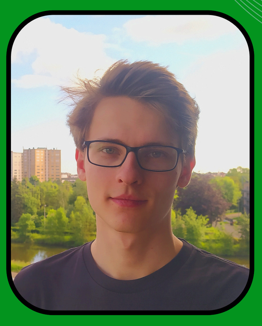

ISM dust destruction by the SN blastwave

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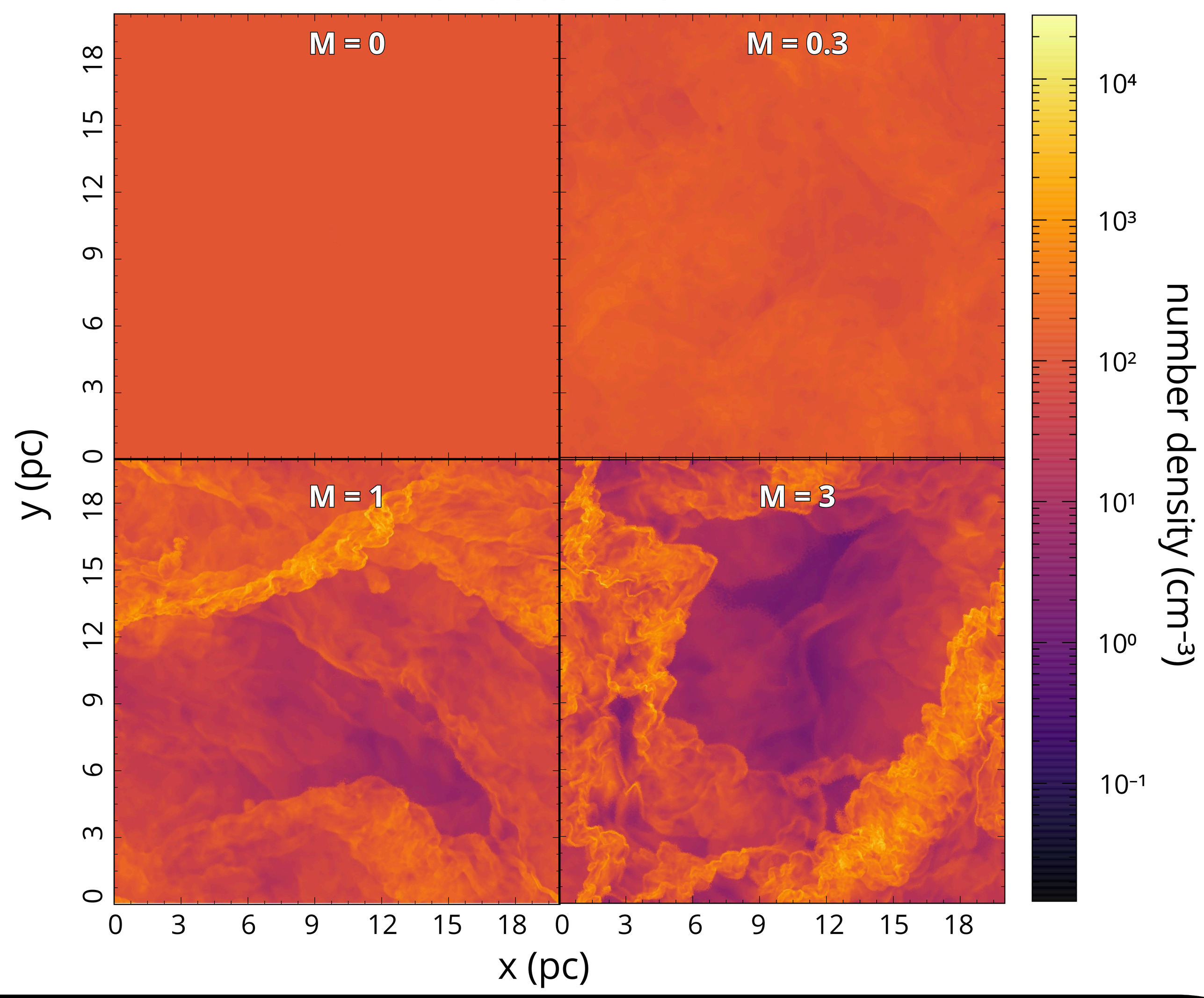
Supernovae (SNe) produce up to 1 $M_\odot$ of dust. However, the energetic reverse shock of their remnant will eventually encounter all of this dust while the forward shock will encounter up to 70 $M_\odot$ of interstellar medium (ISM) dust. The dust destruction efficiency of these shocks is badly constrained, thus it is unknown whether SNe are net dust sources or sinks. Numerical dust destruction studies come to different conclusions because grain-grain collisions, magnetic fields, and turbulence are often neglected even though they were recently shown to be important. Kirchschlager et al. (2024) and Dedikov & Vasiliev (2024) have shown for example that dense filaments are able to shield dust efficiently from shock destruction. However, their turbulent ISM is not driven to match the observed ISM. We aim to study the dust shielding efficiency of observationally resembling filaments from the supernova remnant (SNR) forward shock in the first thousands of years. The dust behavior is studied in post-processing including several dust transport and destruction mechanisms. As a result, we are able to find a realistic lower limit of the SNR forward shock dust destruction.

