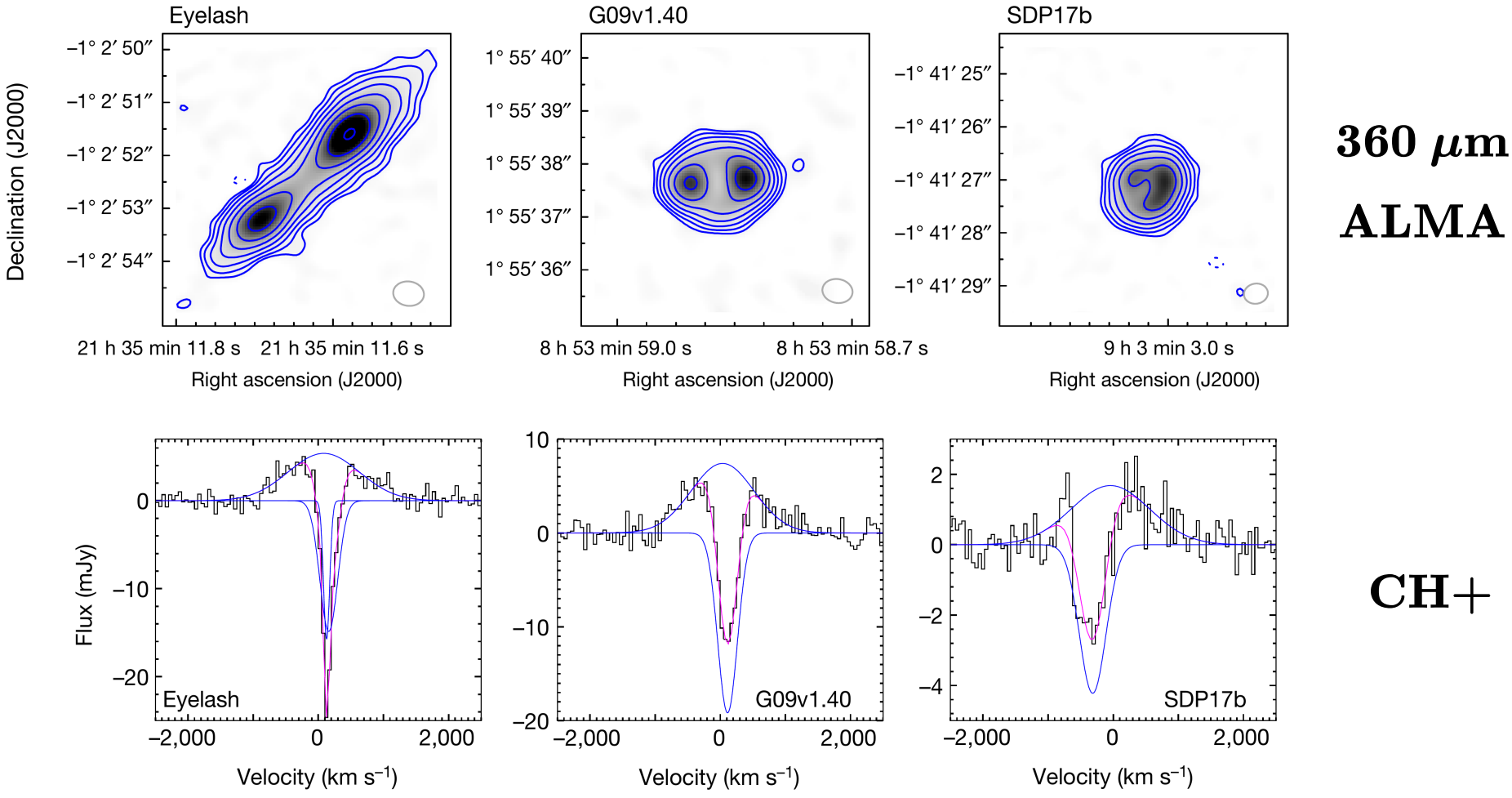
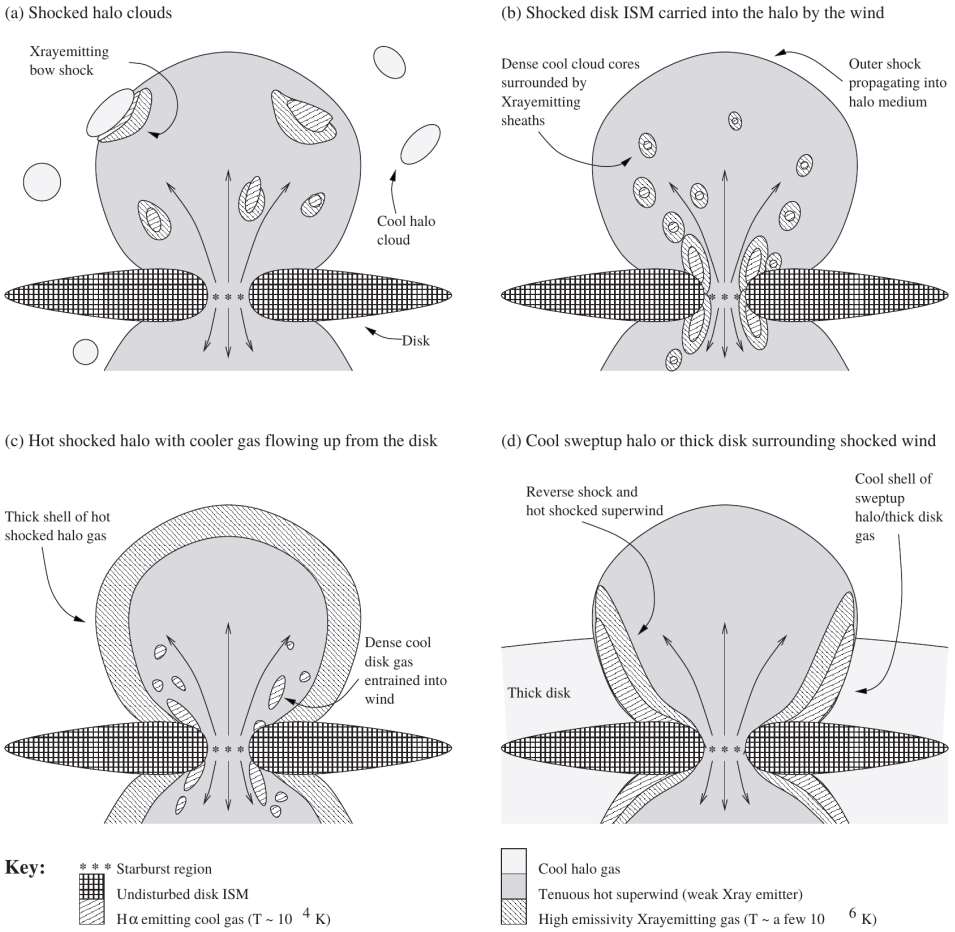
Self-irradiated shocks (OHP 2018)

