Molten Droplet in Gas Flow: Diversity of Chondrule Shapes

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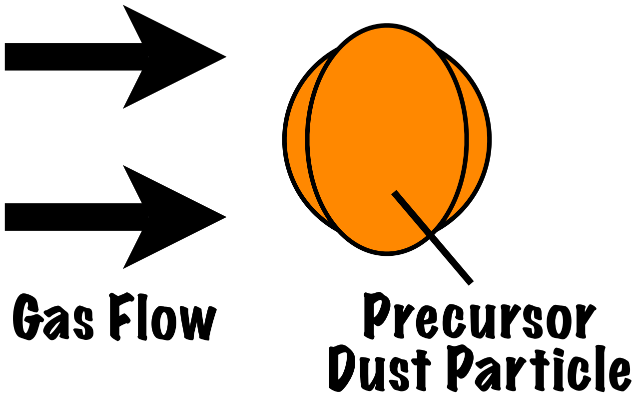
Shock-wave heating model



- Gas flow heats/melts Dusts.

  Hood & Horanyi (1991, 1993)
  Ruzmaikina & Ip (1994)
  Iida et al. (2001)
  Desch & Connolly (2002)
  Ciesla & Hood (2002)
  HM et al. (2002)
  HM & TN (2005) etc...

- Does it also deforms molten droplets?

Deformation of Molten Droplets

Weber number:

$$W_e = p_{\rm fm} r_0/\gamma$$

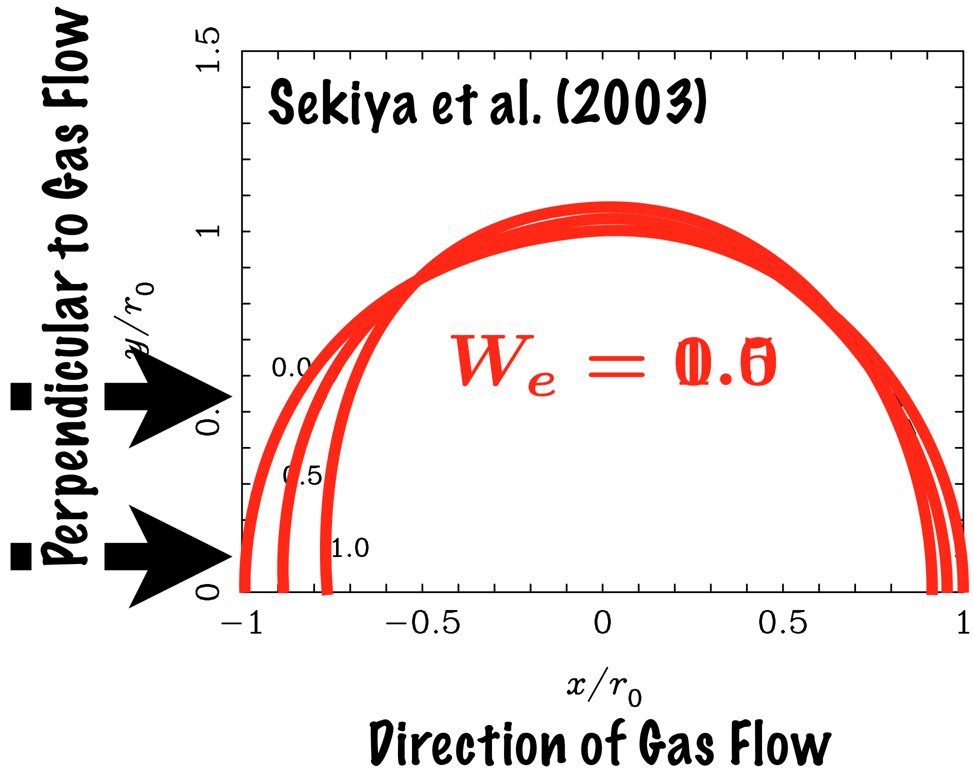
$p_{\rm fm}$: Ram Pressure
$\simeq$ 400 - 4000 dyne cm^{-2}