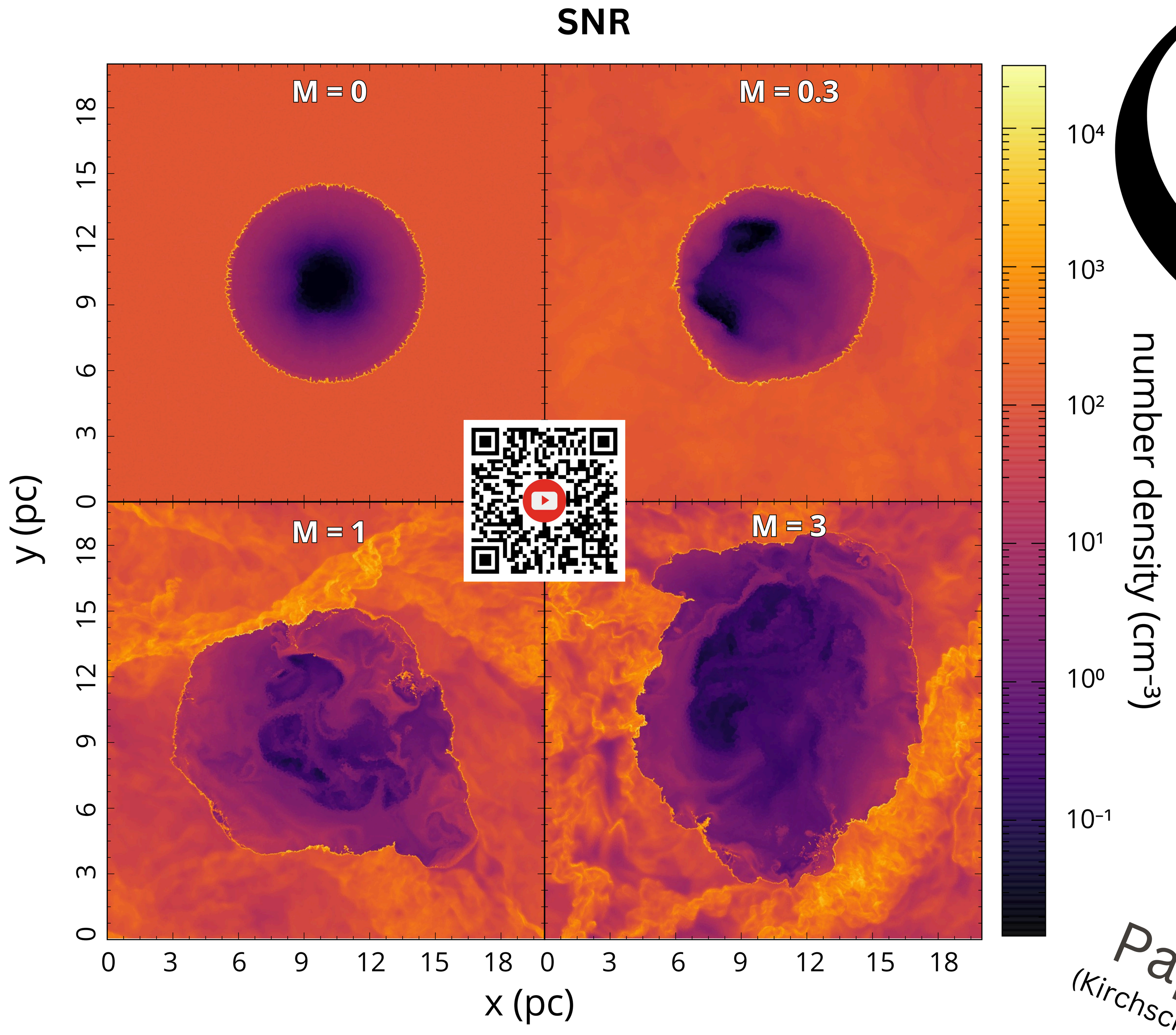
TURBULENCE

Arepo (Springel 2010)

To closely resemble the observed ISM, we drive turbulence in a separate simulation considering:

- Different density contrasts characterized by the turbulence Mach number $M = \sigma_v / c_s = 0, 0.3, 1, 3$ (σ_v: velocity dispersion, c_s: sound speed)
- Average ISM number density of 100 cm^{-3}, resembling a molecular cloud environment, as first step (next step: lower average densities)



