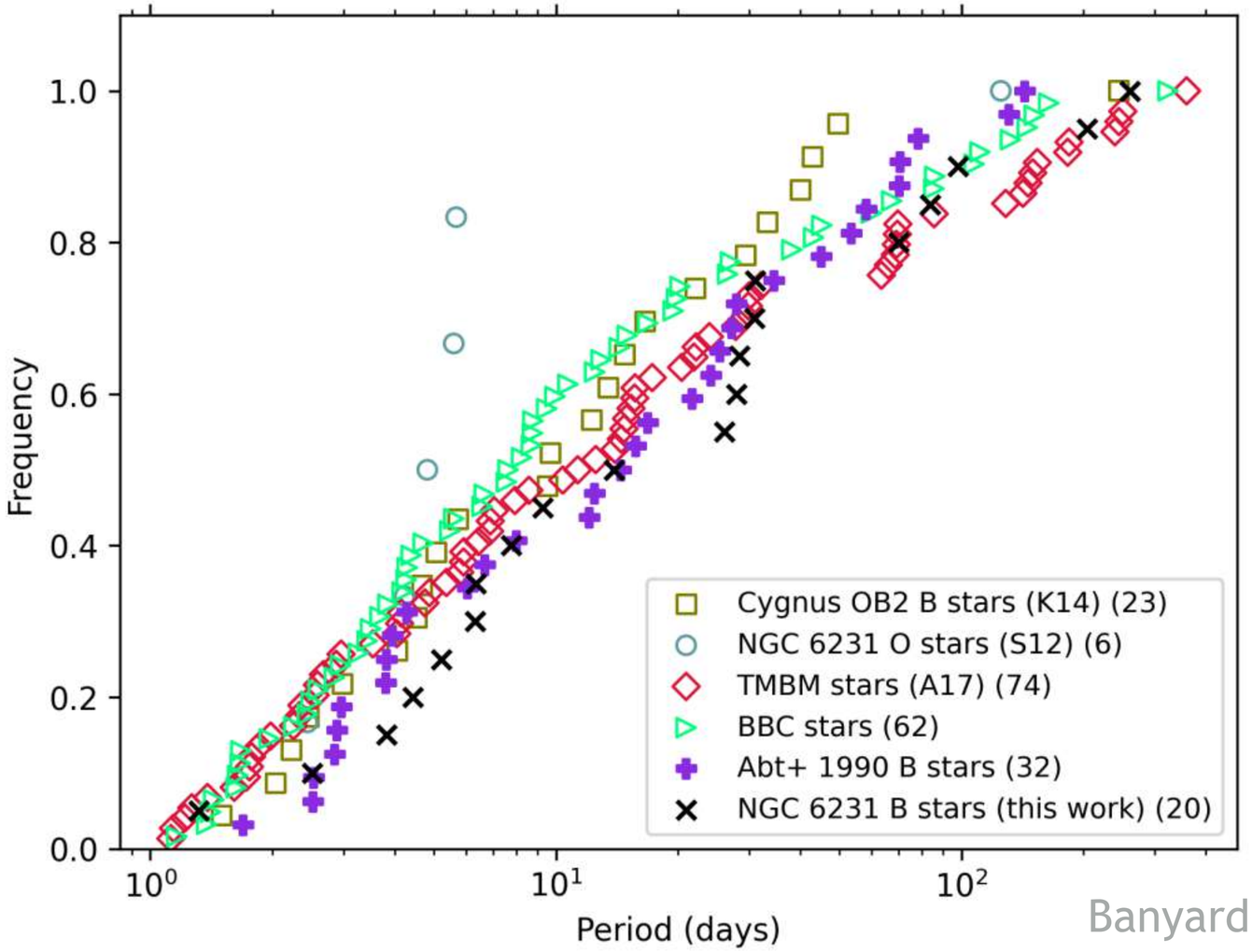
How do massive close binaries come together at the beginning of their life?

María Claudia Ramírez Tannus

The context

More than half of 2-4 Myr old massive stars belong to systems with periods < 1 month (separations < 1 AU).



Banyard+21

See also: Sana+12, Kobulnicky+14, Almeida+17, Barba+17, Villaseñor+21

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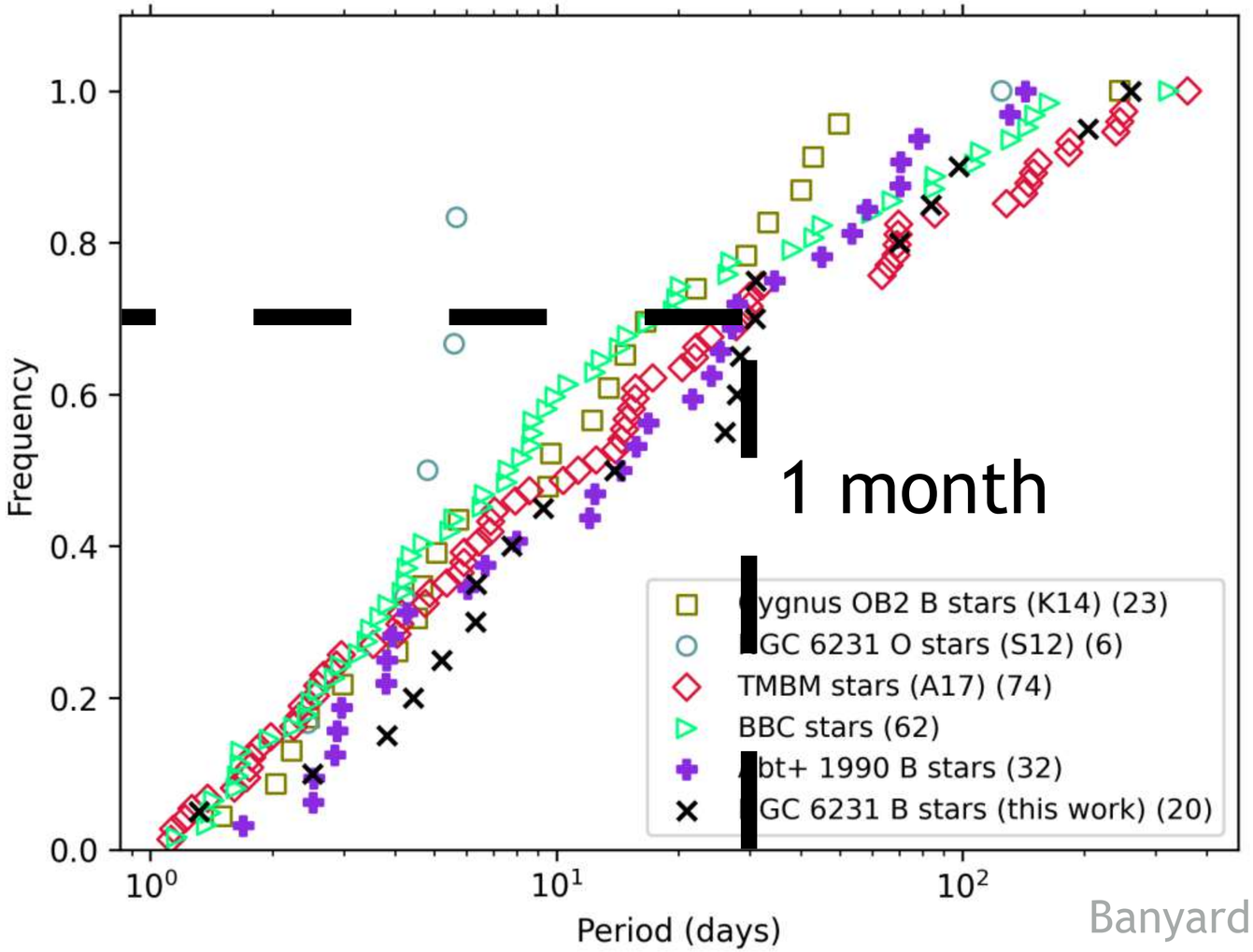

Banyard+21

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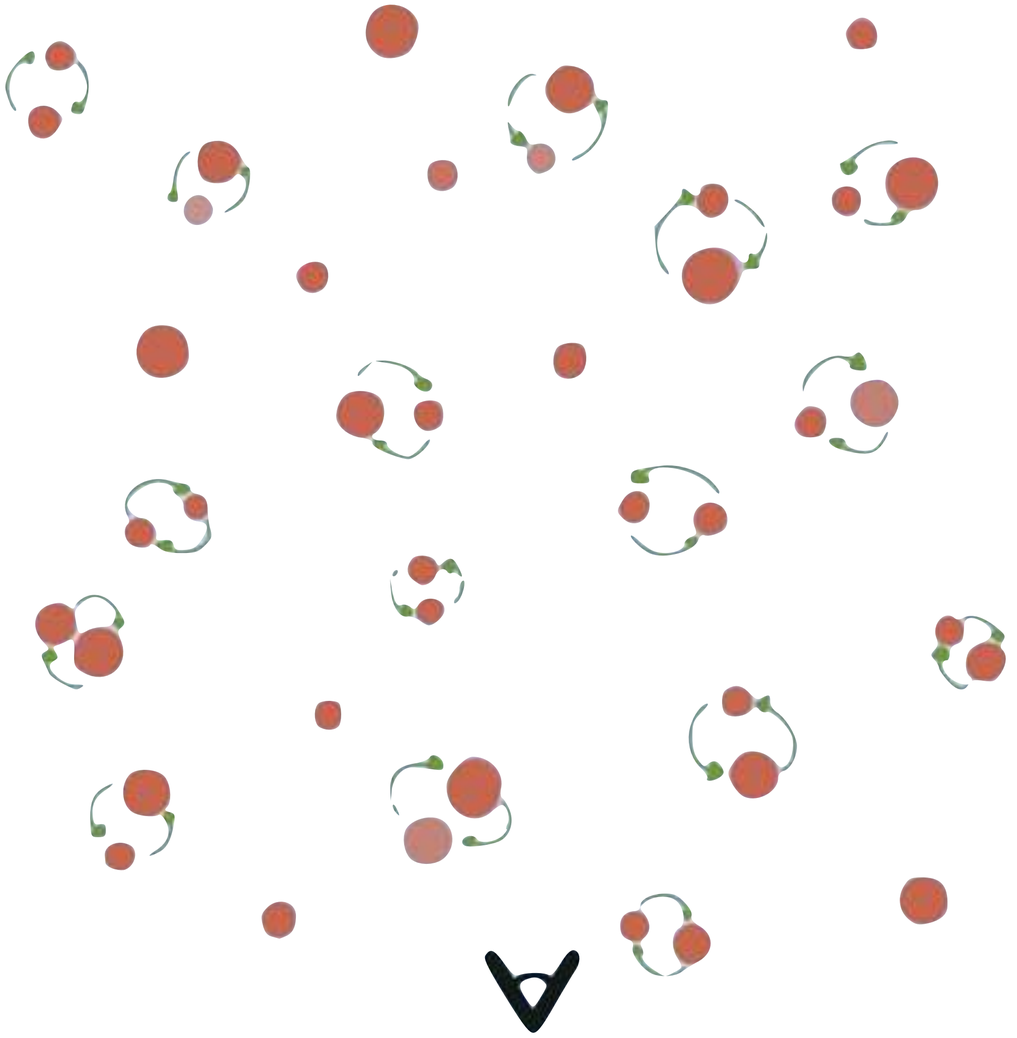
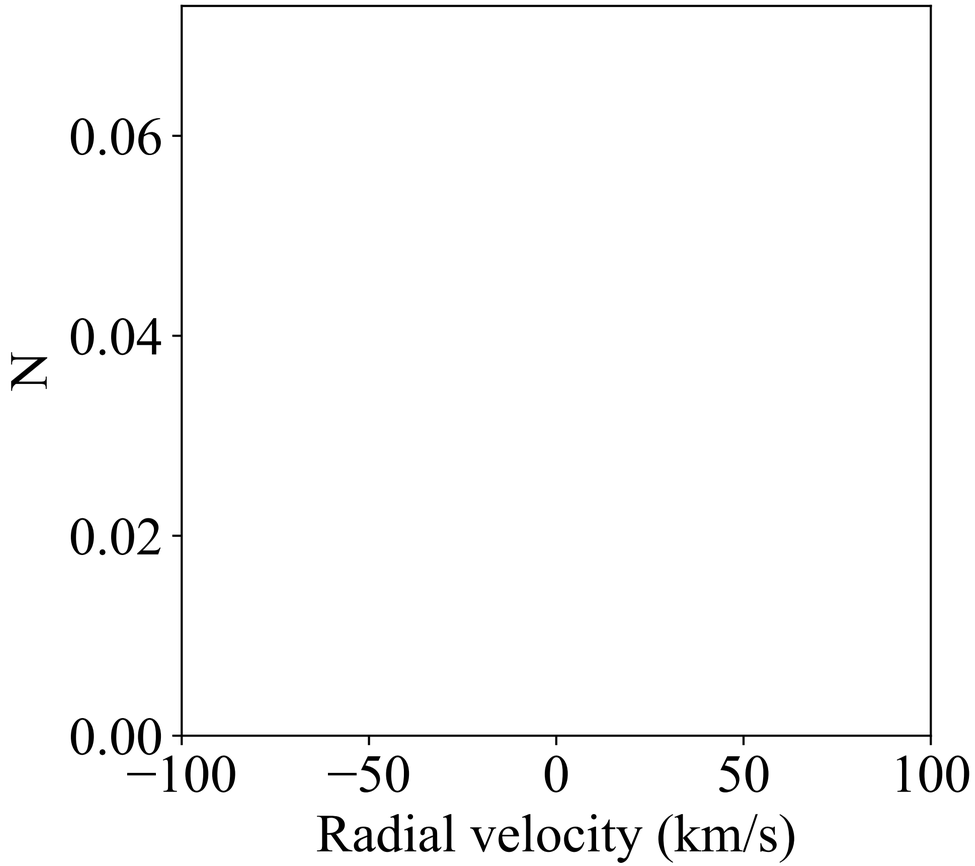
The observations


Massive stars form with wide companions…
and then migrate to become close binaries

