Dust destruction by the reverse shock in Cas A

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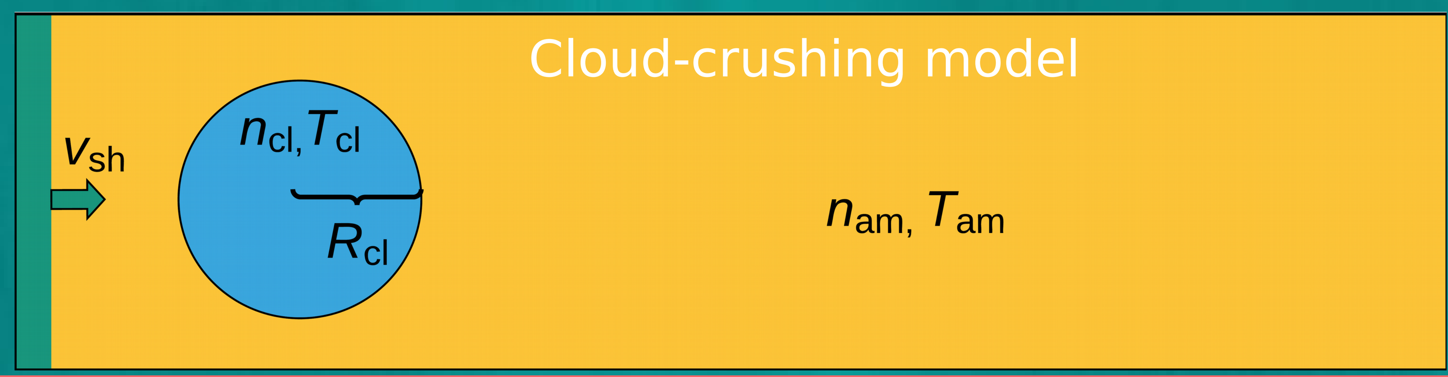
Introduction

The reverse shock in the ejecta of core-collapse supernovae (SNe) is potentially able to destroy newly formed dust material. In order to determine dust survival rates, we have performed hydrodynamic simulations using the code AstroBEAR to model a shock wave interacting with **clumpy SN ejecta**. Dust trajectories and destruction rates were computed using our newly developed external, post-processing code **PAPERBOATS**, which includes gas drag, grain charging, **sputtering and grain-grain collisions**. We have determined dust destruction rates for the oxygen-rich supernova remnant (SNR) Cassiopeia A as a function of initial grain sizes and clump gas density.

I) Hydrodynamic simulations

To simulate the dynamical evolution of a SNR reverse shock impacting a clump of ejecta material, the grid-based hydrodynamic code AstroBEAR is employed (Cunningham et al. 2009, ApJS, 182, 519)



II) Dust processing

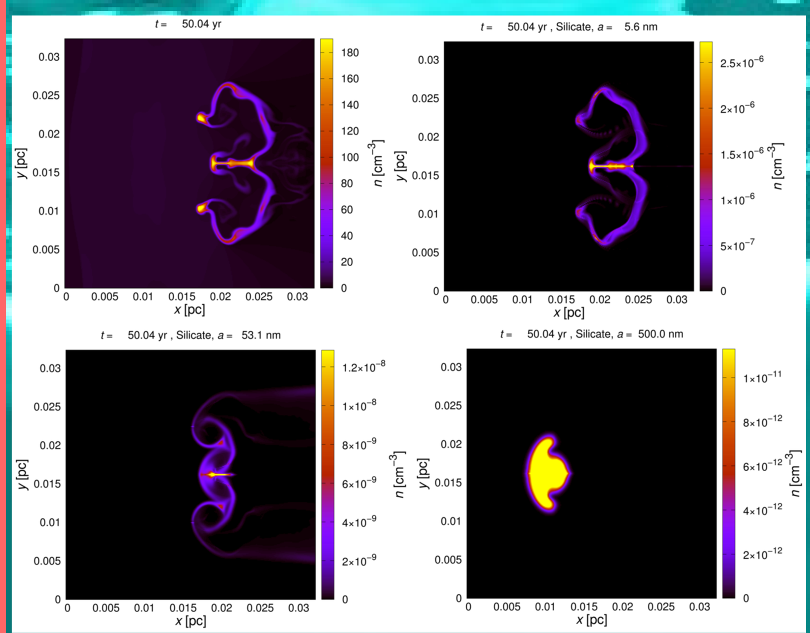
Post-processing code

For the advection, destruction and growth of grains, we developed the parallelised 3D external dust processing code **PAPERBOATS**.

