growth –

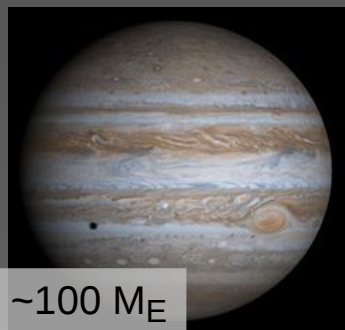
- 1. Explore effects initial/characteristic size of planetesimals**
- 2. Drag-influenced accretion (small particles)**

Chris Ormel
Hubble fellow, UC Berkeley

Disk Instability (gas)



Mayer et al. (2002)



$\sim 100 M_E$

Core accretion (solids)

Dust
Pebbles
Boulders



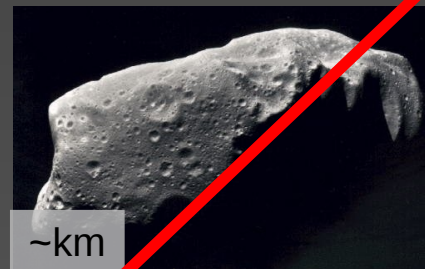
$\sim \mu\text{m}$

$\sim \text{mm}$

$\sim \text{m}$



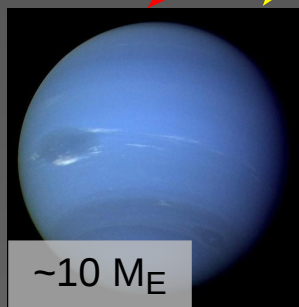
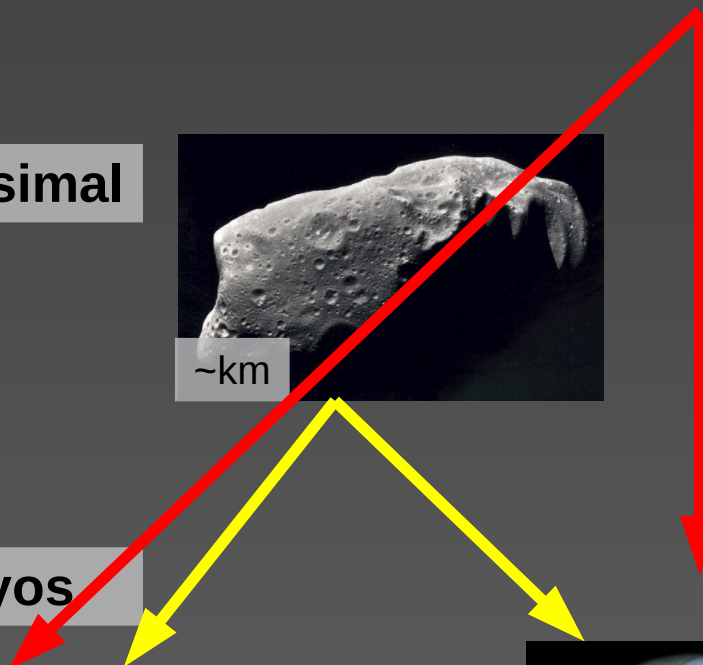
Planetesimal



