Disentangling the role of supernovae, stellar winds and ionising radiation on the structure of galactic discs

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The energy budget

- ionising radiation and winds (early feedback), sharp drop after $t \sim 5 - 10 \text{ Myr}$
- SNe starting after $\sim 3 \text{ Myr}$; they have approximately constant rate
- ionising radiation has smaller coupling efficiency (by factor of $\sim 0.1 - 0.01$ than winds or SNe)
The initial conditions

- box of side lengths $500 \text{ pc} \times 500 \text{ pc} \times 10000 \text{ pc}$ centered at the galactic disc
- resolution 4 pc
- surface density of gas $\Sigma = 10 \, M_\odot \, \text{pc}^{-2}$
- self-consistent modelling of sink particle formation (star clusters) and their feedback
- star clusters populated by a realistic IMF, one SN per $120 \, M_\odot$ of the stellar population
- gravitational acceleration due to gas, sink particles, background stellar potential coupled to mixed BCs
- chemistry $H$, $H^+$, $H_2$, CO, $C^+$
- no magnetic field for now; spatially constant $G_0$; no galactic shear

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SNe, winds and ionising radiation in galactic discs
Modelling stellar feedback

- SNe for $\rho < 10^{-24} \text{ g.cm}^{-3} \rightarrow$ thermal energy injection
- SNe have always fixed radius
- Wind feedback by momentum injection
- Ionising radiation traced by TreeRay
- three thresholds for sink particle formation (implicit parameter; nonuniform SFR):
  $\rho = 2.0 \times 10^{-22} \text{ g.cm}^{-3}$,
  $\rho = 2.0 \times 10^{-21} \text{ g.cm}^{-3}$,
  $\rho = 2.0 \times 10^{-20} \text{ g.cm}^{-3} \rightarrow 24$ simulations

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Overview of the SFR

- For $30 \, M_\odot/kpc^2/\text{Myr}$ (Tammann+ 1994) $\rightarrow \sim 750$ SNe per 100 Myr in the box

![Kennicutt-Schmidt value](image)

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<th>$n_{\text{sink}} , [\text{cm}^{-3}]$</th>
<th>No FB</th>
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<td>7205 8</td>
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<td>606 12</td>
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<td>$10^1$</td>
<td>18316 45</td>
<td>5893 38</td>
<td>5691 71</td>
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- Mass in massive stars at $t=100$ Myr
- Number of Sinks at $t=100$ Myr

Dinnbier et al., in prep.
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**Mass in massive stars at t=100 Myr**

**Number of Sinks at t=100 Myr**

Dinnbier et al., in prep.
SNe feedback only
SNe and wind feedback

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Ionising radiation only

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SNe, winds and ionising radiation in galactic discs
Volume filling fraction of the warm medium 
\( (300 \, \text{K} < T < 1.0 \times 10^4 \, \text{K}) \)

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SNe, winds and ionising radiation in galactic discs
Volume filling fraction of the warm-hot medium

\(1.0 \times 10^4 \, K < T < 3.0 \times 10^5 \, K\)

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SNe, winds and ionising radiation in galactic discs
Volume filling fraction of the hot medium

\[(3.0 \times 10^5 \, \text{K} < T)\]
The mass loading factor

- SNe drive outflows
- winds are unable to drive strong outflows
- when acting together with SNe, ionising radiation tends to decrease mass loading
Conclusions

- Ionising radiation increases the volume filling factor of the warm phase and decreases the volume filling factor of the hot phase.
- When the ionising radiation is included, the values for the VFF are closer to the observed values than with SNe only → ionising radiation is likely to be important to properly model galactic discs.
- When included in self-consistent model of star formation, ionising radiation decreases the SFR substantially more than stellar winds.
- The role of stellar winds is subordinate to ionising radiation in setting the phases of the ISM, and regulating star formation.
Thank you for your attention