Modeling the turbulence ~~decay~~ injection in the multi-phase ISM

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Phases of the ISM

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Turbulence

Herschel map of Cygnus X Region (Credit: ESA/PACS/SPIRE/ Martin Hennemann & Frédérique Motte)

- Origin?
- How (much) heating and cooling affect its dissipation?

Method

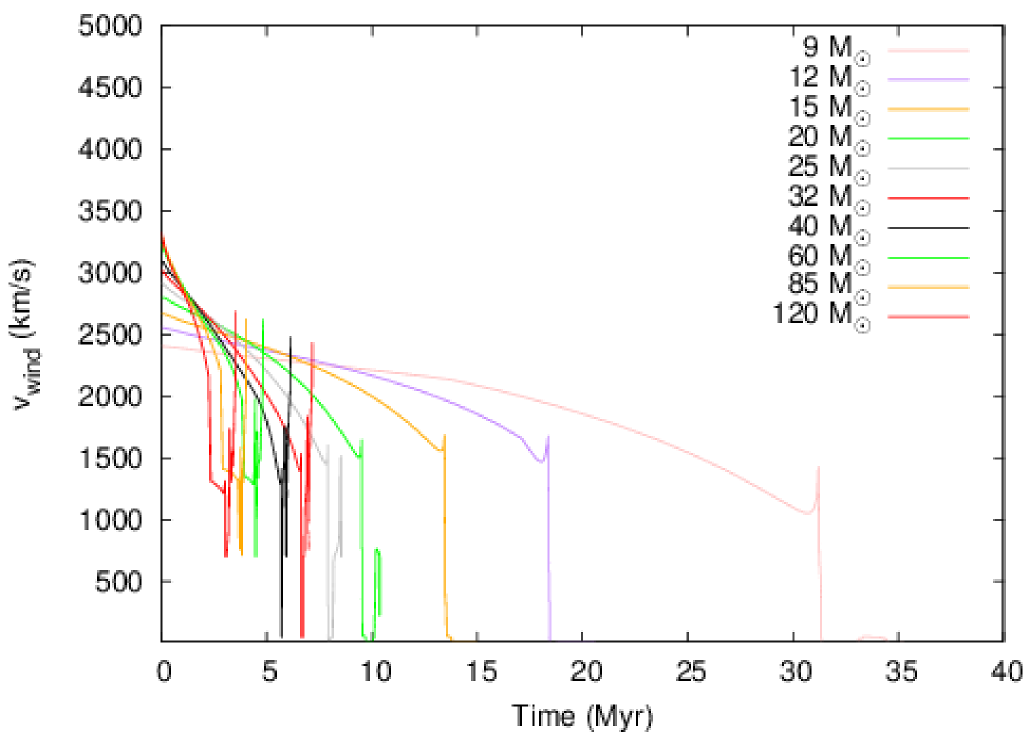
Numerical experiment: cartesian hydro simulation with FLASH 4.0.1 of a 3D periodic box with side 256 pc (res=2 pc) $n = 3\ cm^{-3}$ c_s=2 km/s

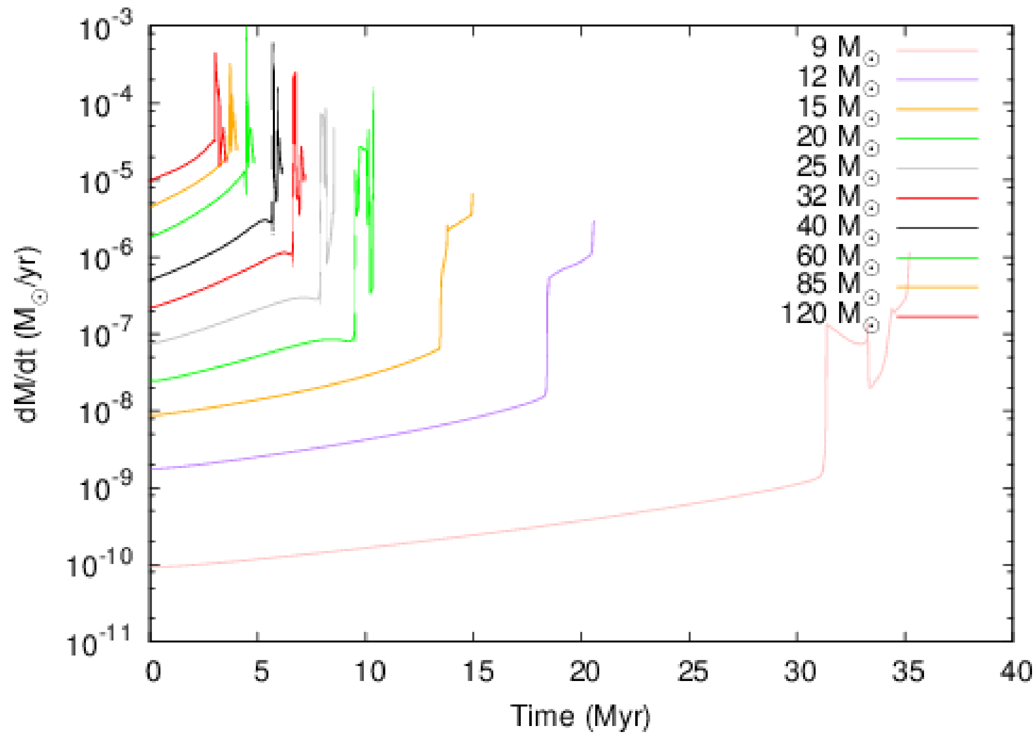
Physics included:

- Artificially driven turbulence from random Gaussian field with fixed v_rms = 10 km/s for the first ~ 30 Myr (P. Girichidis)
- Cooling: chemistry network to track evolution of H_2, H+, HI, C+, CO + Tree solver to compute dust shielding and H_2 formation via adsorption. At high temperatures cooling function computed from CIE (S. Glover, P. Clark, S. Walch, R. Wunsch)
- Heating: photoelectring heating from diffused interstellar UV field + diffused CR and X-ray heating

Winds

Mass loss rates and wind velocities from Ekström et al. (2012) for [8,120] $M_\odot$ at ZAMS





Winds

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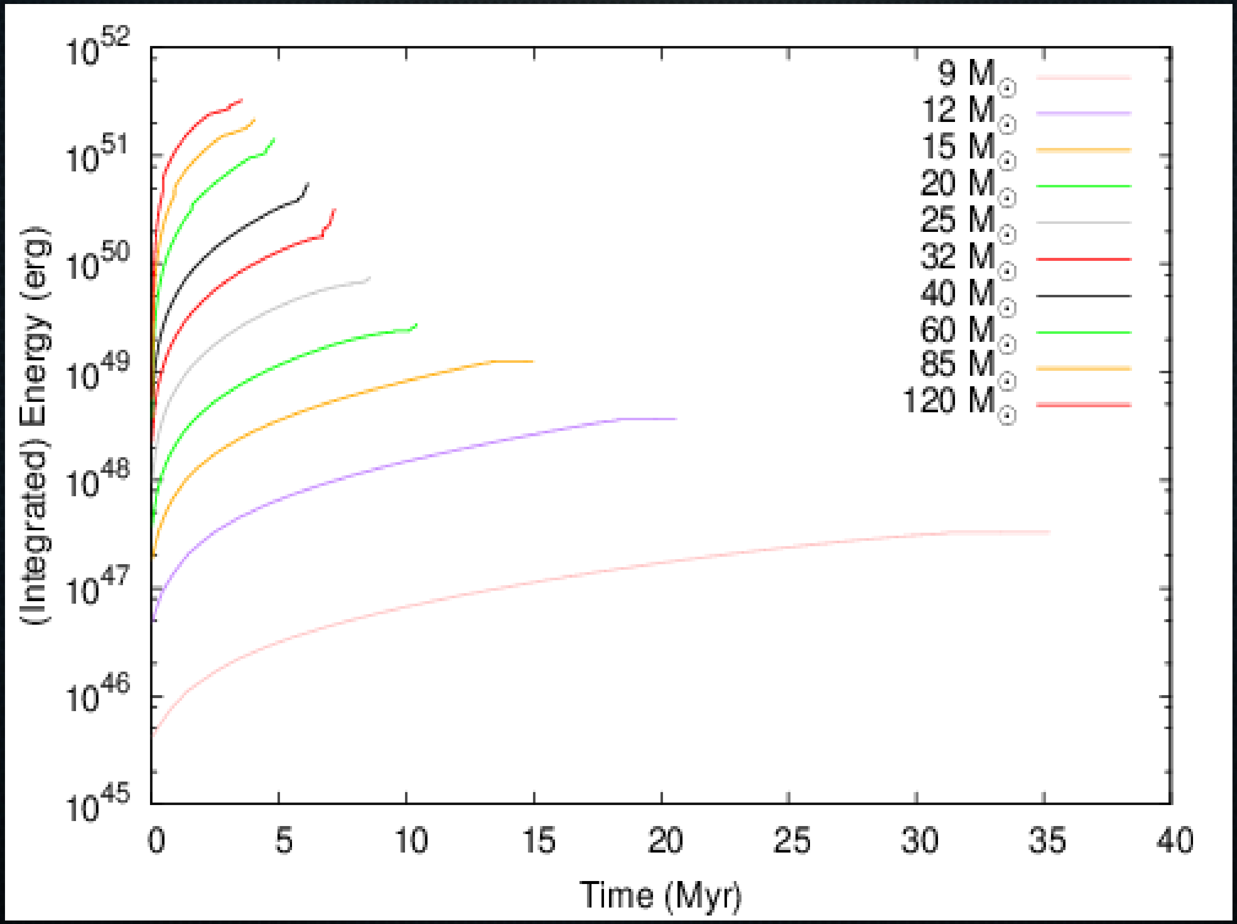
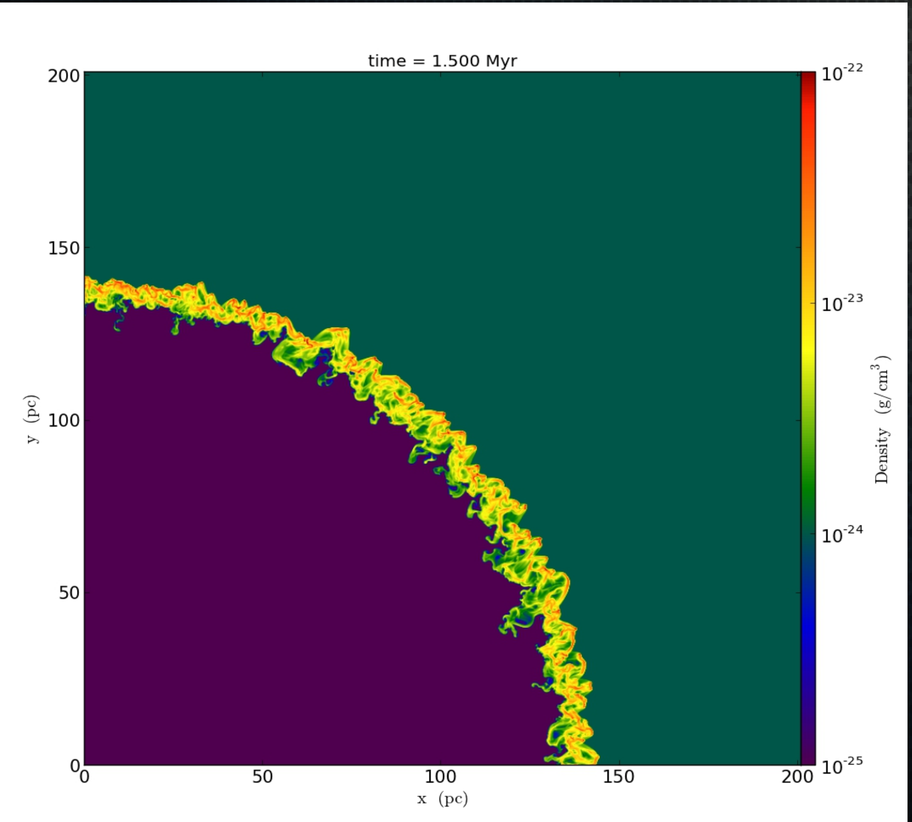