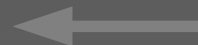
$\sim \text{km}$



Embryos



$\sim 10 M_E$

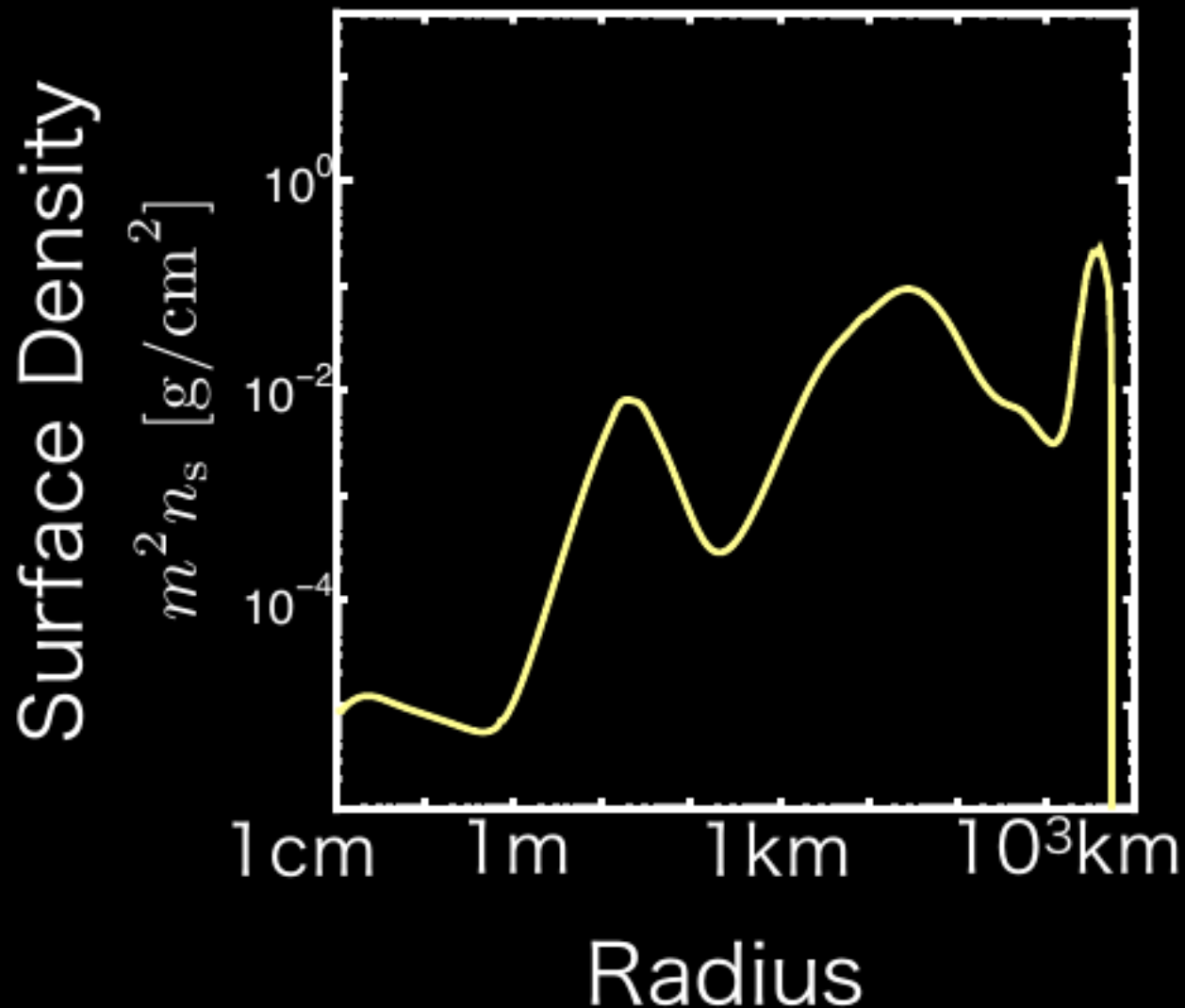


$\sim 0.1 M_E$

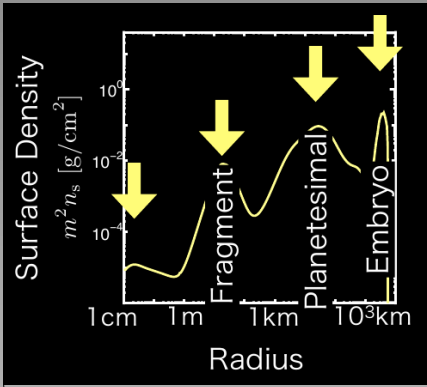
**Planetesimal size
matters**

Planetesimal Size Matters

Kobayashi (2011 2012) “State-of-the-art” coagulation model

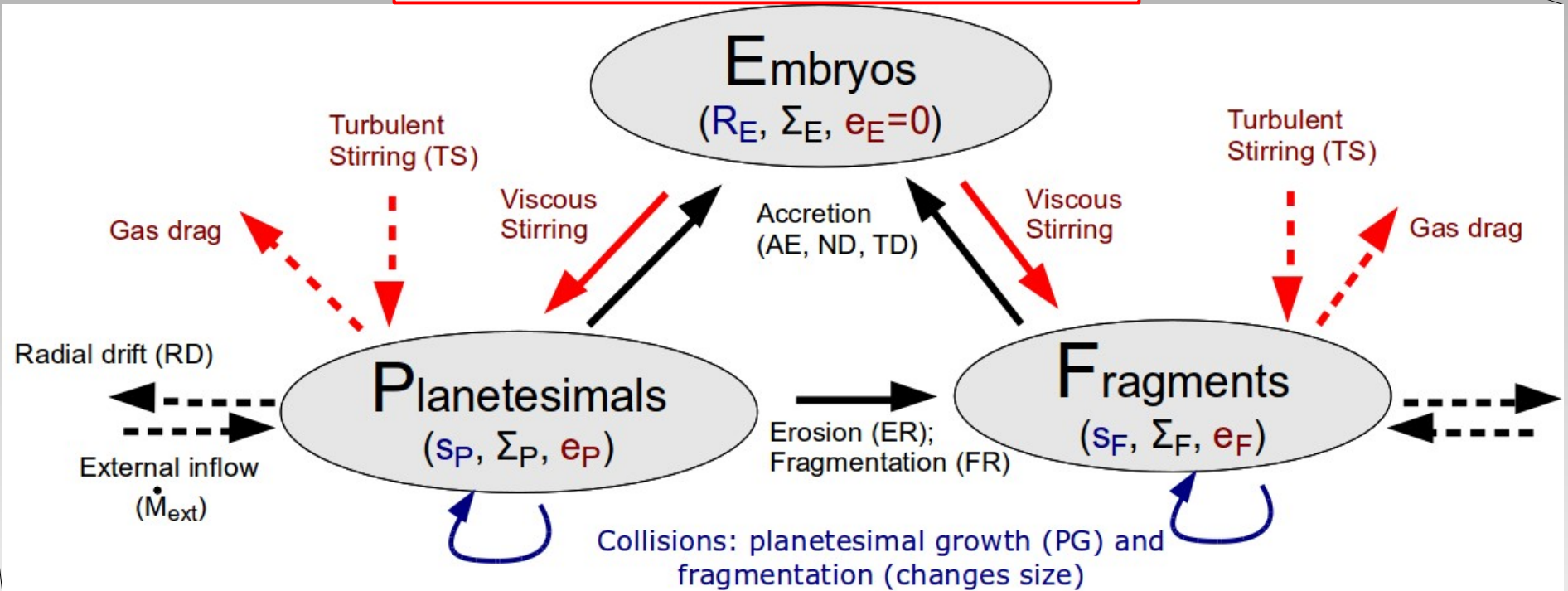


