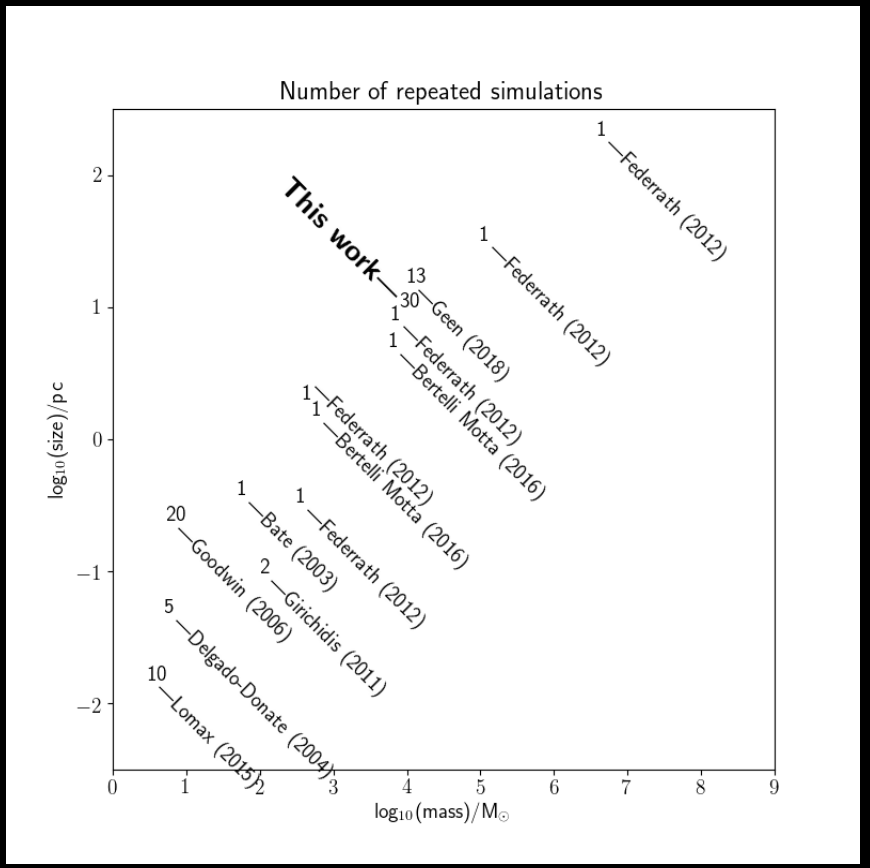
Star formation is chaotic!

Star formation involves several non-linear processes acting over a large range of size, density and energy scales. This makes it formally chaotic - a **small change in initial conditions** can have a large effect on the outcome.

Simulations often try to include as much physics as possible and maximise resolution, leading to **long computational time**. Most simulation studies perform **only one or a handful of realisations**, particularly above the scale of individual star-forming cores.



Methods

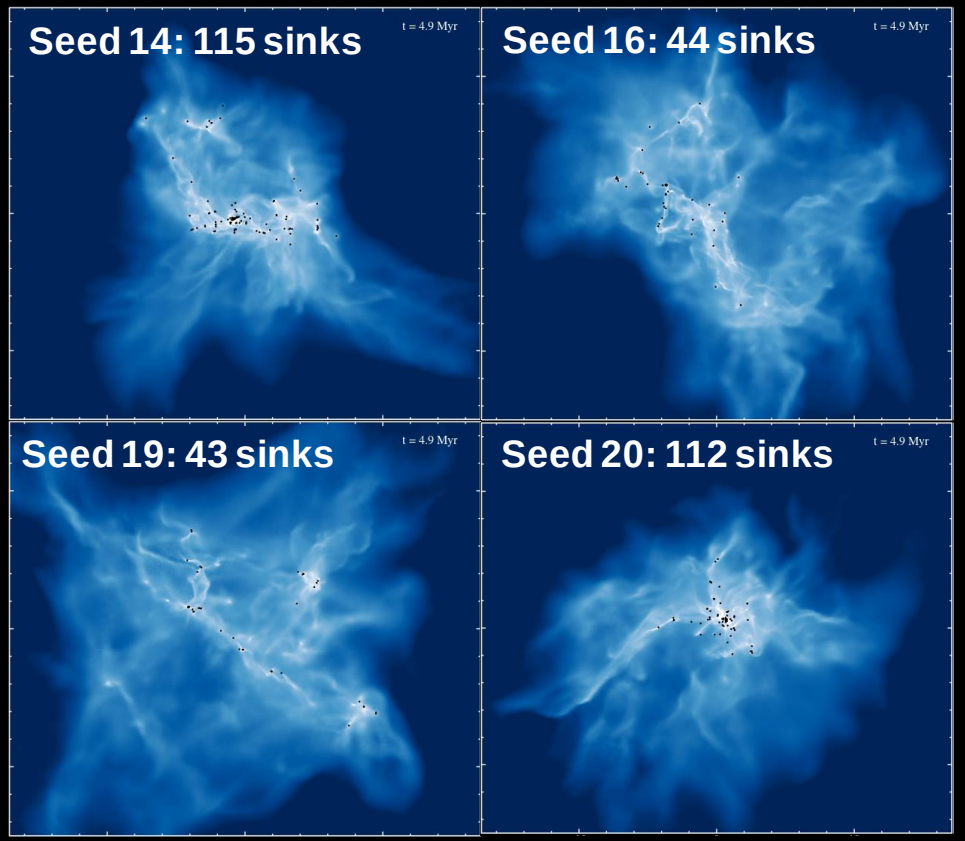
Turbulent velocities are randomly generated