Radial velocity dispersion

70% close binaries





Sana, RT+17

Credit: A. Derkink

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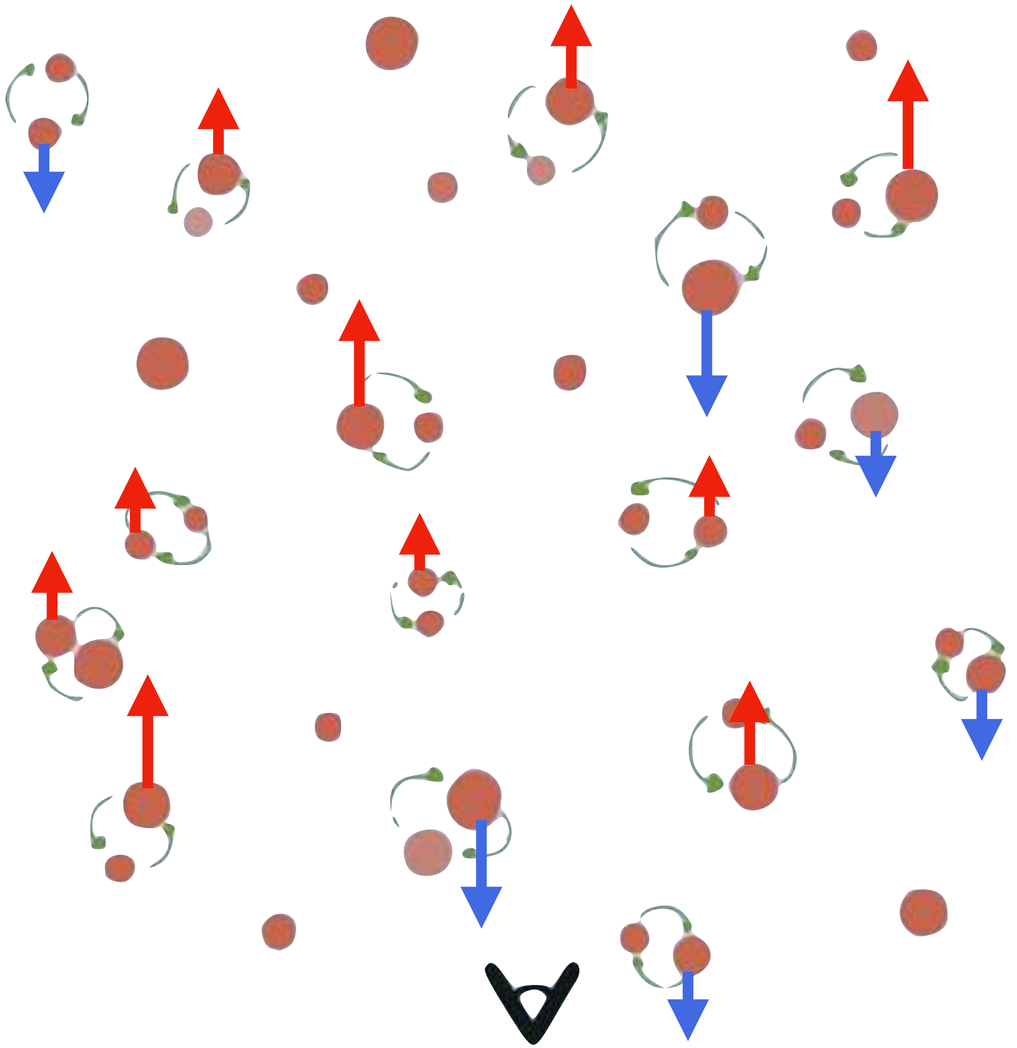

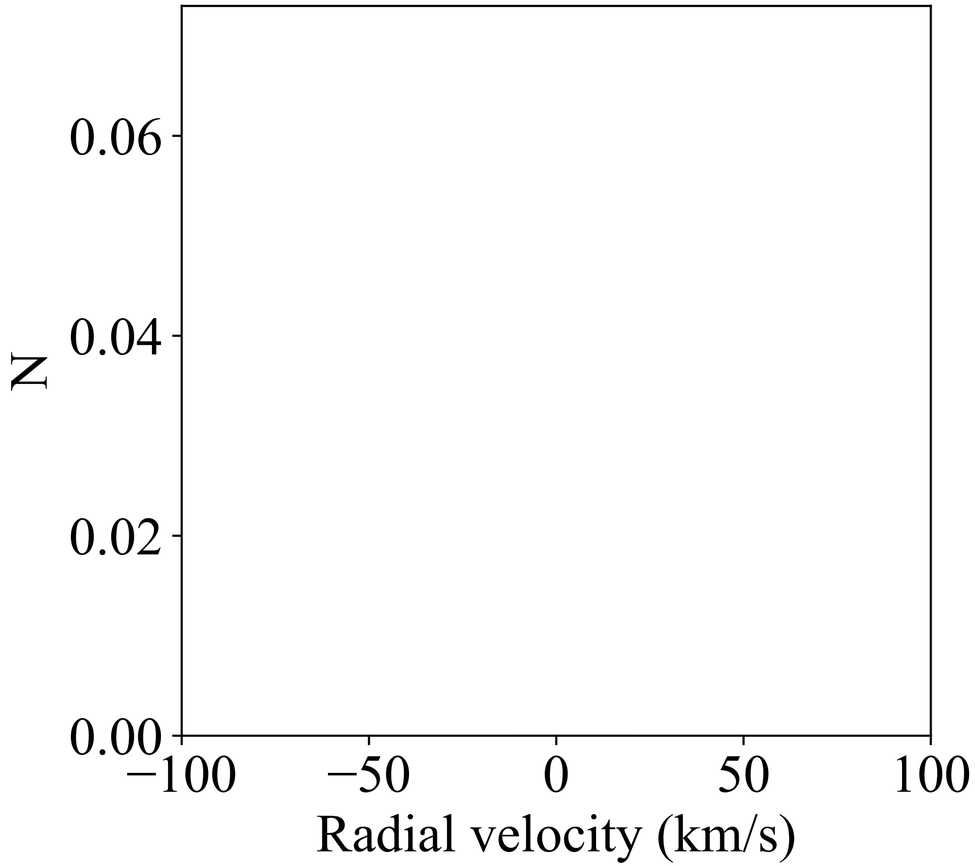

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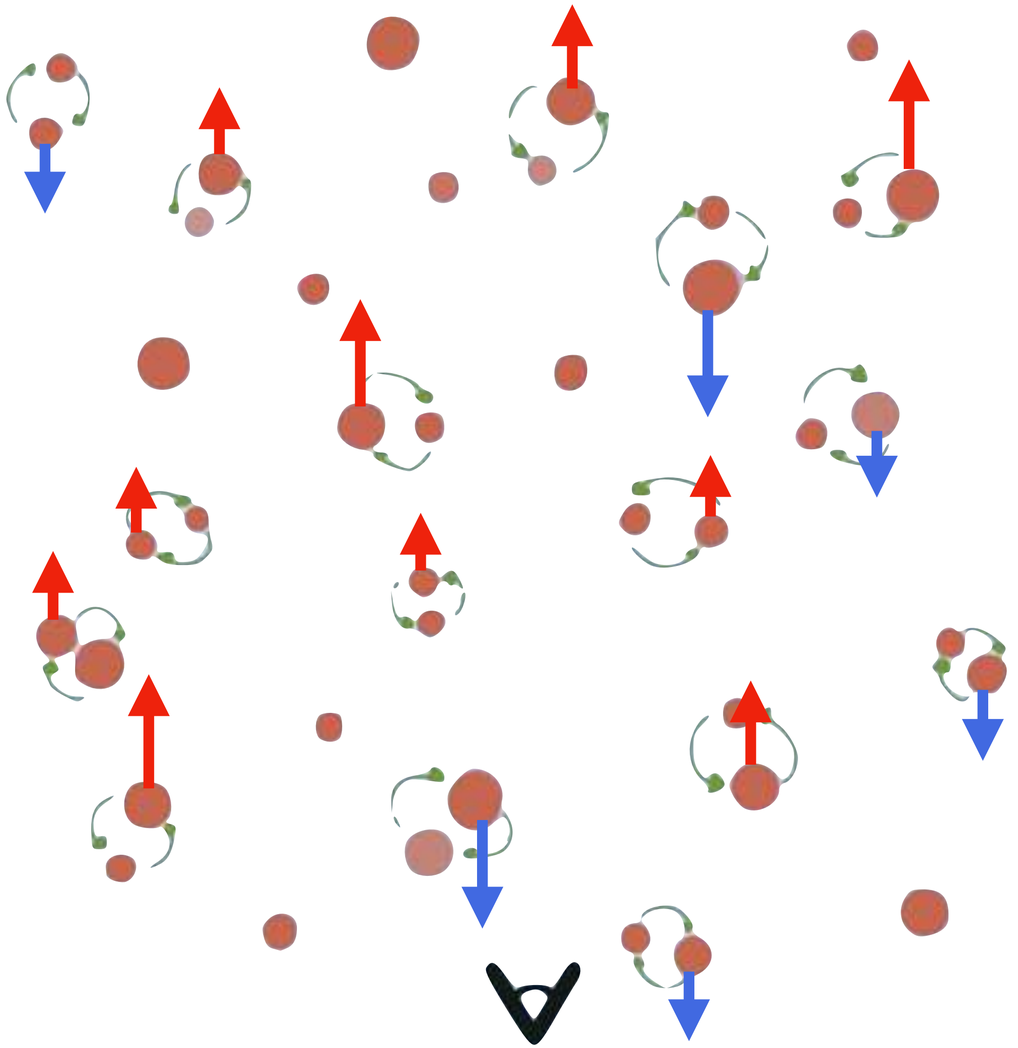

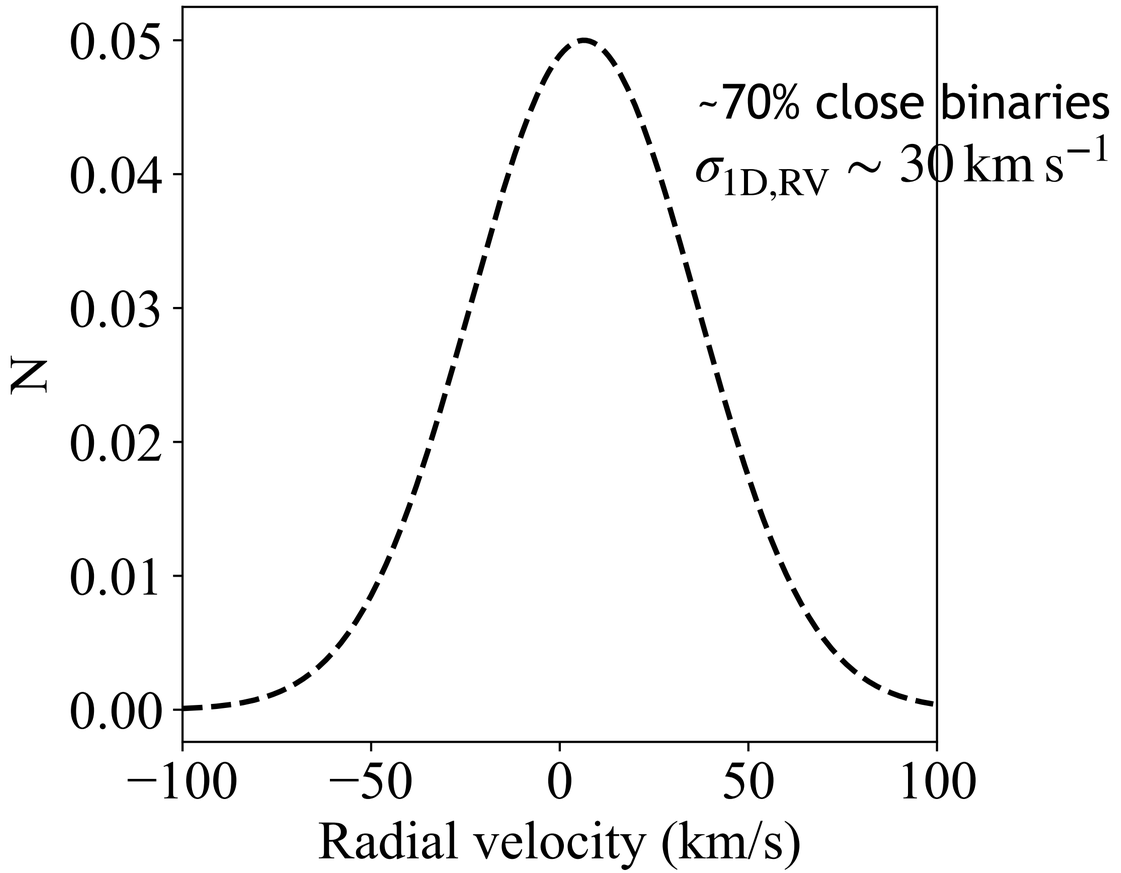

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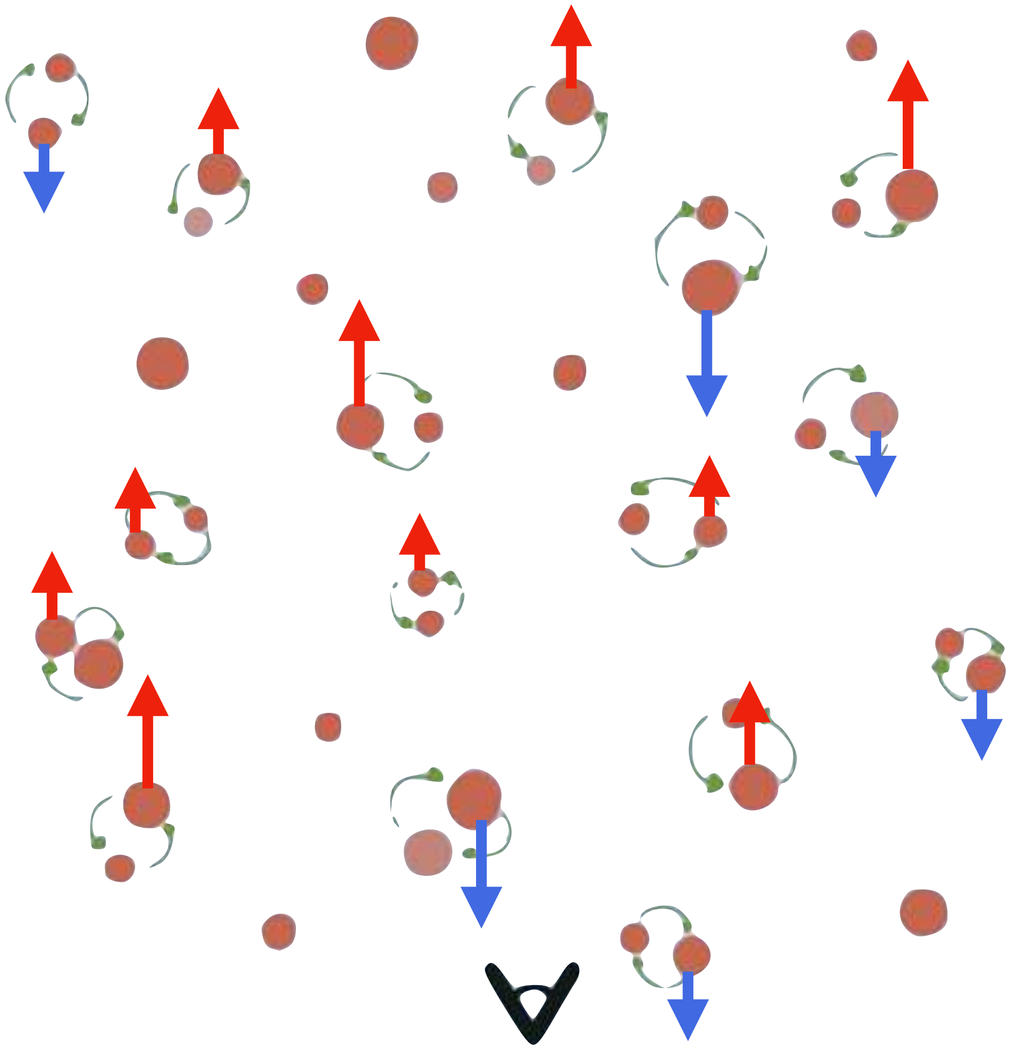