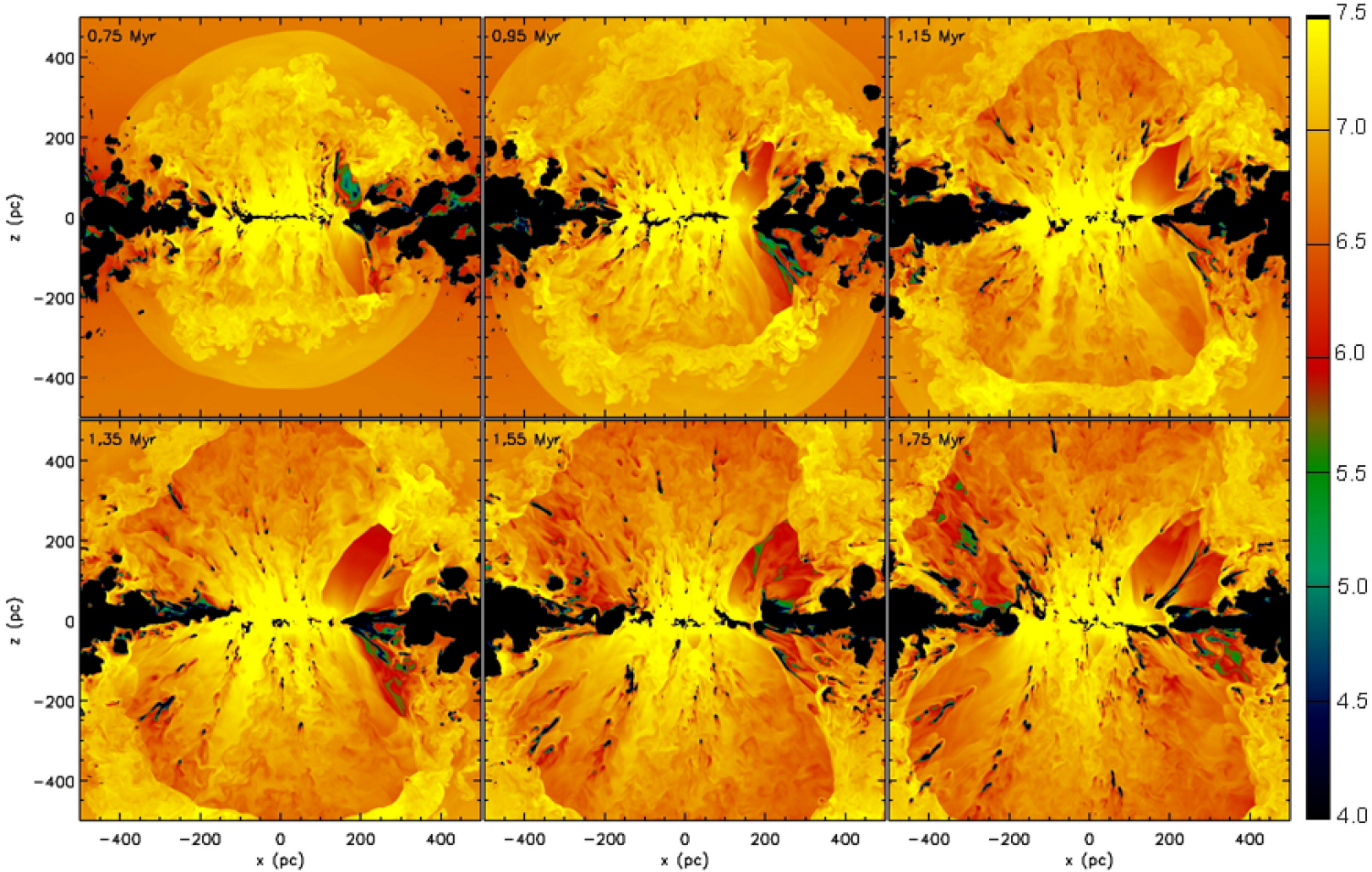
Andrew Lehmann



Falgarone + 2017



Strickland+ (2002)


0.75 Myr
0.95 Myr
1.15 Myr
1.35 Myr
1.55 Myr
1.75 Myr
z (pc)
x (pc)
400
200
0
−200
−400
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0

Cooper+ (2008)

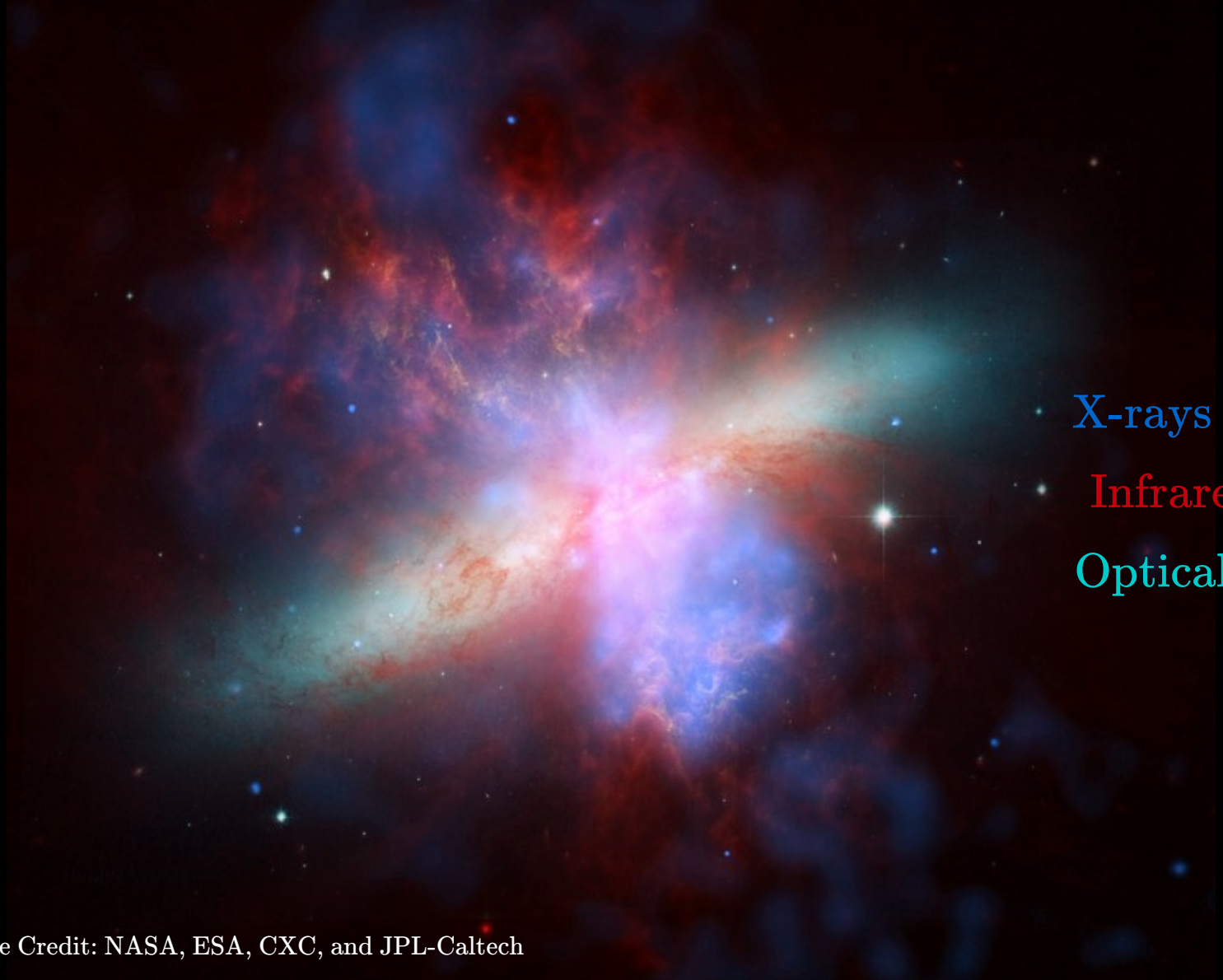
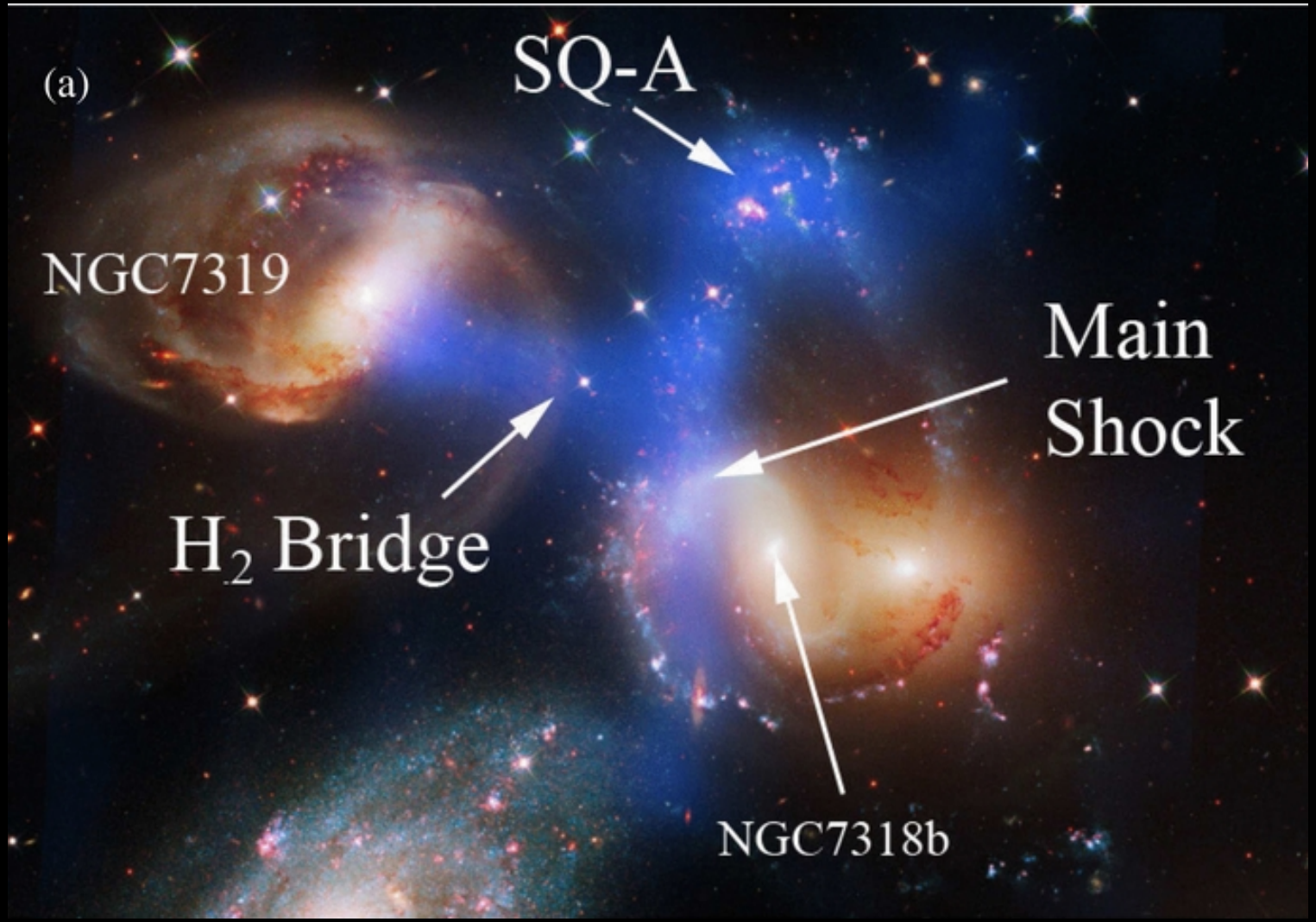
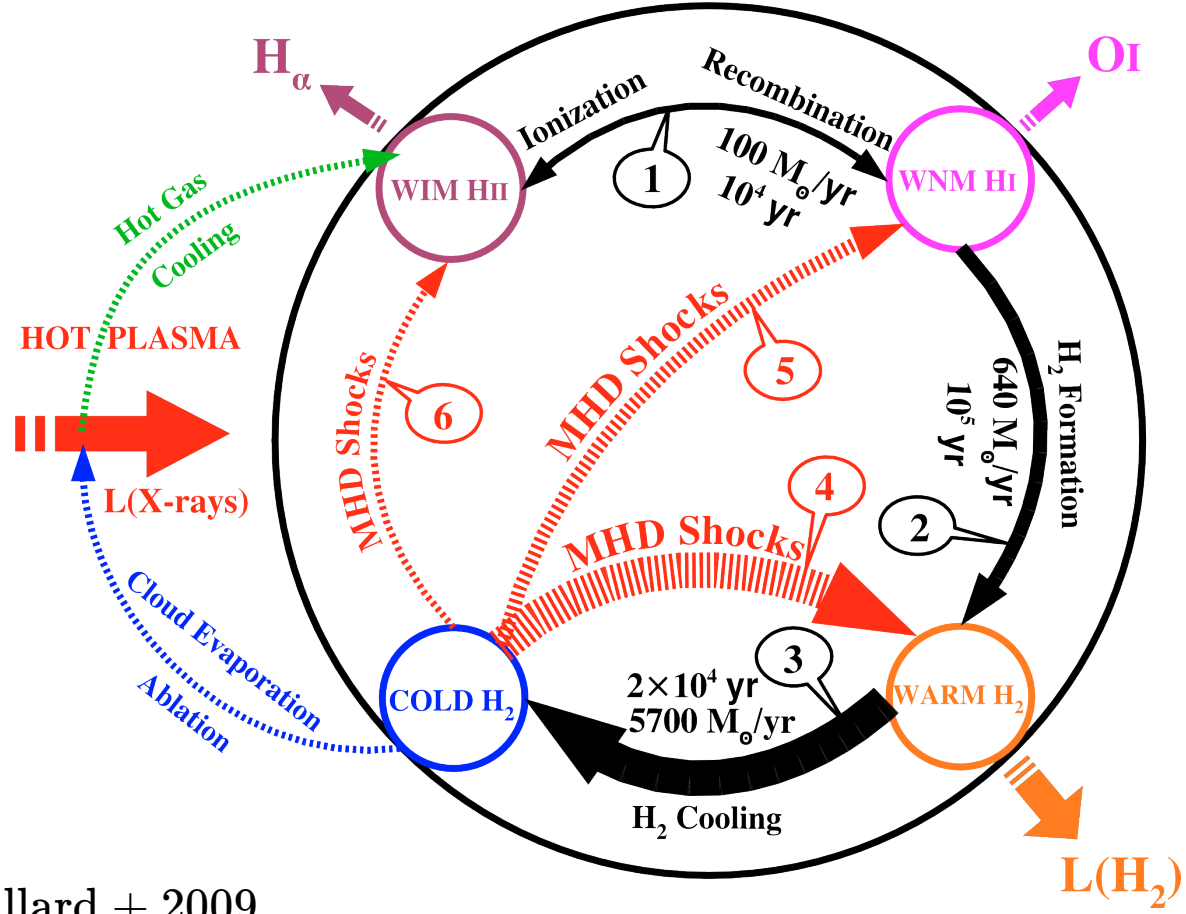


