Clump formation through colliding stellar winds in the Galactic Center

Calderón et al. (2016)

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INSTITUTO DE ASTROFÍSICA
FACULTAD DE FÍSICA

"Dynamics and Accretion at the Galactic Center"
Aspen winter conference, February 9th 2016

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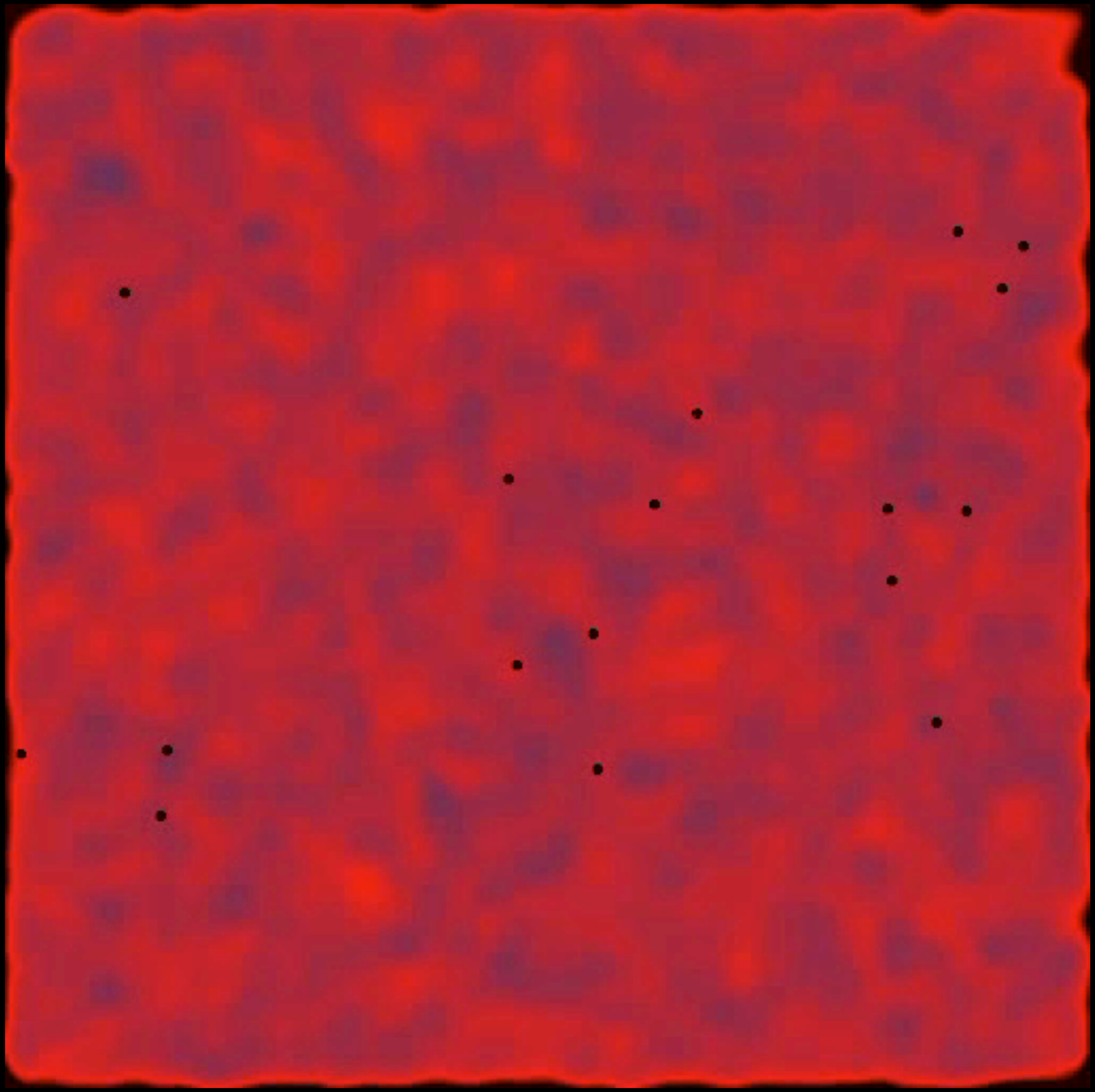
Image of η Carinae by HST

Gas clumps in the Galactic Center



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Animation from Cuadra et al. (2008)

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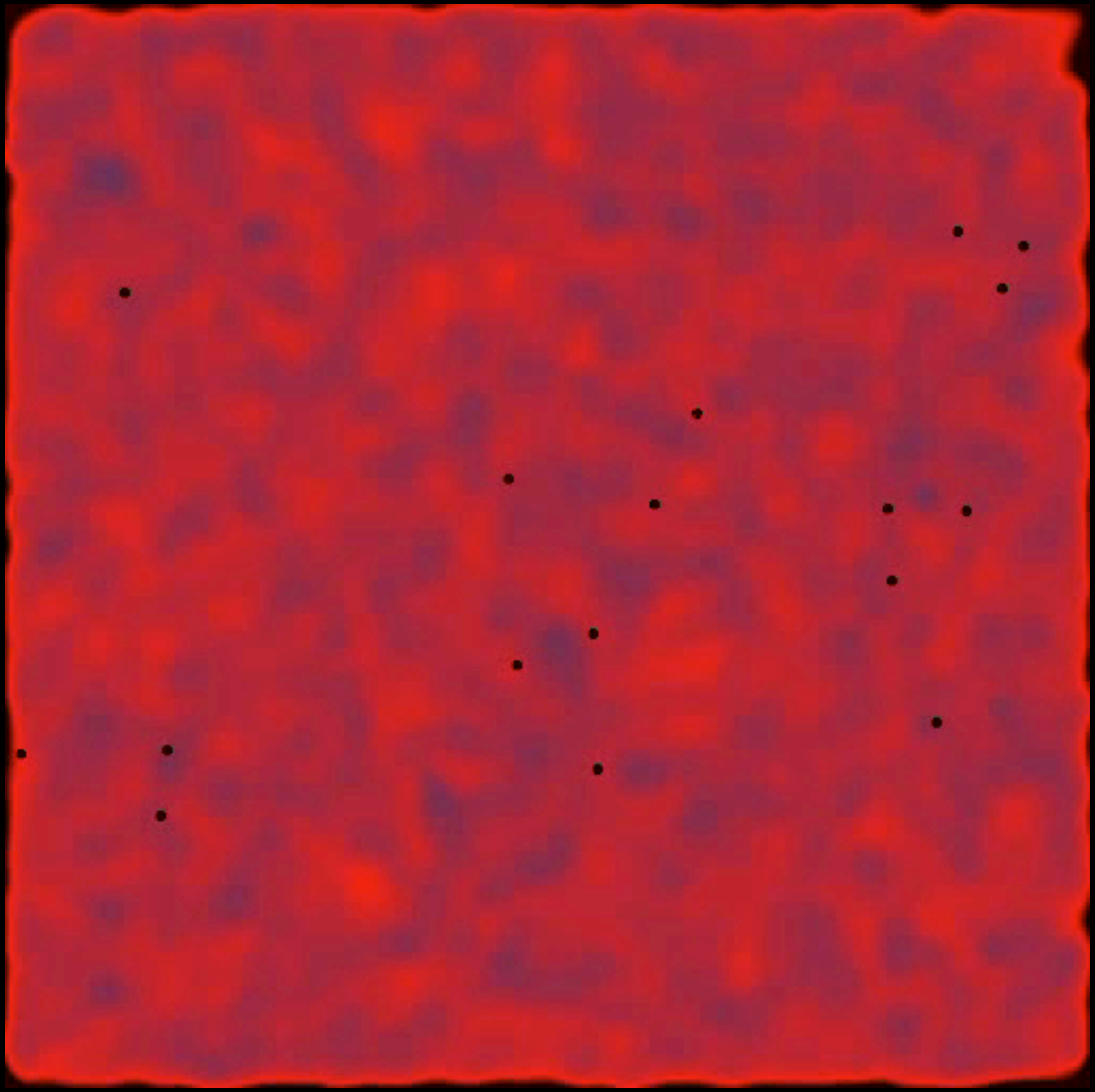