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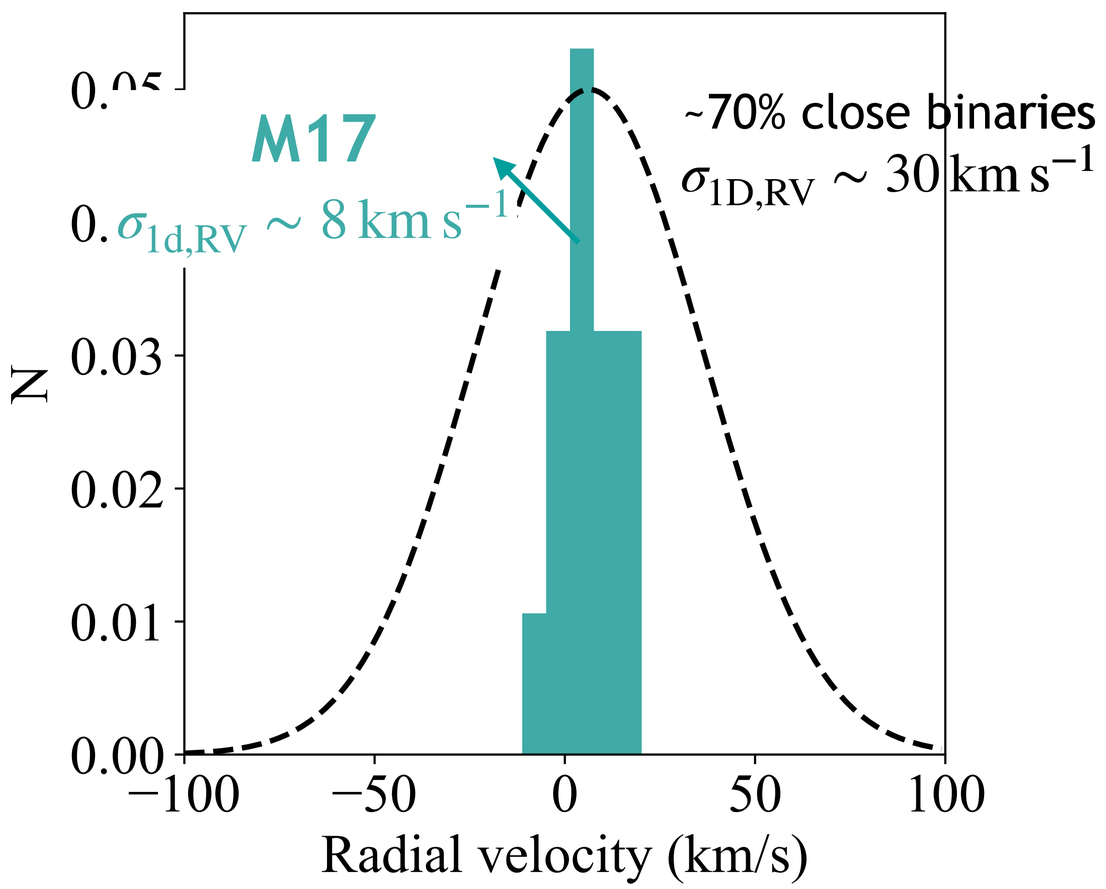


Sana, RT+17

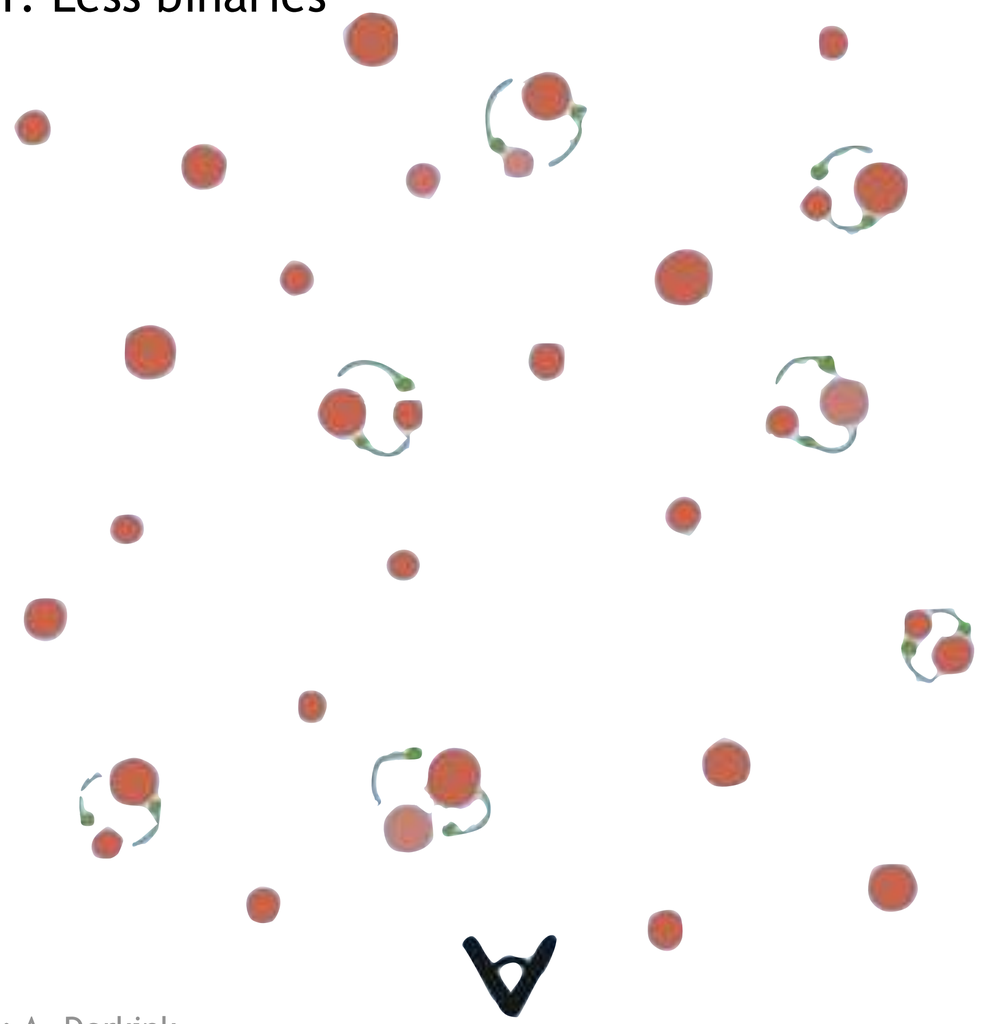
What can cause a low RV dispersion?

Credit: A. Derkink

Sana, RT+17

What can cause a low RV dispersion?

1. Less binaries



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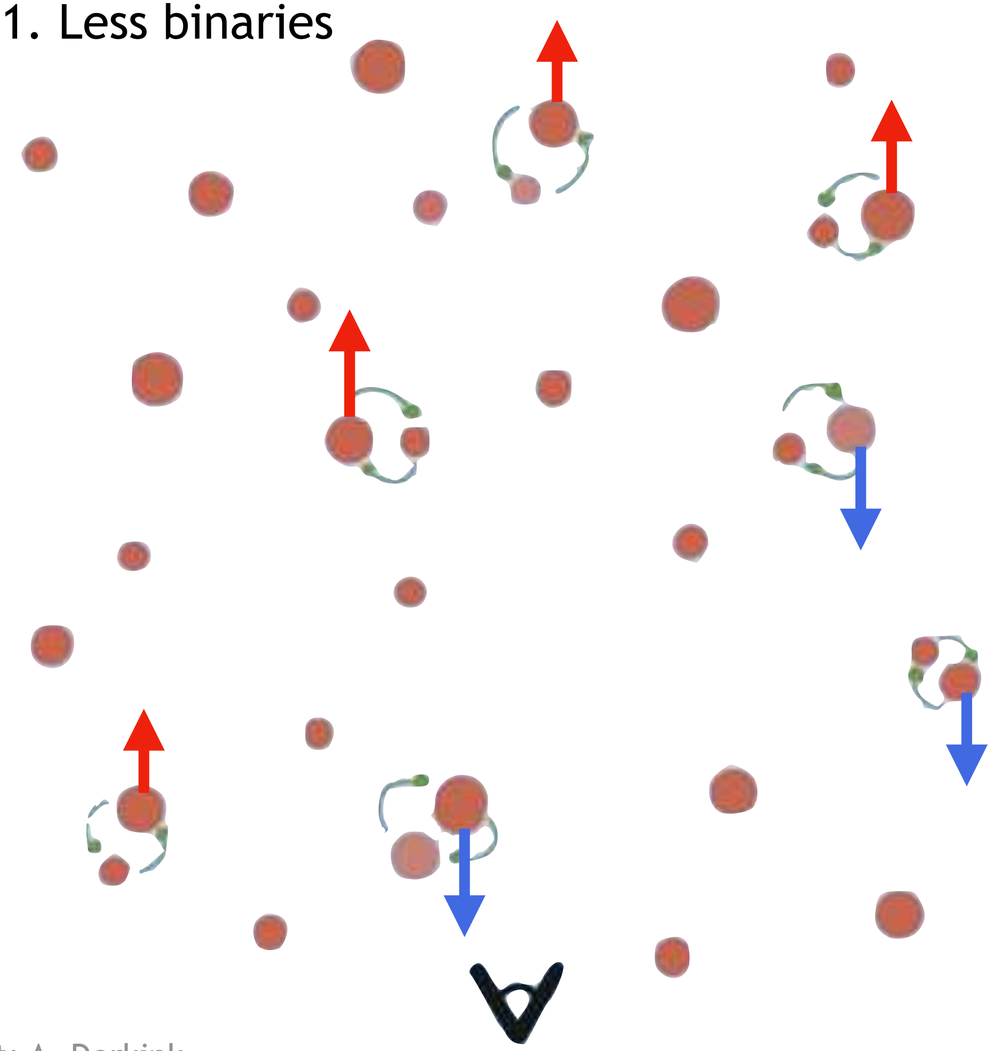

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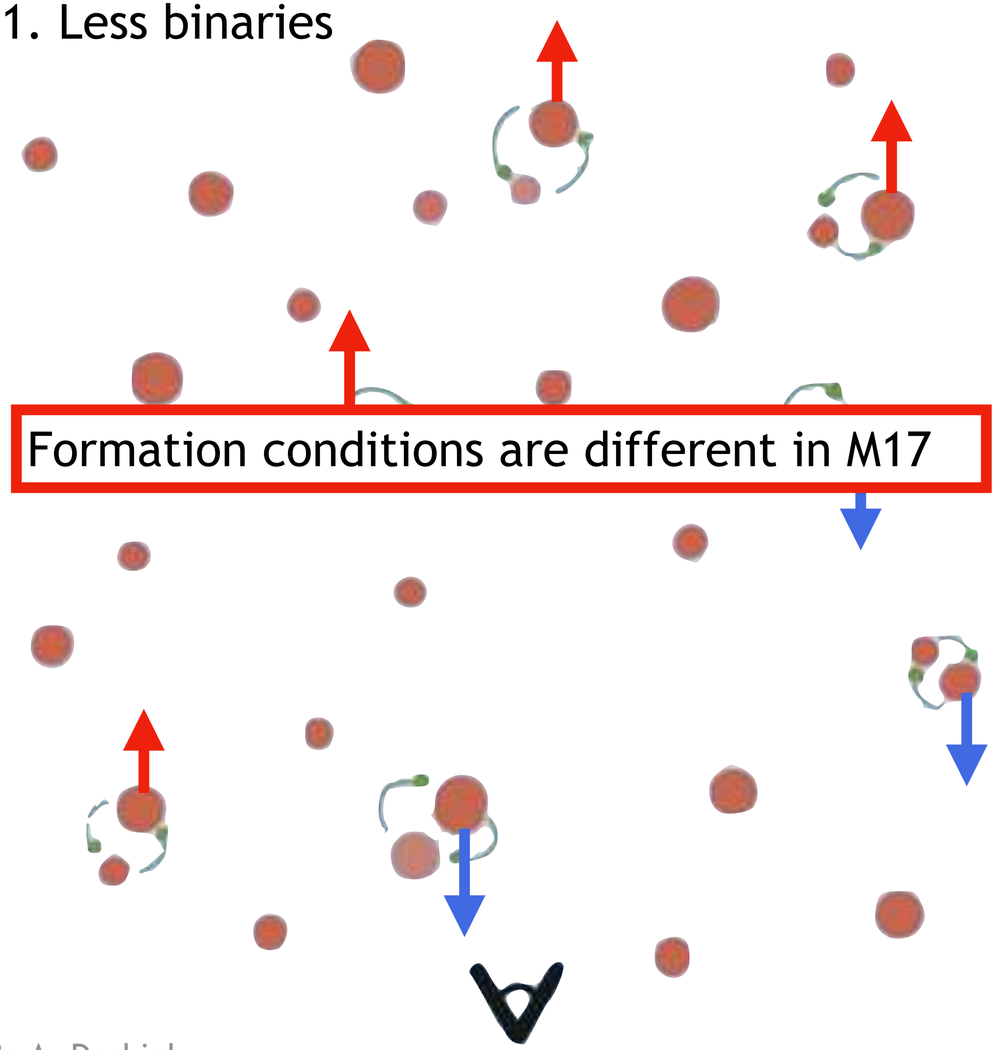

