Formation of Filaments/Feathers in Disc Galaxies: Is self-gravity enough?

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What are Feathers (?)

- Dense, dusty, filamentary kpc scale features in disc galaxies
- Sites of embedded star formation, visible in infrared emission and dust attenuation maps

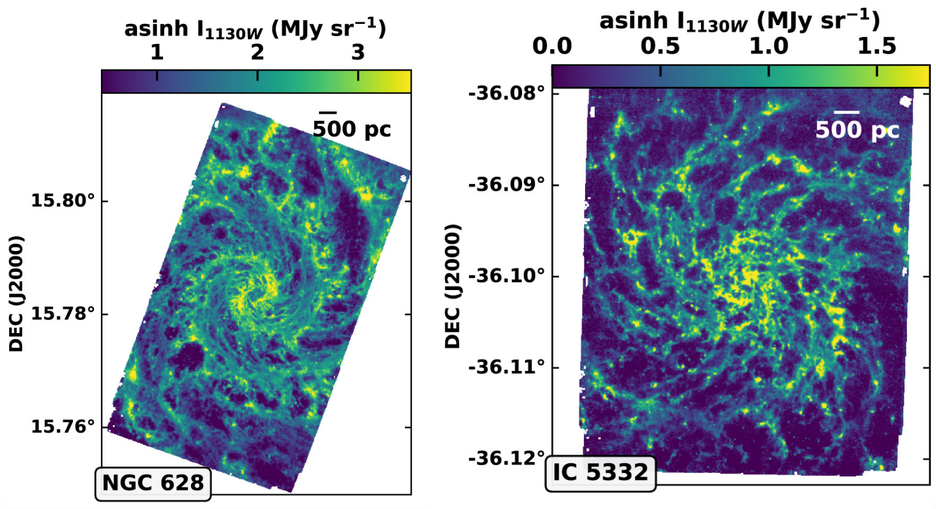
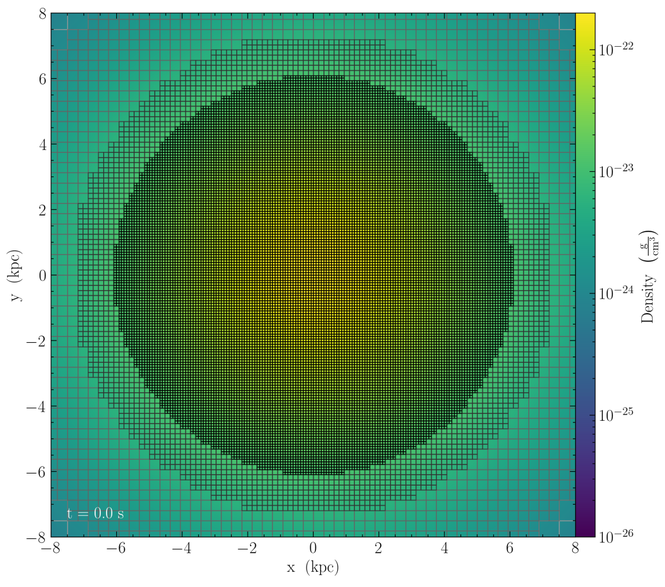


Fig: **JWST/MIRI** 11.3 micron images of 2 nearby galaxies Meid et. al. 2023.

Simulations

- Hydrodynamical simulations in adaptive mesh refinement code FLASH (Fryxell et. al. 2000)
- 3D, isothermal, high-resolution ($\Delta x \simeq 5$ pc), self-gravitating global disc galaxies initialised in equilibrium



- Two dimensionless parameters uniquely characterise our galaxies

$$Q = \frac{\kappa c_s}{\pi G \Sigma} \qquad \mathcal{M}_c = \frac{v_c}{c_s}$$

- Parameter space spanning $Q \in \{1,2,3\}$ and $\mathcal{M}_c \in \{14, 21, 29, 36\}$ corresponding to v_c in (100-250) km s^{-1} and $c_s = 7$ km s^{-1}