- Utilises the hydro-code output (AstroBEAR) for gas density, temperature and velocity to calculate dust trajectories
- Dusty grid approach

Dust movement

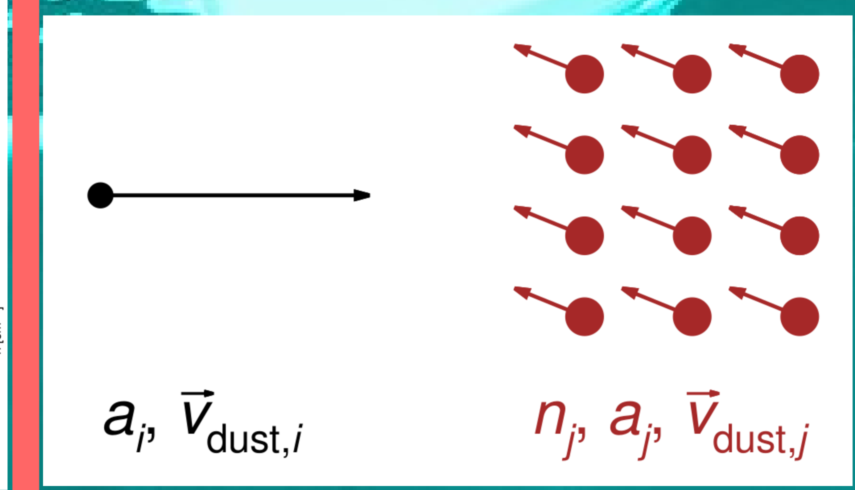
- Size-dependent gas drag:
  - Collisional drag
  - Plasma drag
- Small & large grains decouple



Grain-grain collisions

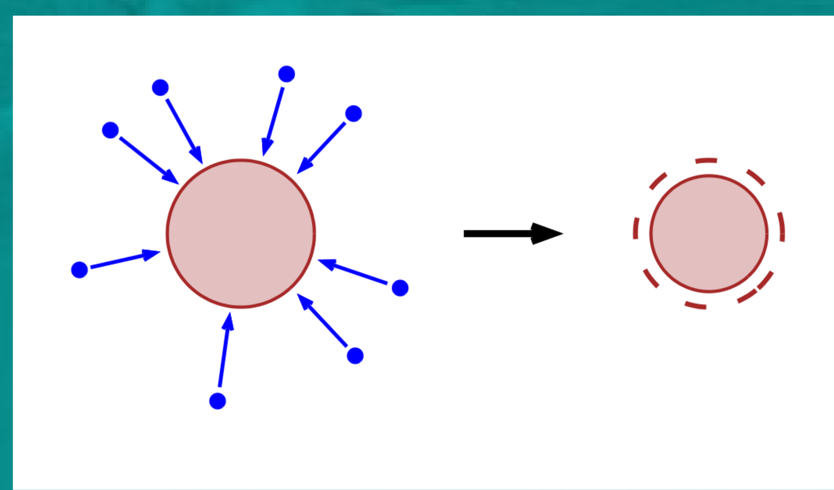
Gas drag causes relative velocities v_{rel} between grains of different sizes ⟶ collisions

- $P_{col} = 1 - \exp(-n\,\sigma\,v_{rel}\,\Delta t)$
  - Vaporisation
  - Fragmentation
  - Sticking