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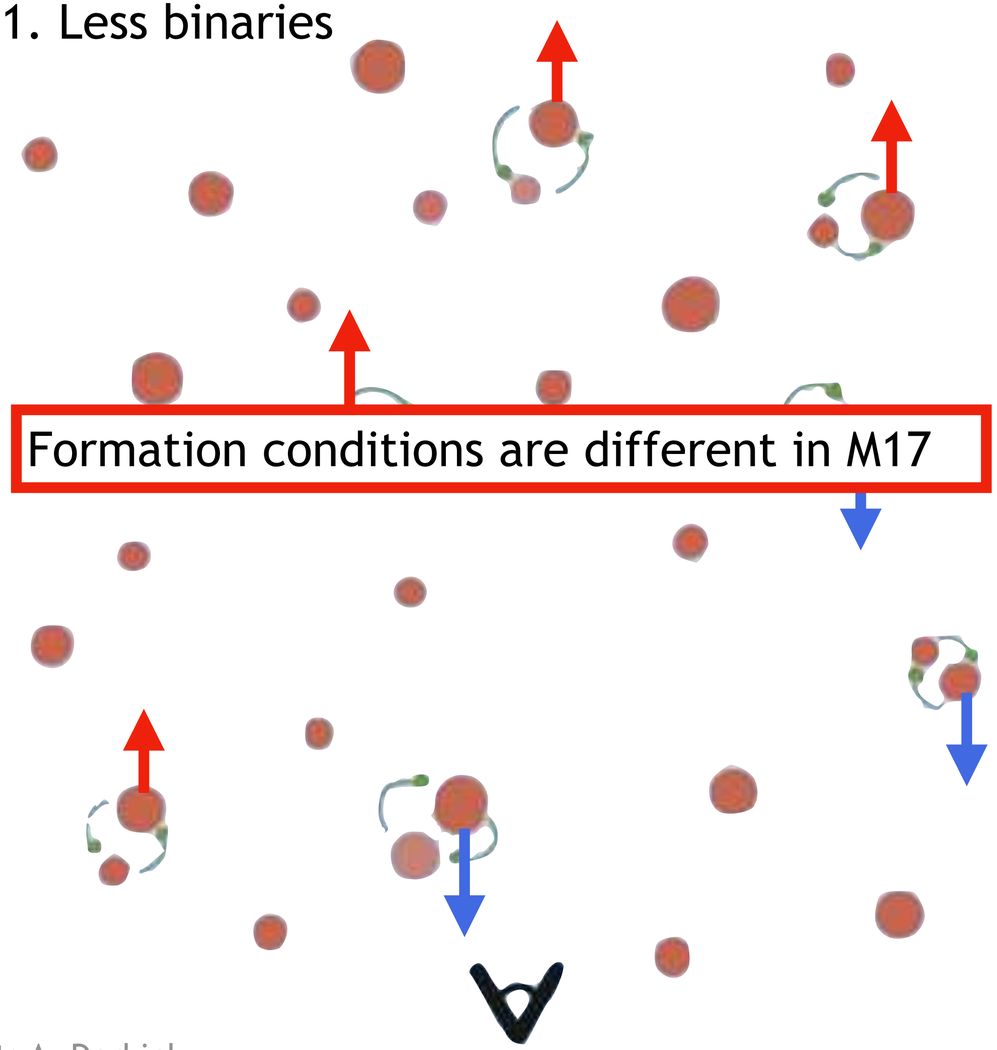
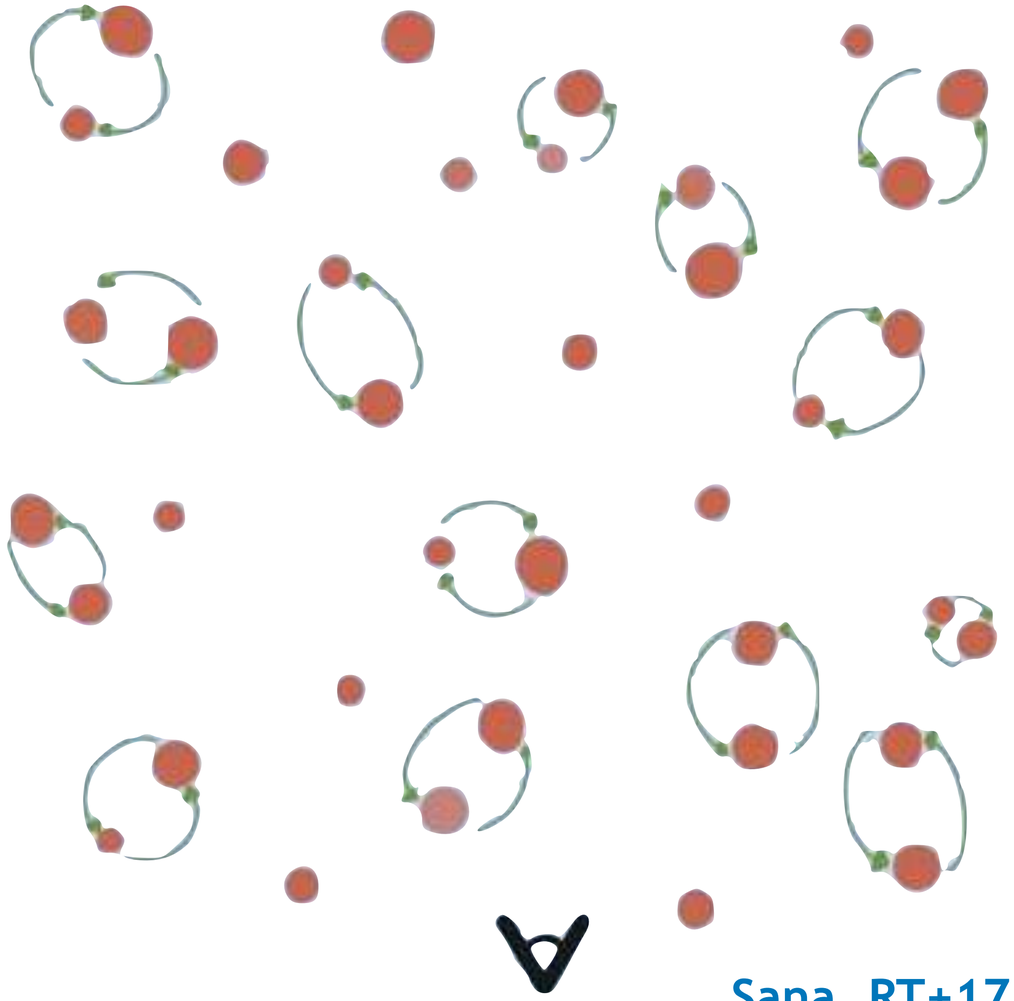


2. Wider binaries



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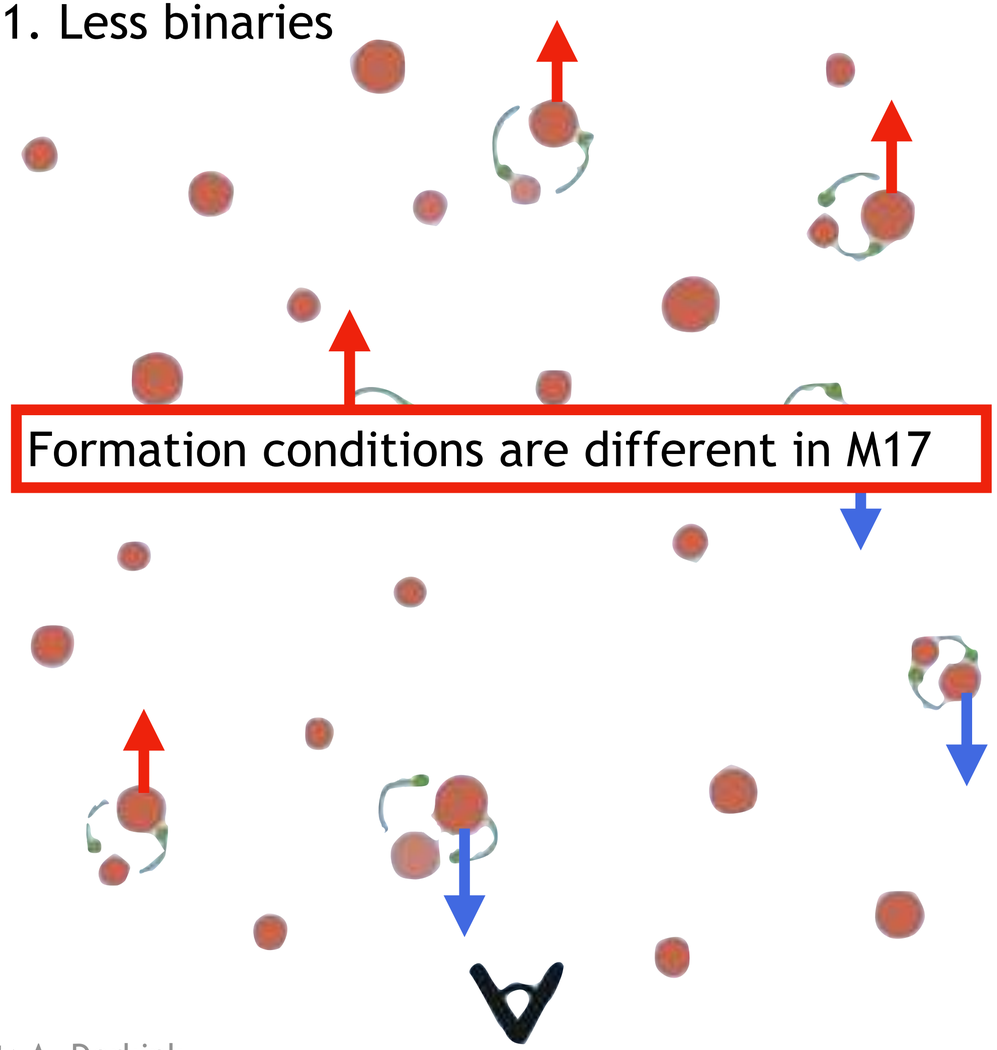

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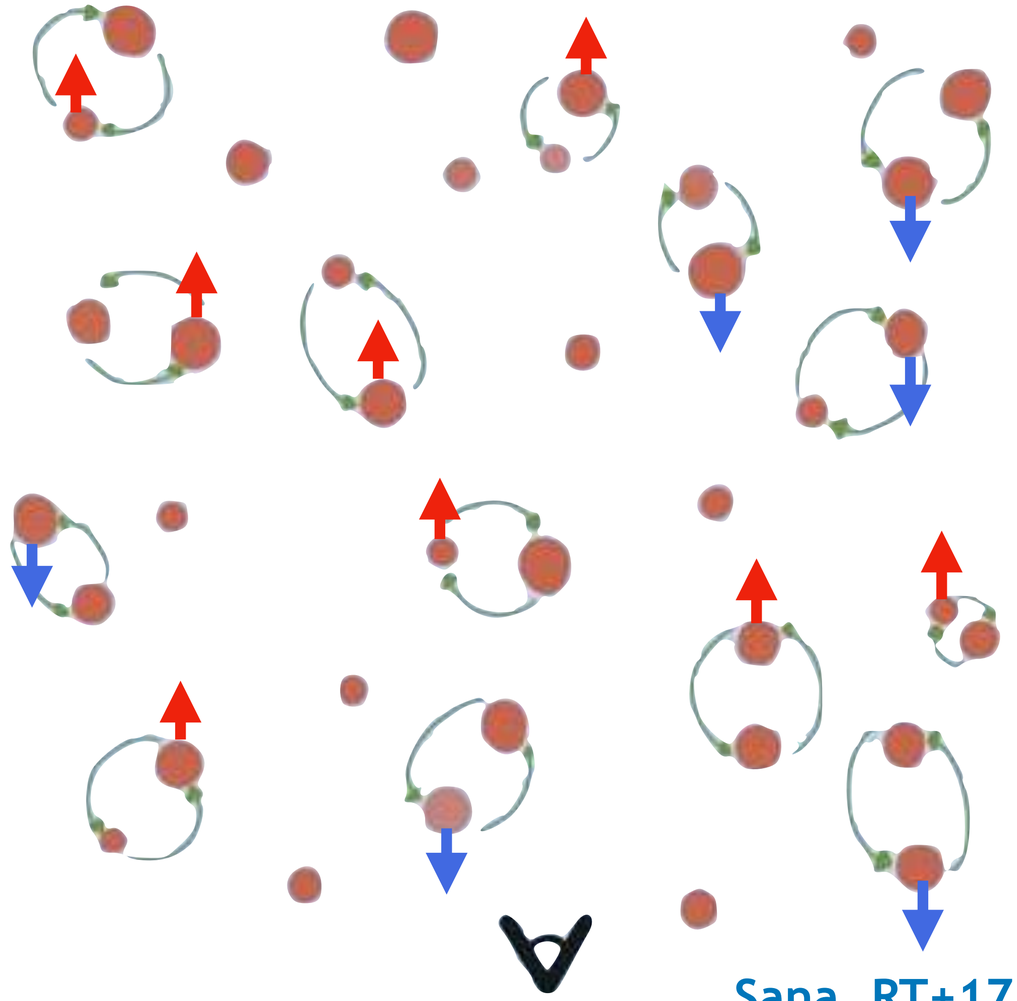

