On the origin and structure of multiphase galactic winds BUGS@Vienna

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Ruszkowski & Pfrommer 2023

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log(stellar / halo mass)

14





Resolved ISM simulations in the GRIFFIN framework

- Example: 19 solar mass star.
- First: Developing Ionization front.
- FUV-heating from stars coupled to the non-equilibrium chemistry solver.
- Second: SN-feedback.
- Important: Photo-Ionizing feedback
 Iowers SN-environmental density.





LMC-type global model with resolved ISM



- Individual single stars are sampled from the IMF (from 4 to 50 solar masses).
- 4 solar mass resolution, 0.5 parsec.

Steinwandel et al (2023a), ApJ in press



Measuring outflows

Measure outflows at 1 (black line), 3 (red line), 5 (blue line), 10 (golden line) kpc in slabs of with thickness of 100, 300, 500 and 1000 pc.

Compute mass outflow rate in each slab:

$$\dot{M}_{\rm out} = \sum_{i, v_{i,r} > 0} \frac{m_i v_{i,r}}{dr}$$

Compute energy outflow rate in each slab:

$$\dot{E}_{\text{out}} = \sum_{i, v_{i,r} > 0} \frac{m_i [v_i^2 + \gamma u_i] v_{i,r}}{dr}$$



Steinwandel et al (2023a), ApJ in press

The nature and origin of multiphase galactic outflows



 $\eta_{\rm m}^{\rm out} = \dot{M}_{\rm out} / \overline{\rm SFR}$



Steinwandel et al (2023a), ApJ in press

What do these numbers mean?

dependence between the two quantities.

galaxies?

 Are the numbers we get self consistent within the model framework? Can we build a toy model that predicts mass and energy loading and moreover the

Are these numbers consistent with a galaxy formation scenario for dwarf

Dependence of mass and energy loading factors







Steinwandel and Goldberg (2023, arXiv:2310.11495)

Multiphase structure of mass and energy





 $i, v_{i,r} > 0$

We have all of these for different heights and different radial regions in the paper.

Steinwandel et al (2023a), ApJ in press

Model Failures: The need for metal diffusion models

Without metal diffusion



Example outflow PDFs measured @1kpc height We have all of these for different heights and different radial regions in the paper

With metal diffusion



Steinwandel et al. (in prep)



The magnetized ISM



• Individual single stars are sampled from the IMF.

• 4 solar mass resolution, 0.5 parsec.

See Dedner et al. (2002), Tricco, Price and Bate (2016), Steinwandel and Price (in prep)

Example Future Aspects: The resolved magnetized ISM

- Magnetic field is quickly amplified by gravitational collapse in the dense regions.
- The global field remains lower in the global mid plane.
- Initial findings suggest that there is only a weak dynamo competing with the venting of magnetic energy in the stellar feedback driven wind.





Conclusions

- The predicted mass loading factors of my simulations are in relatively good agreement with observations of mass loading factors in local dwarf galaxies.
- The predicted energy loading factors are low compared to energy loadings adopted in some other theoretical models.
- The models are self consistent in the sense that mass and energy loading factors behave as predicted by the theory of clustered blast wave evolution.
- Galactic winds transport most of the mass in the warm wind and most of the energy in the hot wind.