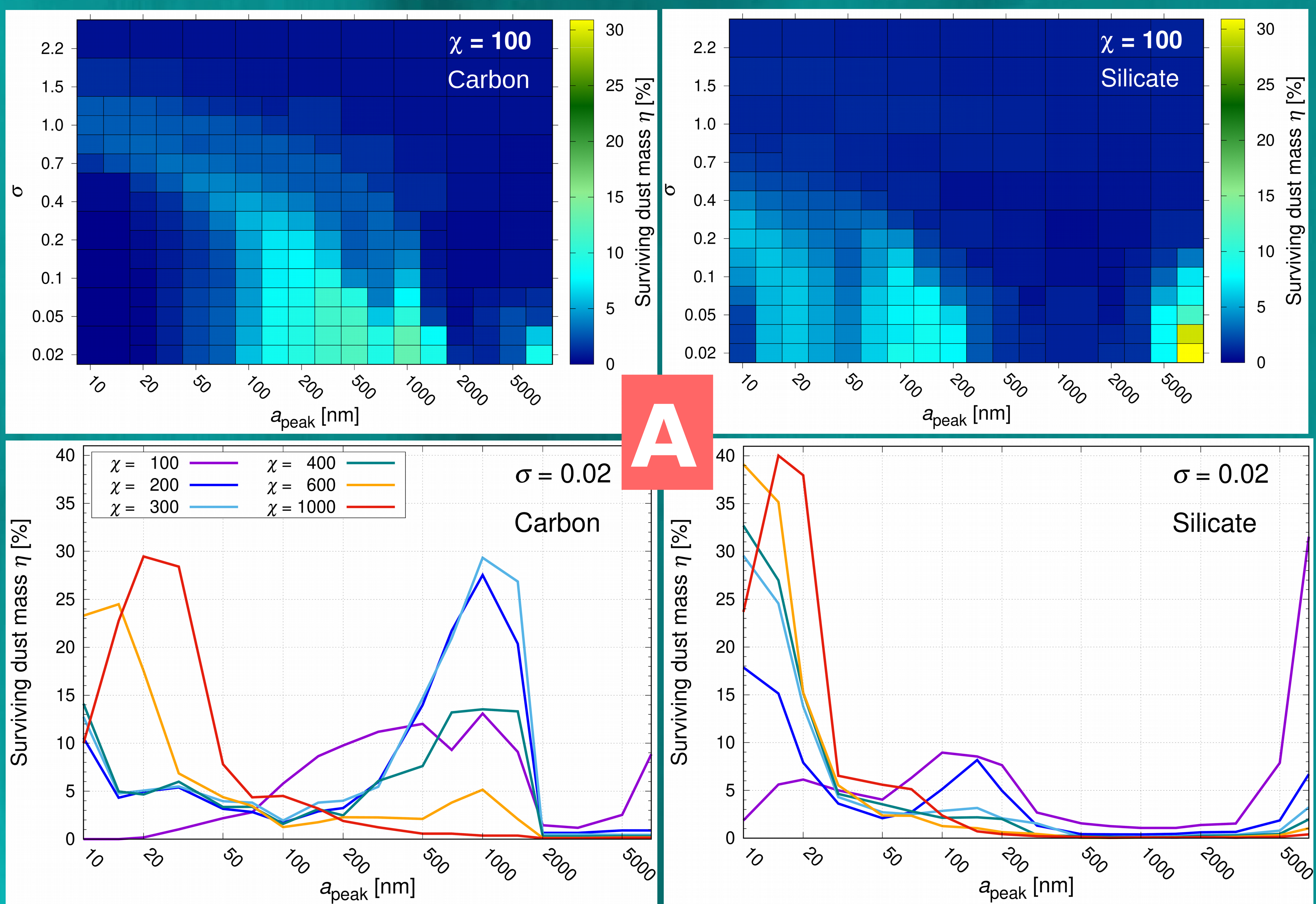


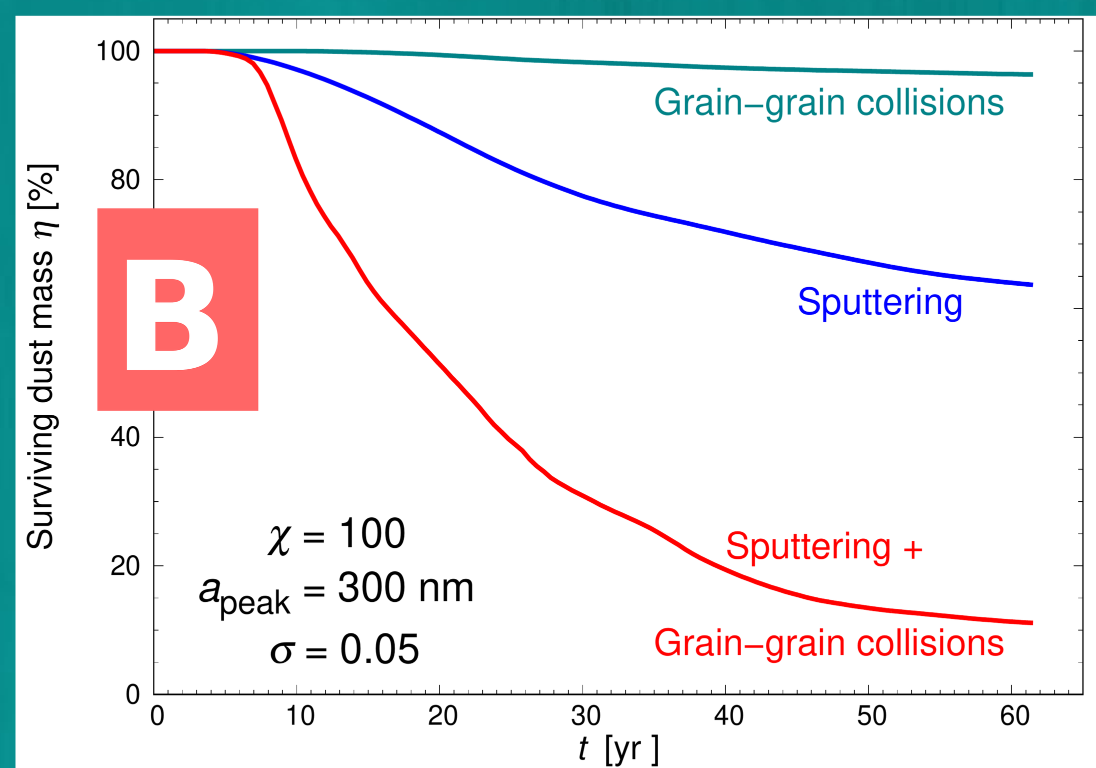
Gas accretion & sputtering

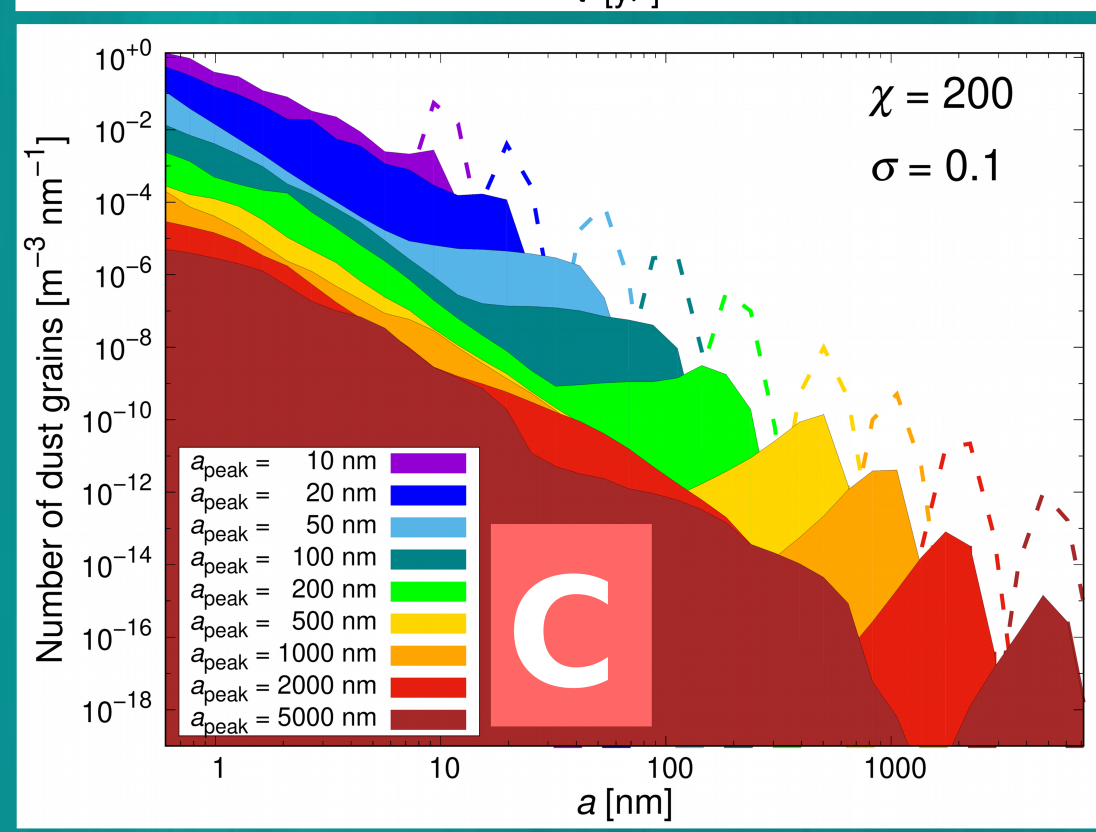
- Ejection of dust atoms due to collisions with gas particles
- Gas accretion = negative sputtering
- Thermal & kinetic sputtering
- Size-dependent effect (tunnelling of tiny grains)



III) Results: Dust survival







A Dust survival rates η depend on:

- Gas density contrast χ between clump & amb. medium
- Initial grain size distribution (peak-radius a_{peak}, width σ)

Carbon: η < 30 %, Silicate: η < 40 %

B Grain-grain collisions & sputtering are synergistic

C Final grain size distribution: Power-law + log-normal

Our results for the dust destruction in the supernova remnant Cassiopeia A can be found in **Kirchschlager et al. (MNRAS, subm.)**.

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