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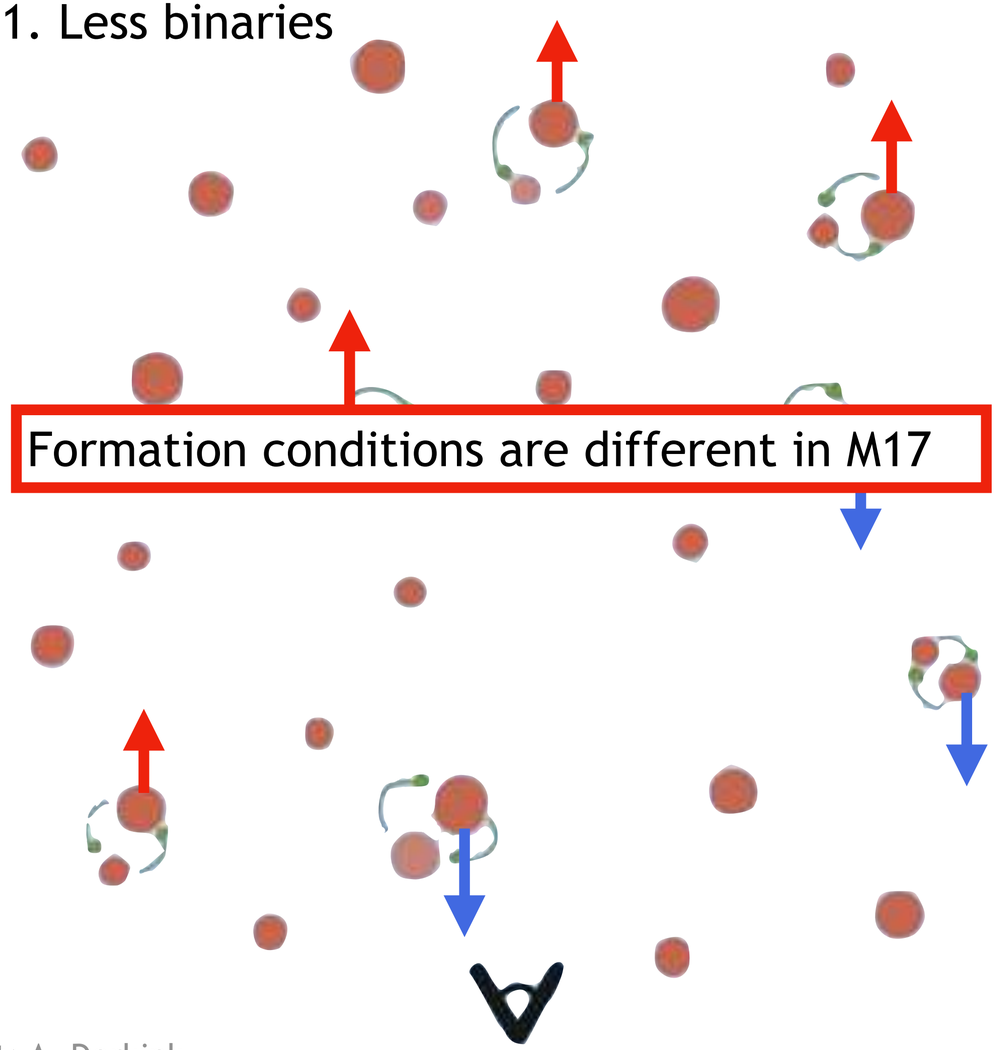

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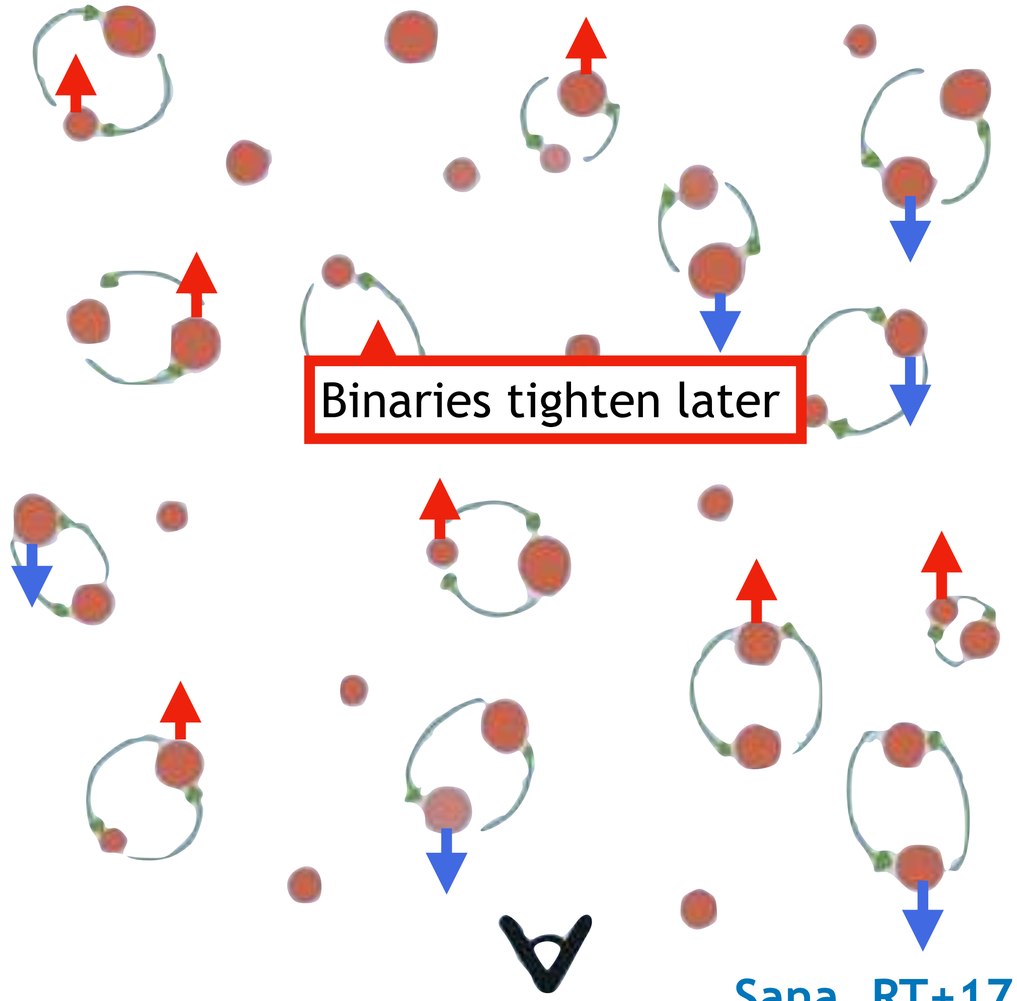

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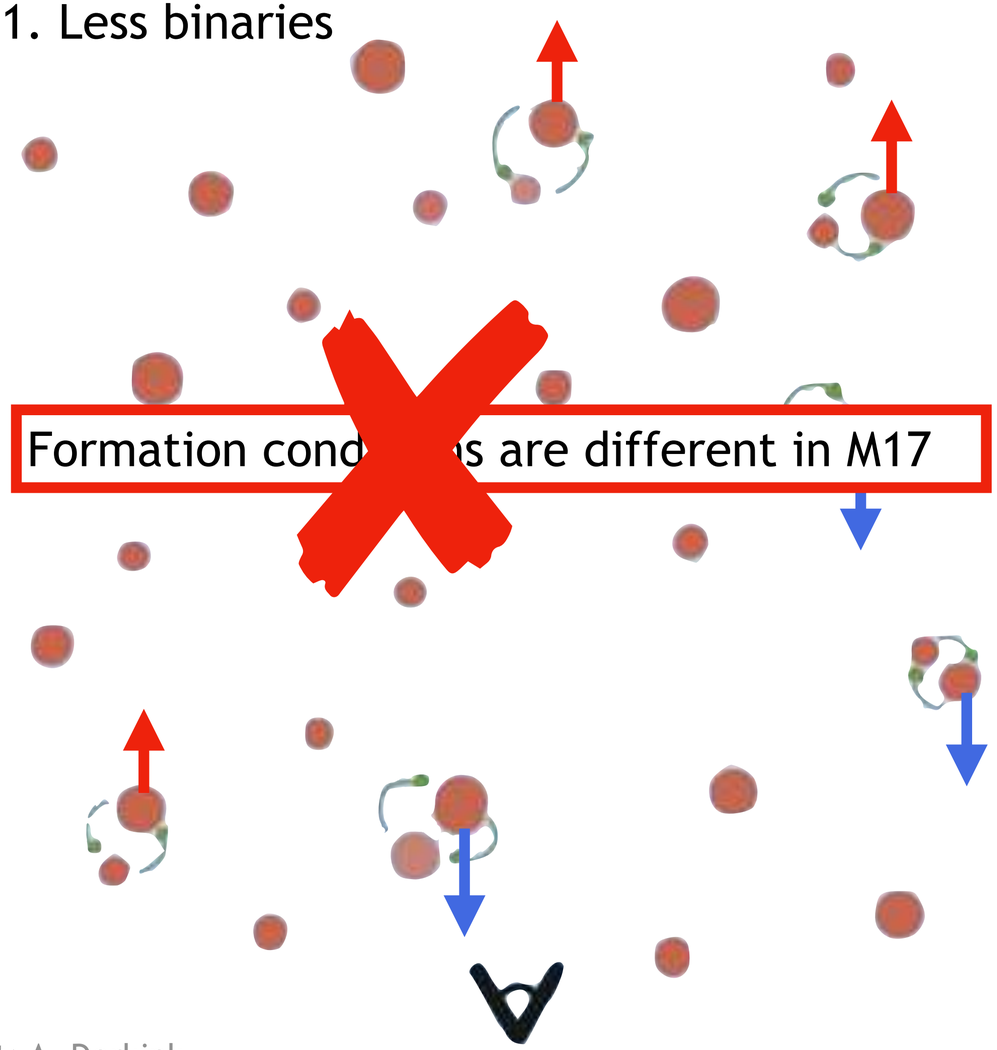

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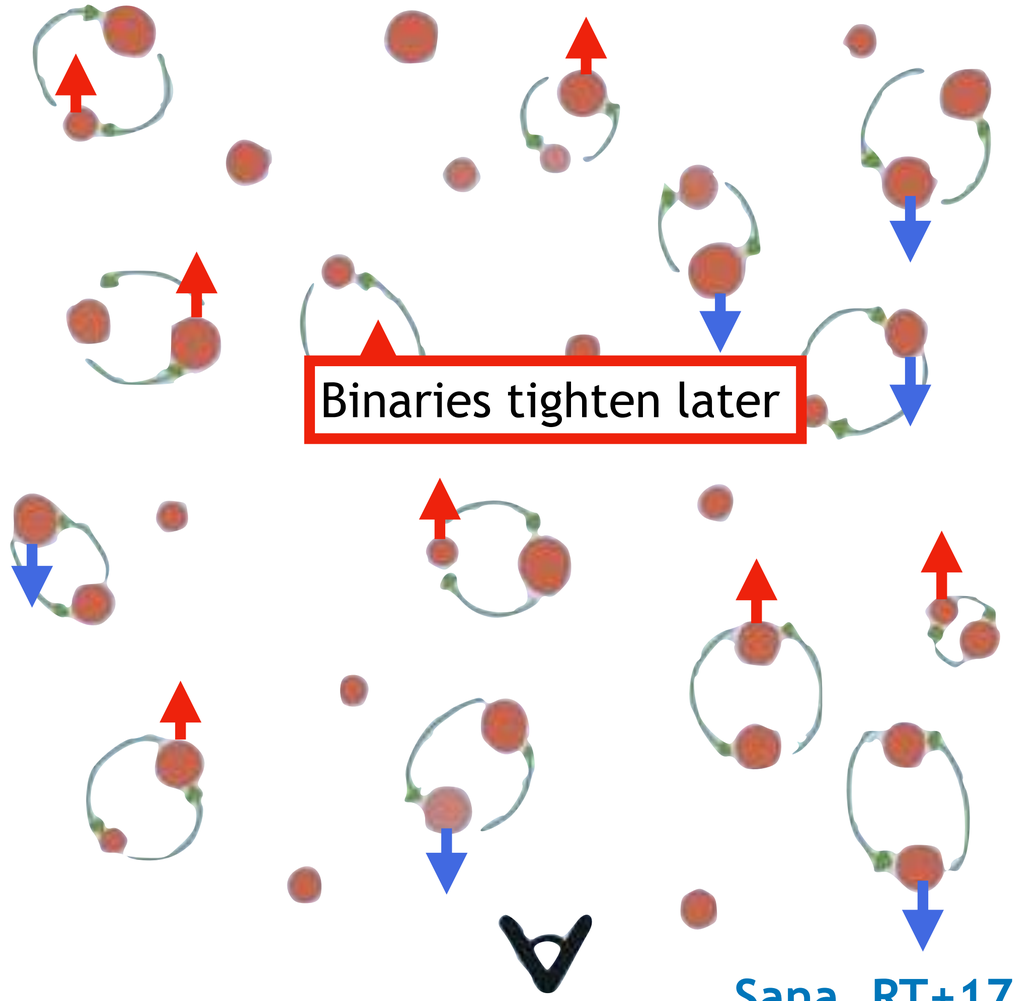

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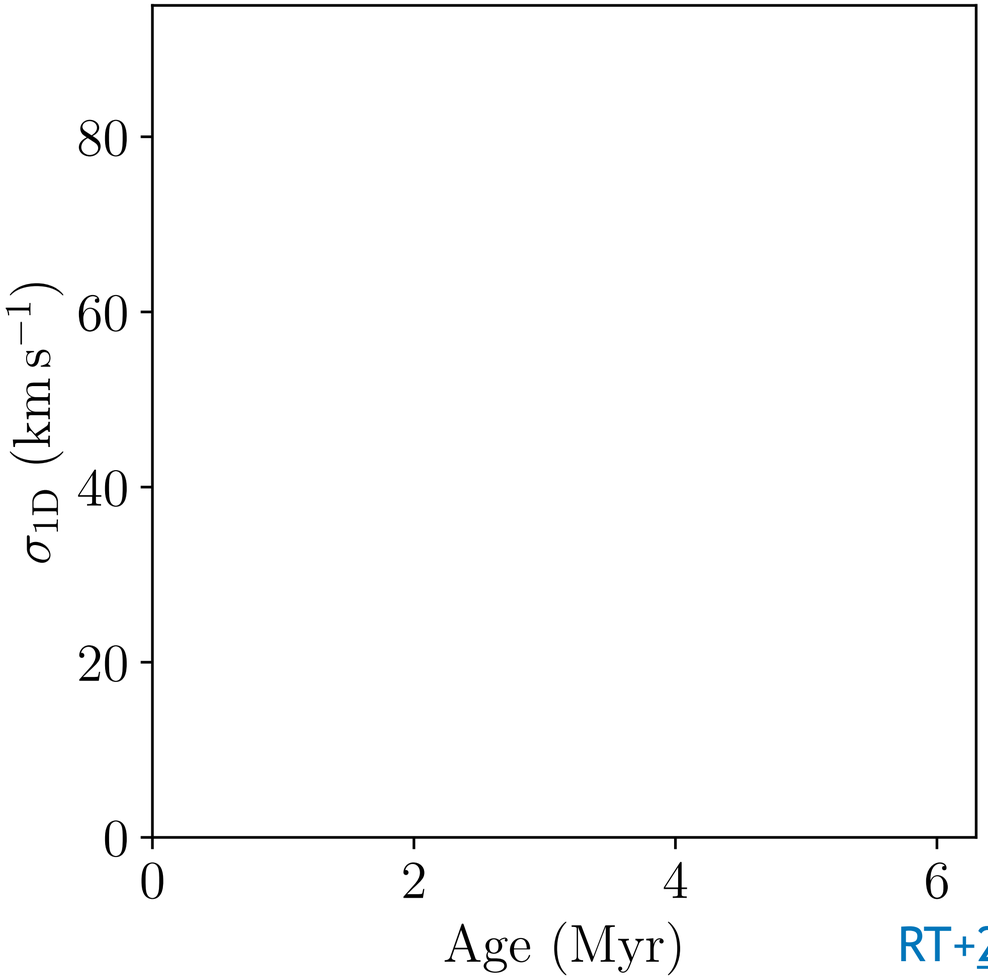
If binaries are born in wide orbits...