r_0: Droplet Radius
$\simeq$ 100 - 1000 μm

γ : Surface Tension
$\simeq$ 400 dyne cm^{-1}

W_e can be $\simeq$ 1

Section of Droplet Shapes

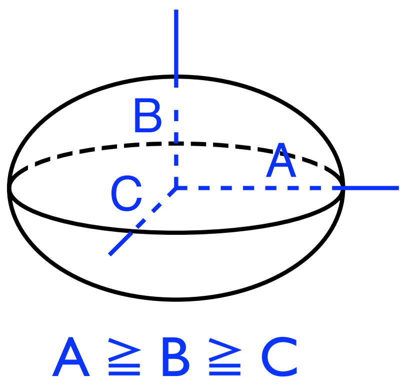


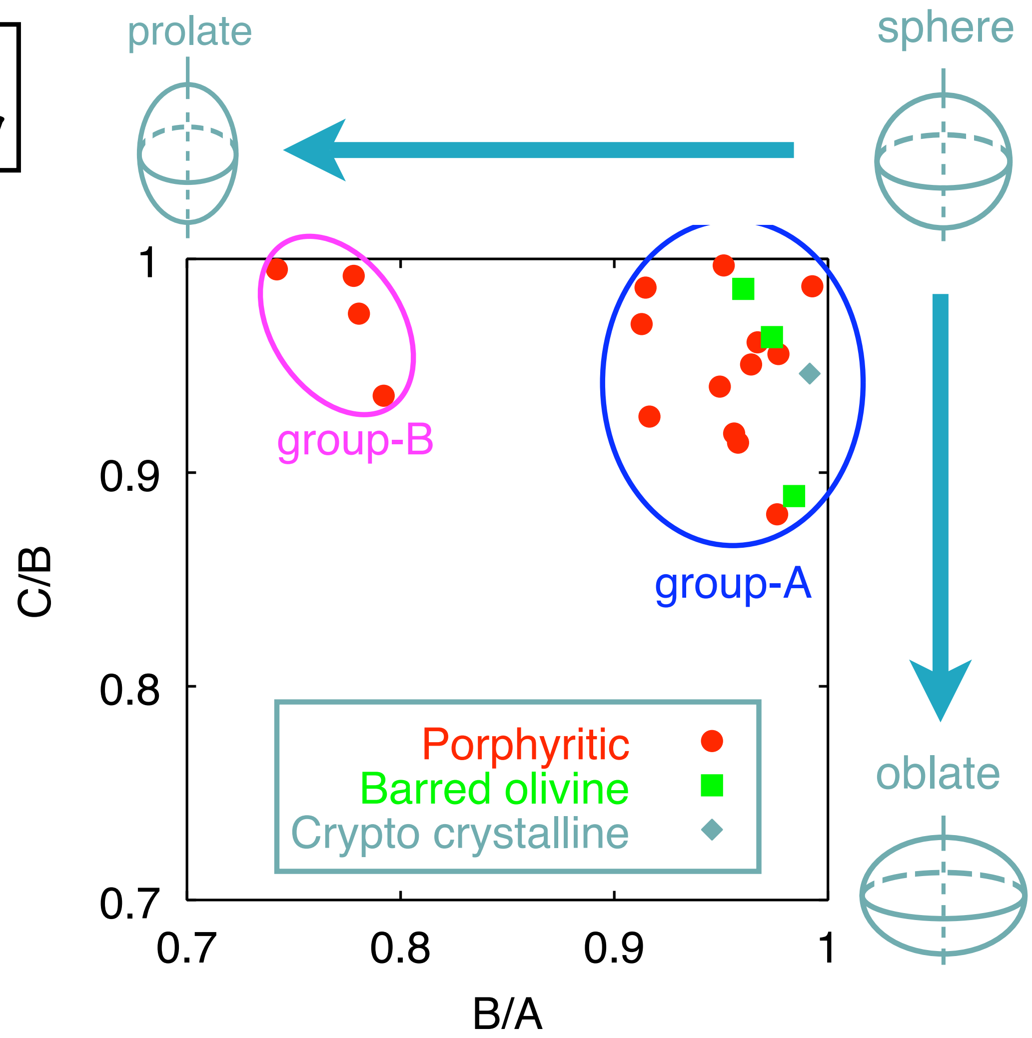
Deformation of Chondrules

Shape measurement by X-ray micro-tomography

Tsuchiyama et al. (2003)