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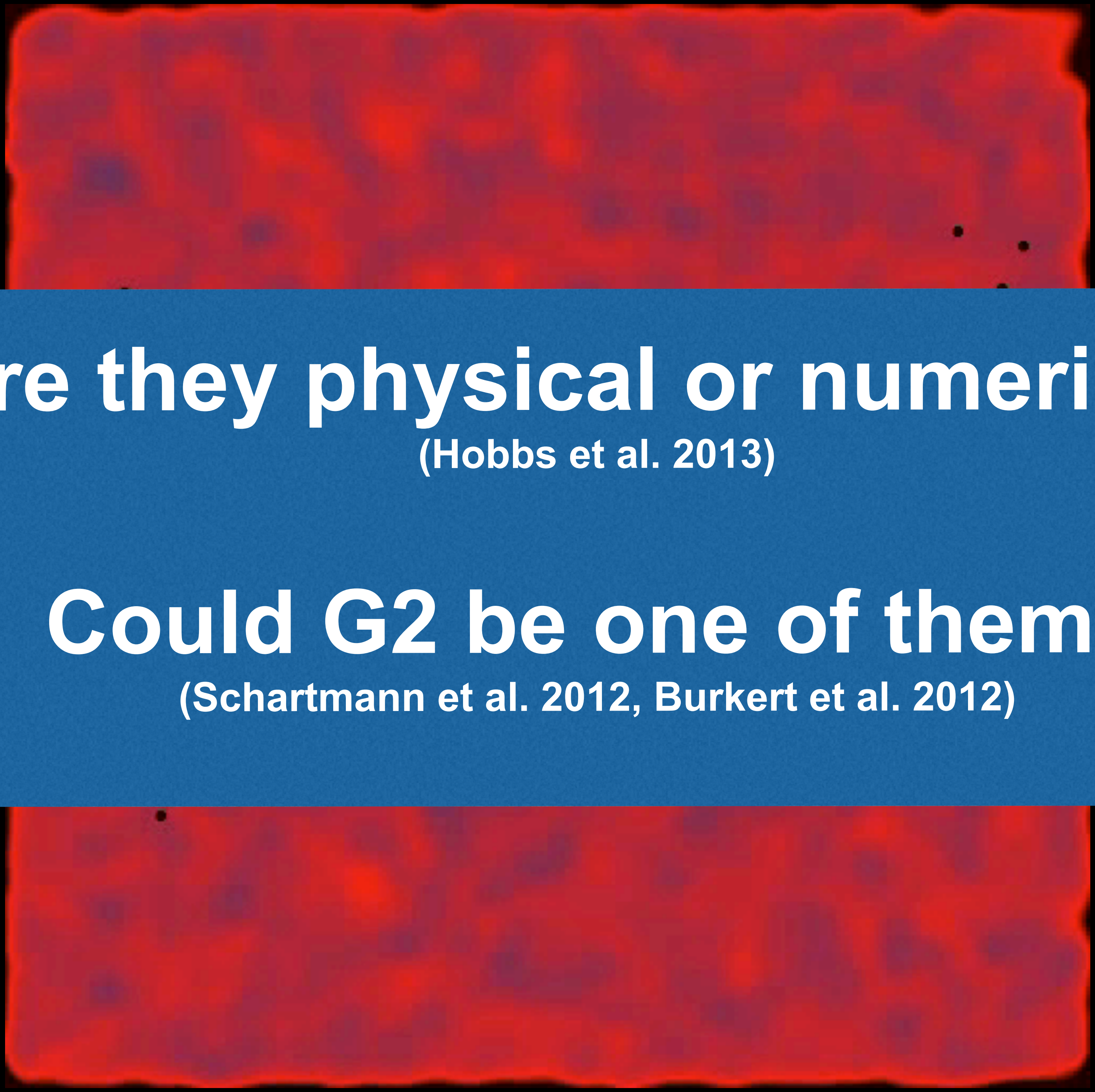


Are they physical or numerical?

(Hobbs et al. 2013)

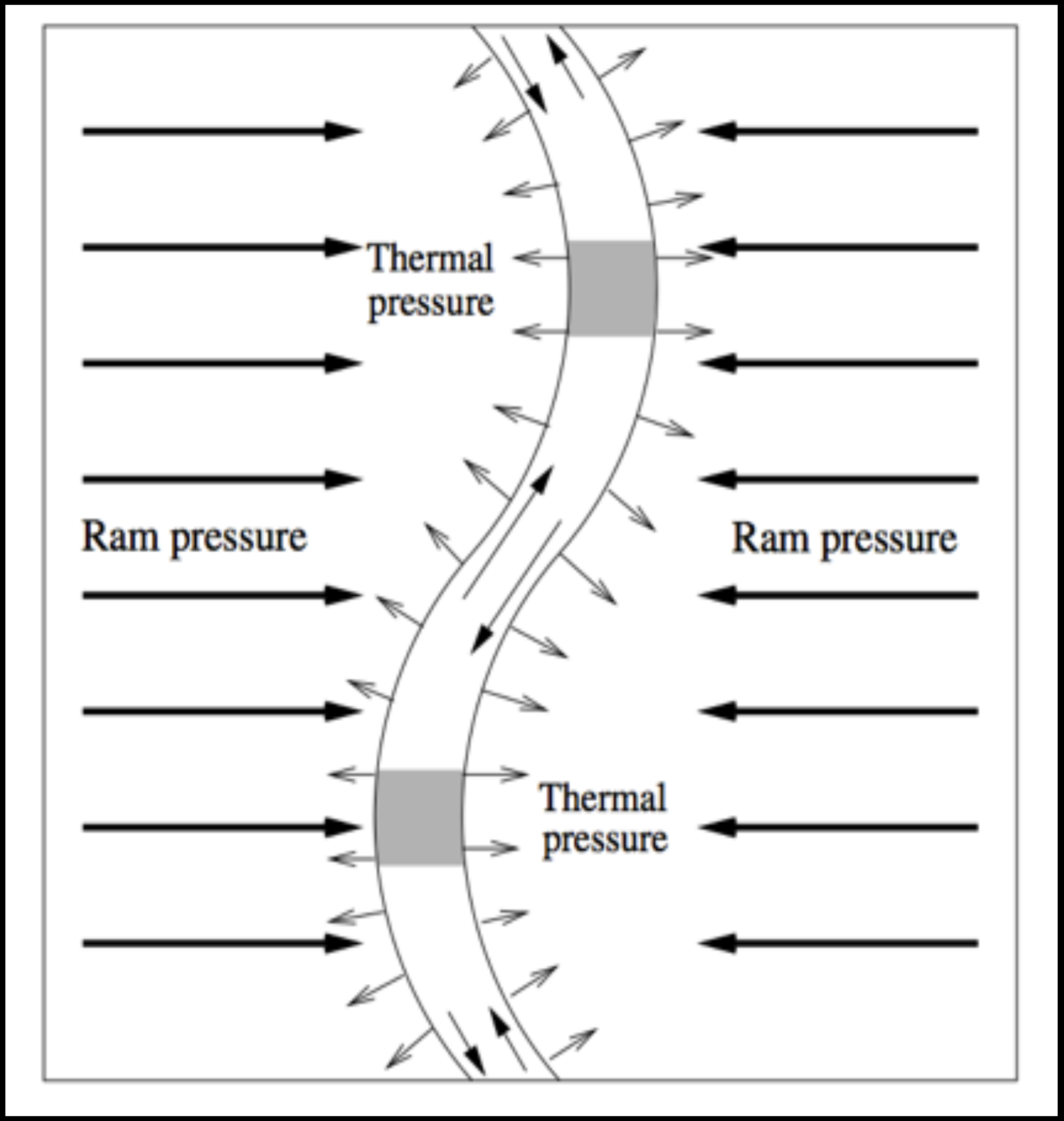
Could G2 be one of them?

(Schartmann et al. 2012, Burkert et al. 2012)

Animation from Cuadra et al. (2008)

Non-linear Thin Shell Instability (NTSI)

Vishniac (1994)



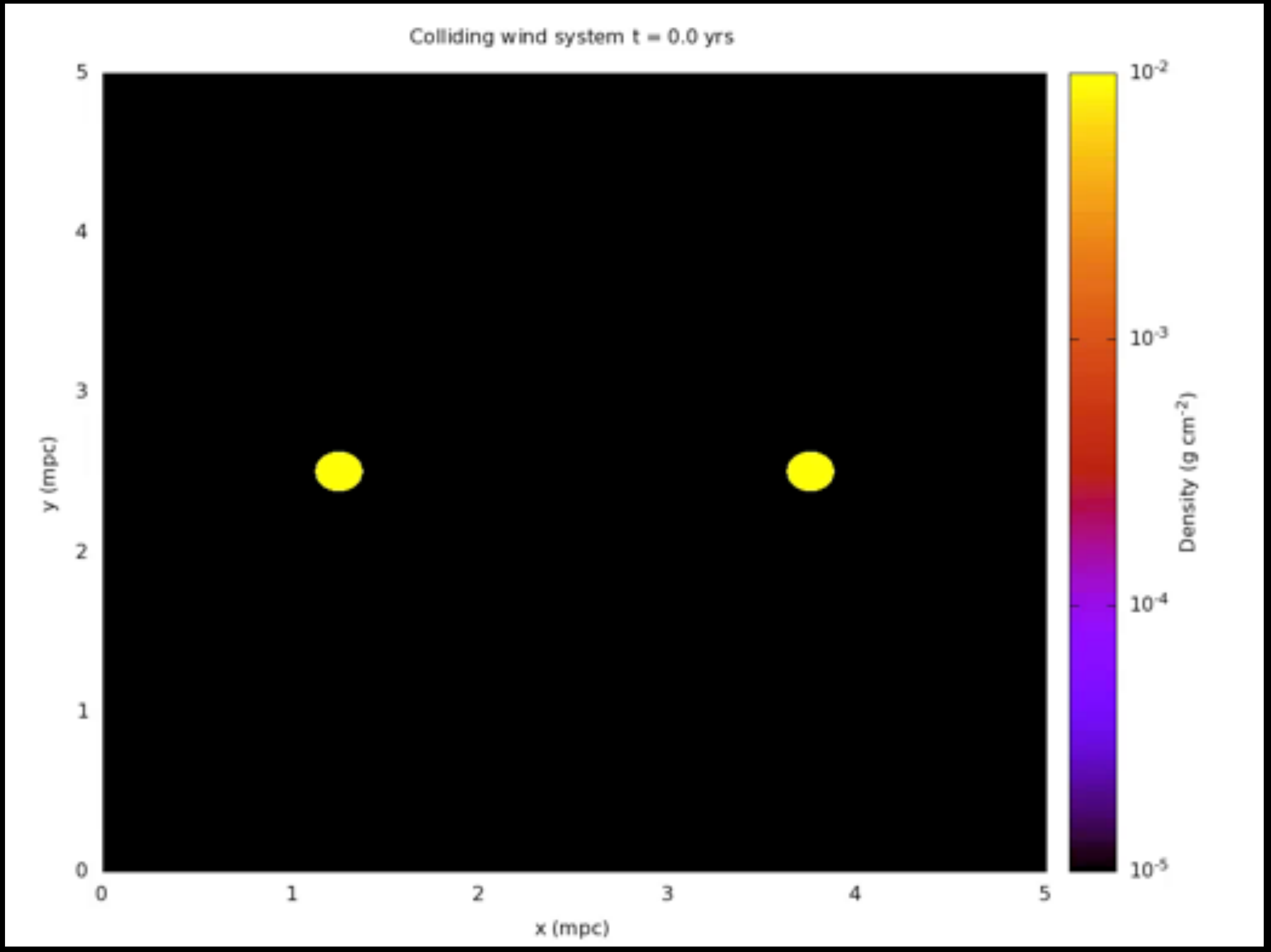


Figure from McLeod & Whitworth (2013)

