Stellar feedback in interacting Giant Molecular Clouds

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Abstract

We extract sub-regions from galaxy evolution models and re-simulate at higher resolution with improved stellar feedback. We include photoionization, stellar winds, self-gravity, and galactic potentials. Clouds interact together based on their inherited galaxy-scale dynamics - this is an essential improvement over isolated spherical cloud initial conditions. Photoionization increases the SFE/SFR, produces more dense cores, and dominates as the source of gas dispersal. Winds only produce small cavities (<30 pc), but affect how star formation is distributed across clusters.

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Paper

- Ali, Bending, & Dobbs, 2022, MNRAS, 510, 5592

1. Introduction

The thermodynamics of star-forming giant molecular clouds (GMCs) is primarily set by O stars via stellar feedback. The resulting heating, dispersal, and compression may affect the formation and properties of new stars/clusters.

Since GMCs/clusters interact with other GMCs/clusters, it is necessary to improve upon initial conditions of isolated spherical clouds.

2. Method: galaxy zoom-ins

- use smoothed-particle hydrodynamics (sphNG; Bate et al.)
- **extract 500 pc** from a MW-mass galaxy model (Dobbs et al. 2013)
    - GMCs form self-consistently
    - but feedback is very simple (SNe)

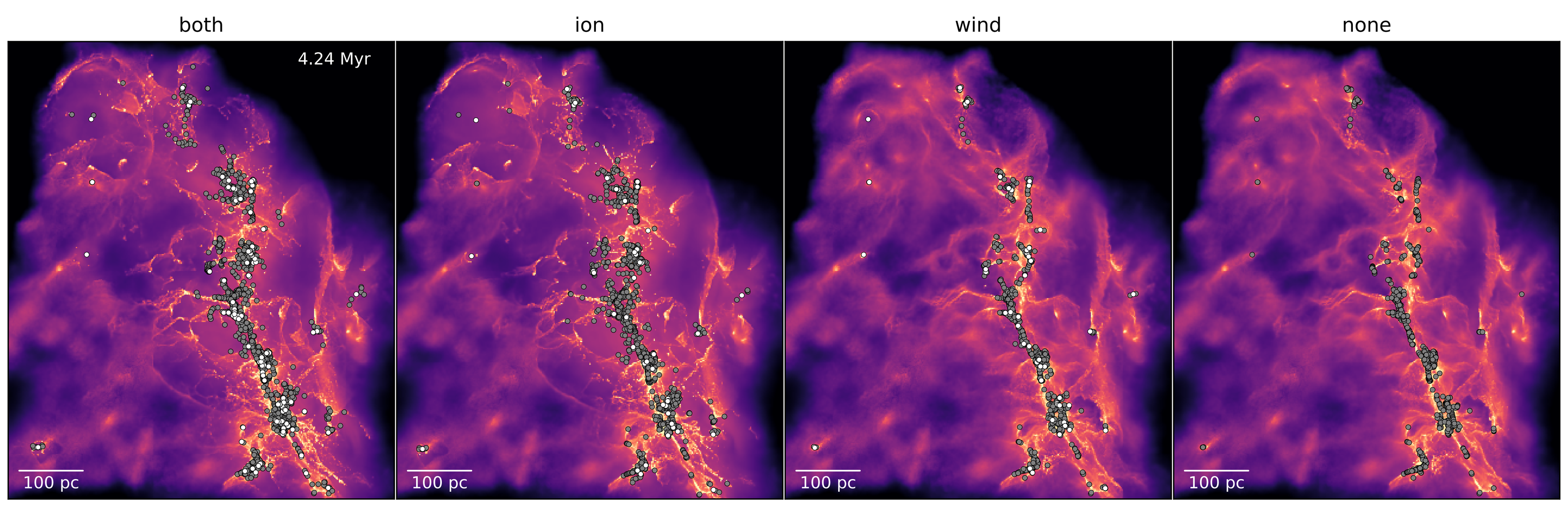
- **enhance resolution** to 1 $M_\odot$ per particle (particle splitting)
- GMCs inherit motions (e.g. from galaxy potential, shear, tidal forces)