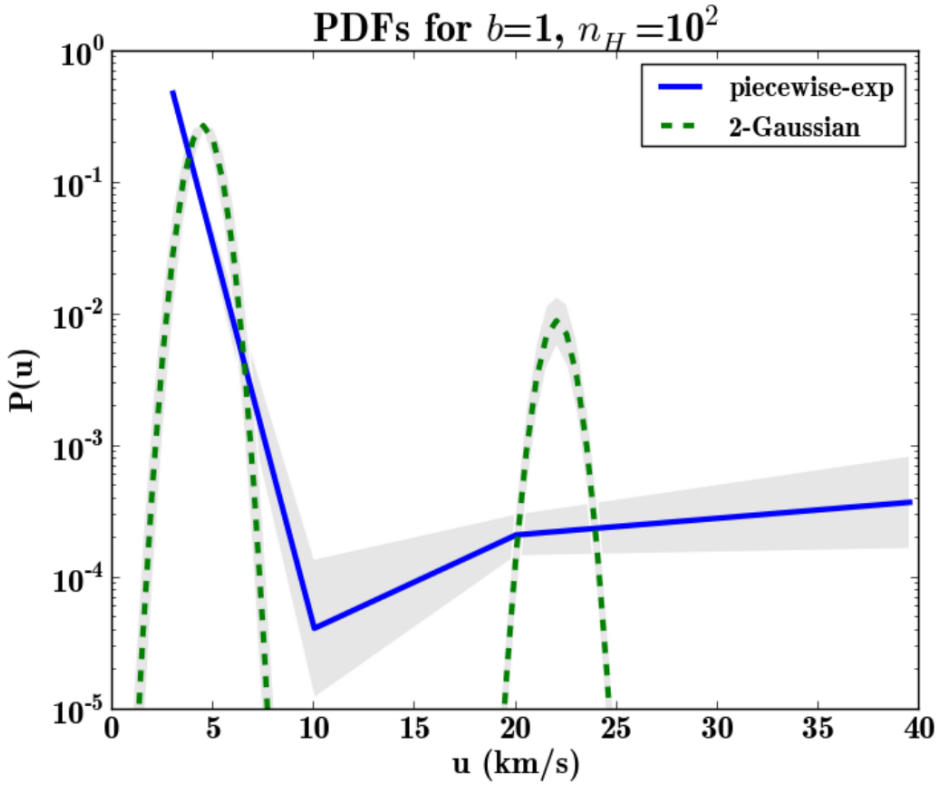
Image Credit: NASA, ESA, CXC, and JPL-Caltech