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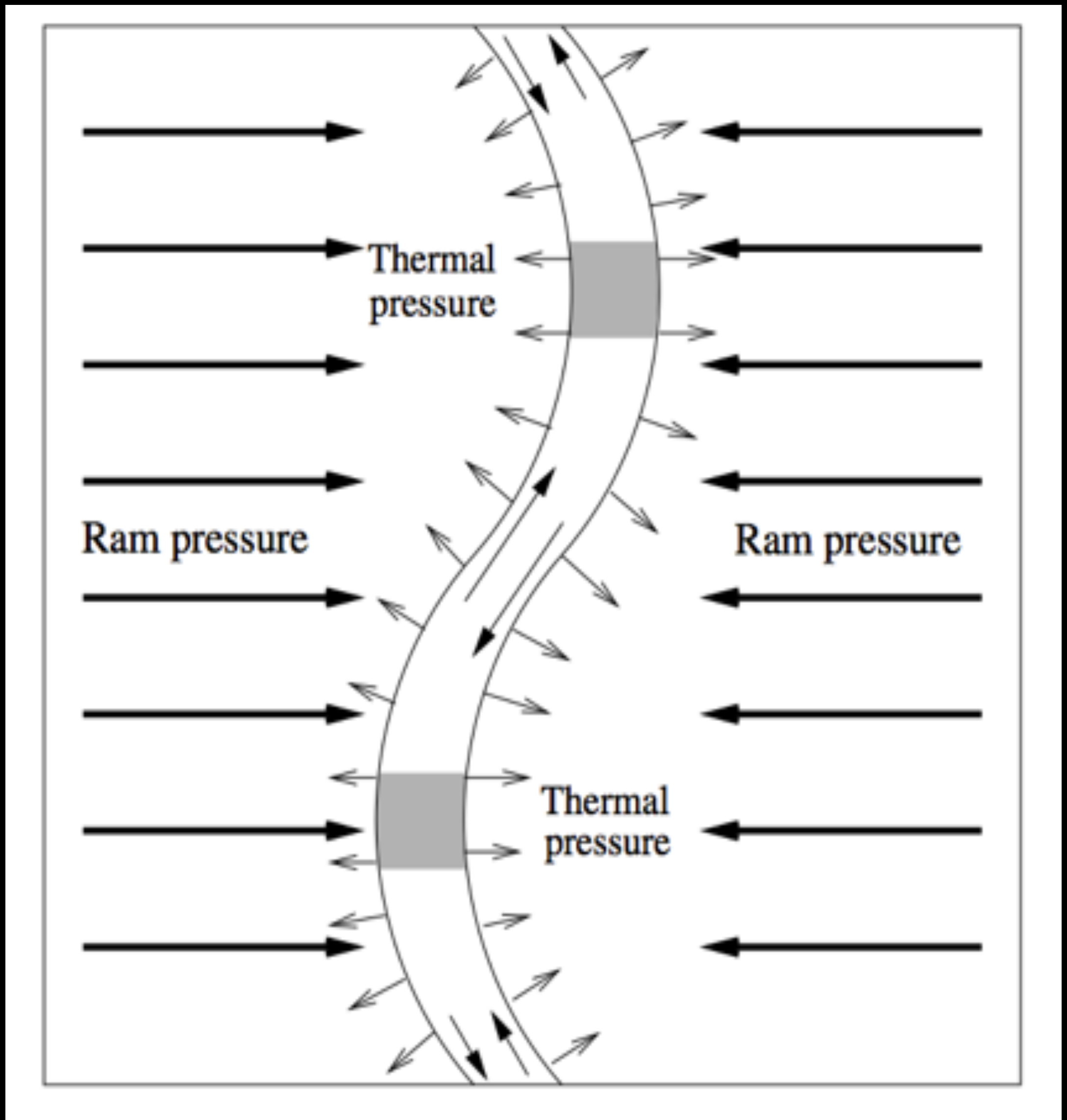