Planetesimal Size Matters



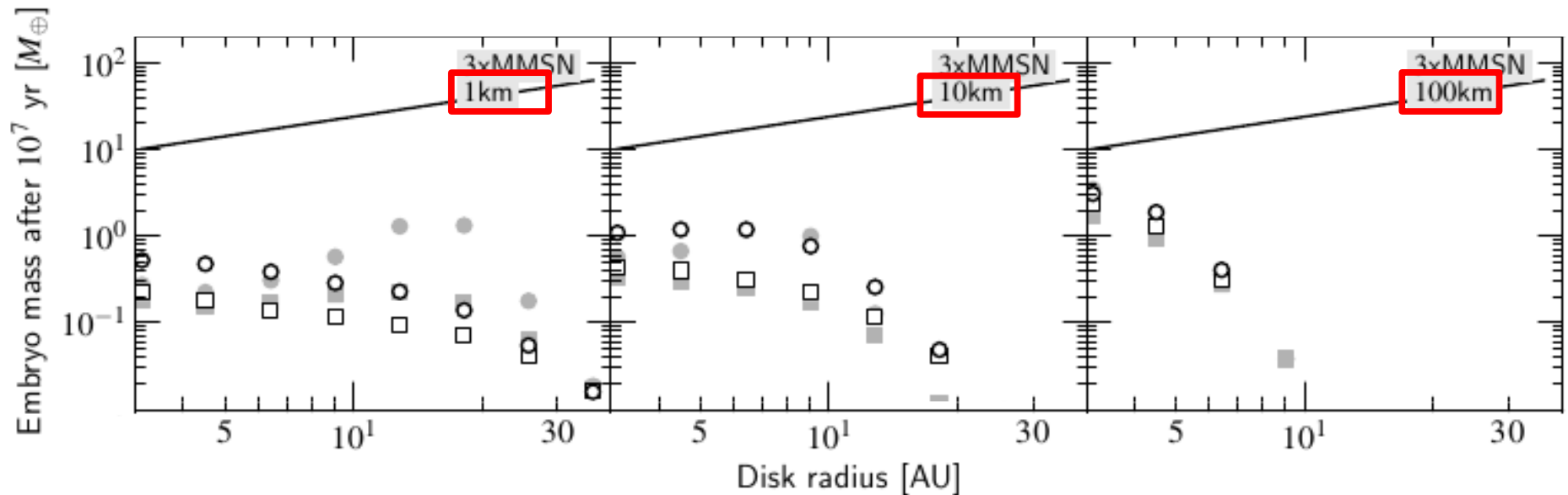
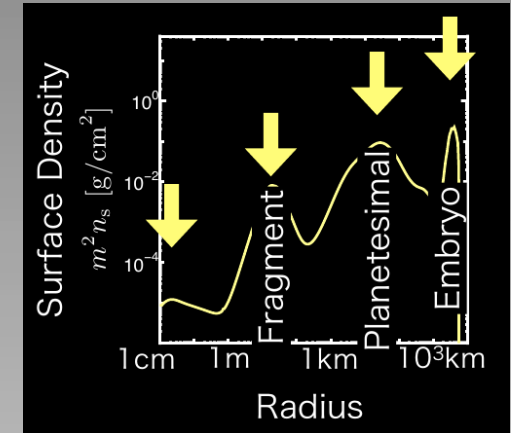
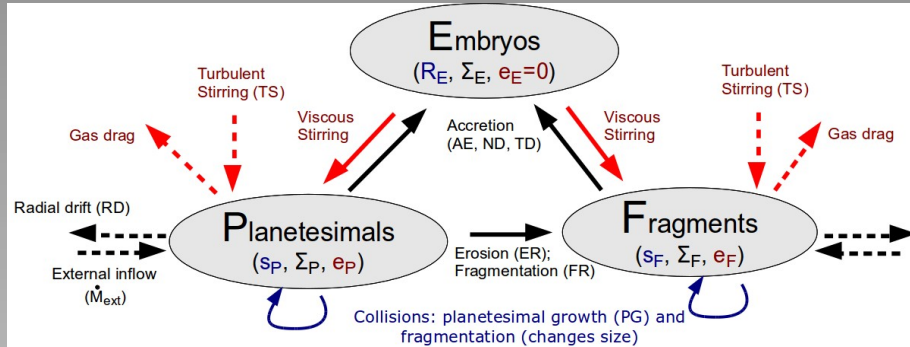
“State-of-the-art” coagulation model

“Toy model”



Planetesimal Size Matters

Ormel & Kobayashi (2012) “Toy Model”



Open: OK12; filled: K+11; circles include atmosphere enhancement

“Pebble Accretion”