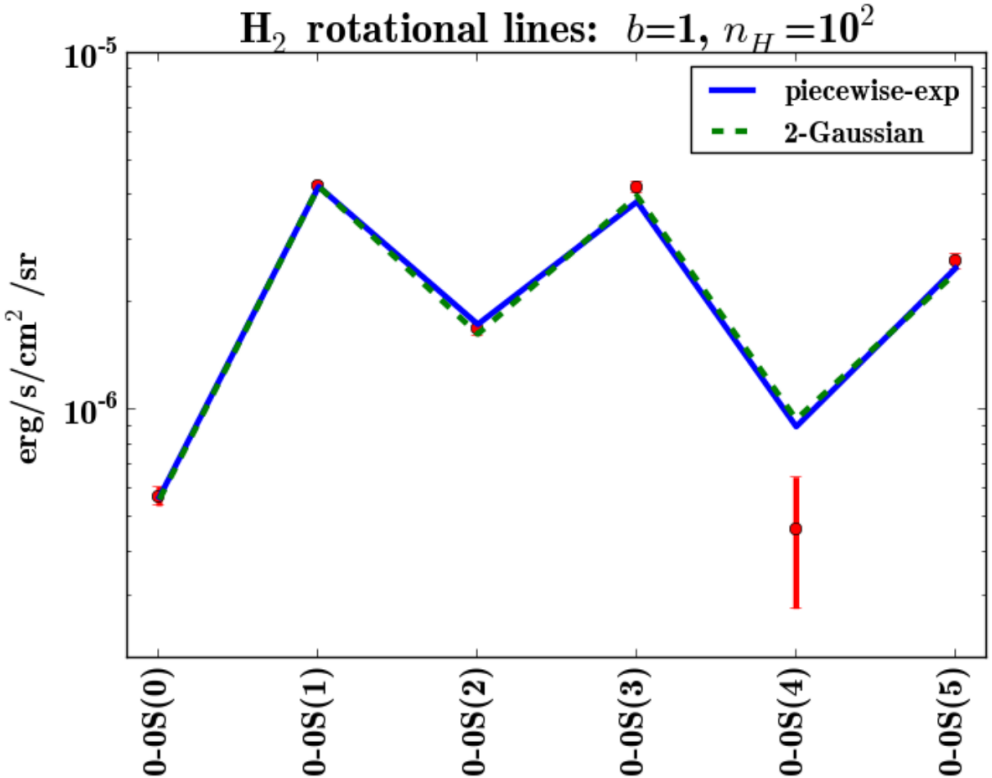

(a)
SQ-A
NGC7319
Main
Shock
H_2 Bridge
NGC7318b

Mass and energy cycle

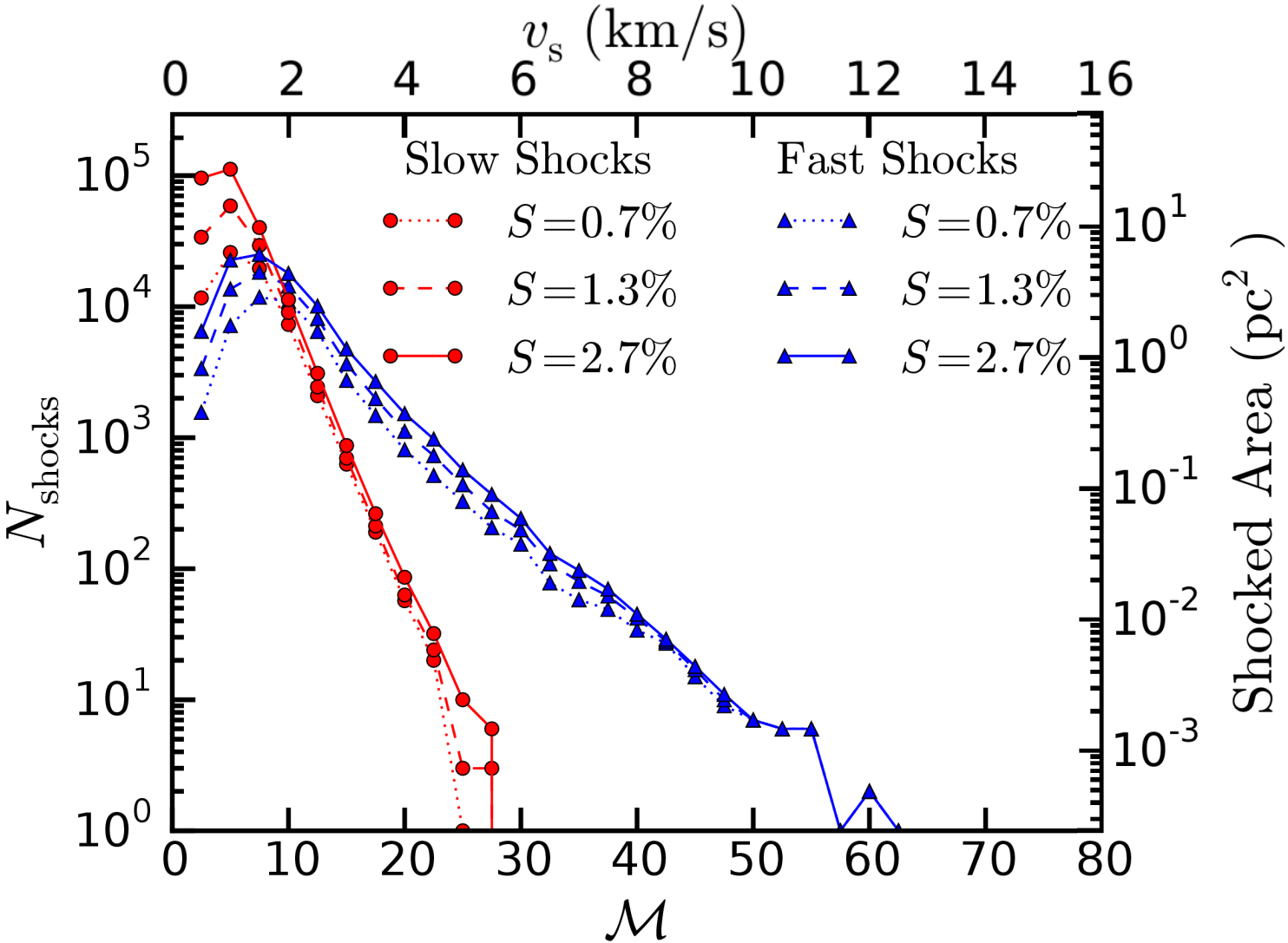


Guillard + 2009

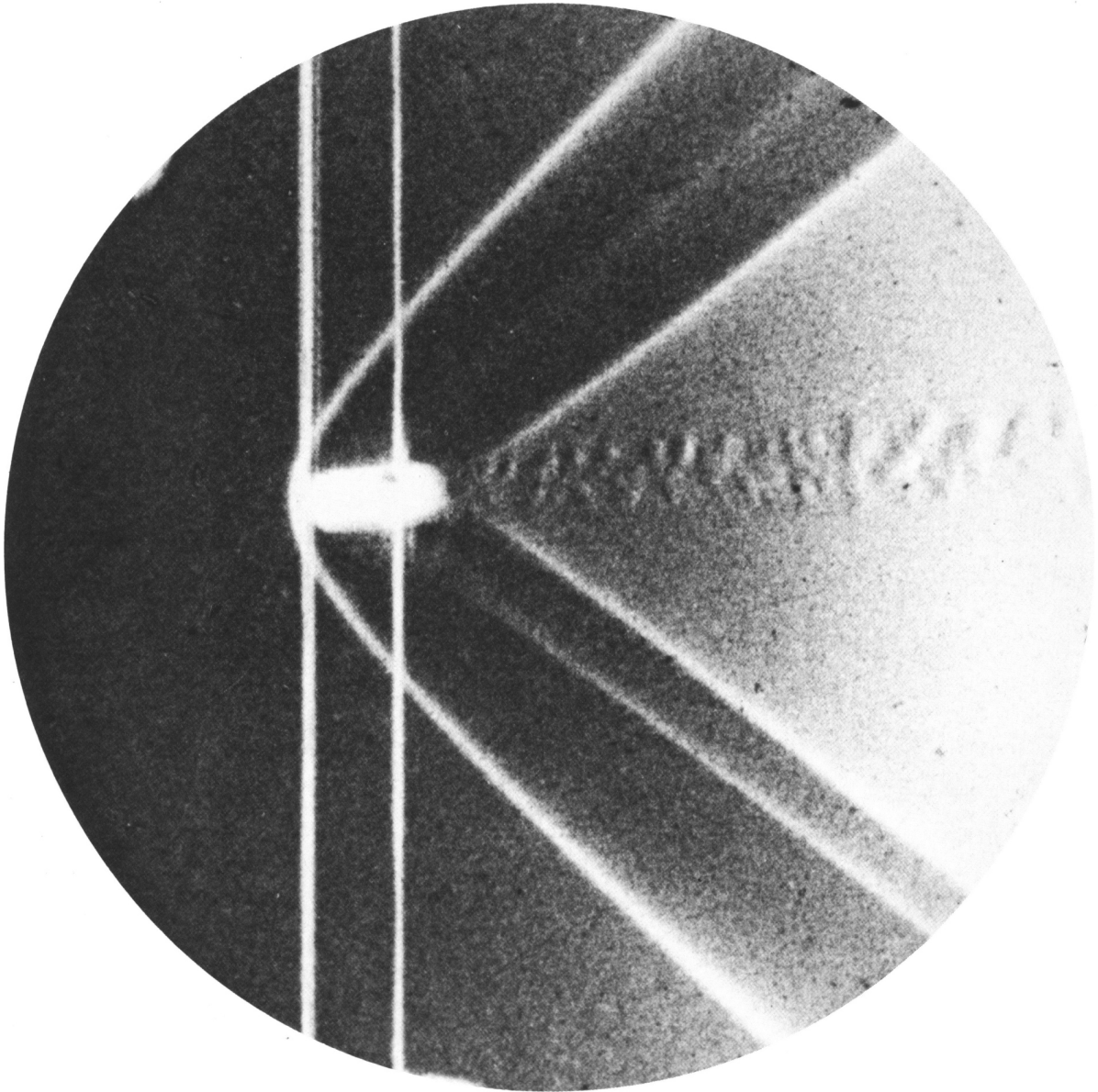