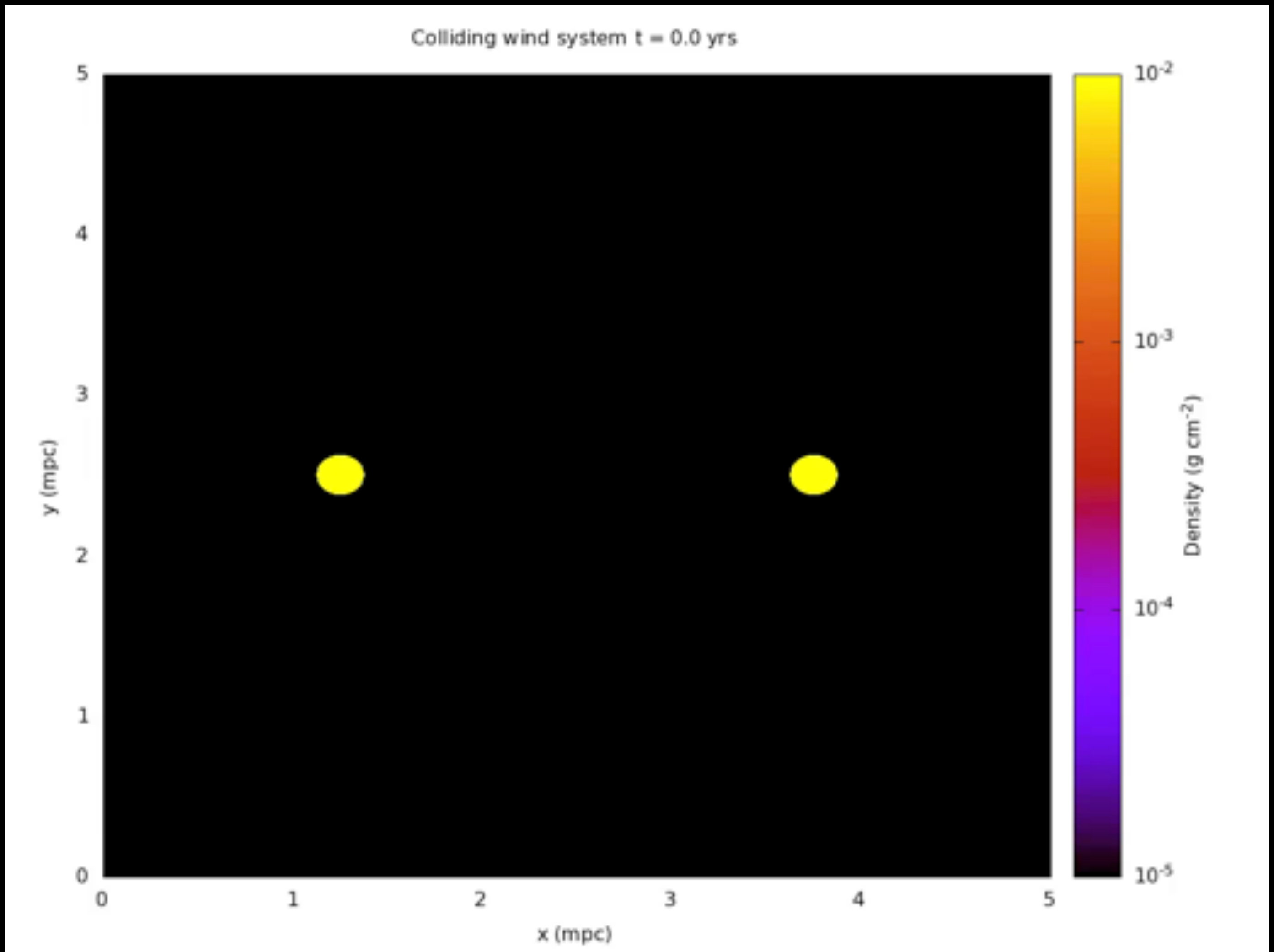

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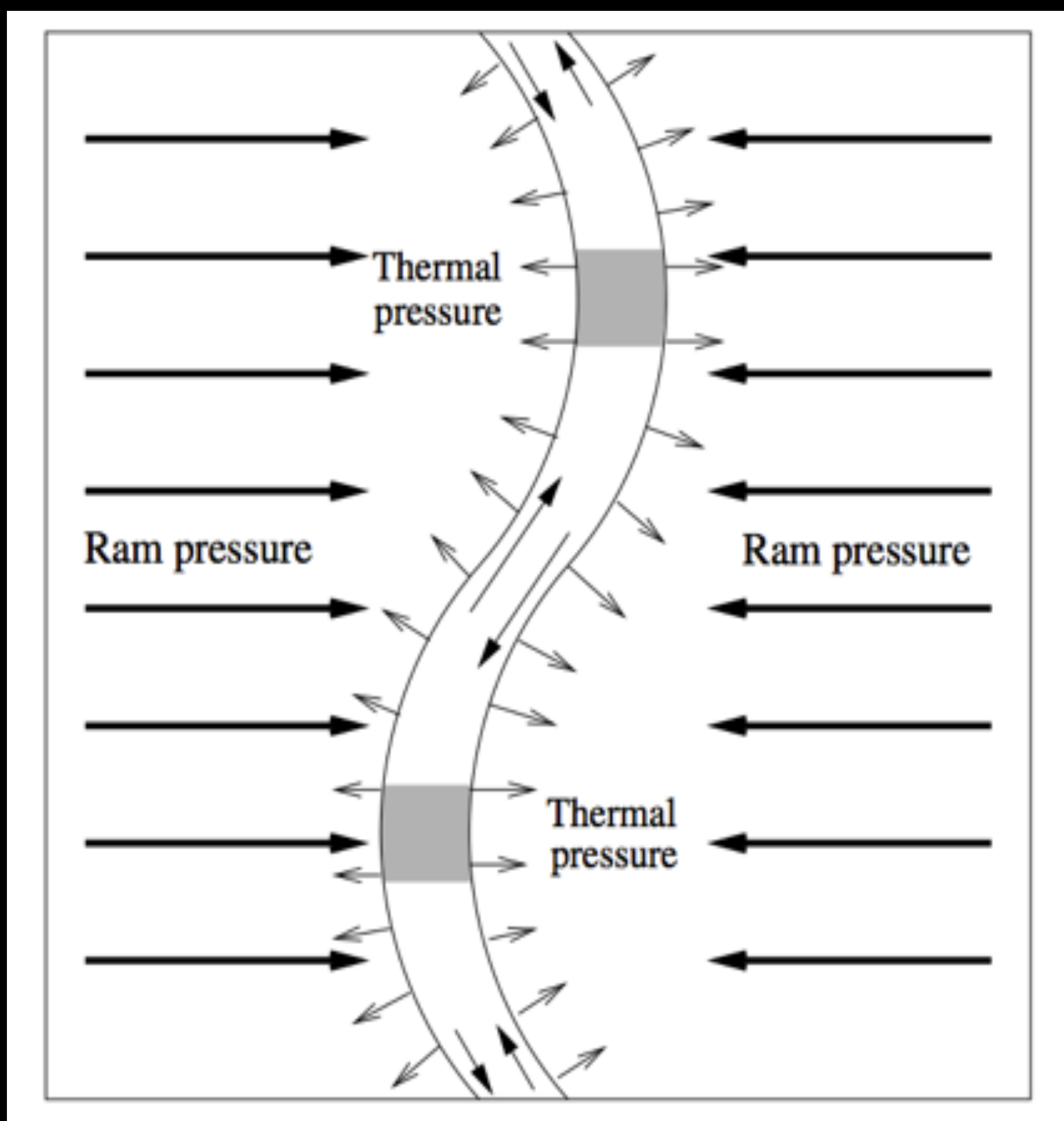


Isothermal case

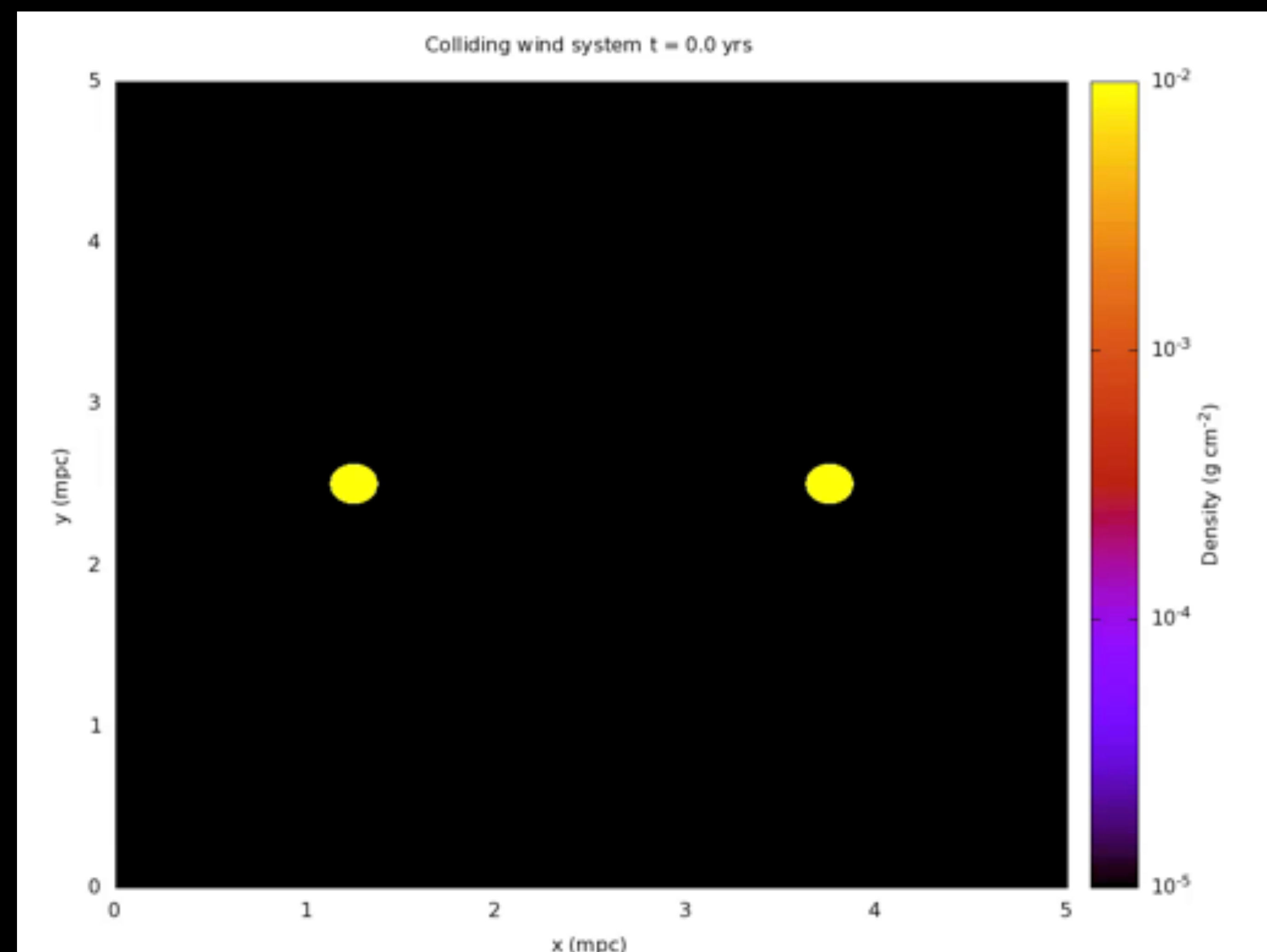


Figure from McLeod & Whitworth (2013)