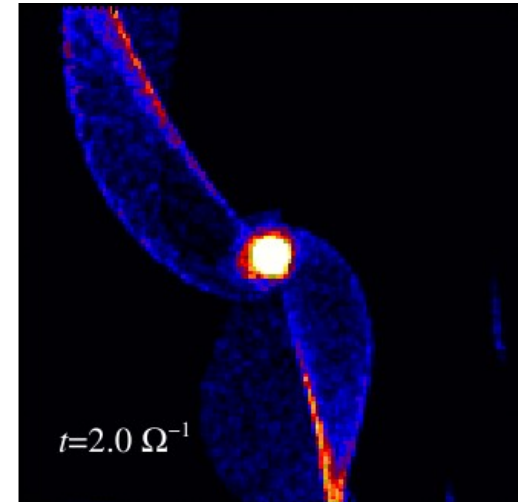
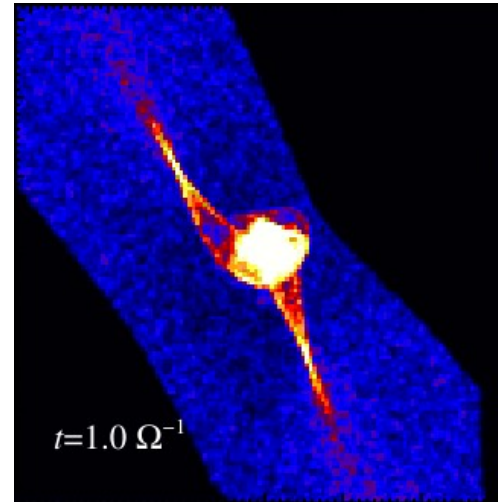
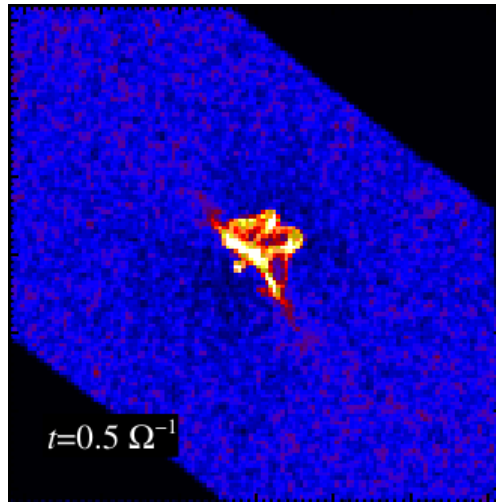
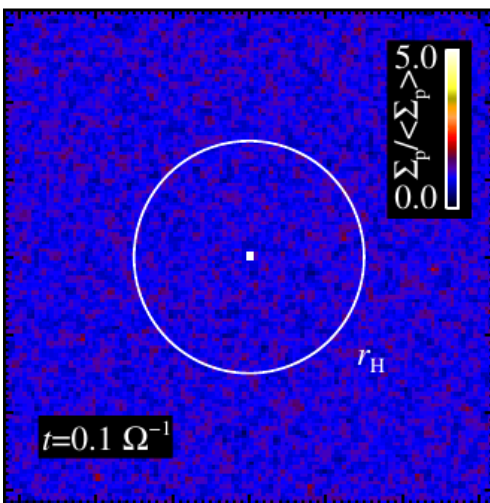
Ormel & Klahr (2010)

Perets & Murray-Clay (2011)

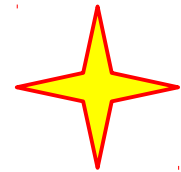
Lambrechts & Johansen (2012)

Morbidelli et al. (2012)

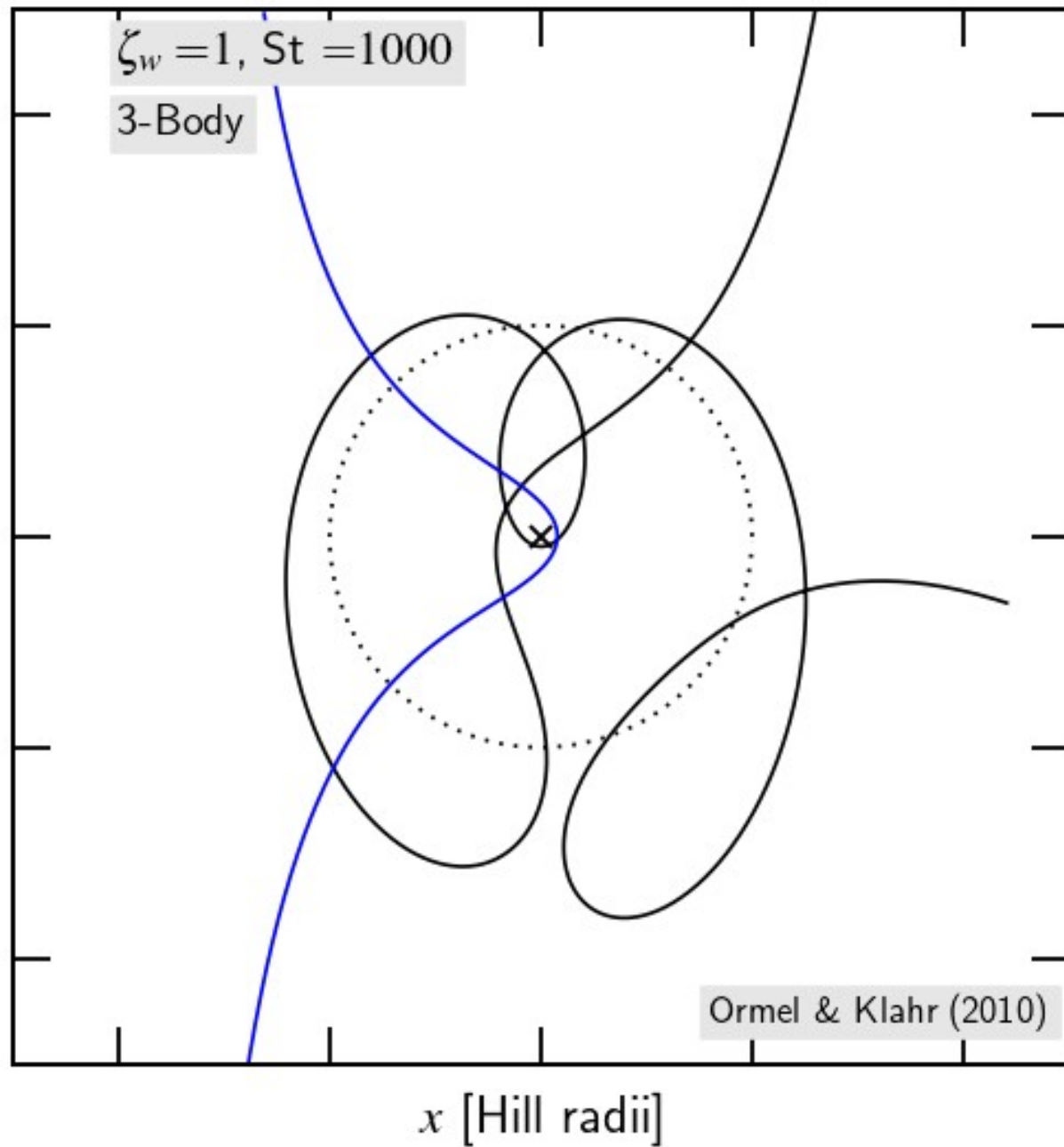
Lambrechts & Johansen (2012)