RT+21,24

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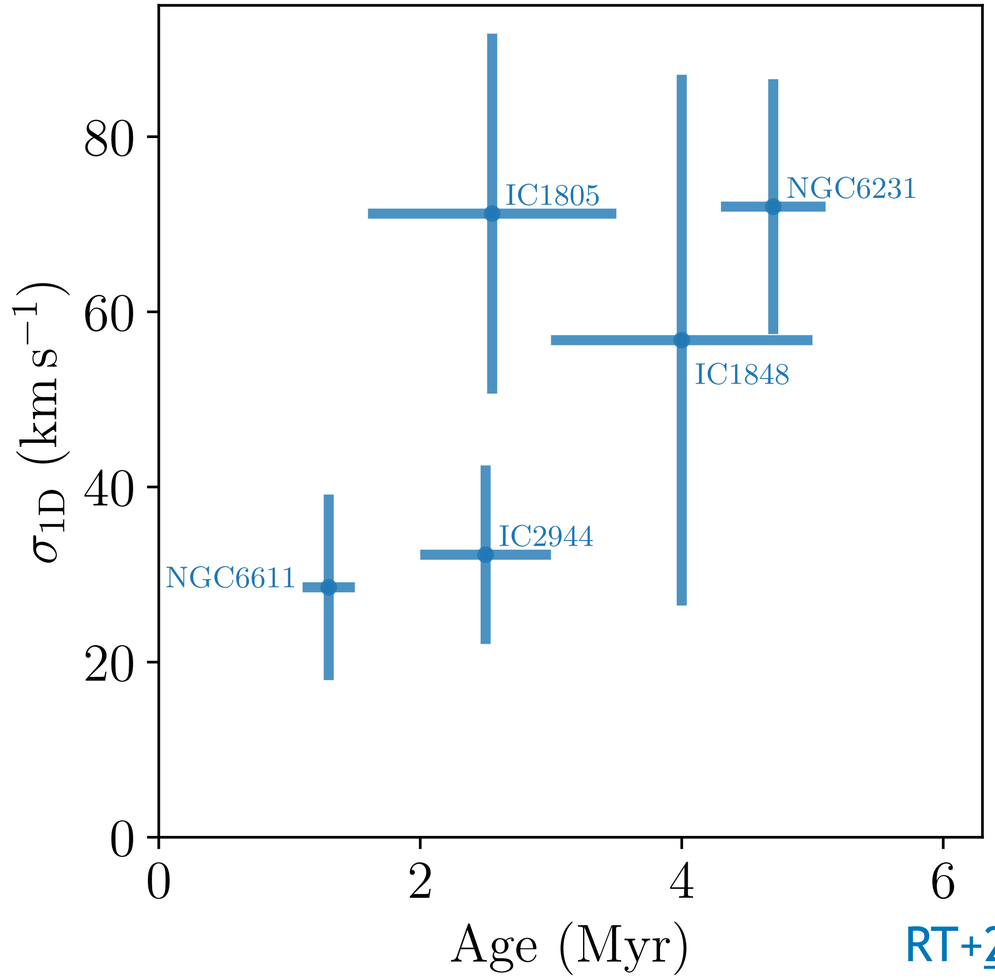
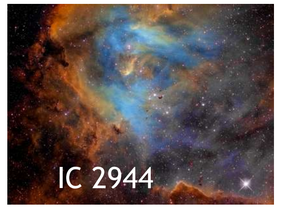


RT+21,24



Sana+12

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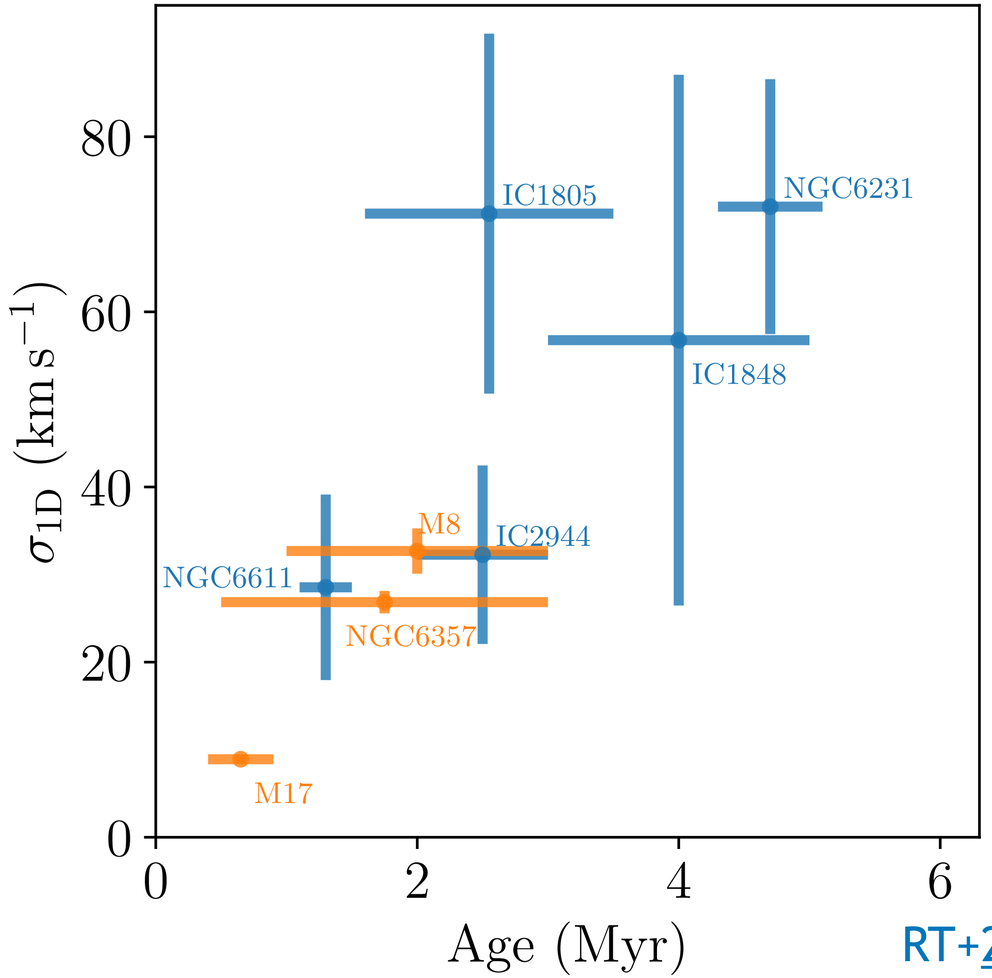

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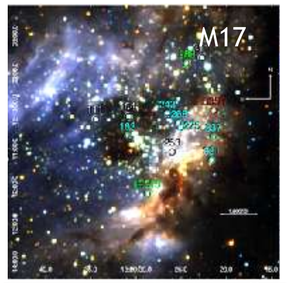
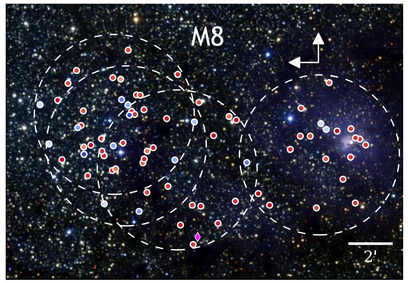
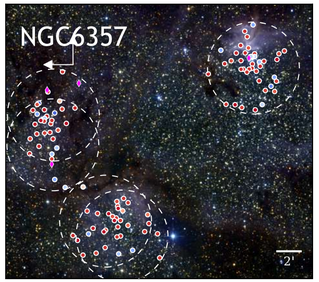
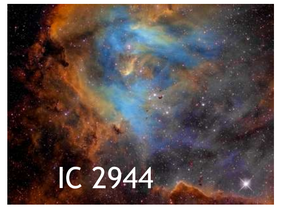






Ramírez-Tannus+17,20



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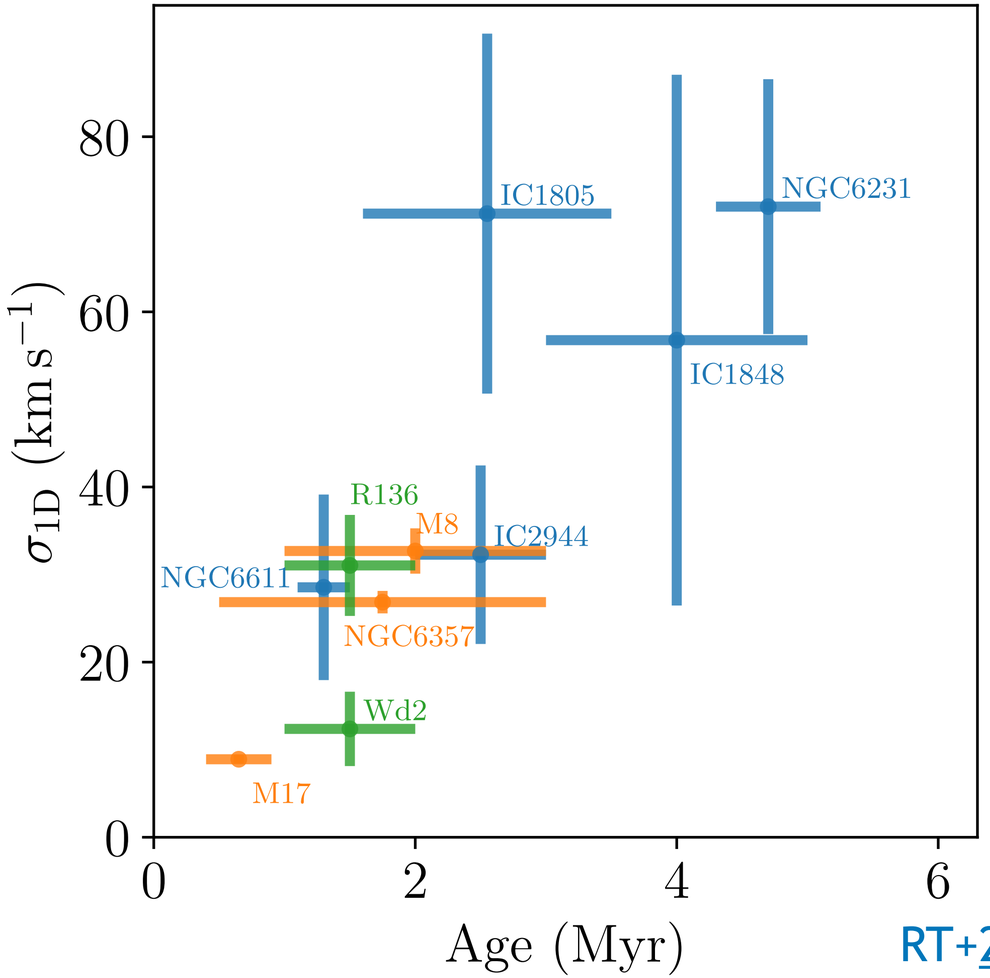

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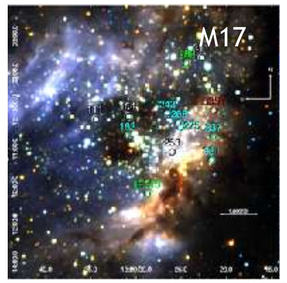

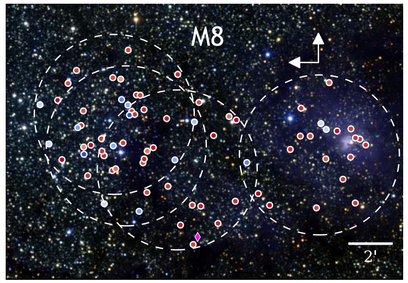

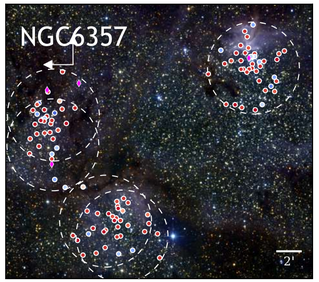

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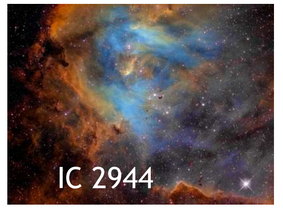

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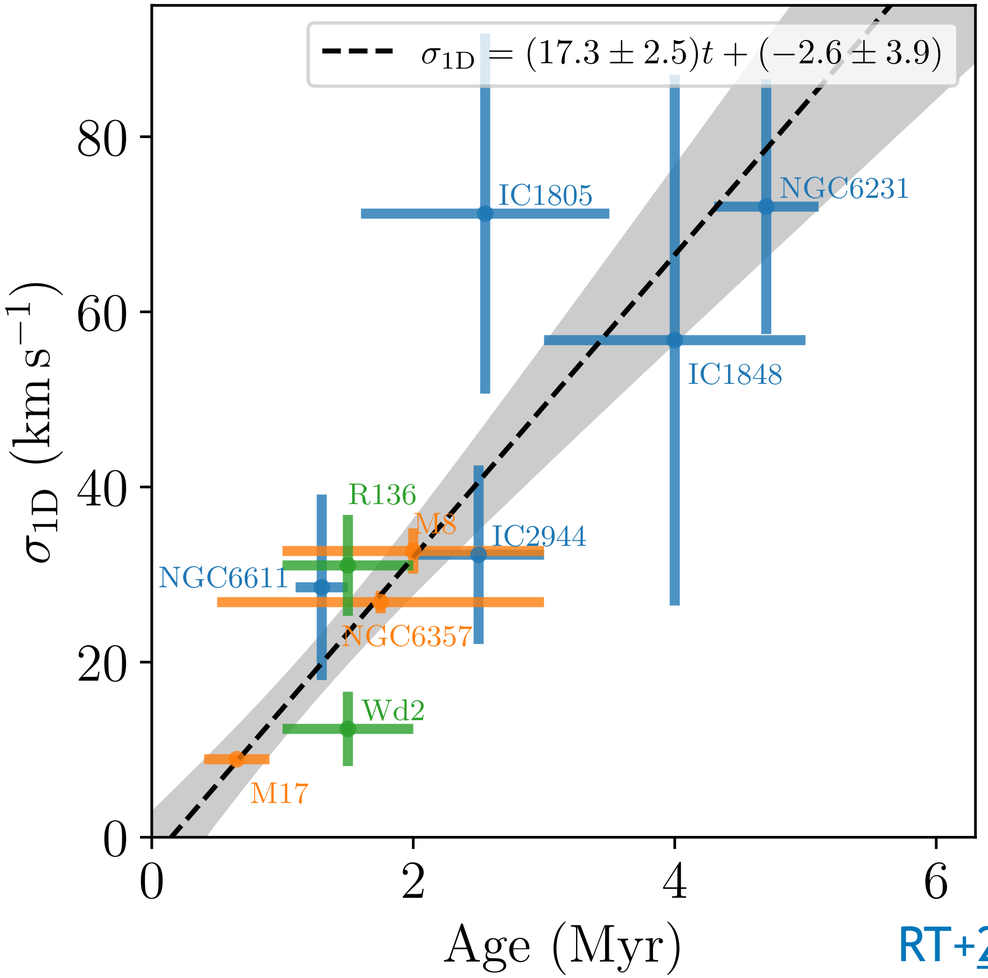