3-axial ellipsoid approximation



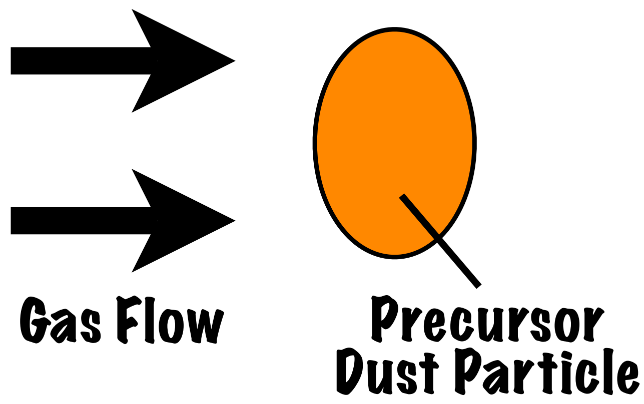


Aim of This Work

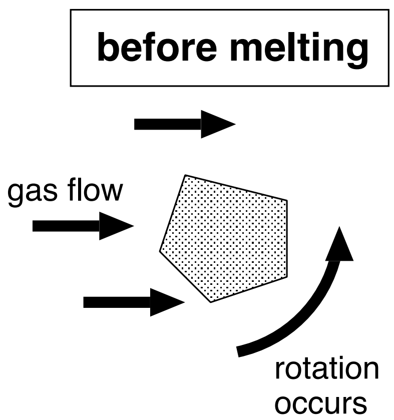
In gas flow, droplets must deform!

If they re-solidify keeping the deformation,
it would result into deformed chondrules.

We analyze the droplet shapes in gas flow.



The point of our study is Droplet Rotation.