Then evolve with:

- cluster-sink particles (1 sink represents many stars)
- **photoionization (ray-tracing)**
- **stellar winds (momentum-driven)**
- galactic potentials (e.g. spiral arms, disc, bulge, halo)

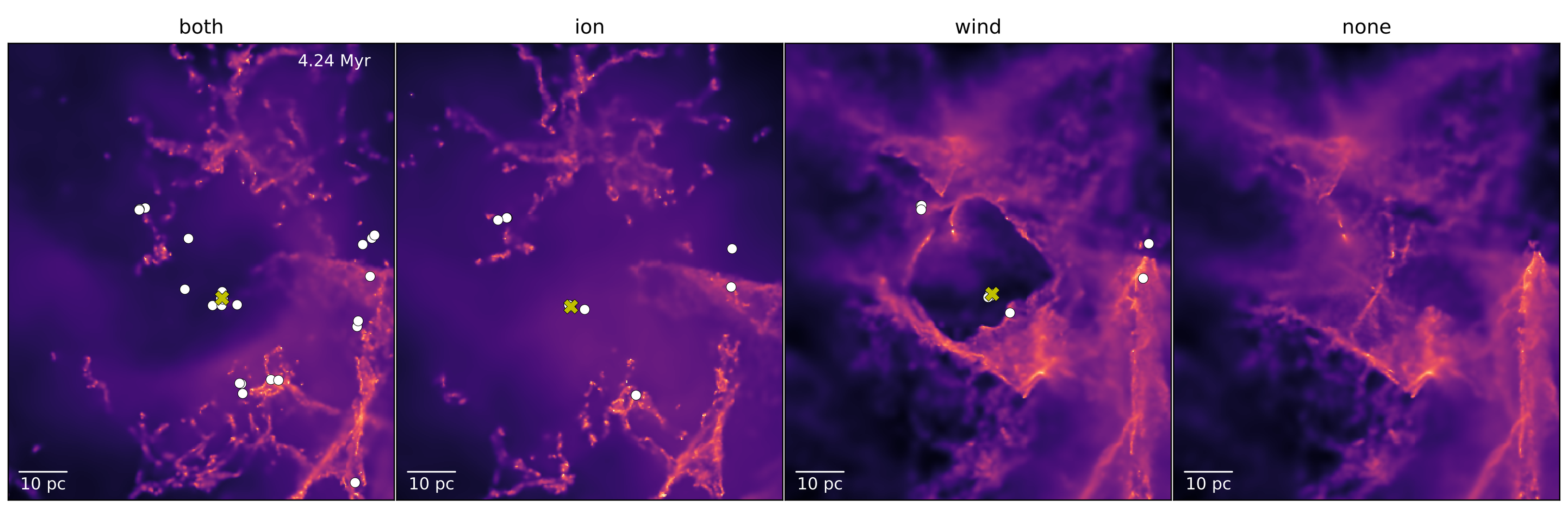
3. Results: gas dispersal

The region is disrupted as gas gets ionized and heated to 10^4 K. High-density gas resists the ionization front, creating neutral filaments/shells. Low-density gas streams out at the ionized sound speed (10 km/s). Winds create bubbles – if expanding into cold neutral gas, this is bounded by a dense shell (e.g. wind-only model).