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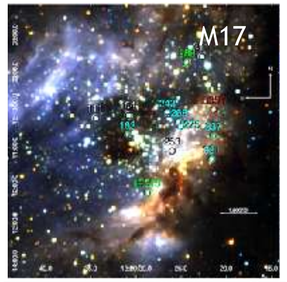

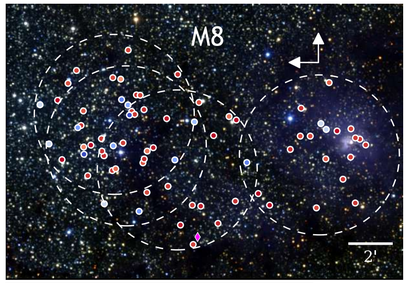

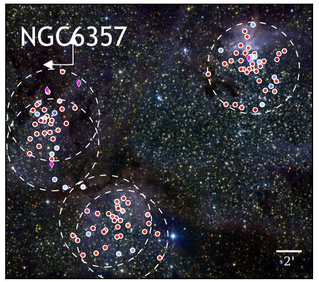

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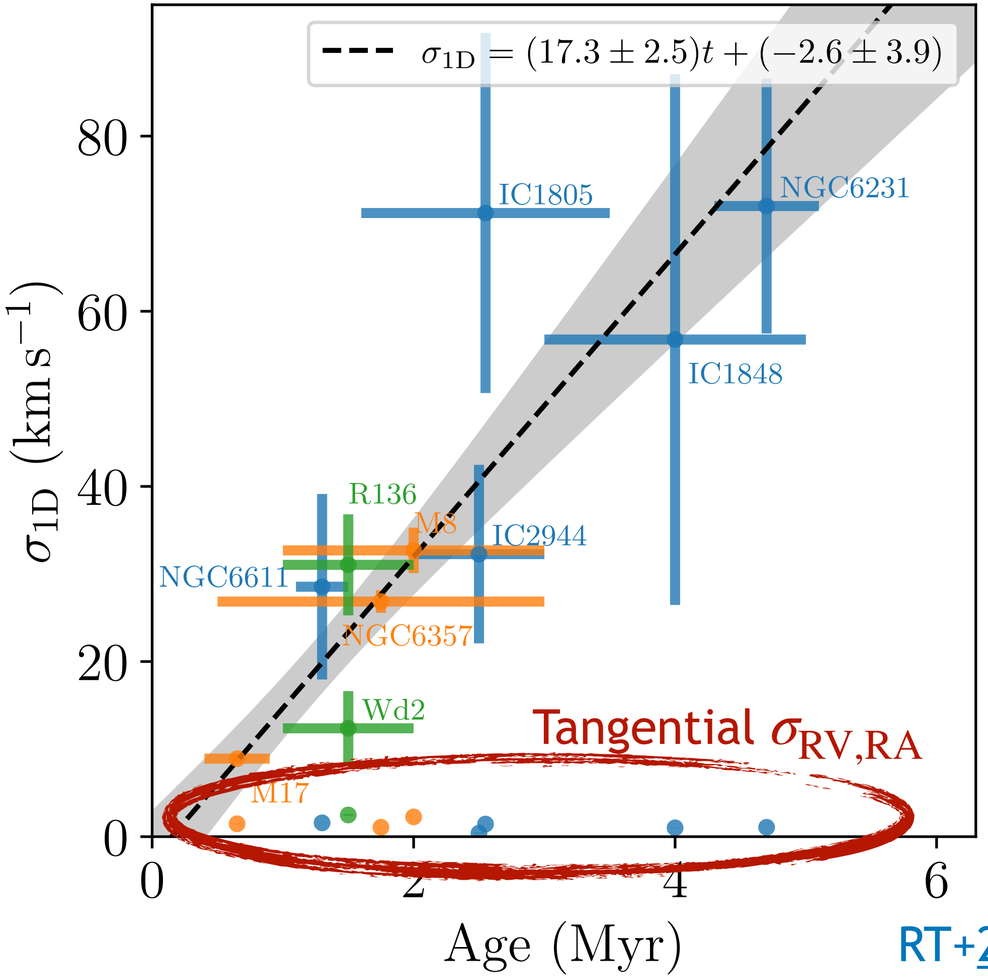

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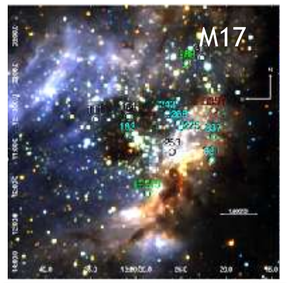

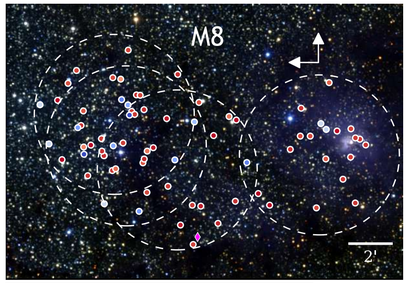

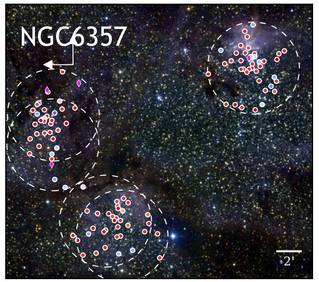

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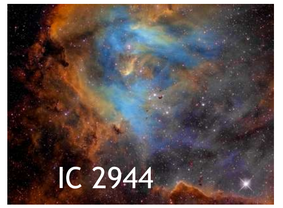


Sana+12

The puzzle

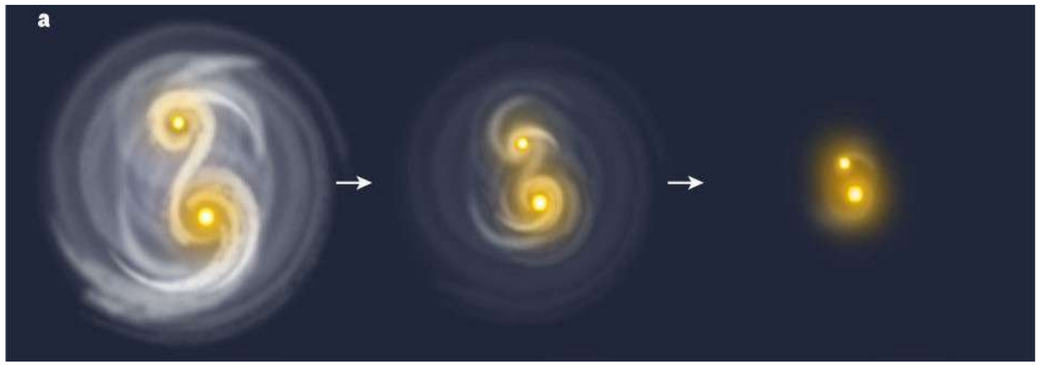
Poorta+25

How to shrink these orbits?

How to shrink these orbits?

1. Interaction with a disk

Poorta+25



Geller 2017

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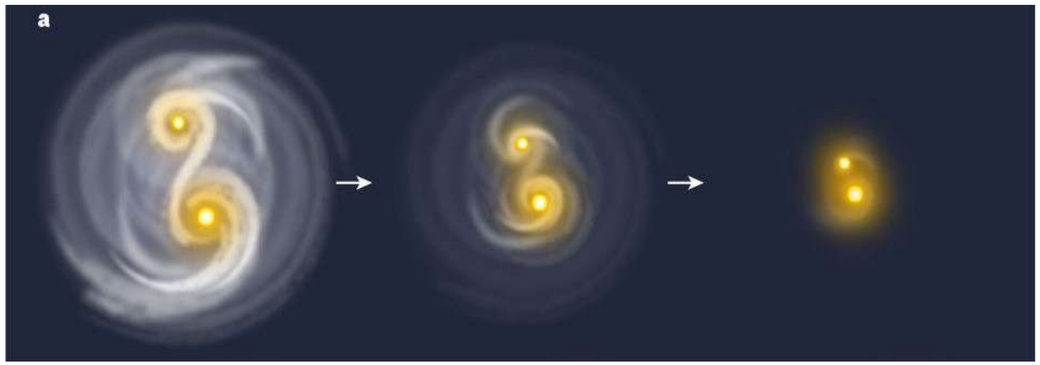

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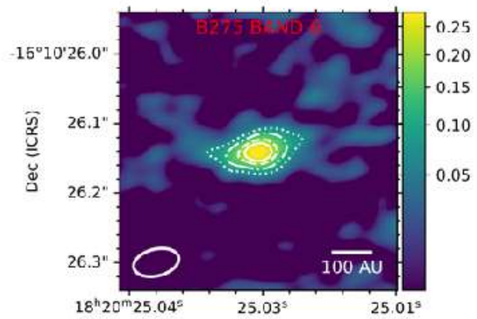

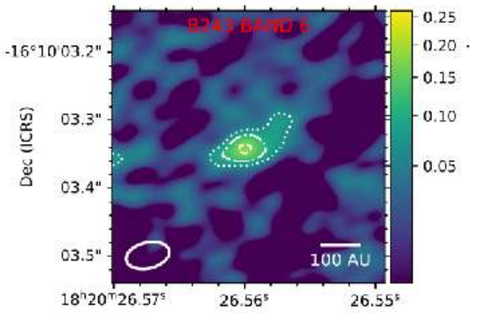

Compact disks

Dust masses are (at most) a few $M_\oplus$

How to shrink these orbits?

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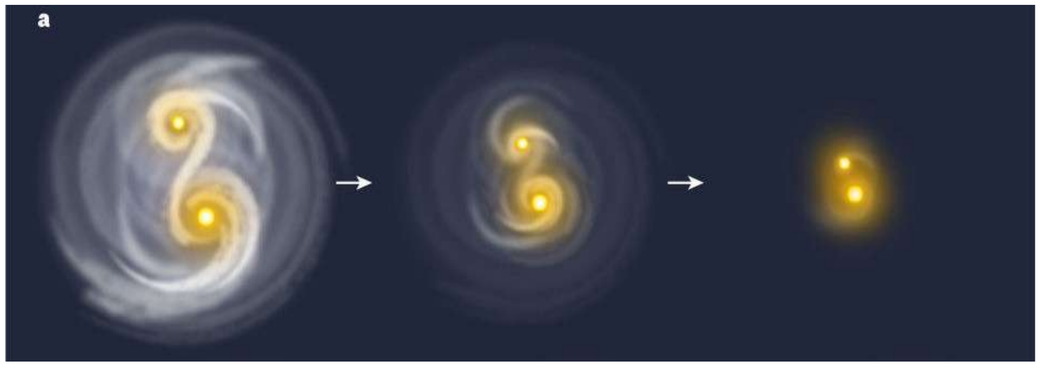
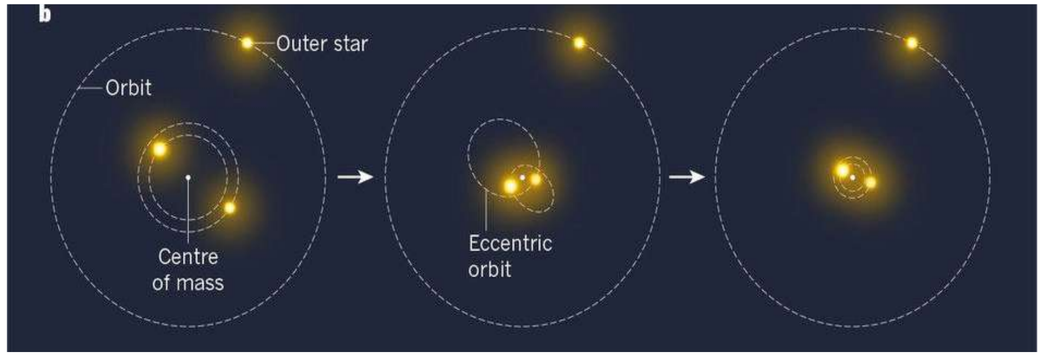


Geller 2017, Nature 547, 41

2. Triple systems

Bordier+22



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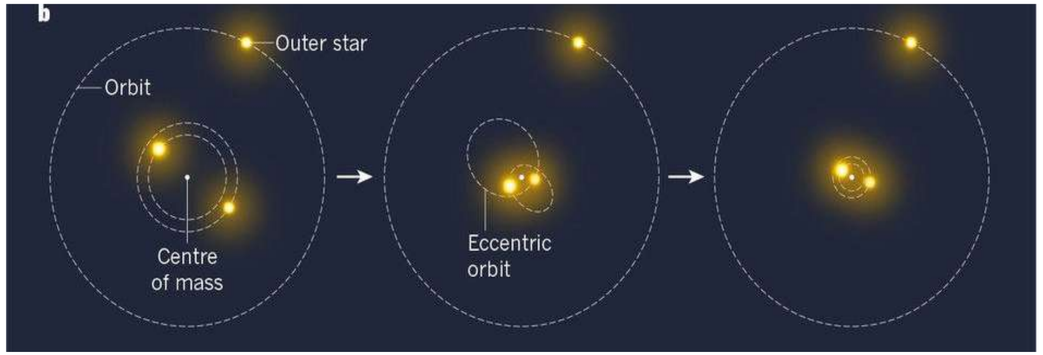
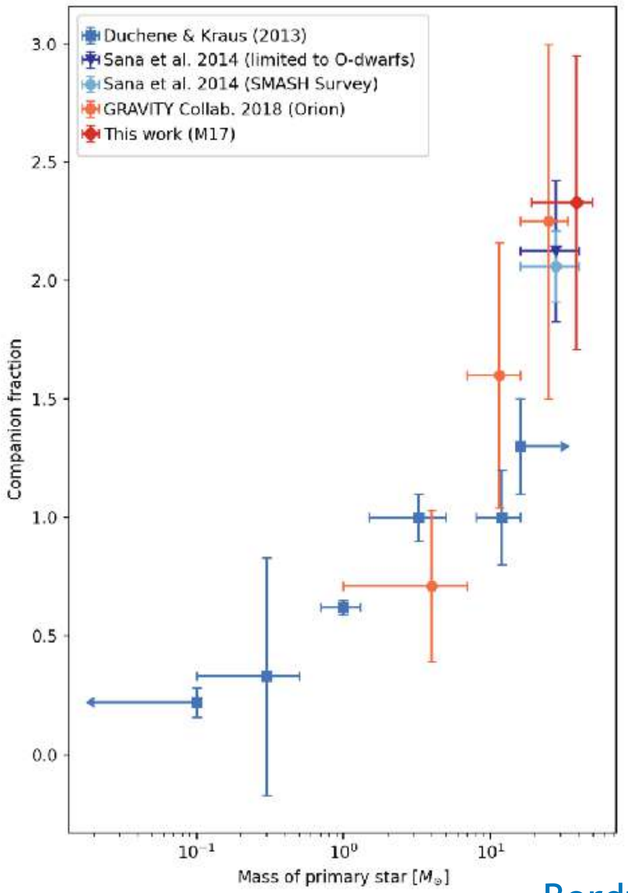


Geller 2017, Nature 547, 41



Bordier+22

At least 2 companions per system

All companions within ~120 au

How to shrink these orbits?