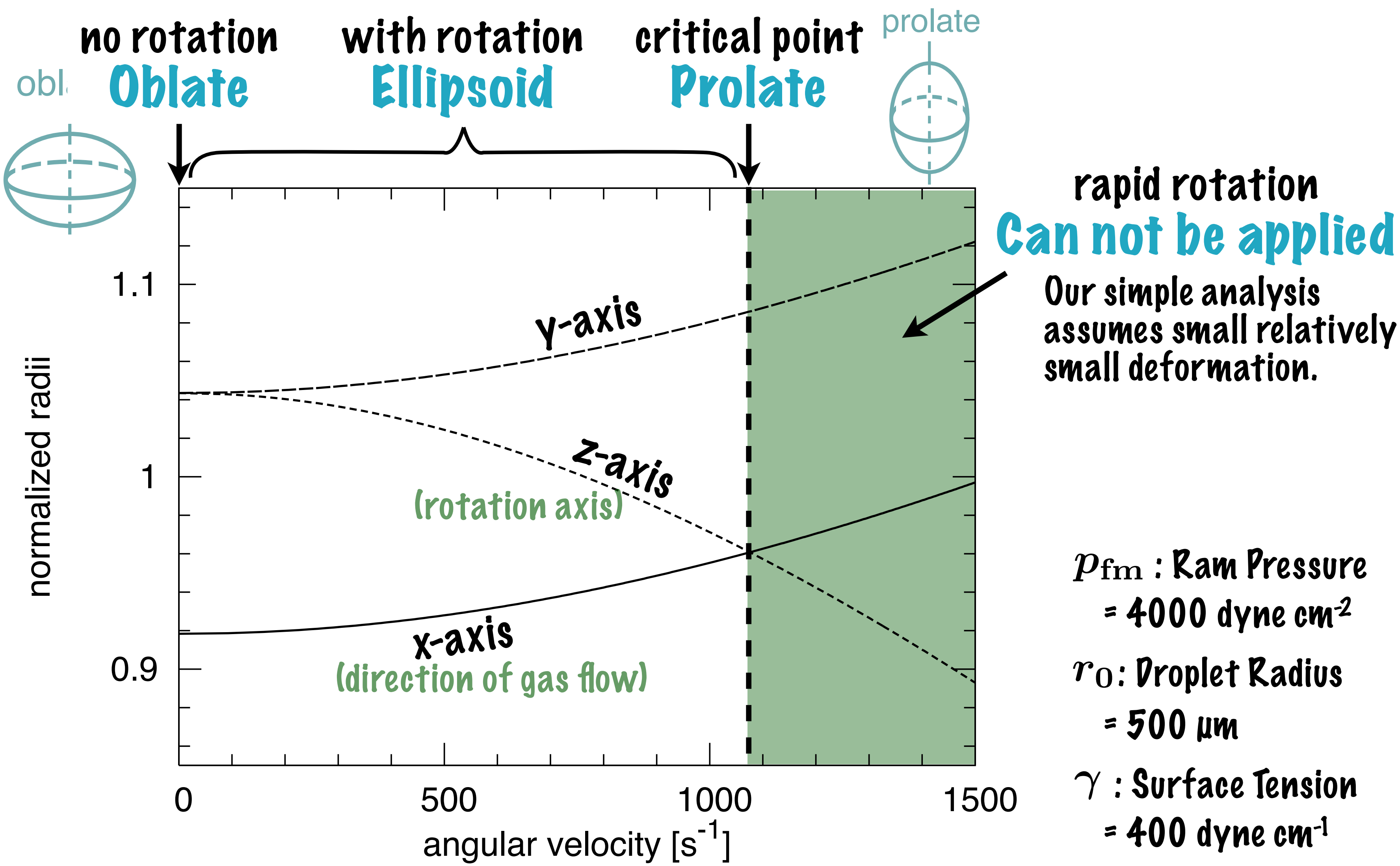
Precursors would be irregular shapes.

They would begin to rotate in gas flow.

Rotation axis must be perpendicular to gas flow!

(gas flow = x-axis, rotation axis = z-axis, another = y-axis)