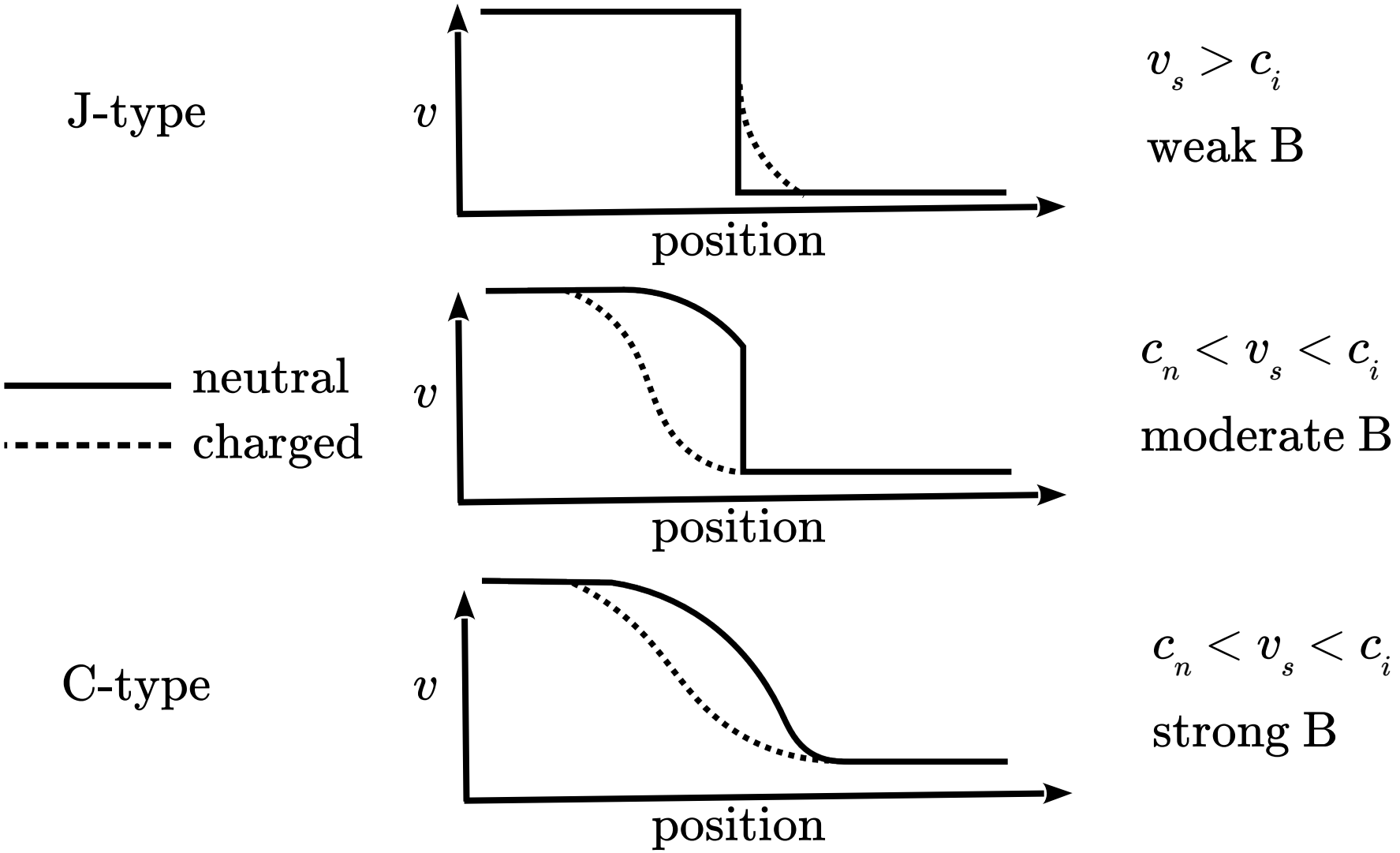


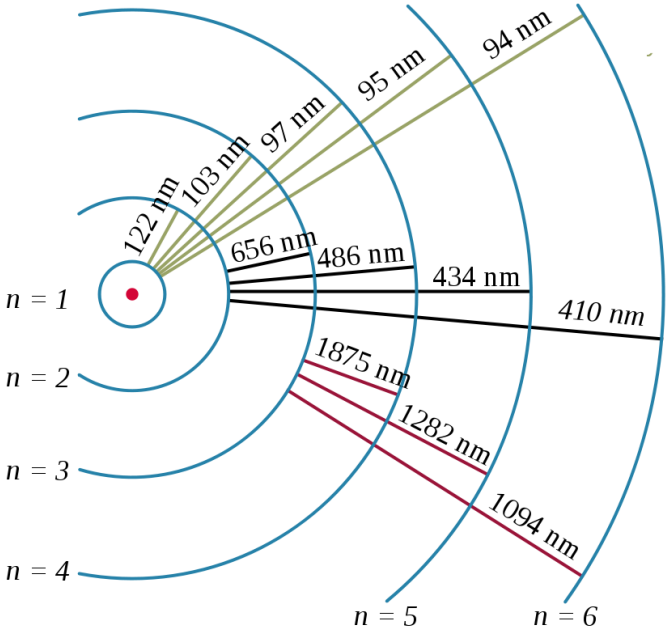
Lesaffre et al. (A&A, 2013)

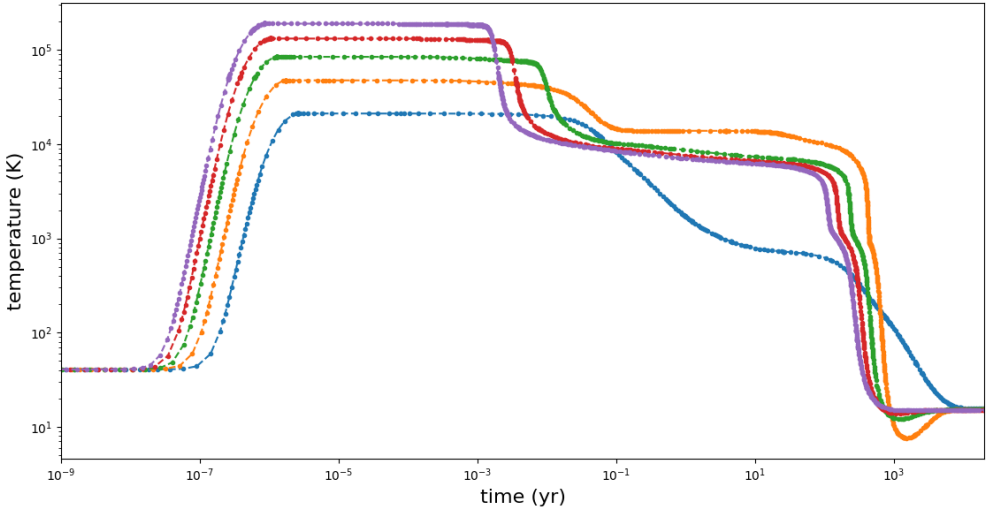


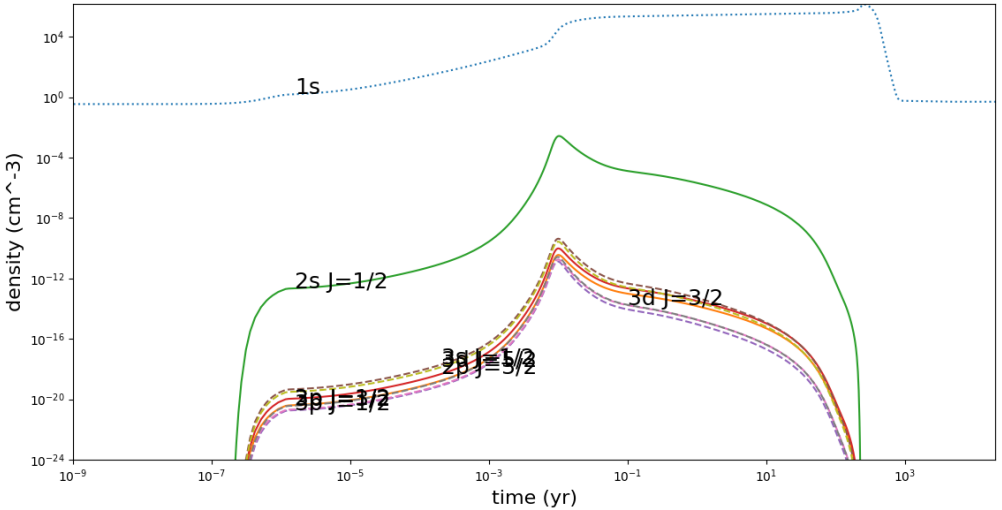
Lehmann, Federrath and Wardle (MNRAS, 2016)