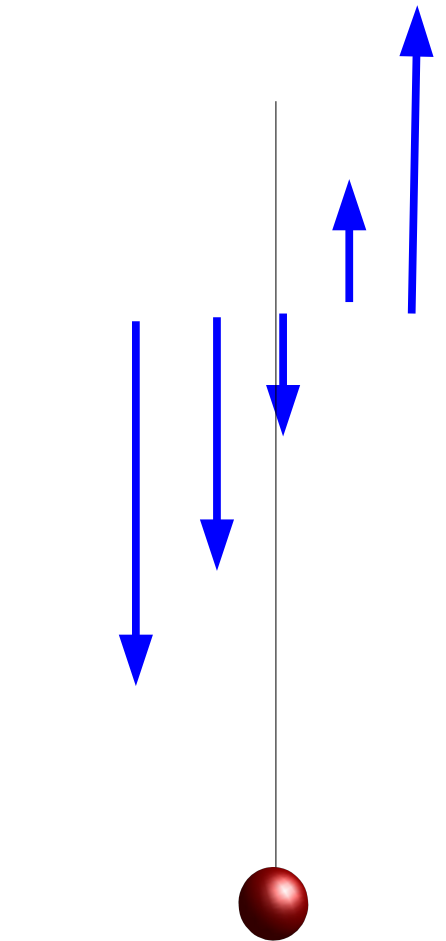
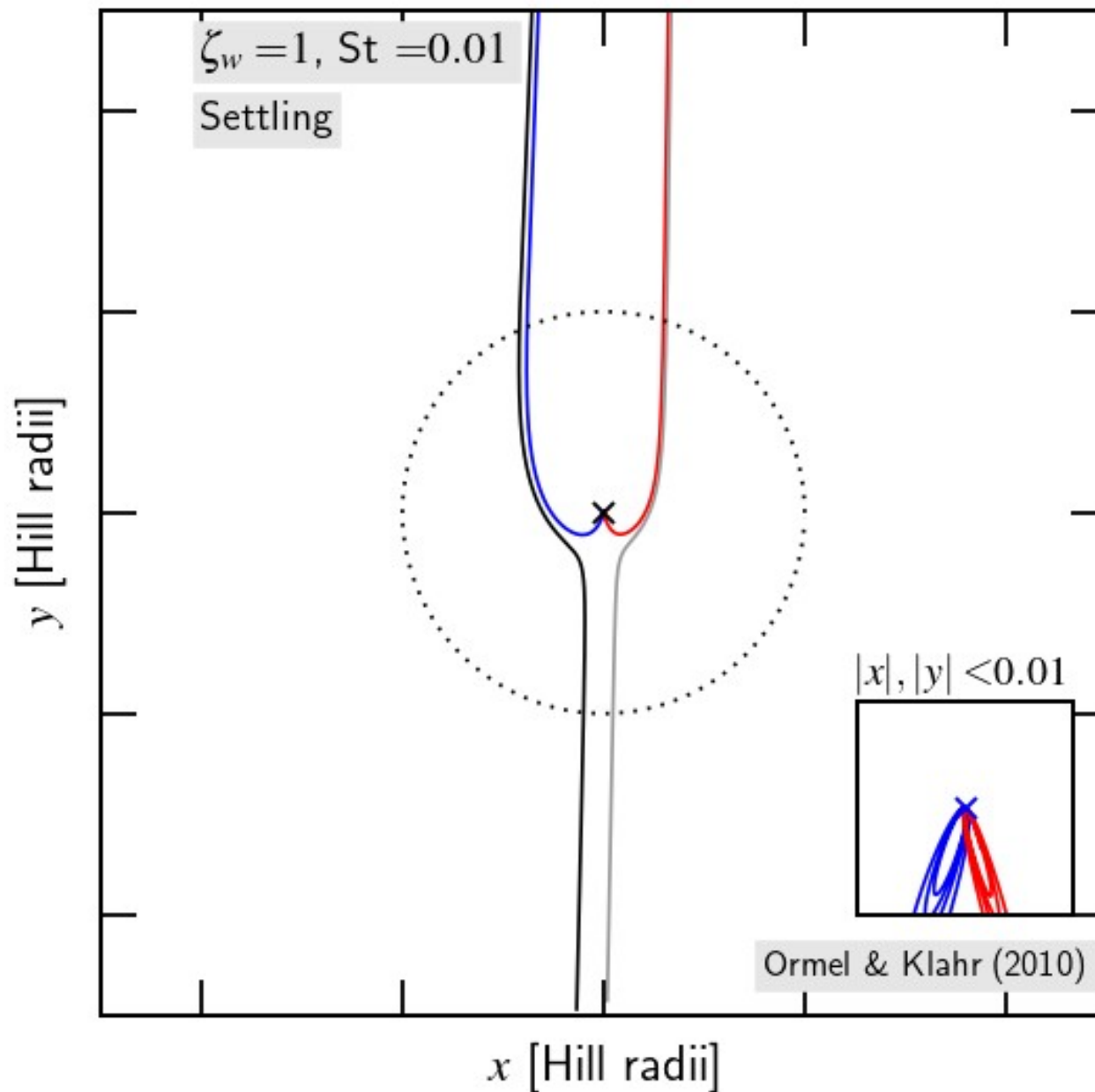
Gravity only