Colliding Winds

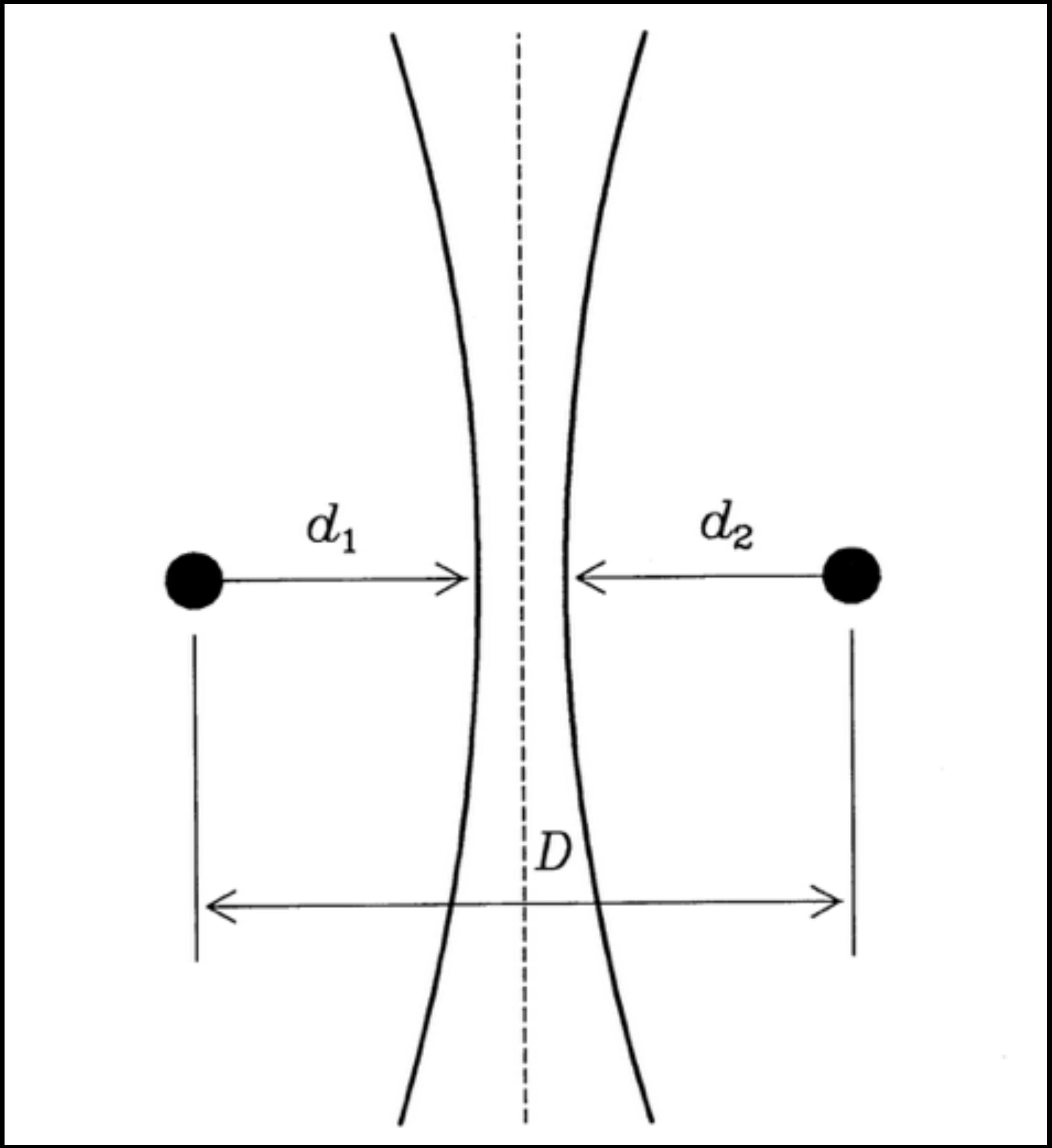
From Stevens et al. (1992),

$$\chi = \frac{t_{\rm cool}}{t_{\rm dyn}} \approx \frac{1}{2}\frac{v_8^{5.4} d_{12}}{\dot{M}_{-7}}$$

$$\chi \geq 1 \Rightarrow adiabatic\ wind$$

$$\chi < 1 \Rightarrow radiative\ wind$$

The NTSI can take place only if winds are radiative, i.e., form a thin shell.



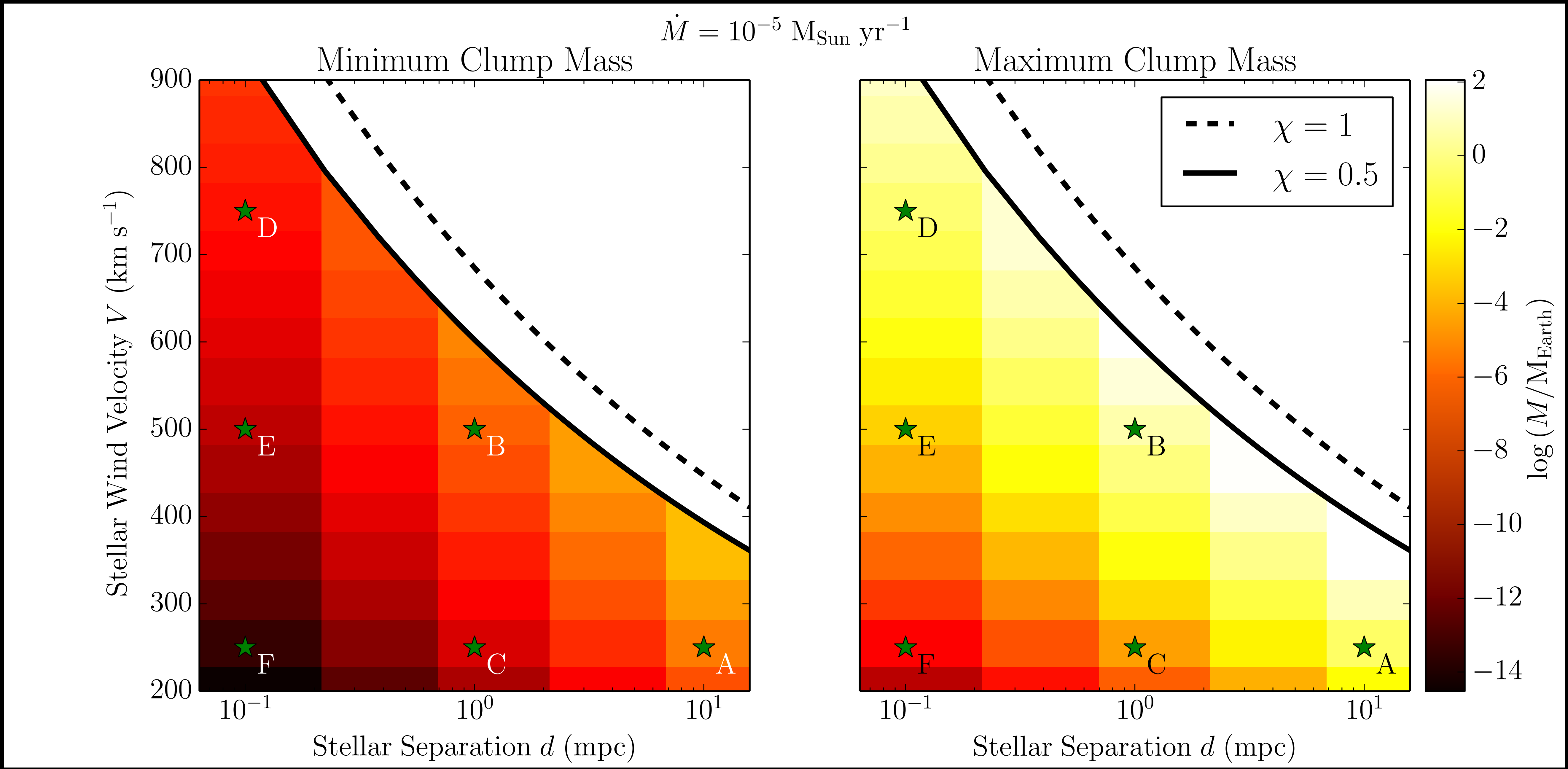
Schematic representation of a colliding winds system

Figure from Stevens et al. (1992)

Model for a symmetric wind collision

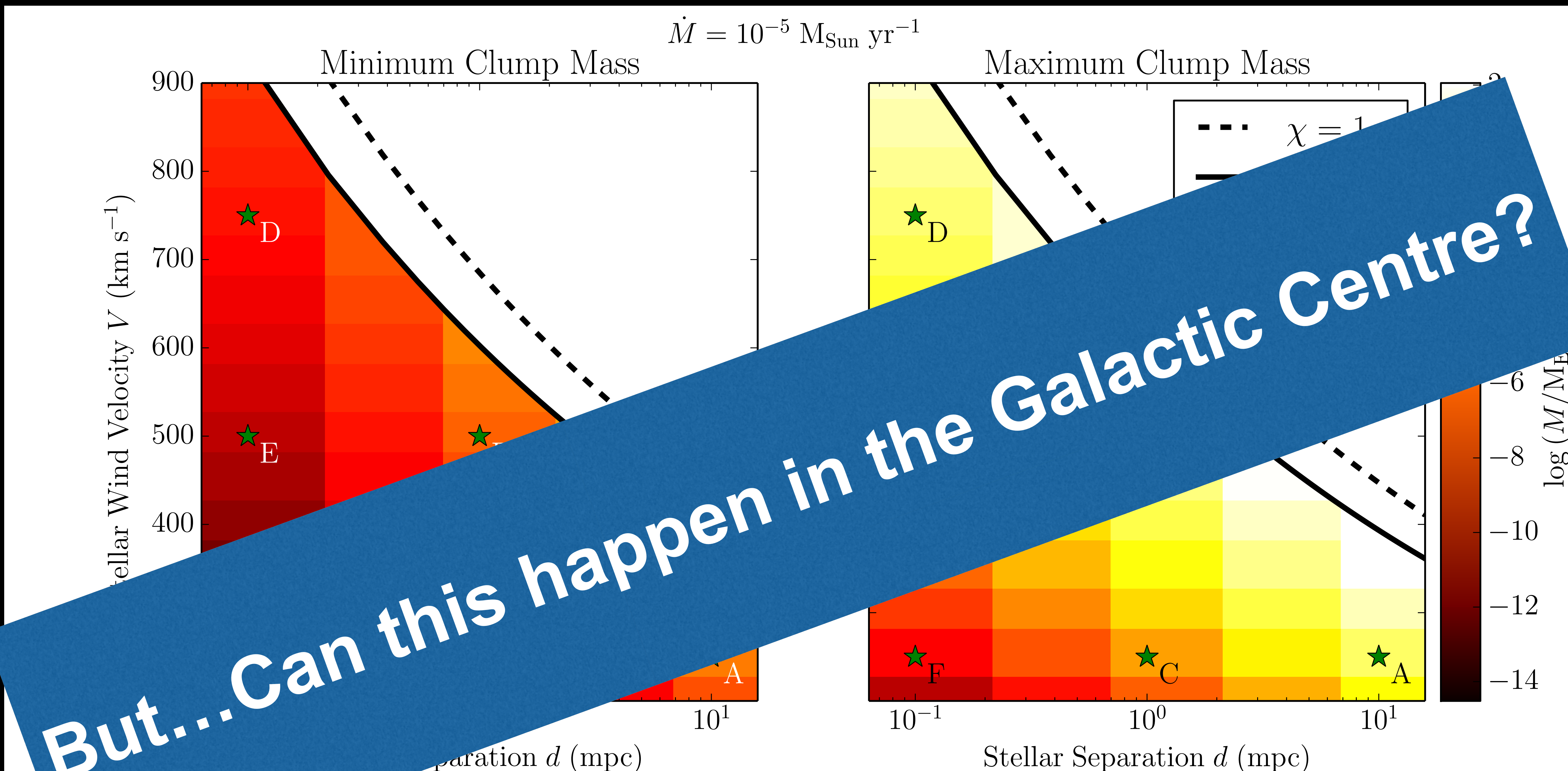
Describing the thermal evolution of the slab, we can estimate the unstable wavelength range, and the mass of possible clumps (assuming $\lambda \sim$ clump size).