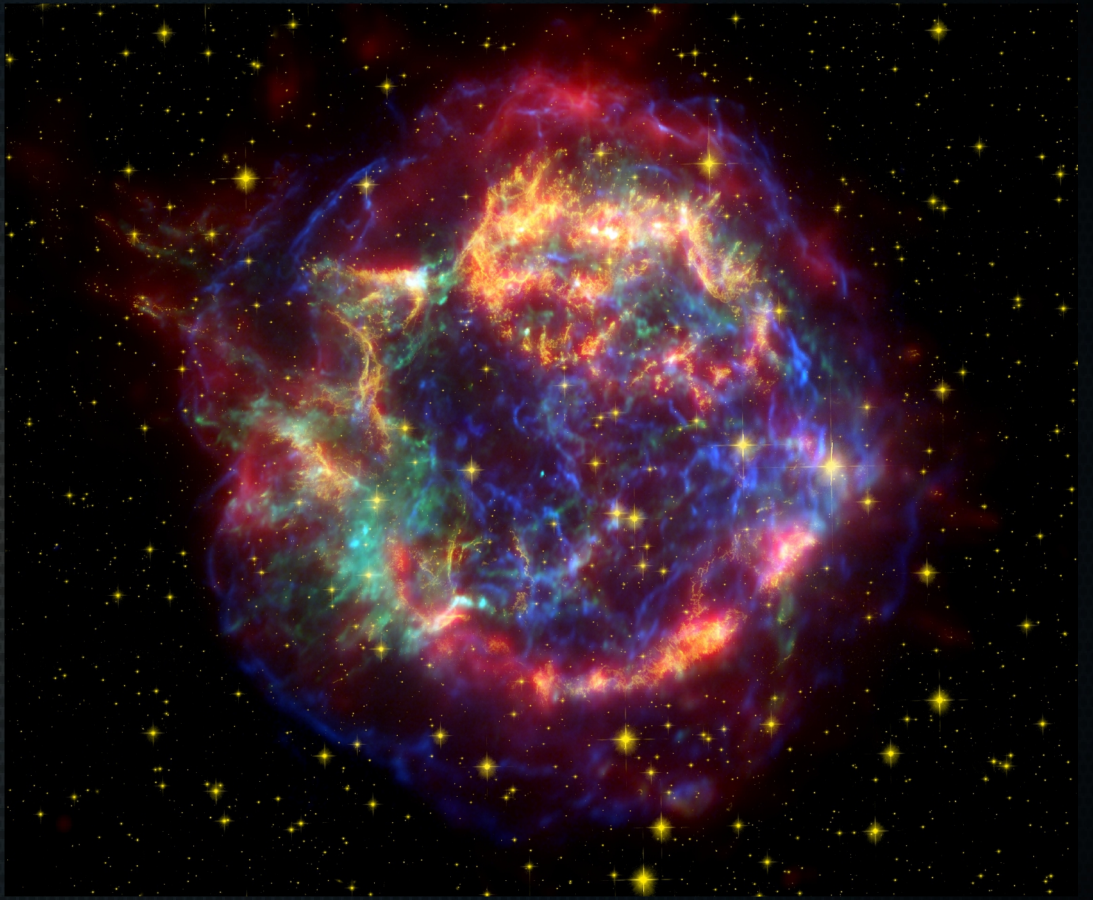
Winds

Test wind

Supernovae

- Energy: 10^{51} erg, thermal or kinetic
- Position: random or from density peaks
- Radius of injection: fixed or variable





Infrared, optical, X-ray emission from Cassiopea A SNR (Credit:NASA/CXC/SAO,NASA/STScI,NASA/JPL-Caltech/Steward,O.Krause et al.)