y [Hill radii]

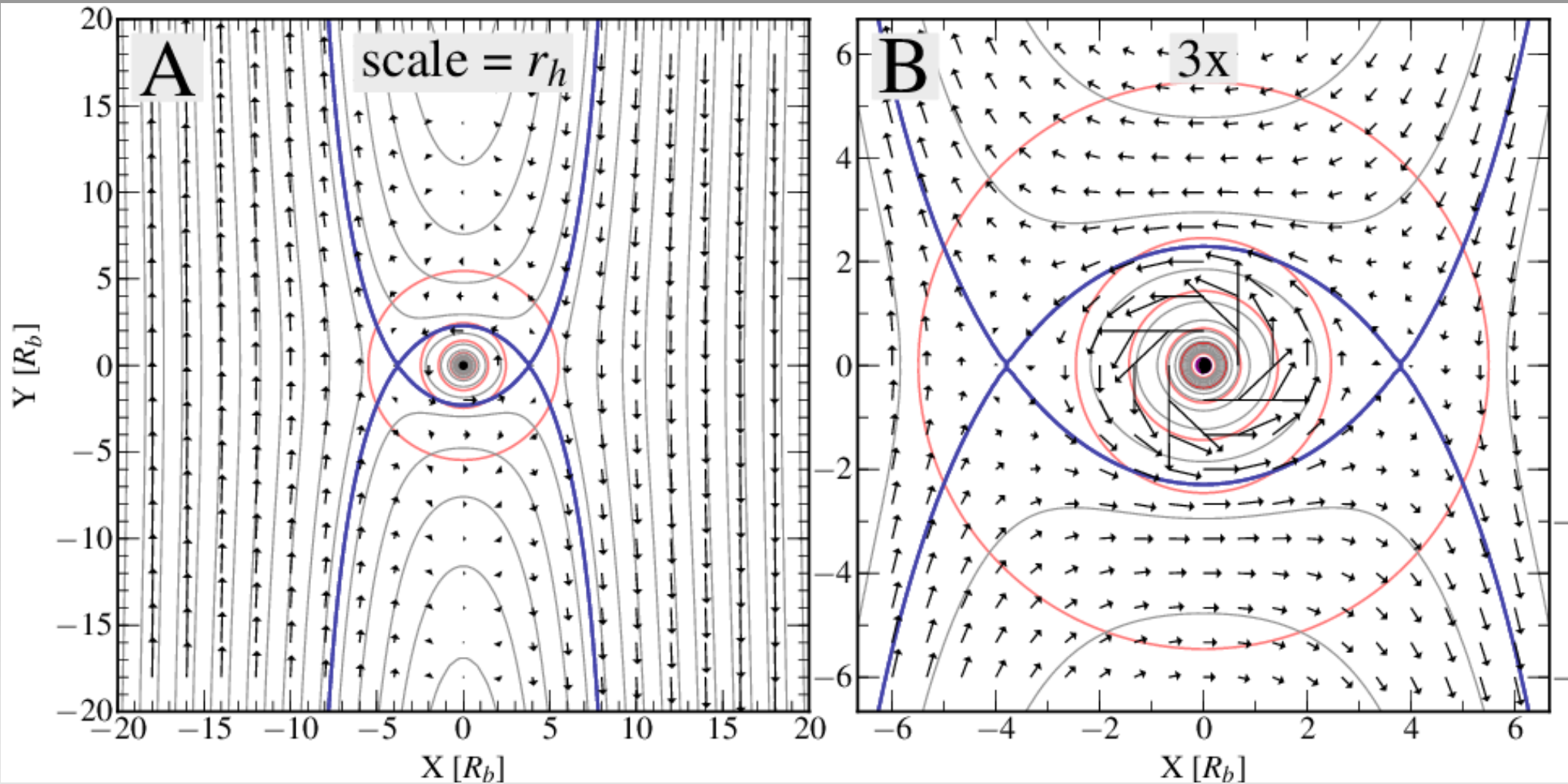


+Gas drag/ nebular gas flow



