Modeling the turbulence decay in the multi-phase ISM

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Phases of the ISM
Heidelberg 30/7/2013

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Turbulence

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

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

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

Physics included:

- Artificially driven turbulence from random Gaussian field with fixed $v_{\text{rms}} = 10 \text{ km/s}$ for the first $\sim 30 \text{ Myr}$ (P. Girichidis)
- Cooling: chemistry network to track evolution of $\text{H}_2$, $\text{H}^+$, HI, C+, CO + Tree solver to compute dust shielding and $\text{H}_2$ 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
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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

\[ V_{\text{rms}} = 7.5 \text{ km/s} \]

\[ V_{\text{rms}} = 10 \text{ km/s} \]
Results

- $V_{rms} = 7.5$ km/s
- $V_{rms} = 10$ km/s
With winds
Conclusions and Future

- Gas out of the equilibrium
- Low fraction of hot gas produced (winds?)
- SNe able to maintain $v_{rms}$ 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