Results

Slice rho

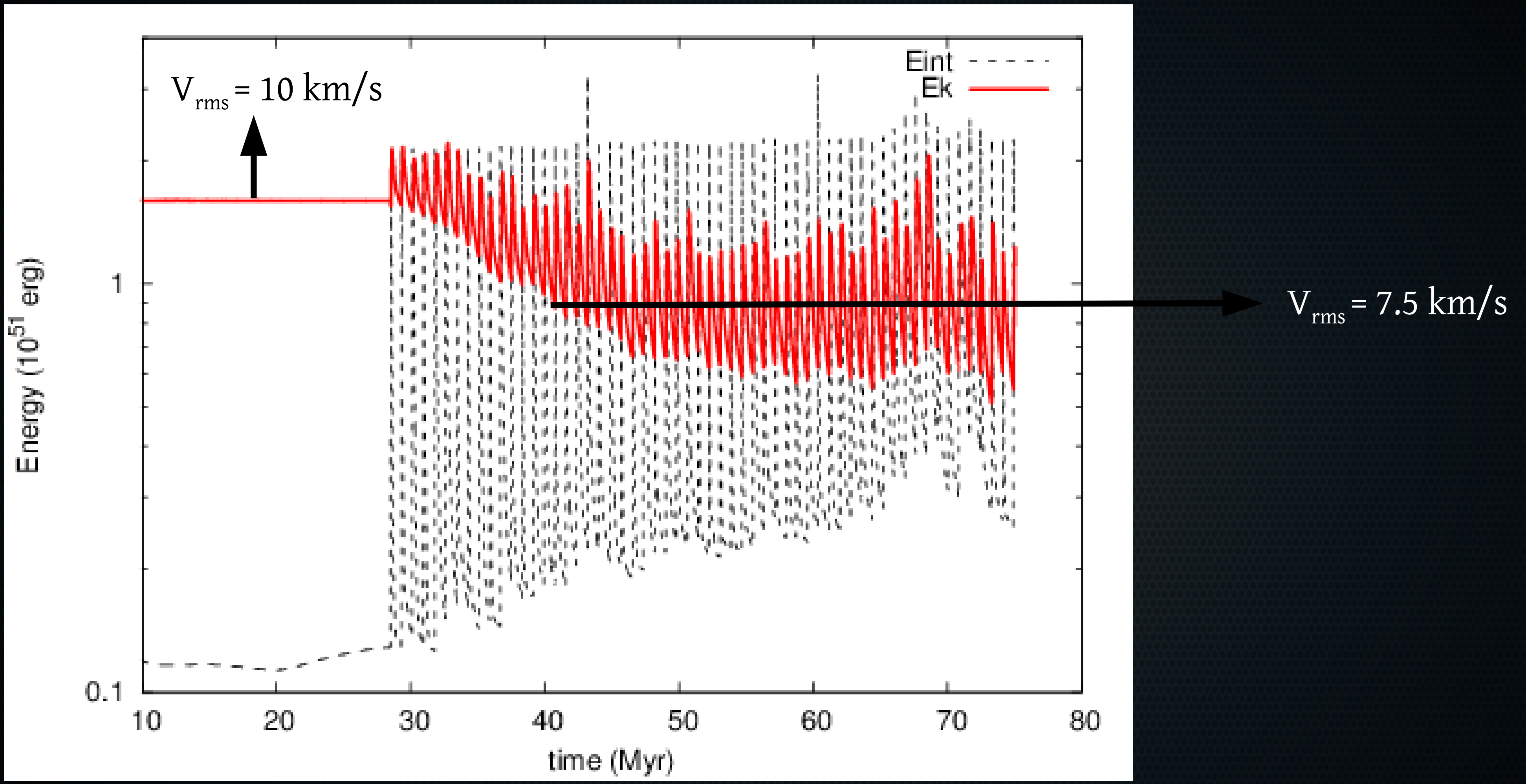
Results

rhoTM

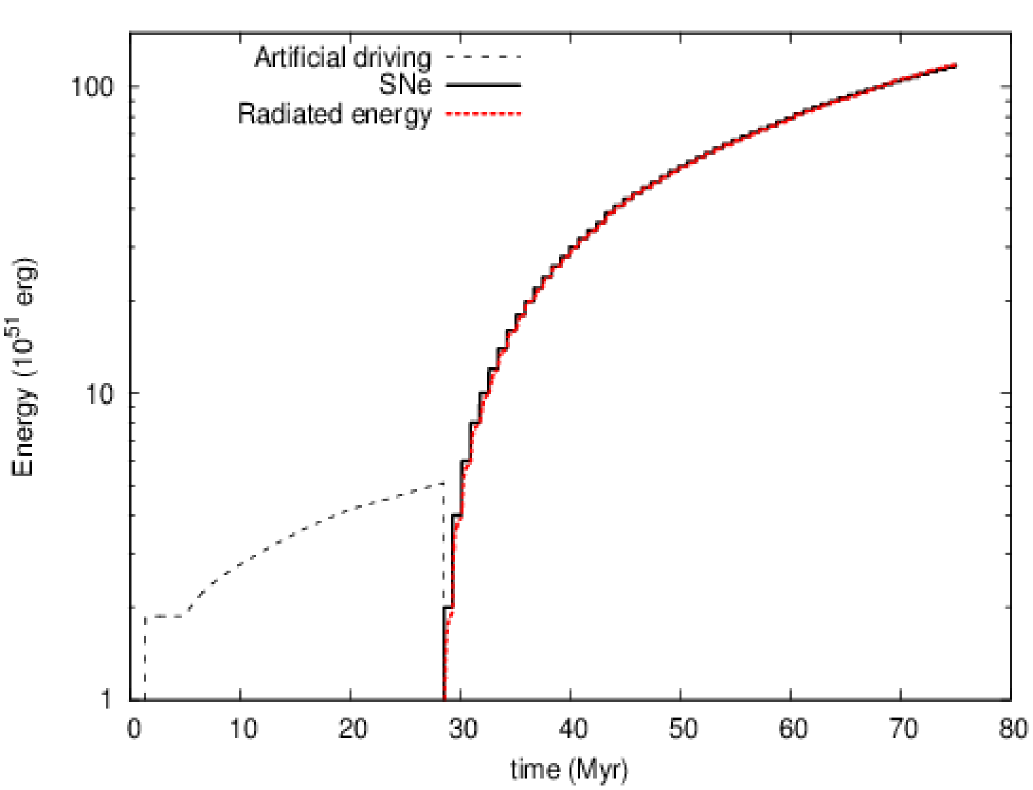
Results

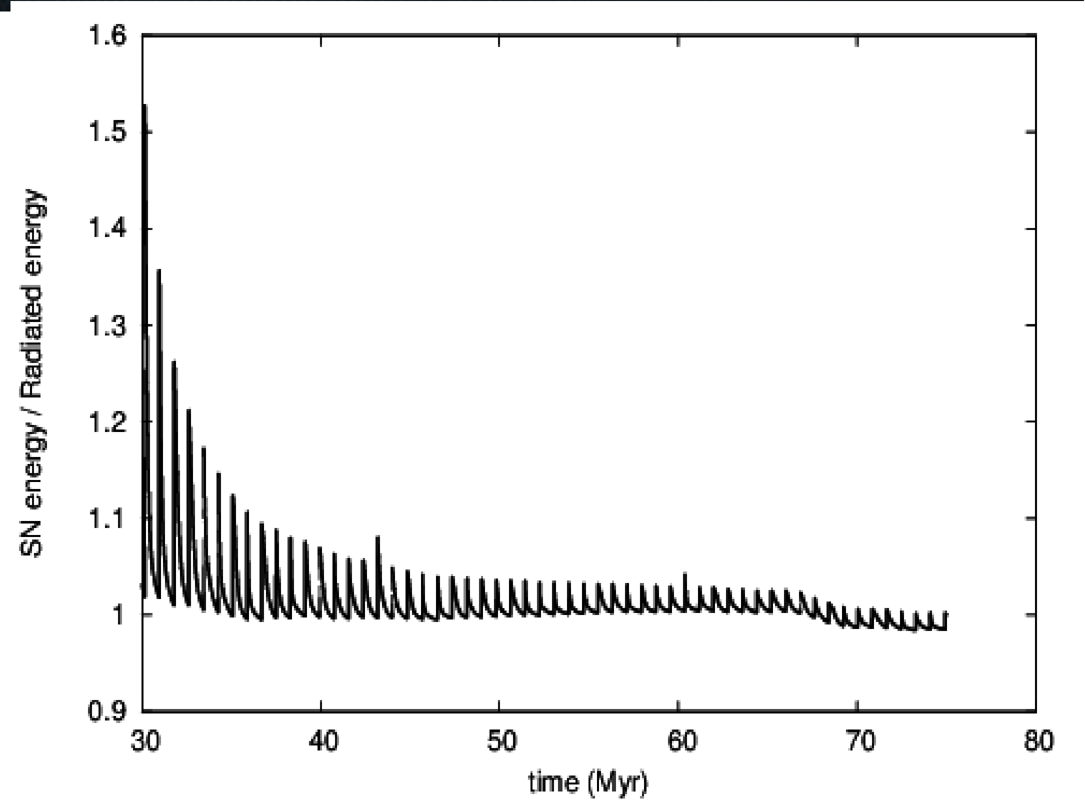
ffv

Results


Eint
Ek
V_{rms} = 10 km/s
V_{rms} = 7.5 km/s
Energy (10^{51} erg)
1
0.1
10
20
30
40
50
60
70
80
time (Myr)

Results


Artificial driving
SNe
Radiated energy
Energy (10^{51} erg)
100
10
1
0
10
20
30
40
50
60
70
80
time (Myr)


SN energy / Radiated energy
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
30
40
50
60
70
80
time (Myr)

With winds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2% milkfat
HALF GALLON (1.89L)
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Conclusions and Future

- Gas out of the equilibrium
- Low fraction of hot gas produced (winds?)
- SNe able to mantain v_{rms} consistent with artificial driving input value
- Energy injected by SN several times higher than artificial driving: cooling reacts and stabilize

Future:

- Wait for winds: relative importance of different feedback processes