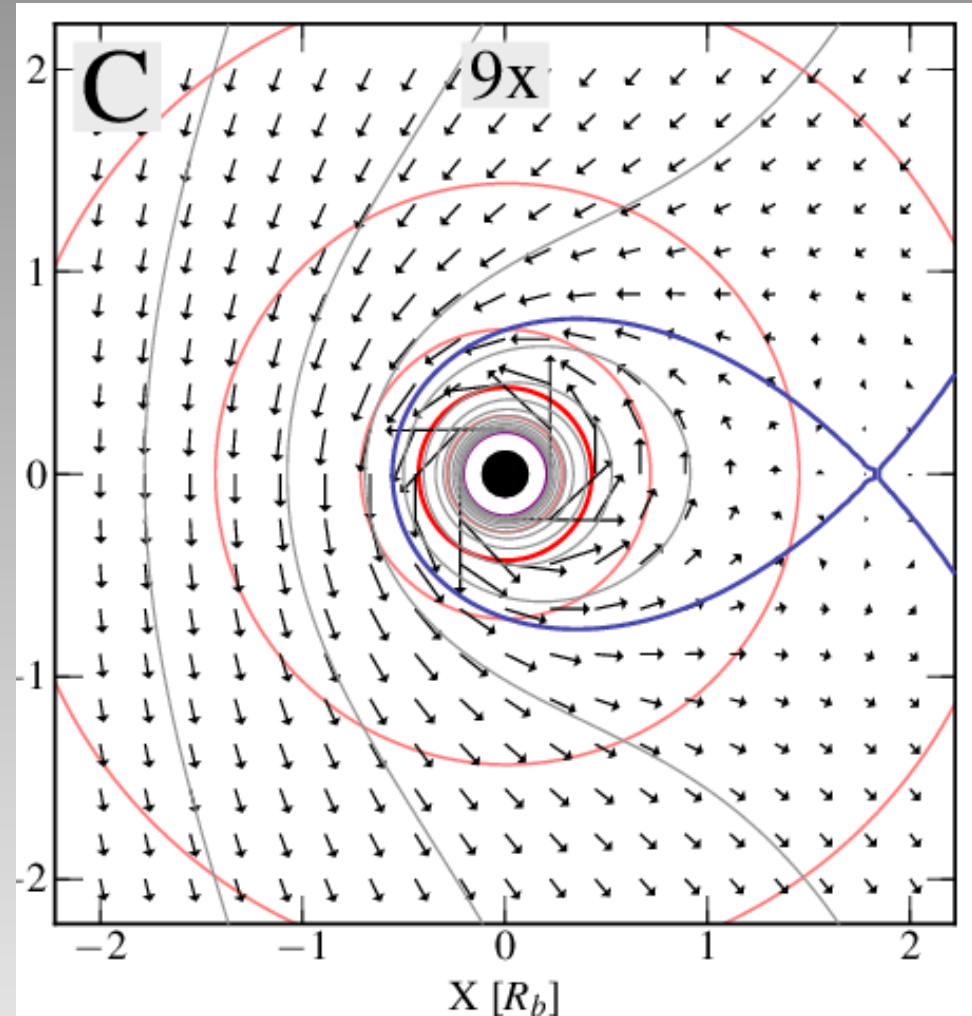
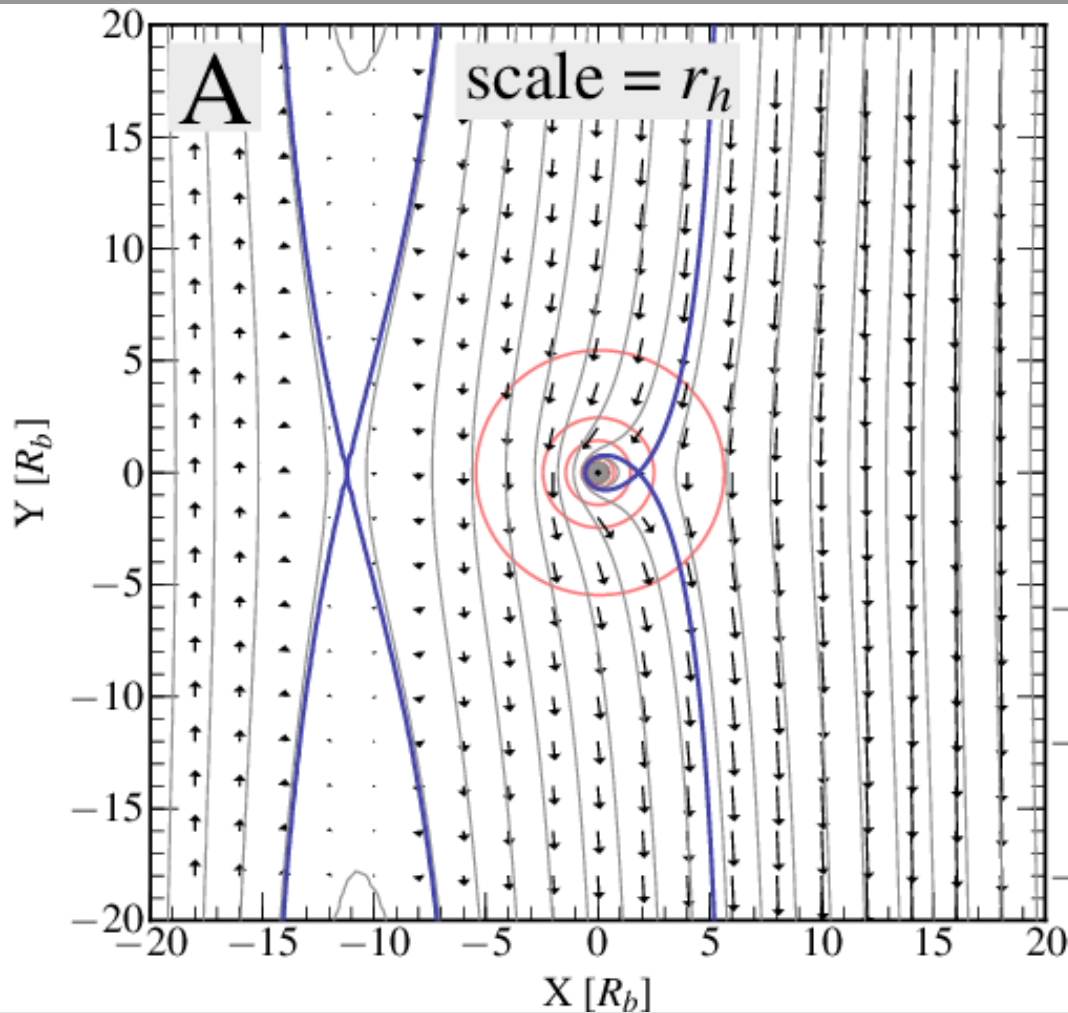
**Gas flow in disk
w.r.t. planet**