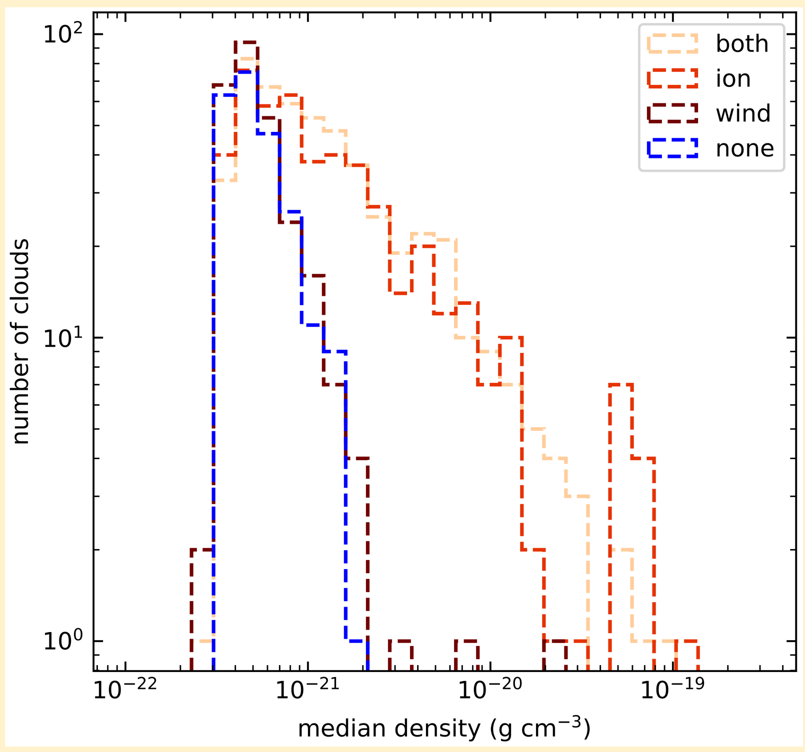


Above: *Column density snapshots. Title shows which feedback mechanism is included. Dots are sink particles – white dots emit feedback.*

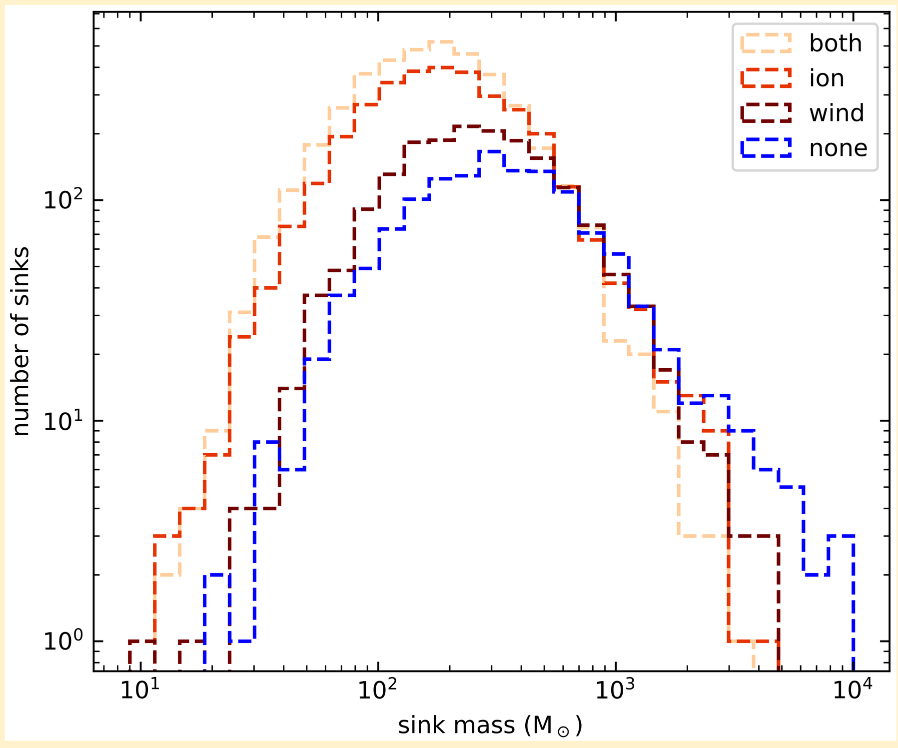
Below: *One sub-region highlighting the impact of winds (cavities) vs ionization (large scale dispersal).*