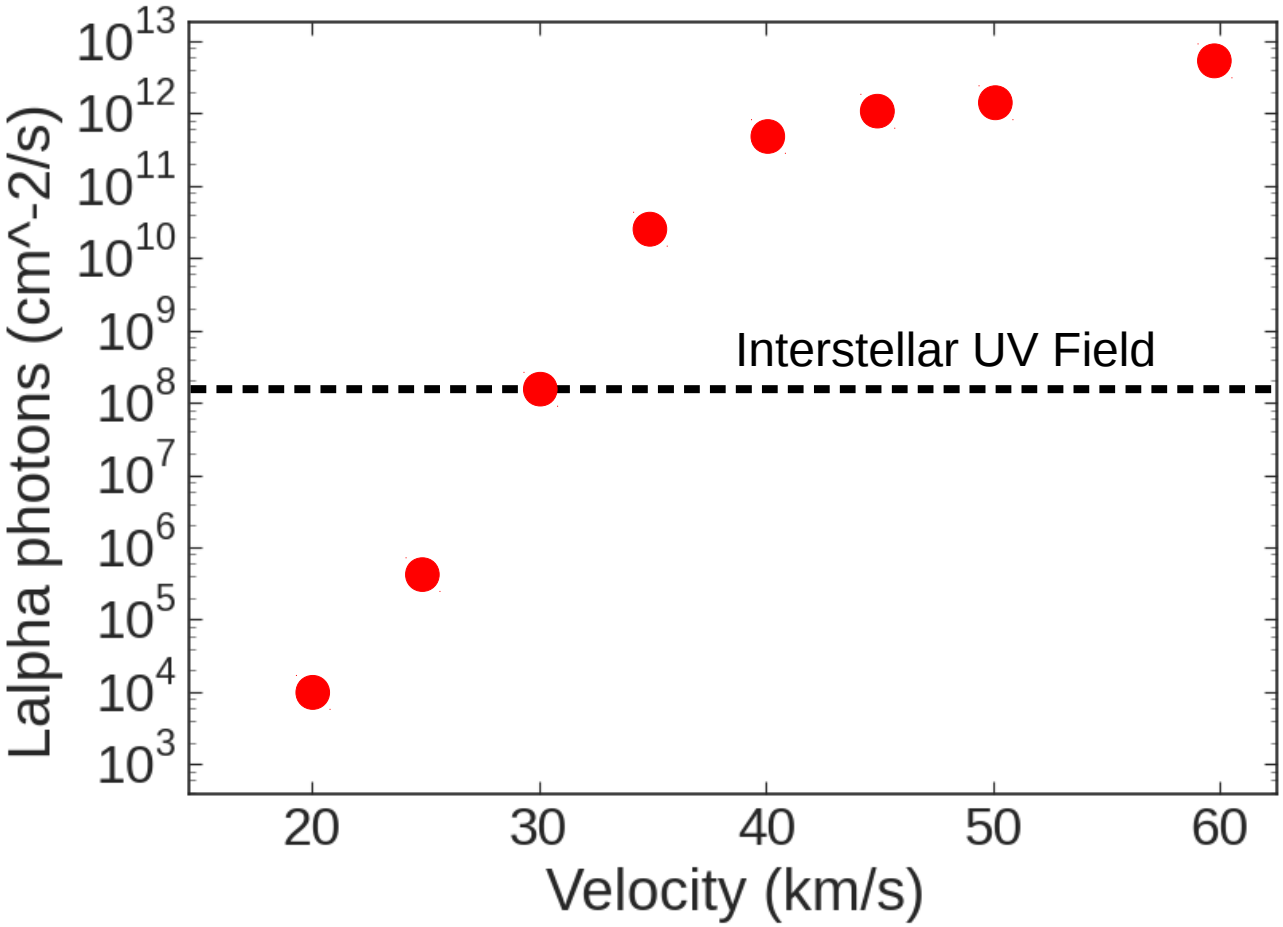


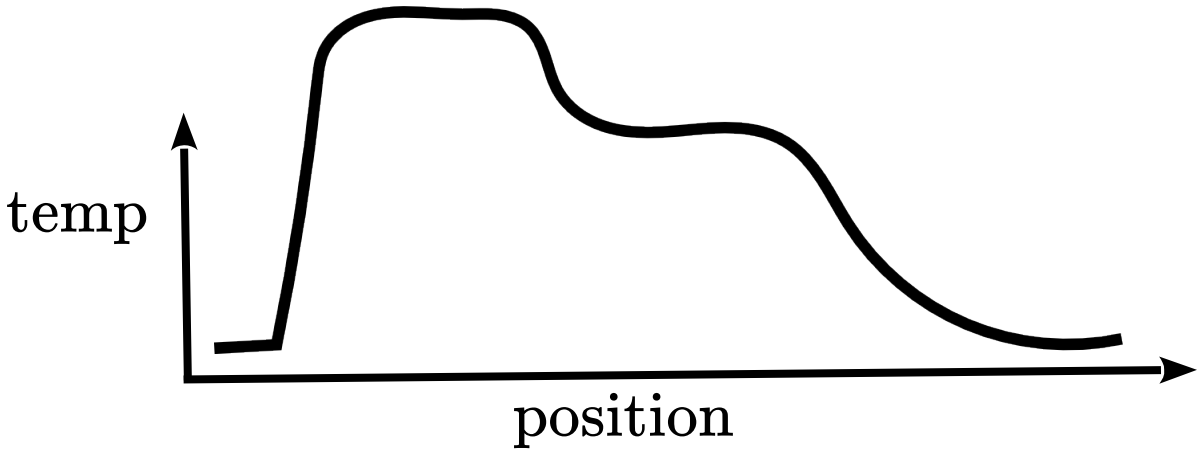

J-type
v
position
$v_s > c_i$
weak B
neutral
charged
v
position
$c_n < v_s < c_i$
moderate B
C-type
v
position
$c_n < v_s < c_i$
strong B

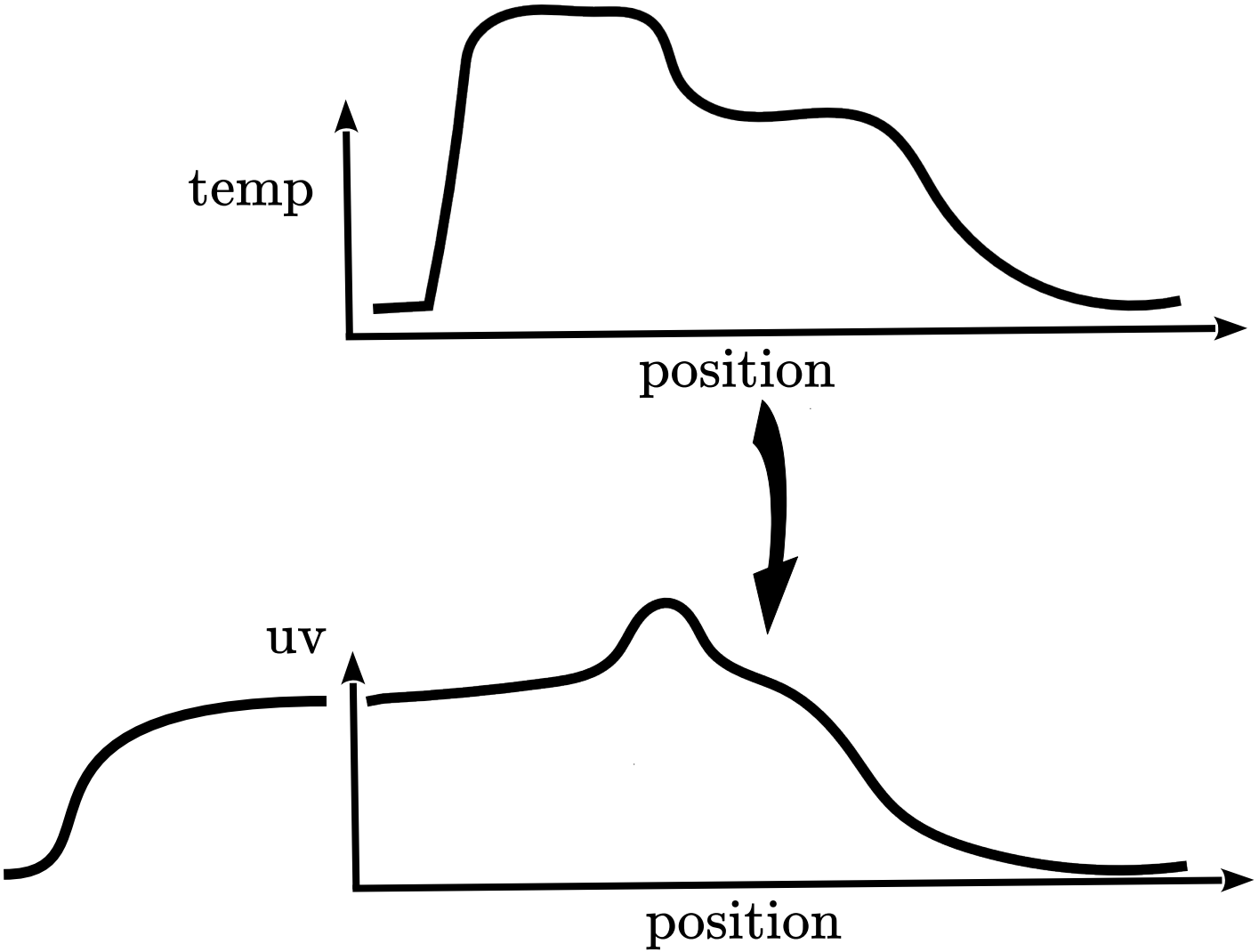

n = 1
n = 2
n = 3
n = 4
n = 5
n = 6
122 nm
103 nm
97 nm
95 nm
94 nm
656 nm
486 nm
434 nm
410 nm
1875 nm
1282 nm
1094 nm