Solve gas *flow*



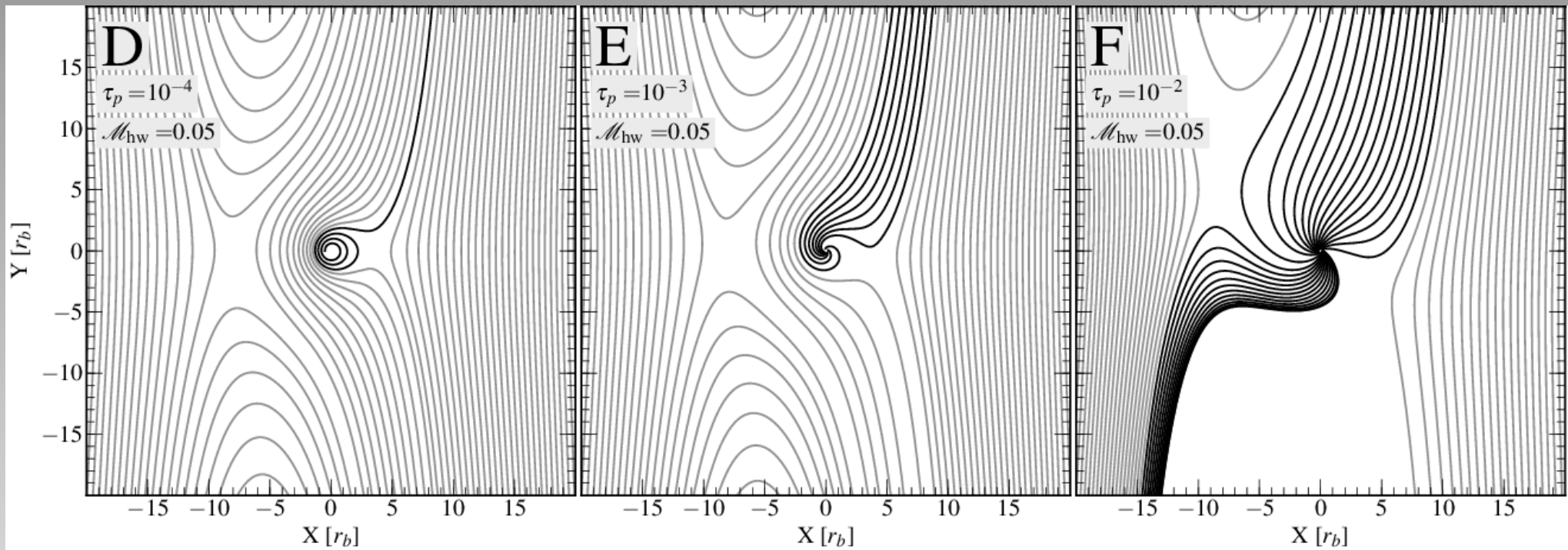
Ormel (2012) submitted

Including headwind



Ormel (2012) submitted

Accretion behavior



Dust

Pebbles

Ormel & Kobayashi (2012) “Toy Model”