4. Results: core & sink properties



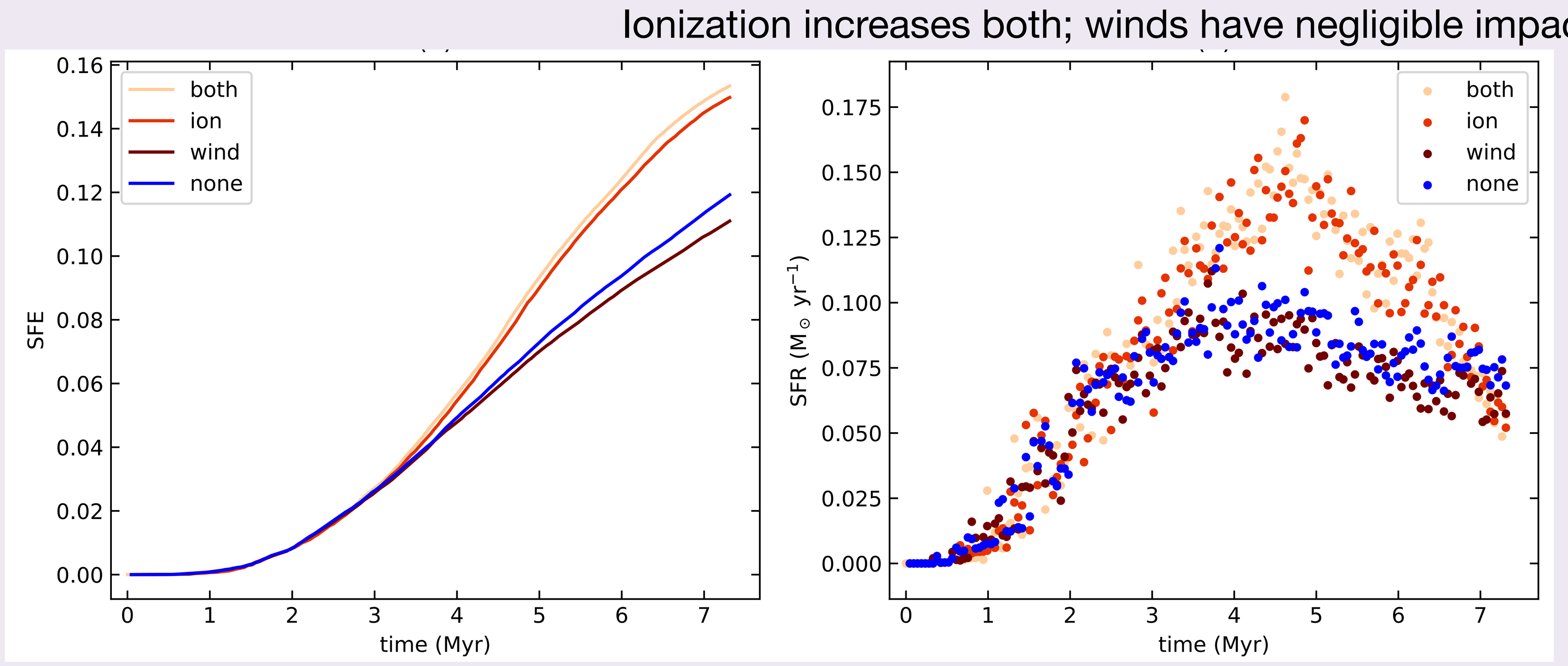
Left: histogram of core densities. Ionization creates 2x more cores, which are denser. Winds only add 10% more cores.