Most simulations include at least self-gravity and turbulence. The **turbulent velocity field (TVF) is randomly generated**, and its exact morphology can affect where dense gas collects and therefore **how and where star formation proceeds**!

I have performed **30 SPH simulations** of one physical setup, changing only the **random seed** used to generate the TVF.

This changes the **detail of the TVF** but the power spectrum, solenoidal vs. compressive fraction, Mach number and **everything else is kept the same**.

Selected simulations at 5 Myr



Preliminary results

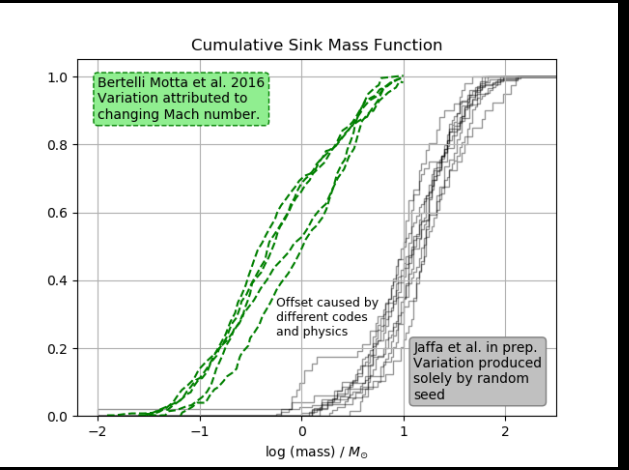
IMF and SFE show significant variation

MASS FUNCTION

Bertelli Motta et al. 2016 (BM16) performed 5 simulations, **changing the Mach number** of the turbulence. Their **IMF shifted to higher masses** (green dashed lines to the left of the plot).

My simulations show a **variation of the same order** without changing the Mach number, **just due to the initial TVF** (grey solid lines to the right of the plot).

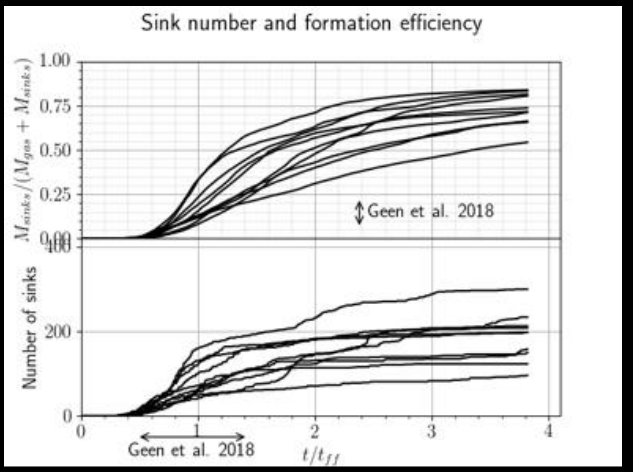
It is well known that the **density, resolution and choice of physics** can shift the IMF, which explains the **offset** between my results and BM16. I plan to **repeat this experiment with different setups** to investigate the parameter space.



SINK FORMATION EFFICIENCY

The **SFE and number of sinks varied greatly**.

Geen et al (2018) performed 13 AMR simulations and found a much greater variation in the onset of star formation (horizontal arrow) but a much smaller variation in SFE (vertical arrow). I plan to test different numberical methods to provide a benchmark.



Conclusions

Randomly generated turbulence affects simulation in unexplored ways!

- The long runtime for state-of-the-art simulations means repeated experiments are rare.
- We have not thoroughly investigated how randomly generated turbulent velocity fields affect the results.
- Preliminary work suggests the variation in IMF and SFE can be of the same order as results attributed to changing physical setups.

FUTURE PLANS:

- Investigate different metrics used in literature: Mach number, virial ratio, morphology of gas and clusters, dense gas fraction...
- Change initial conditions: mass, density profile, resolution, sink density...
- Additional physics: radiative and mechanical feedback, stellar evolution, different EOS...
- Create identical setups using different codes: Phantom SPH vs. Gandalf SPH, SPH vs. AMR vs. MM...

If you think this work is interesting, important or wrong, **contact me** to collaborate at s.jaffa@herts.ac.uk, or **hire me** in August 2021.