Model for a symmetric wind collision



Clumps can be created in a wide range of masses, some of them can even reach ~100 Earth masses.

Model for a symmetric wind collision



But…Can this happen in the Galactic Centre?

…ps can be created in a wide range of masses, some of them can even reach ~100 Earth masses.

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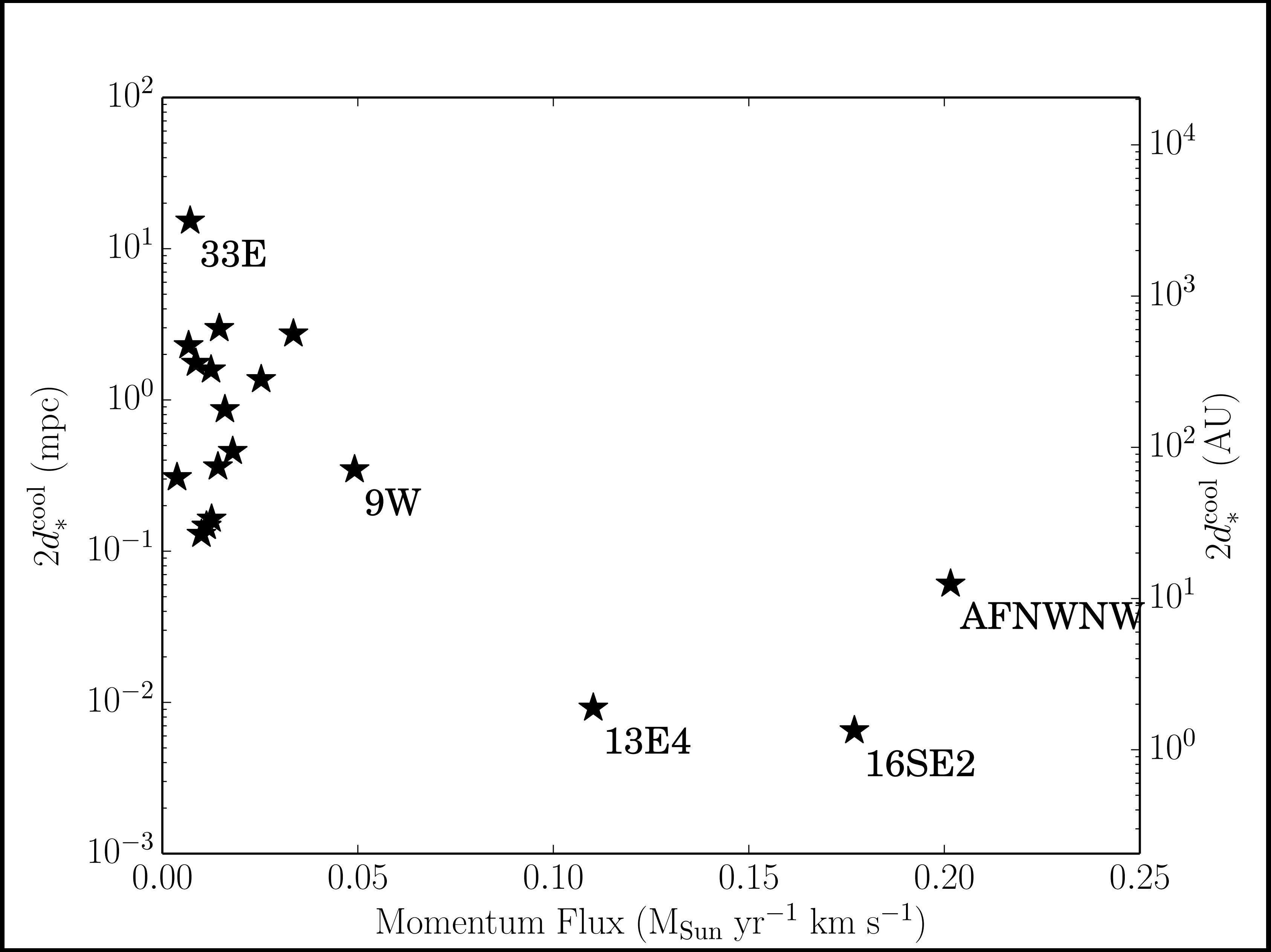
Clump formation in the Galactic Centre

y-axis shows maximum stellar separations for identical winds to be radiative, i.e., form *thin shells.*

Separations of miliparsec (~200AU) scales are not very common.



Stellar properties from Martins et al. (2007)

Animation Pittard (2009)

Clump formation in the Galactic Centre

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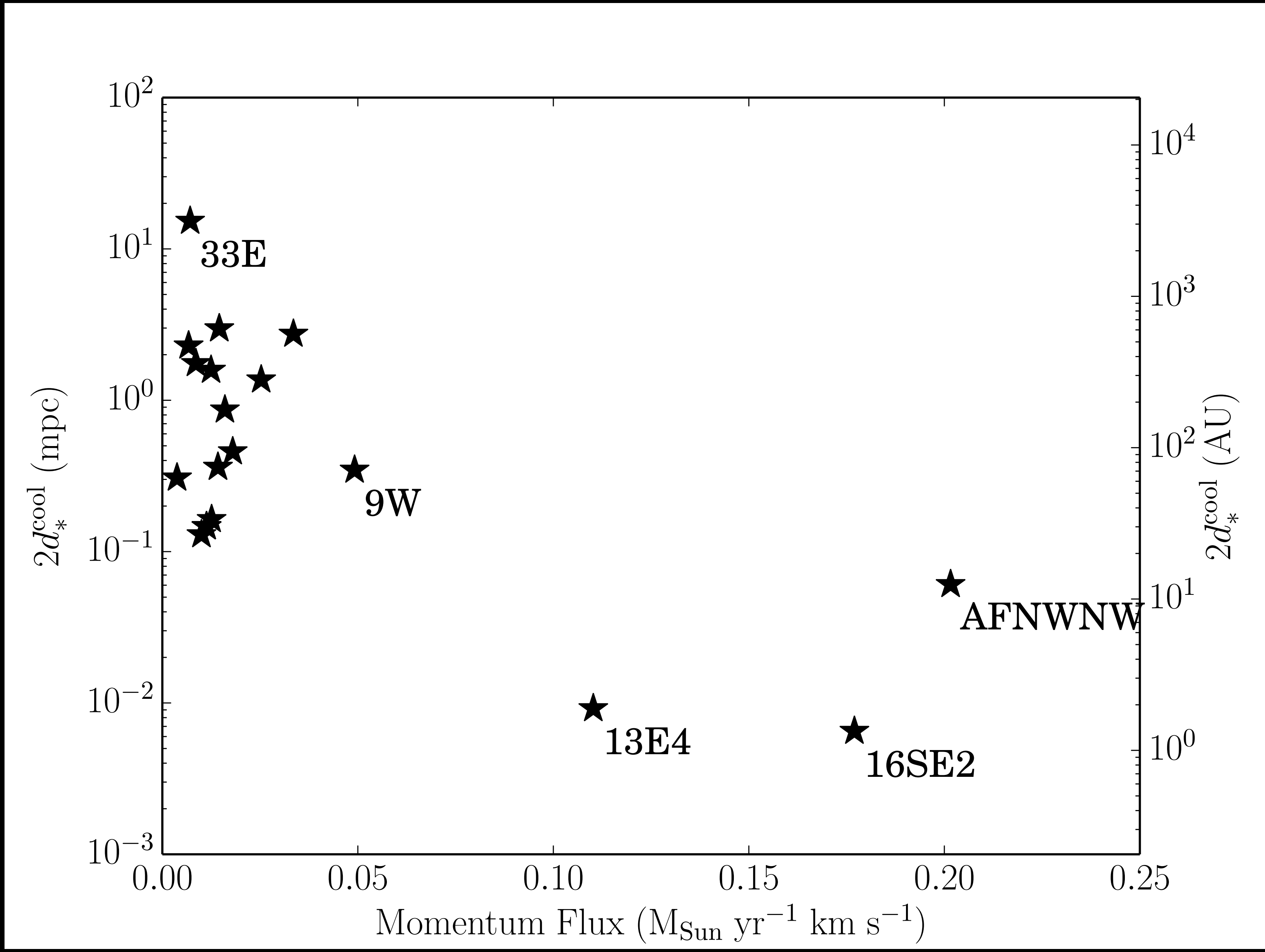
What about binaries?