Result: Self-gravity's triumph

- $Q = 1$ runs forms feathers/filaments, while $Q = \{2,3\}$ runs are stable
- Quantified by a raise in the standard deviation of the clumping factor (η) of the galaxy

$$\eta = \ln \frac{\Sigma}{\langle \Sigma \rangle}$$

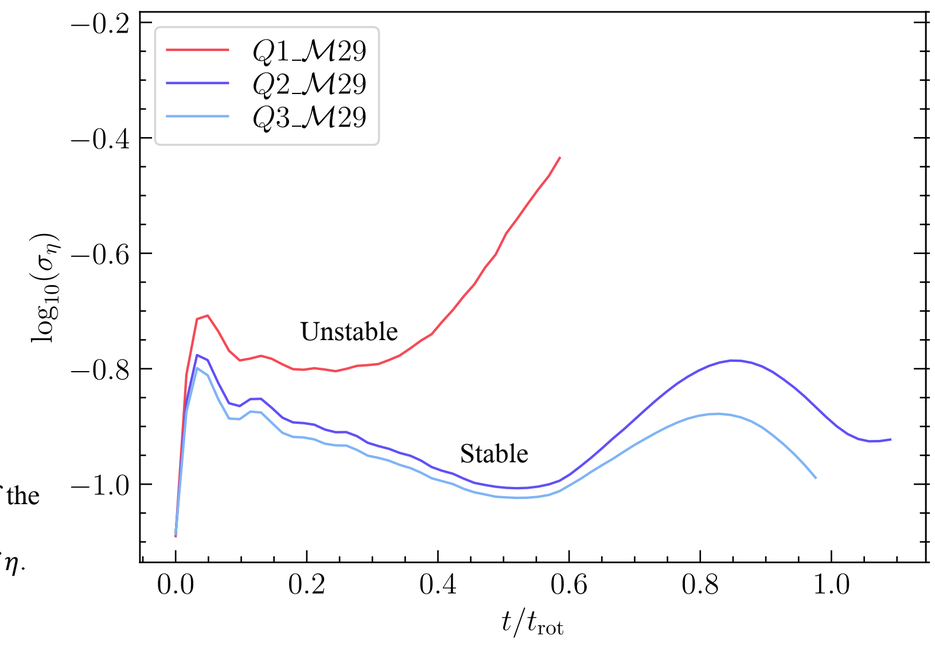


Fig: Time evolution of the standard deviation of η.

Increasing Toomre-Q

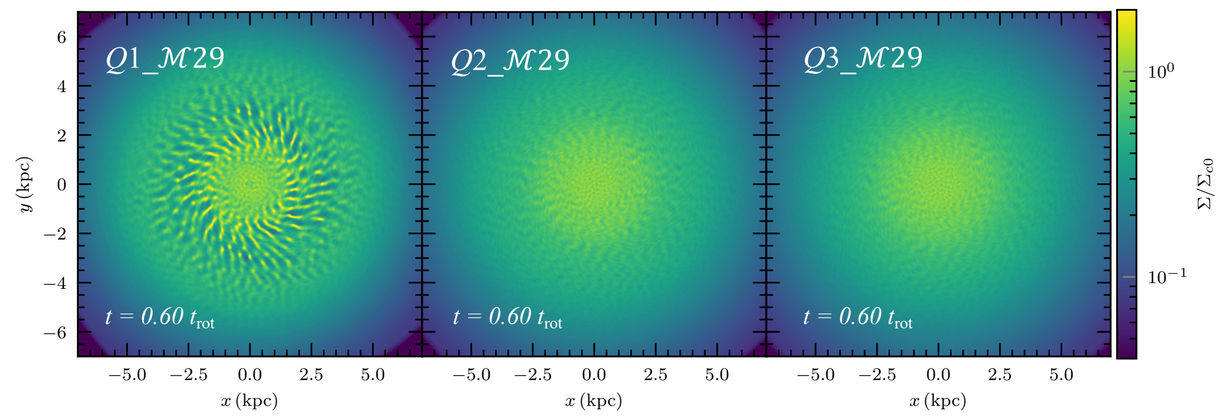


Fig: Projected density maps of simulations with varying Toomre-Q.