Effect of Rotation

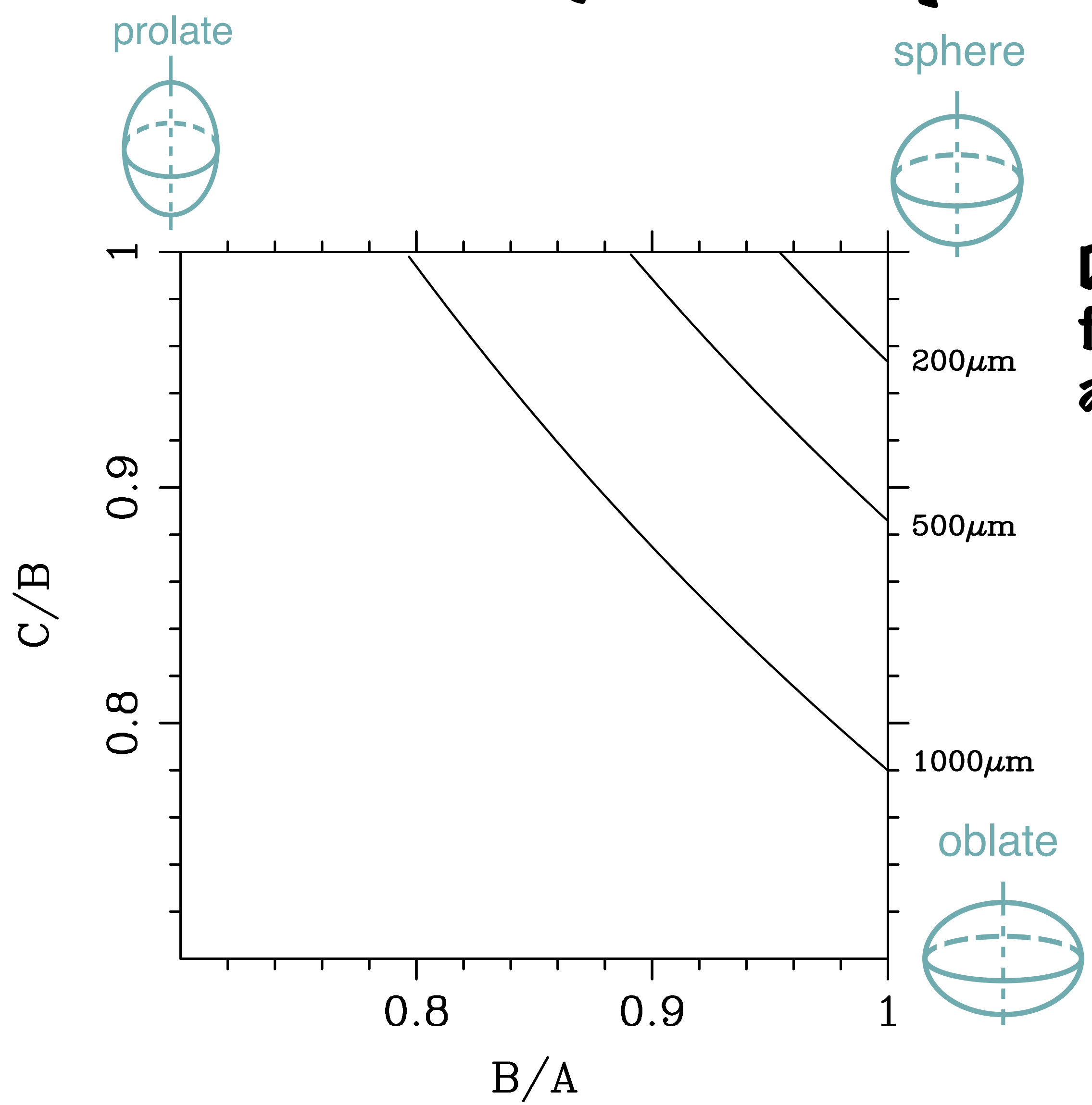


$p_{\rm fm}$: Ram Pressure
= 4000 dyne cm^{-2}

r_0: Droplet Radius
= 500 μm

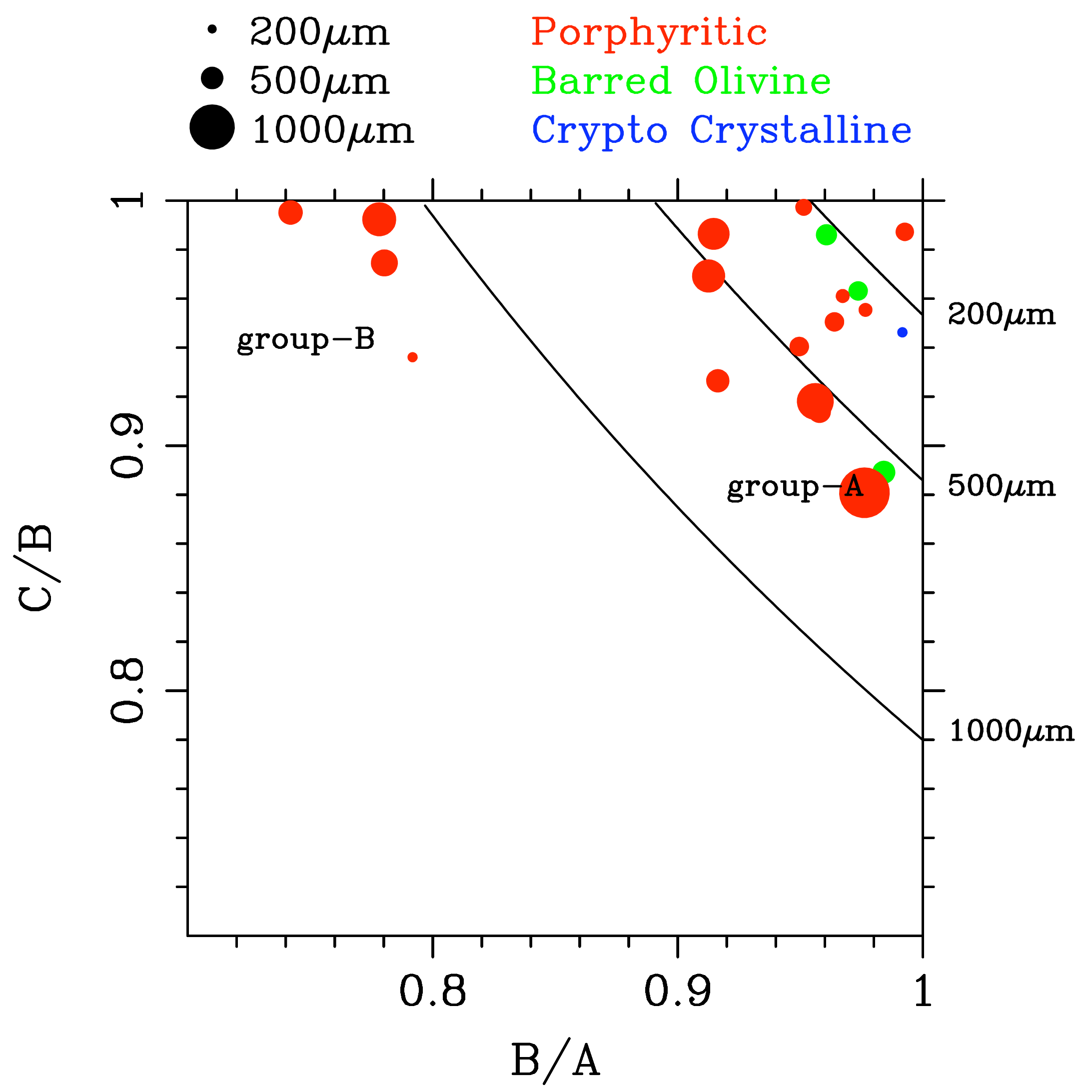
γ : Surface Tension
= 400 dyne cm^{-1}

Diversity of Droplet Shapes



Droplet shapes change from oblate to prolate as rotation gets rapid!

Comparison with Chondrules



Droplet shapes change from oblate to prolate as rotation gets rapid!

