DUST GROWTH AND PLANETESIMAL FORMATION

Joanna Drążkowska
LMU Munich

Image credit: ESA/Hubble
MAKING PLANETS IS HARD

➤ 40 orders of magnitude in mass to make an Earth
➤ Even longer way to make a Jupiter
INTRODUCTION: STOKES NUMBER

(Size doesn’t matter, Stokes number does)

\[ St = \frac{\text{stopping time}}{\text{local orbit}} \]
INTRODUCTION: IMPACT SPEEDS

![Graph showing impact speeds with scales for St and collision velocity in m/s. The graph includes units for different scales.]
GROWTH BARRIERS: COLLISIONS

Particle-Aggregate-Collision

collision velocity:
17 mm/s
fov size:
17 mm x 17 mm

Weidling et al. 2011

Beitz et al. 2011
GROWTH BARRIERS: RADIAL DRIFT

Brauer et al. 2008
TYPICAL OUTCOME OF DUST COAGULATION

- drift barrier
- fragmentation barrier

made with DUSTPY code by Stammler & Birnstiel

analytical predictions for growth barriers:
Birnstiel, Klahr, & Ercolano 2012
Streaming instability needs pebbles (St > 10^{-3}) and enhanced dust-to-gas ratio to produce km-sized planetesimals

Kowalik et al. 2013

DUST GROWTH + STREAMING INSTABILITY

see also:
Drążkowska & Alibert 2017
Schoonenberg & Ormel 2017
Drążkowska & Dullemond 2018
Pignatale et al. 2018

Drążkowska et al. 2016
**PLANETS TRIGGER PLANET(ESIMAL) FORMATION?**

\[
\tau_\nu = 0.5 \frac{Q_\nu}{0.4} \left( \frac{\alpha}{0.001} \right)^{\frac{1}{2}} \left( \frac{St}{0.1} \right)^{-\frac{3}{2}}
\]

**Stammler, Drążkowska, et al., submitted**
PLANETS TRIGGER PLANET(ESIMAL) FORMATION?

made with
(COA)LA-COMPASS
by Li et al.

Drążkowska et al., submitted
DUST COAGULATION IN 2-D

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Drążkowska et al., submitted
DUST COAGULATION IN 2-D VS 1-D

Drażkowska et al., submitted
TAKE HOME MESSAGES

- It seems very unlikely that planetesimals form by direct growth of dust aggregated to kilometre sizes.

- Even with the help of the streaming instability, planetesimals only form at some particular locations in the disk (pebble pile-ups, pressure traps, snow lines?)

- We have indirect evidence of ongoing planetesimal formation in dust ring of HD 163296.

- Modelling of dust coagulation in 2-D gives significantly different results from previous 1-D models (also: including dust coagulation gives significantly different results from fixed size models...).