Result: Different kinds of feathers

- Properties of the feathers depend upon the $\mathcal{M}_c$ of the galaxy
- The inverse of feather spacing is linearly dependent upon $\mathcal{M}_c$

Increasing $\mathcal{M}_c$

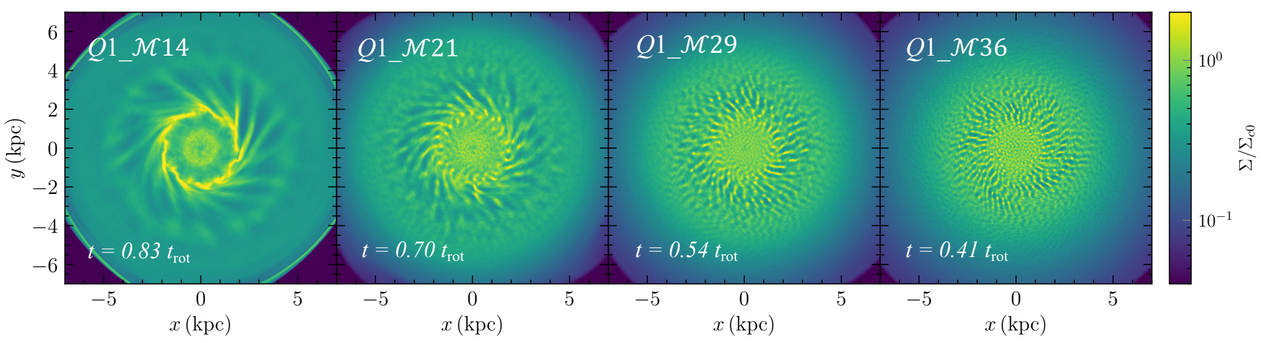


Fig: Projected density maps of simulations with varying $\mathcal{M}_c$.

- Good agreement with observations of feather spacing of nearby galaxies

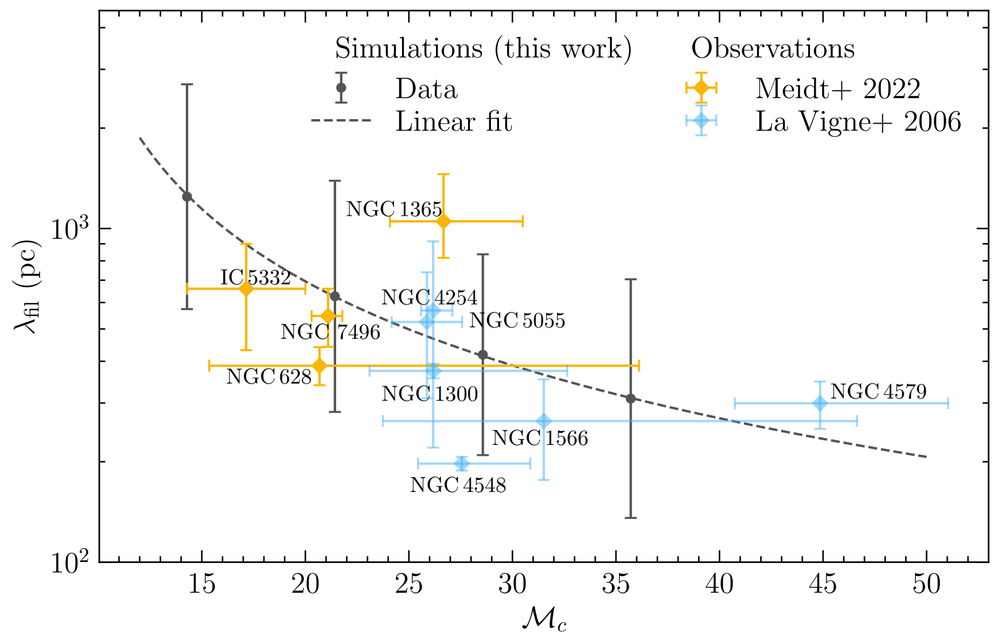


Fig: Filament spacing (λ_{fil}) of nearby galaxies, compared with our simulated galaxies.

References

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