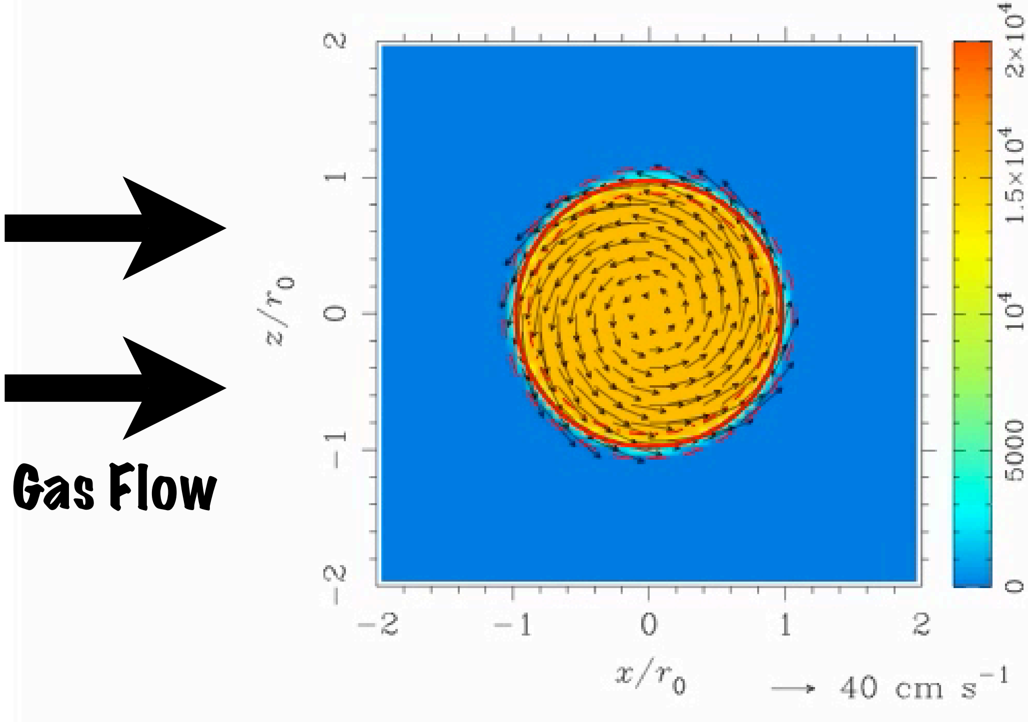
Group-As are similar to rotating droplets with various angular velocities.

How about Group-Bs...?

Hydrodynamic Simulations

We develop 3D hydrodynamic simulation code.

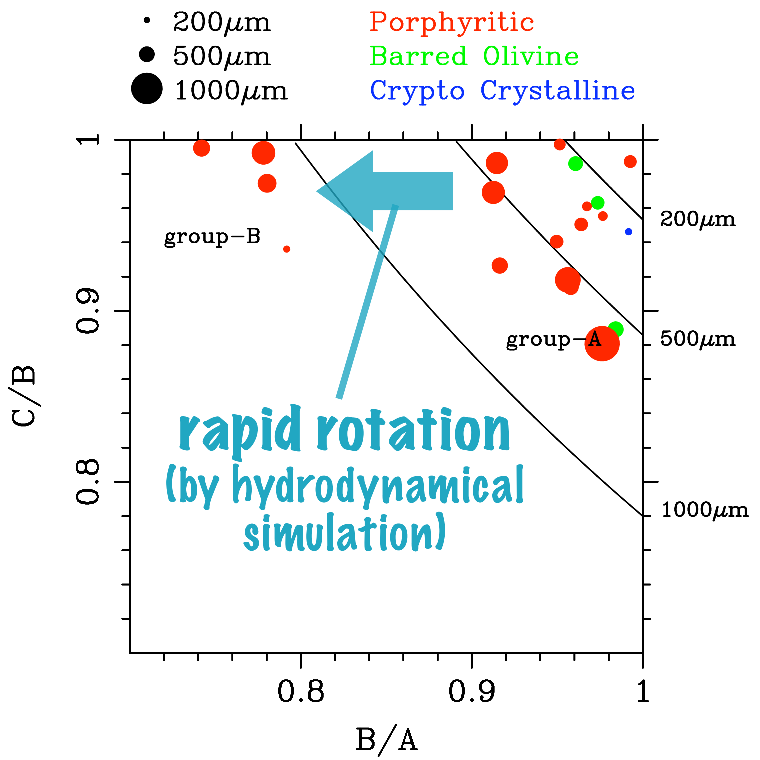
HM & TN, submitted to Icarus
HM & TN, in prep.



Rapidly rotating droplets result into largely deformed Prolate shapes

similar to
Group-B chondrules

Summary



If droplets re-solidify in gas flow, the shapes must deform!

We analyzed 3D shapes of droplets which rotate rapidly.

> Group-A: similar to the droplet shapes which rotate with various angular velocities.
>
> Group-B: rapidly rotating droplets (by hydrodynamical simulation)

Next issue:
- Do droplets really re-solidify keeping the deformed shapes?

We are planing to analyze viscous droplets by our hydrodynamic code.