3 systems so far

~30% expected (Pfuhl+2014)



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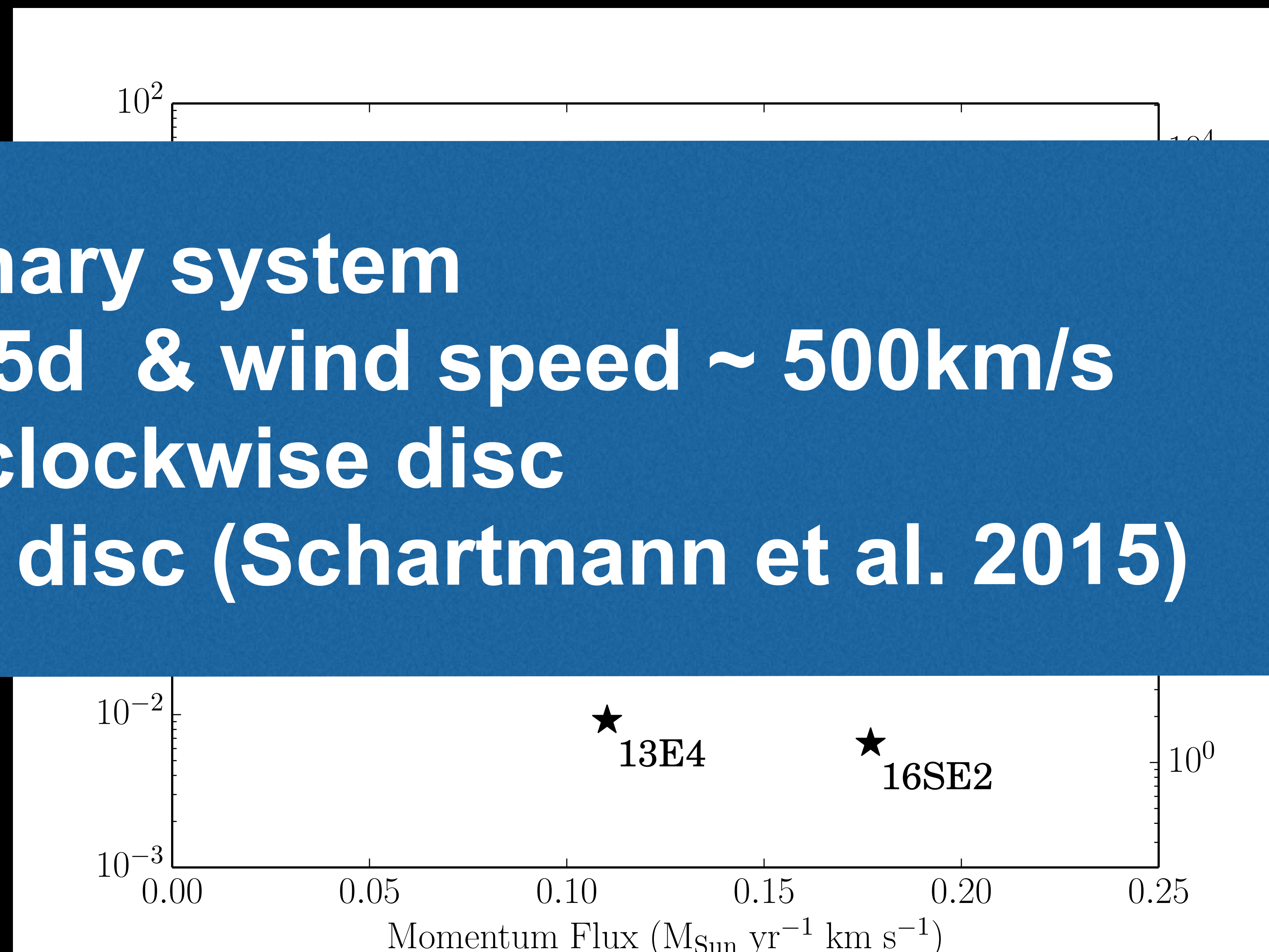
Clump formation in the Galactic Centre

y-axis shows maximum stellar separations for identical winds to be

- IRS 16SW -> binary system
- d~10μpc, P~19.5d & wind speed ~ 500km/s
- Located in the clockwise disc
- G2 origin in the disc (Schartmann et al. 2015)



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Clump formation in the Galactic Centre

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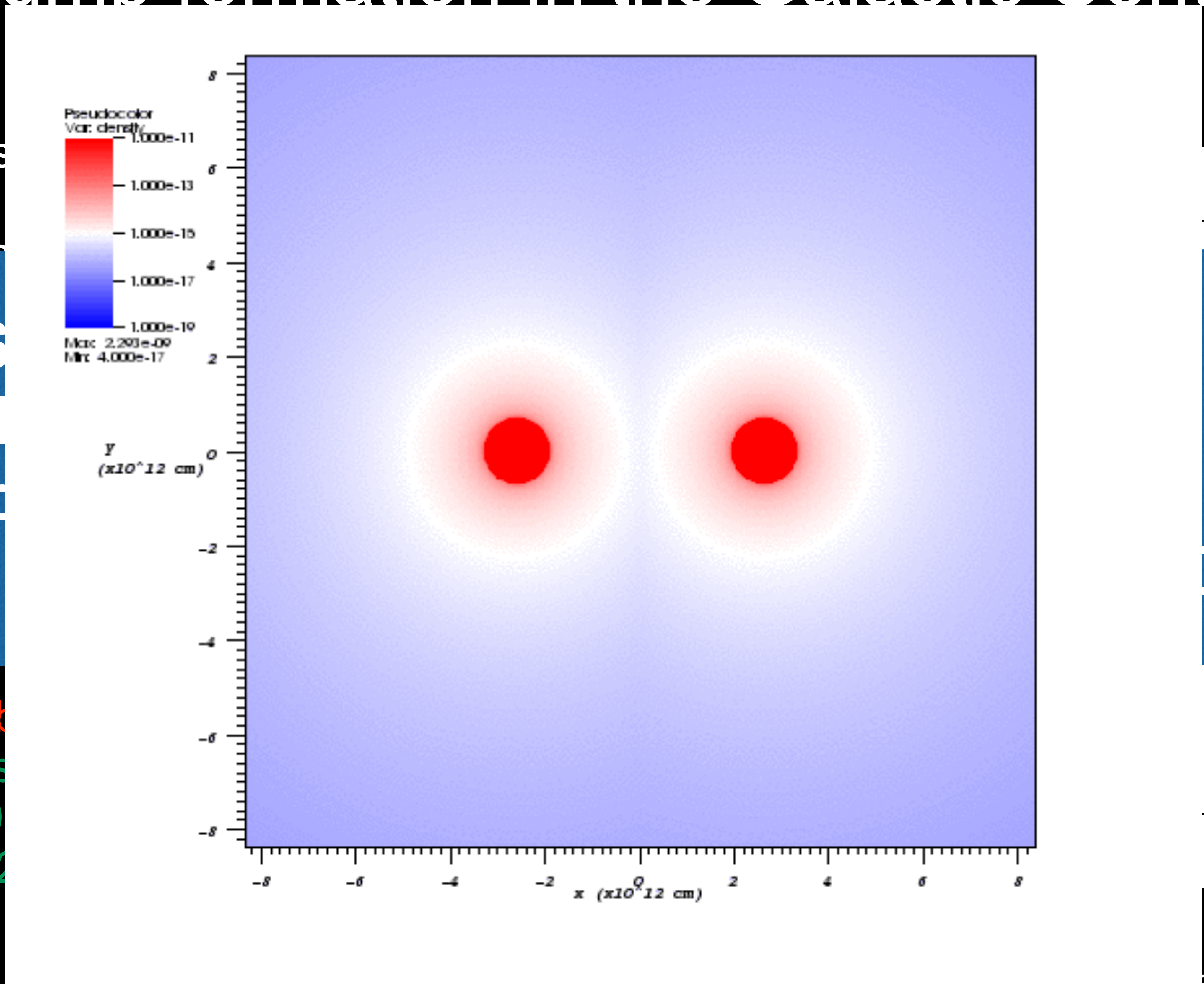

10^0
0.25

et al. (2007)
Animation Pittard (2009)

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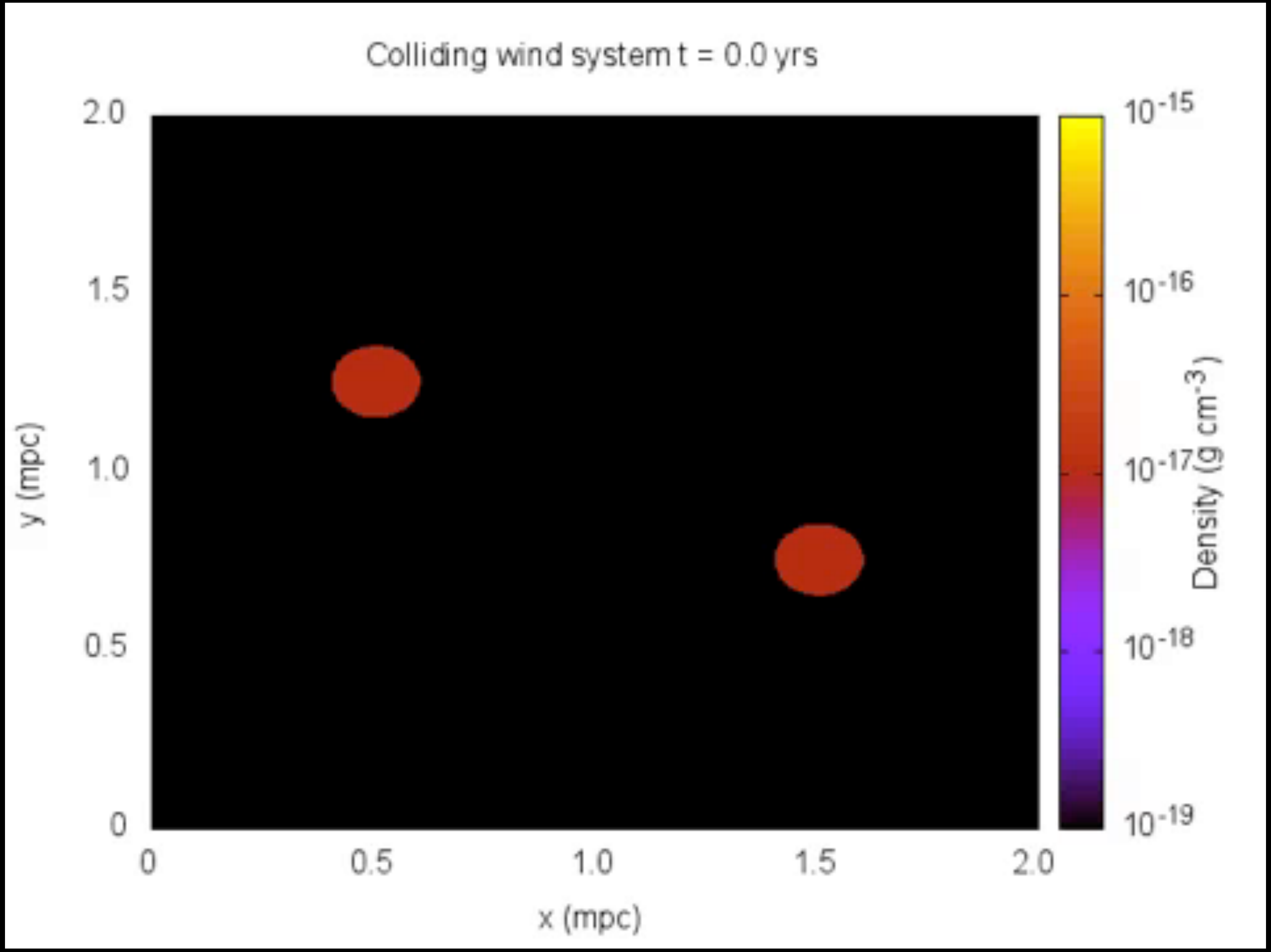
Another option: Mass-losing star encounters