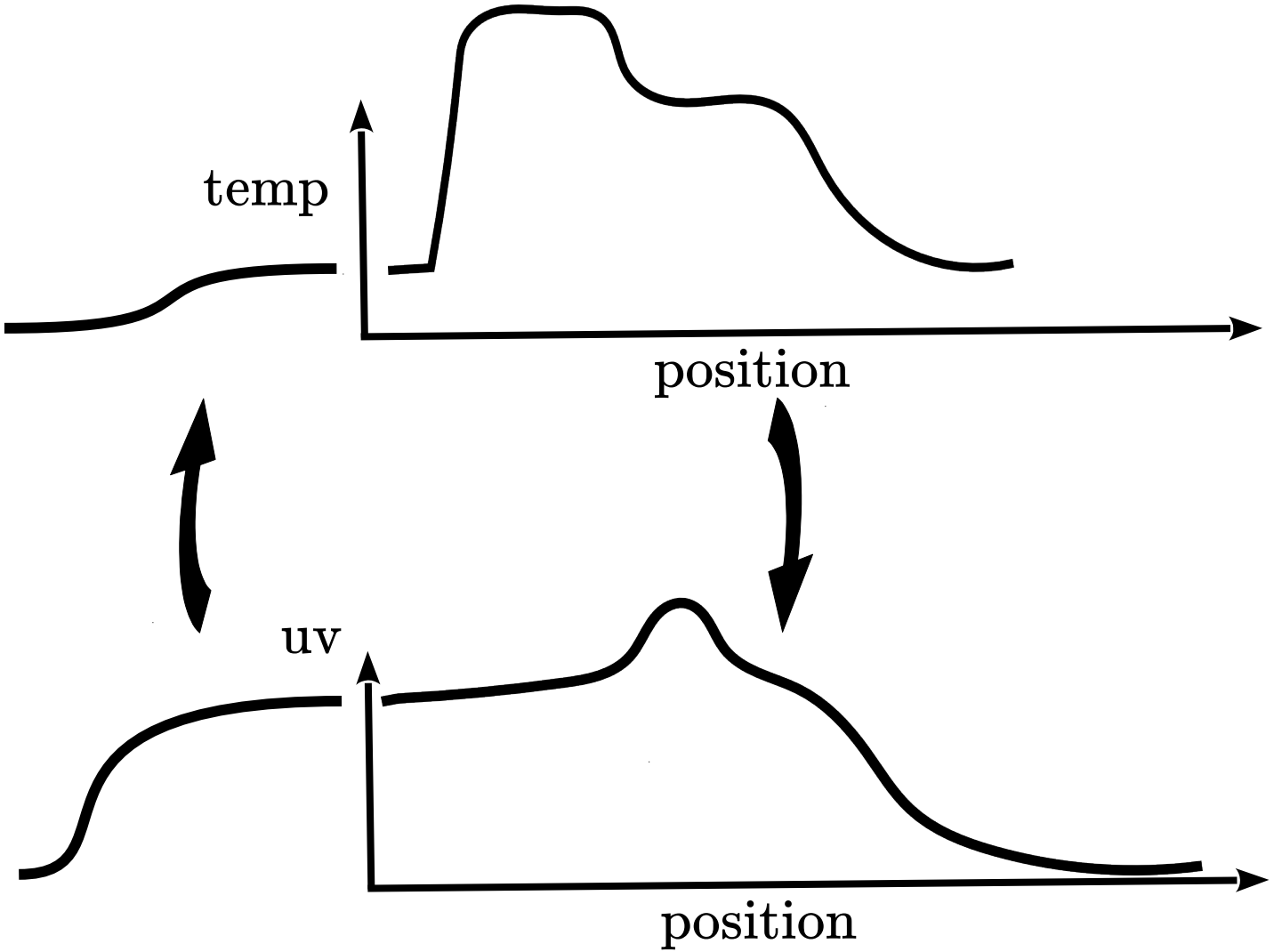

temperature (K)
time (yr)


density (cm^-3)
time (yr)
1s
2s J=1/2
3d J=3/2
3s J=1/2
2p J=3/2
3p J=3/2


Lalpha photons (cm^-2/s)
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
Interstellar UV Field
20
30
40
50
60
Velocity (km/s)

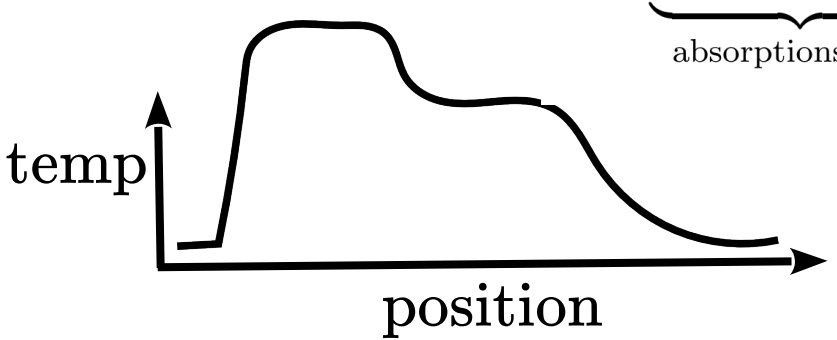

temp
position

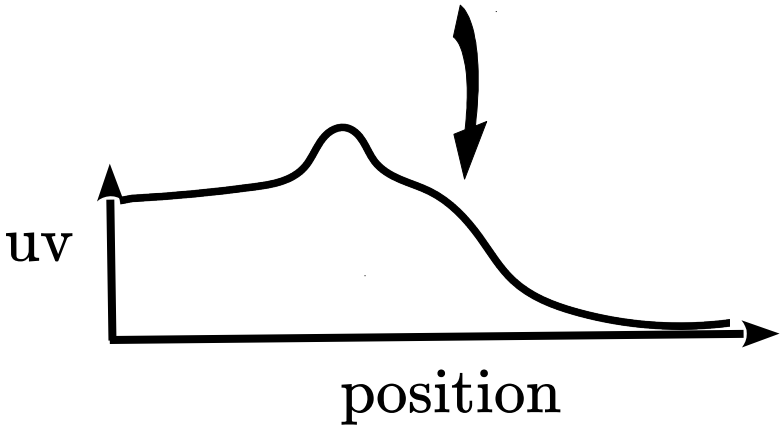

temp
position
uv
position


temp
position
uv
position

$$\frac{dn_i}{dt} = \overbrace{\sum_{j\neq i} C_{ji} n_c n_j}^{\text{collisions into } i} - \overbrace{\sum_{j\neq i} C_{ij} n_c n_i}^{\text{collisions out of } i} + \overbrace{\sum_{j>i} A_{ji} n_j}^{\text{spont. decay into } i} - \overbrace{\sum_{j<i} A_{ij} n_i}^{\text{spont. decay out of } i} +$$

$$\underbrace{\sum_{j<i} \frac{g_i}{g_j} A_{ij} n_\gamma^{ij} n_j}_{\text{absorptions into } i} - \underbrace{\sum_{j>i} \frac{g_j}{g_i} A_{ji} n_\gamma^{ji} n_i}_{\text{absorptions out of } i} + \underbrace{\sum_{j>i} A_{ji} n_\gamma^{ji} n_j}_{\text{stim. emis. into } i} - \underbrace{\sum_{j<i} A_{ij} n_\gamma^{ij} n_i}_{\text{stim. emis. out of } i} .$$