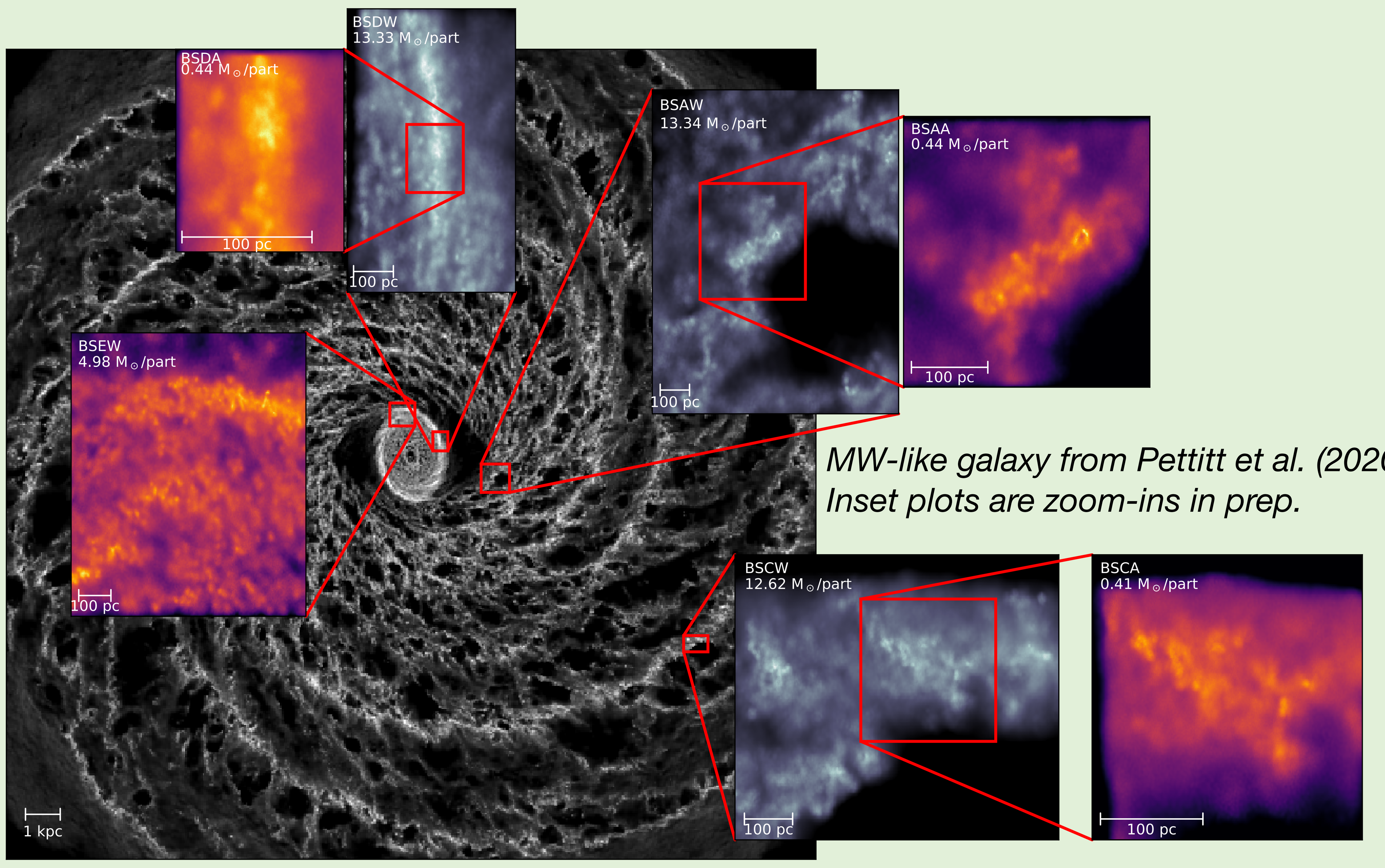
Above: histogram of sink masses. Feedback creates more low-mass sinks and stops accretion onto high-mass sinks.

5. Results: star formation

Below: integrated star formation efficiency & rate. Ionization increases both; winds have negligible impact.



6. Future work: environmental dependence



MW-like galaxy from Pettitt et al. (2020)
Inset plots are zoom-ins in prep.

Work in progress – how do results depend on galactic environment?

Variations within a galaxy:

- bar vs. spiral arms vs. interarm regions
- different galactocentric radii
- different metallicities

Galaxy properties:

- isolated vs. interacting
- grand design vs. flocculent
- MW-mass vs. dwarf

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