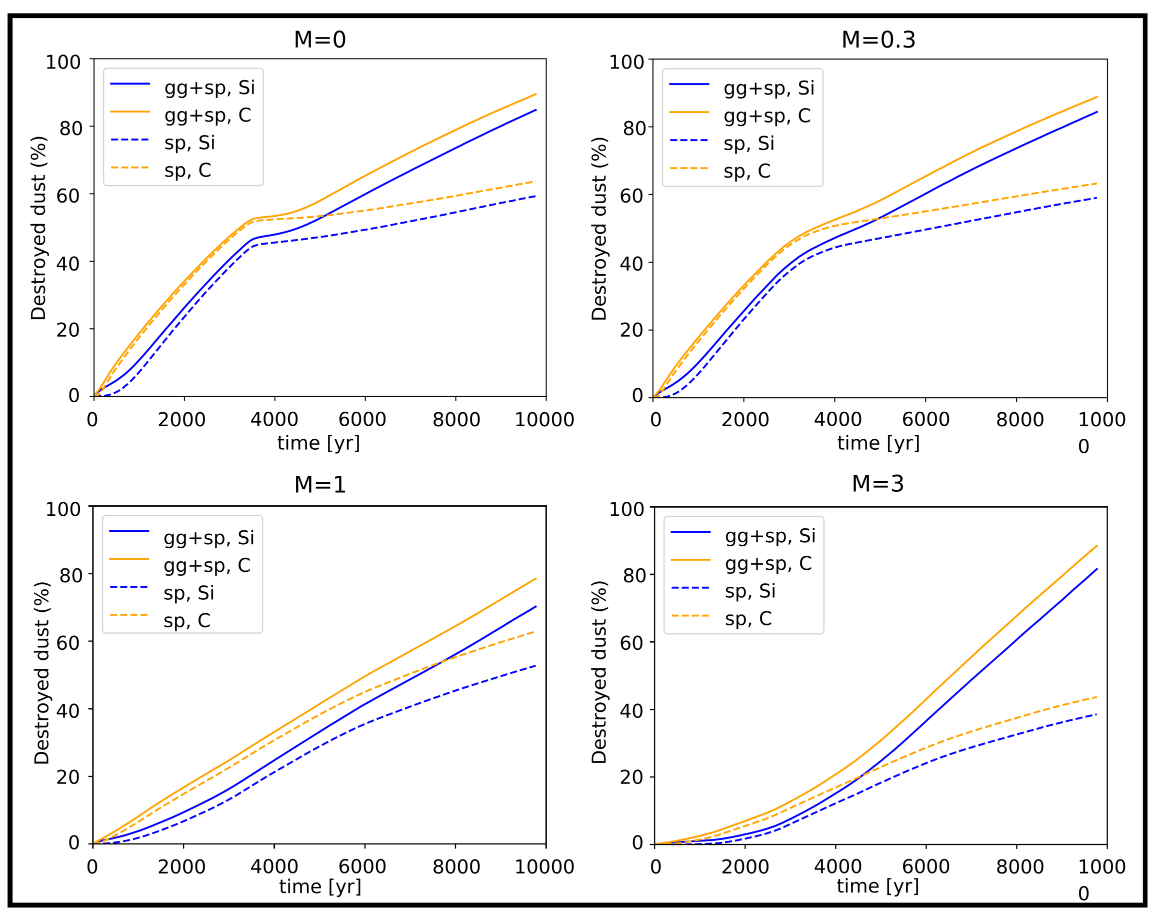


SUPERNOVA

Arepo (Springel 2010)

An SN is set off in a void of the turbulent medium to mimic pre-SN feedback. We focus on the first 10 kyr of SNR evolution where the forward shock slows down to ~130 km s^{-1}.

When the blastwave encounters filaments in the high Mach simulations, it is slowed down significantly. At ~4 kyr, the transition from radiative to snowplow phase is well visible in the low Mach simulations (see the movies with the QR code). This coincides with the kink in the dust destruction graph below.



Dust destruction of an SN blastwave expanding in the different turbulence simulations. We consider either silicate (blue) or carbonaceous (orange) grains, and either grain-grain collisions and sputtering (solid) or only sputtering (dashed).

DUST

Paperboats (Kirchschlager et al. 2019)

Paperboats is a post-processing code that adds dust to the Arepo simulations and calculates its transport (gas drag, plasma drag) and destruction (sputtering, grain-grain collisions) over time.

We use:

- Initial MRN dust size distribution from 5-250 nm (Mathis et al. 1977)
- 20 dust size bins from 0.6-350 nm
- Either silicate or carbonaceous grains
- A gas-to-dust mass ratio of 100

CONCLUSIONS

For the forward shock dust destruction of an SN going off in a molecular cloud environment (number density of 100 cm^{-3}) and at early SNR evolution times (up to 10 kyr), we find that:

- Filaments do not shield the dust efficiently
- At least ~10 $M_\odot$ of dust is destroyed in 3D
- Grain-grain collisions are very important
- Carbonaceous grains are more efficiently destroyed than silicates

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