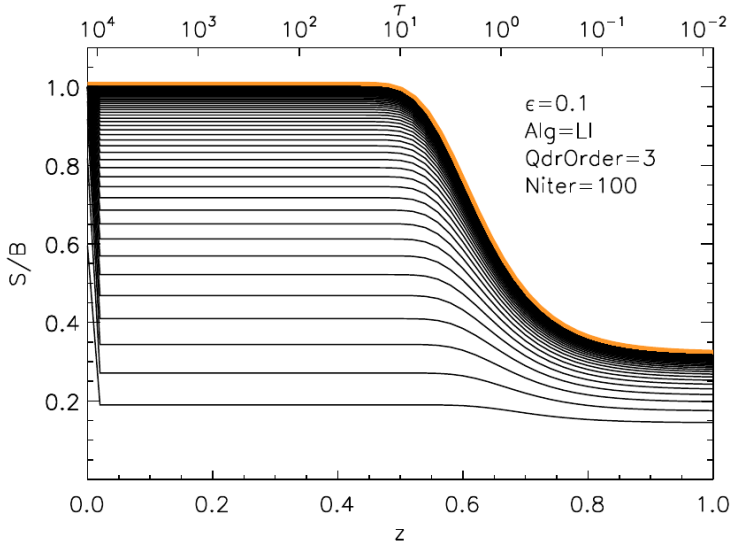


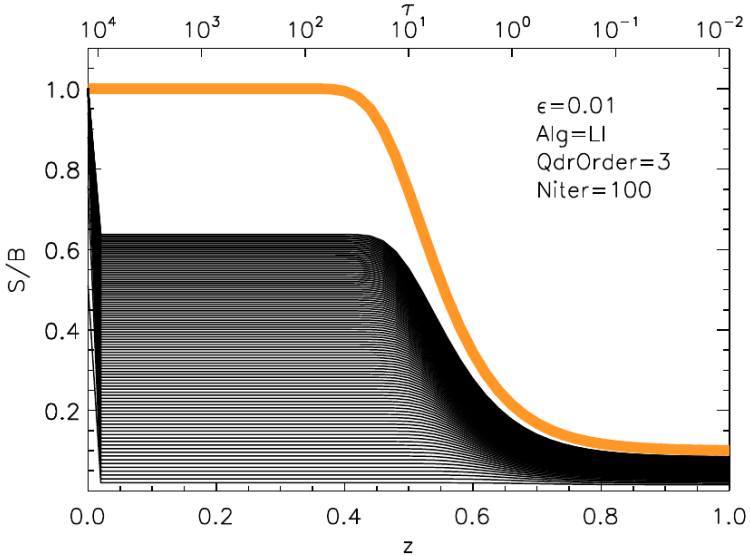


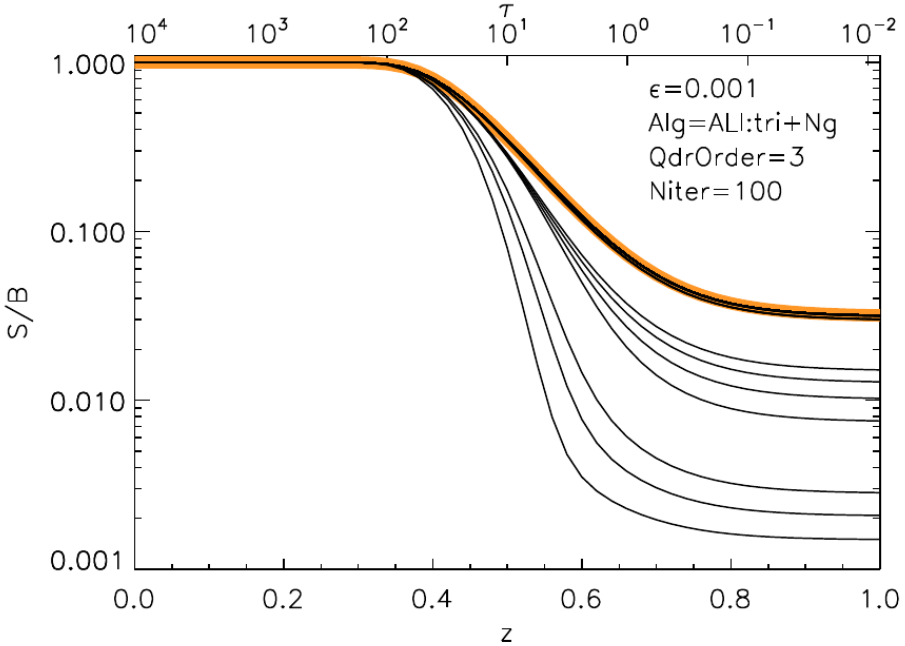
$$\frac{dI_\nu}{ds} = j_\nu - \kappa_\nu I_\nu$$

$$j_\nu = \frac{h\nu_{ul}}{4\pi} A_{ul} \phi_\nu n_u$$

Accelerated Lambda Iteration

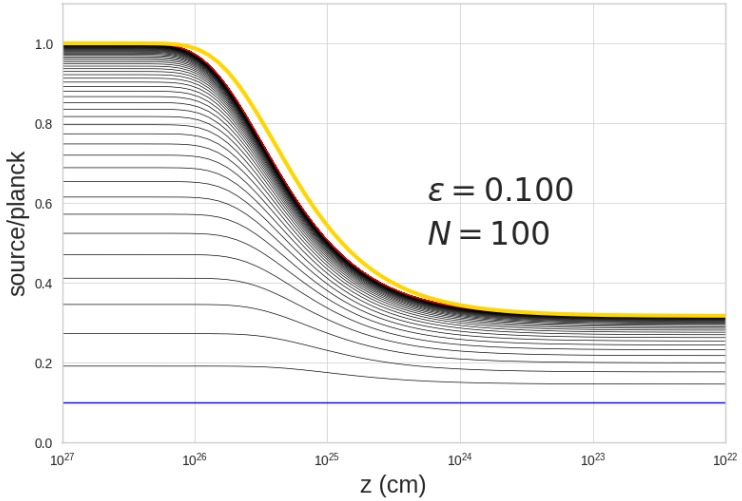


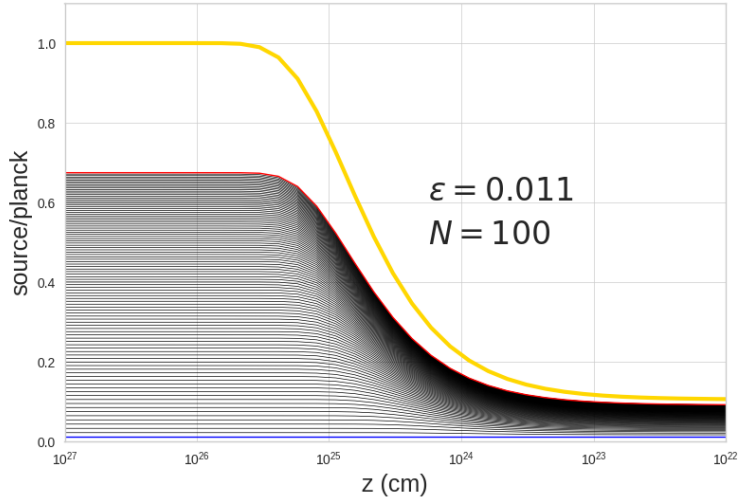


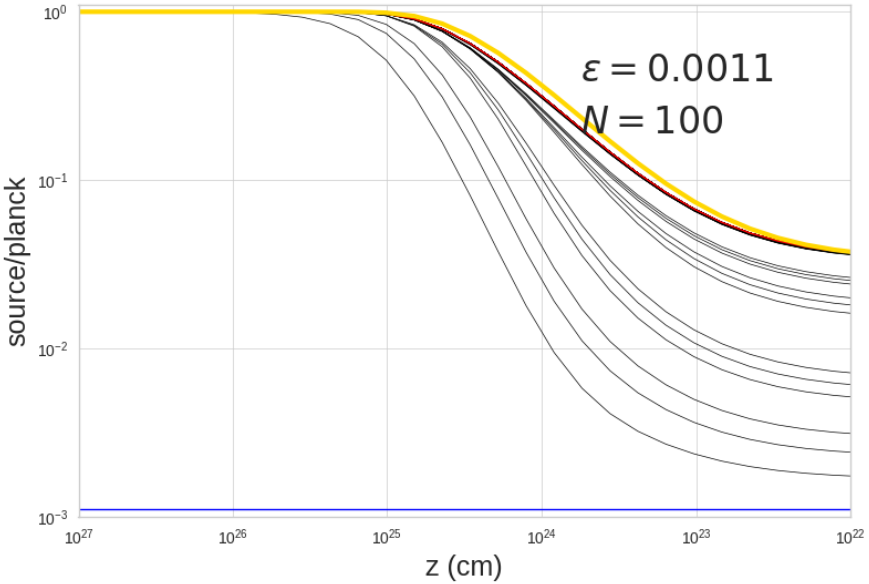


$$\epsilon = \frac{C_{ij}(1 - \exp[-h\nu_{ij}/kT])}{A_{ij} + C_{ij}(1 - \exp[-h\nu_{ij}/kT])}$$

Accelerated Lambda Iteration







$$\epsilon = \frac{C_{ij}(1 - \exp\left[-h\nu_{ij}/kT\right])}{A_{ij} + C_{ij}(1 - \exp\left[-h\nu_{ij}/kT\right])}$$

Questions

- How is the shock structure changed?
- What are the (velocity) limits of the model?
- What happens to the usual shock tracers (OI, H2O, SiO, CH+ etc.)?
- Applications: turbulent cascades, jets, SNRs...