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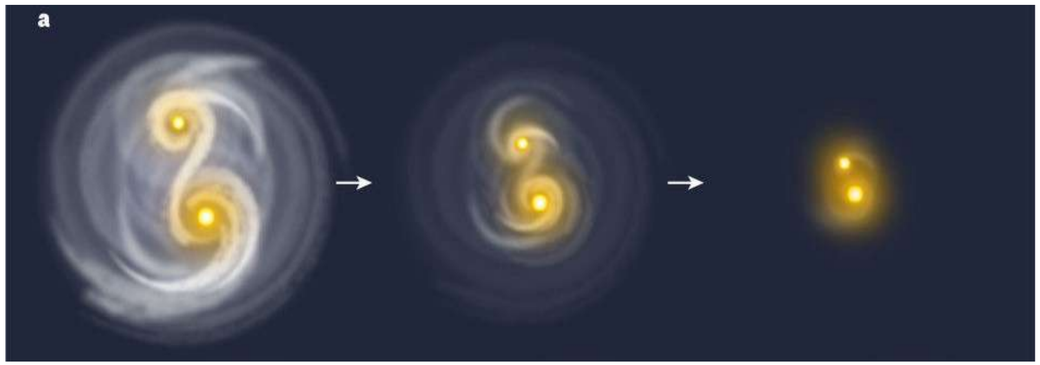
Poorta+25



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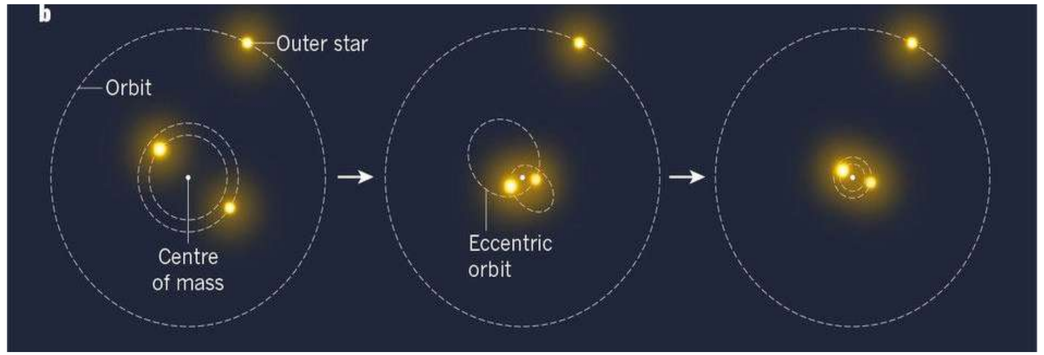

3. Dynamical interactions

Stoop+24

NASA, ESA, and Z. Levy (STScI)

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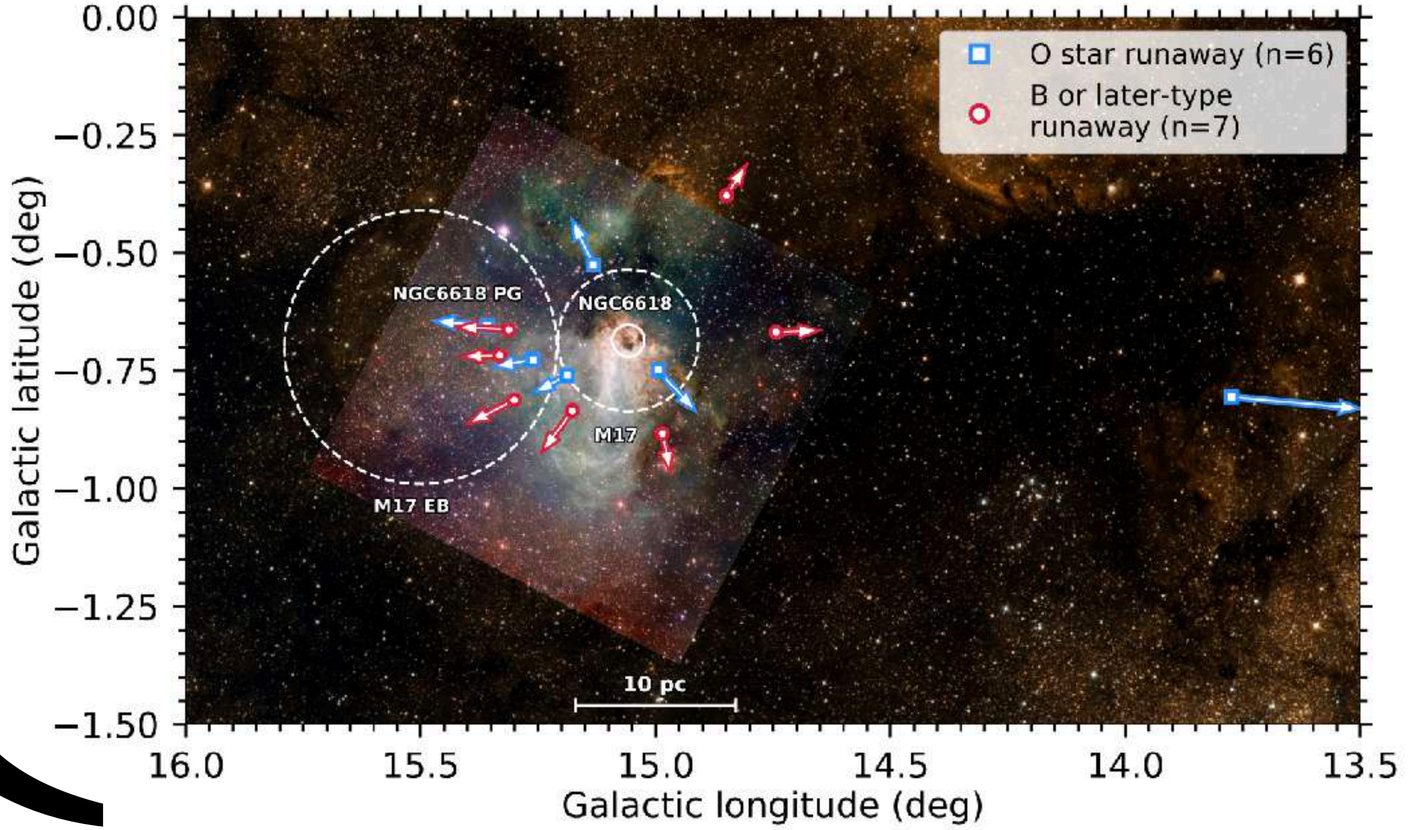
Stoop+24

NASA, ESA, and Z. Levy (STScI)

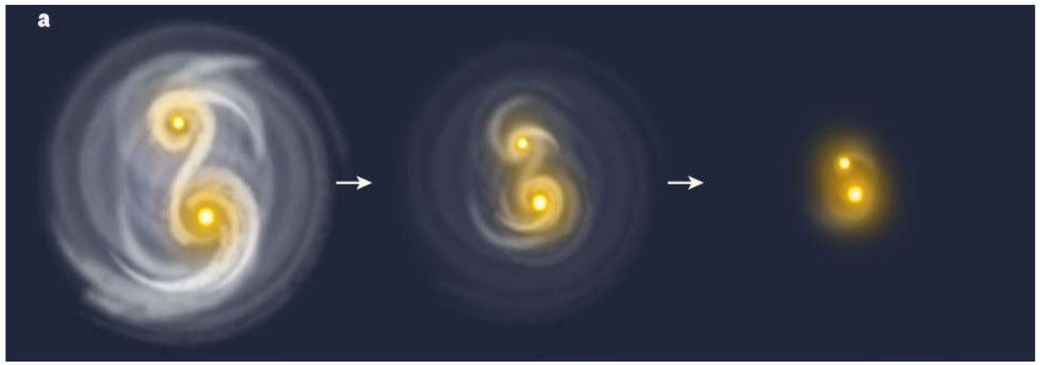


~30% of O stars have been ejected from the cluster

How to shrink these orbits?

1. Interaction with a disk

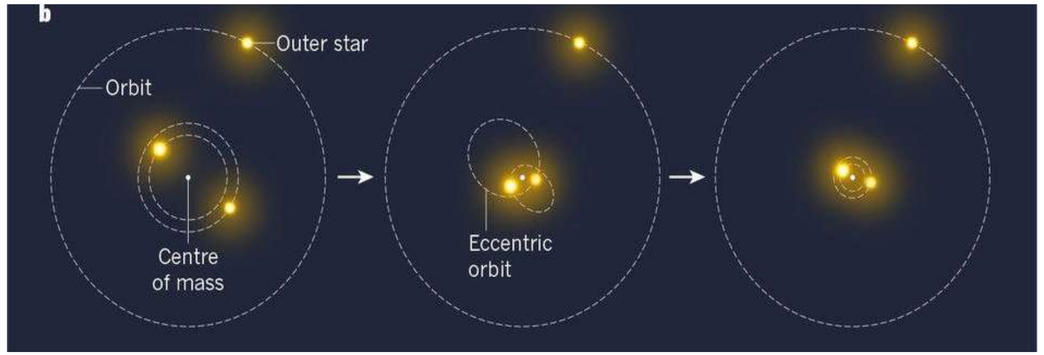
Poorta+25



Geller 2017, Nature 547, 41

2. Triple systems

Bordier+22



3. Dynamical interactions

Stoop+24

NASA, ESA, and Z. Levy (STScI)

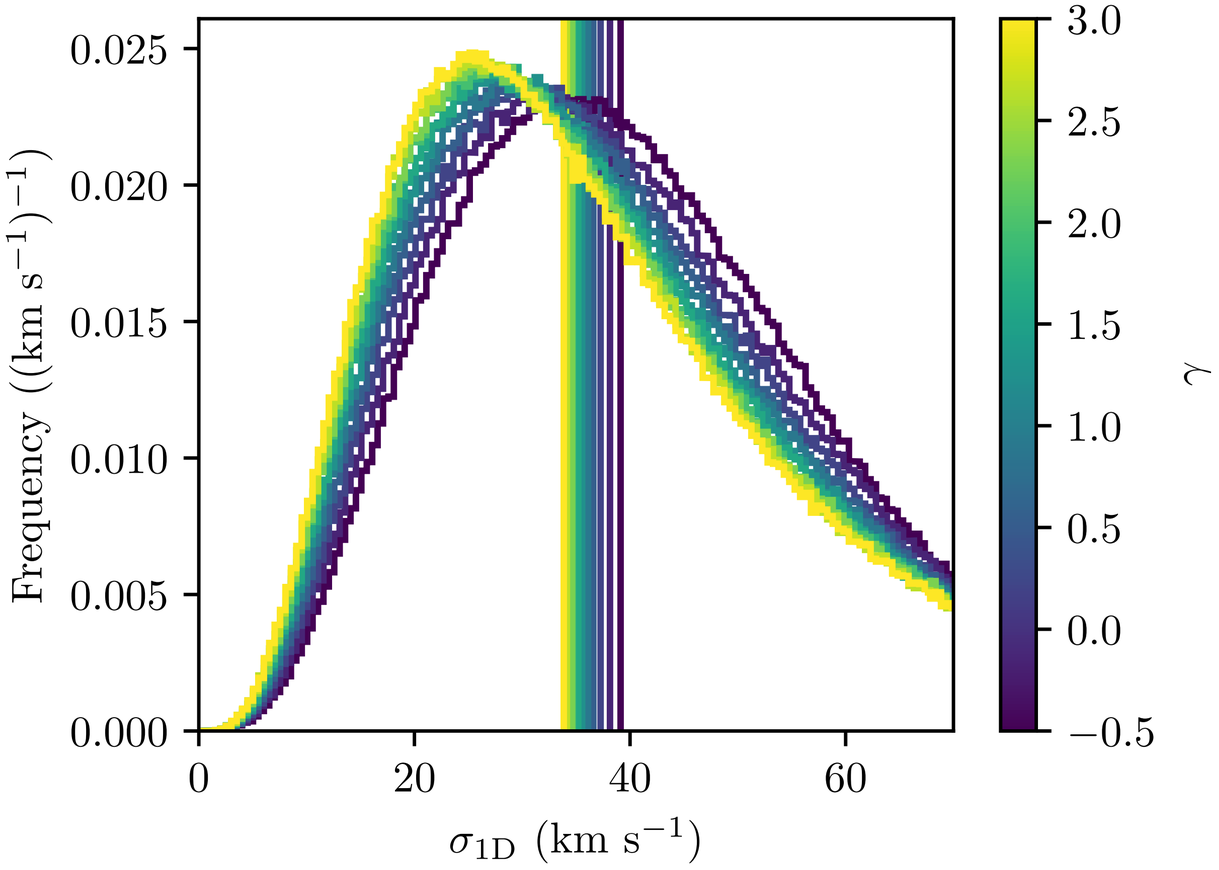
Observations

- Young massive binaries are in wider orbits than 2-4 Myr old binaries
- There are “too many” runaway OB stars
- Most have third companions
- Disks don’t seem massive enough

Puzzle(s)

- **What is/are the physical mechanism(s) responsible for binary hardening?**
  - Can the tertiaries aid the hardening process in a few Myrs?
  - Are dynamical interactions still relevant after formation?
  - Magnetic fields :)?
  - …

Eccentricity



The effect of changing the power index of the eccentricity from -0.5 to 3. Is not enough to reproduce the RV-dispersion observed in M17