Stellar encounters could be clumps sources too!



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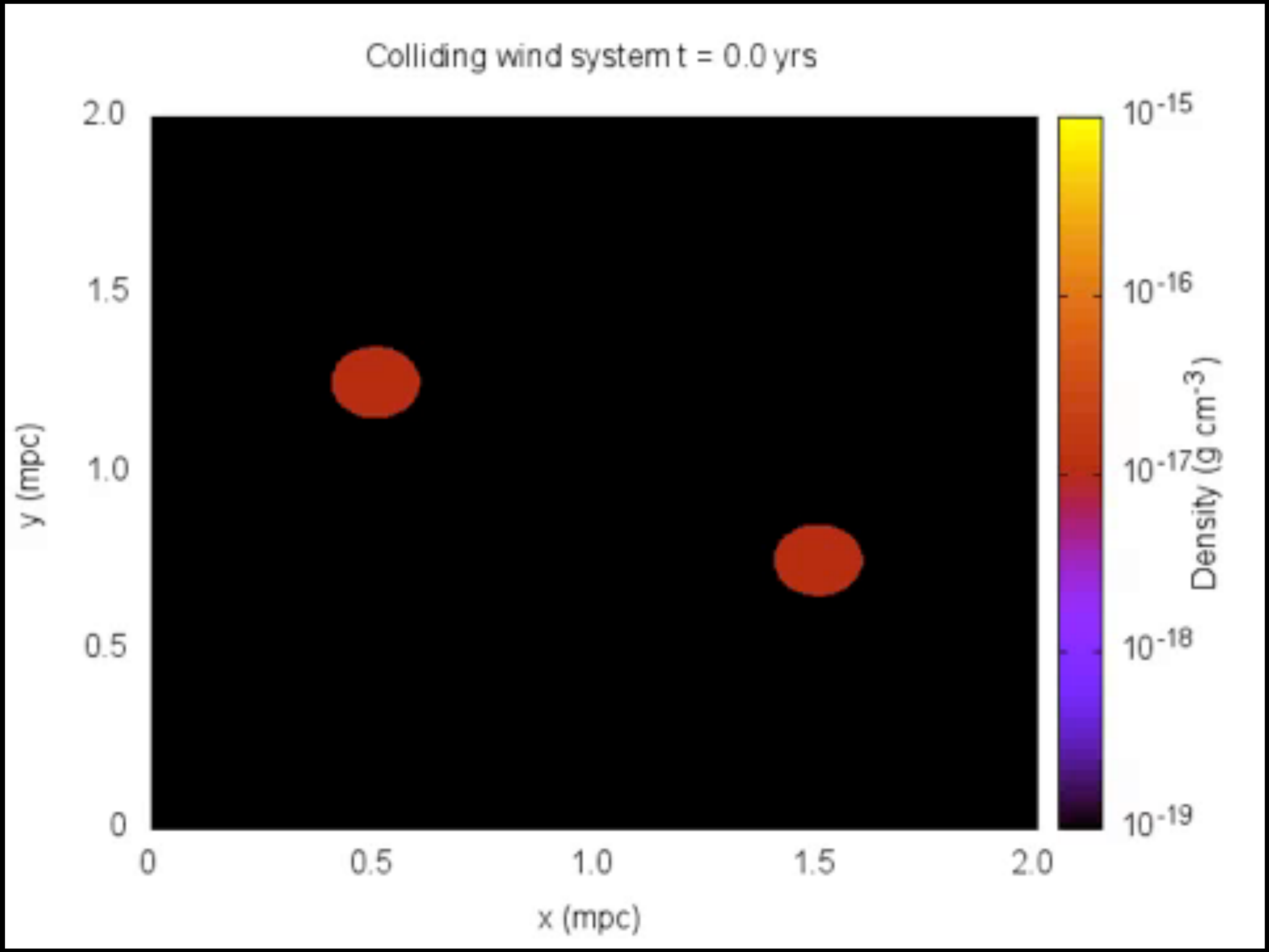

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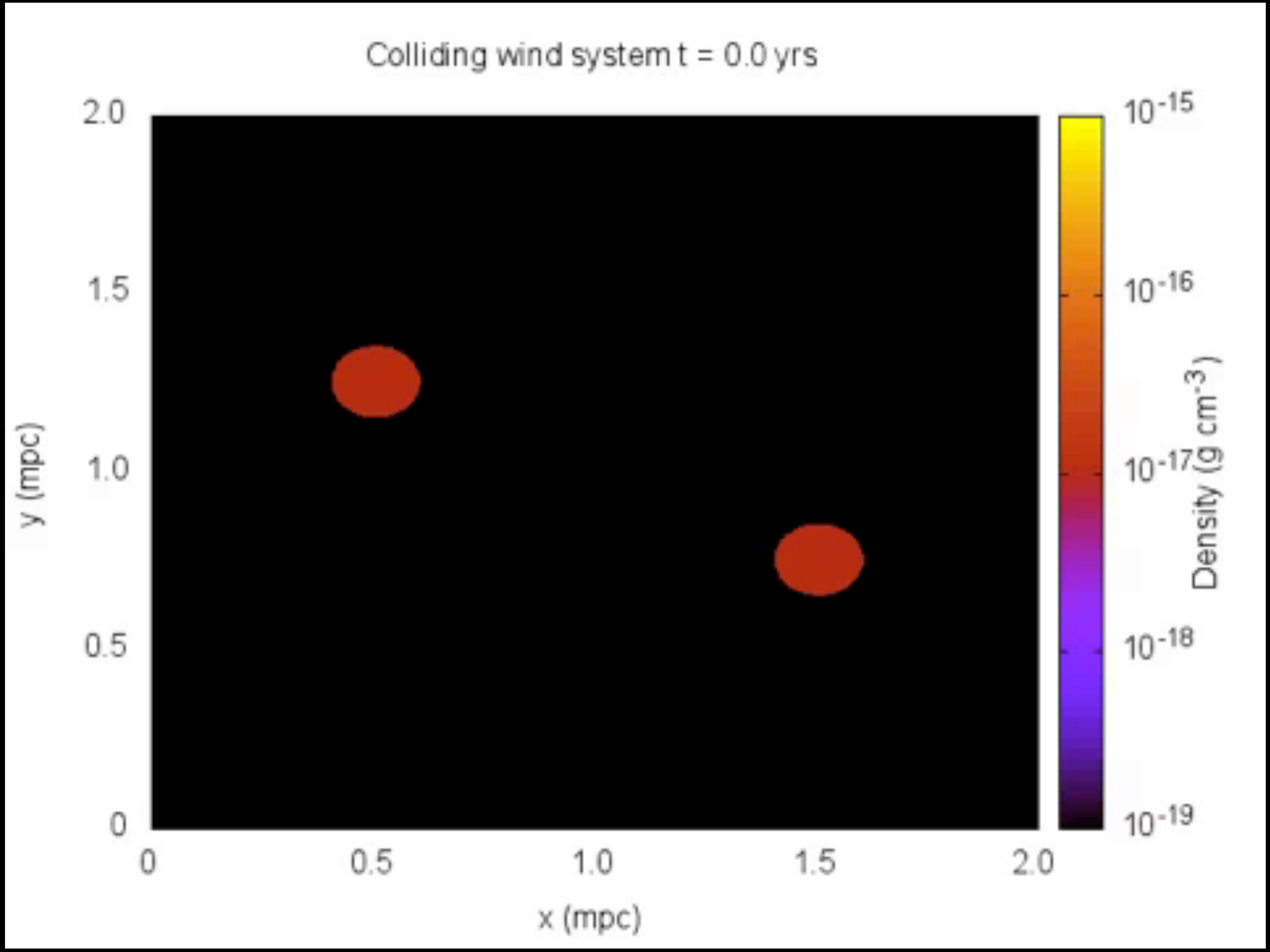

We ran Newtonian test particles gravity simulation of the O/WR stars (using orbital data from Paumard et al. 2006) for 10,000 yrs and register close encounters (<2,000AU~10mpc).

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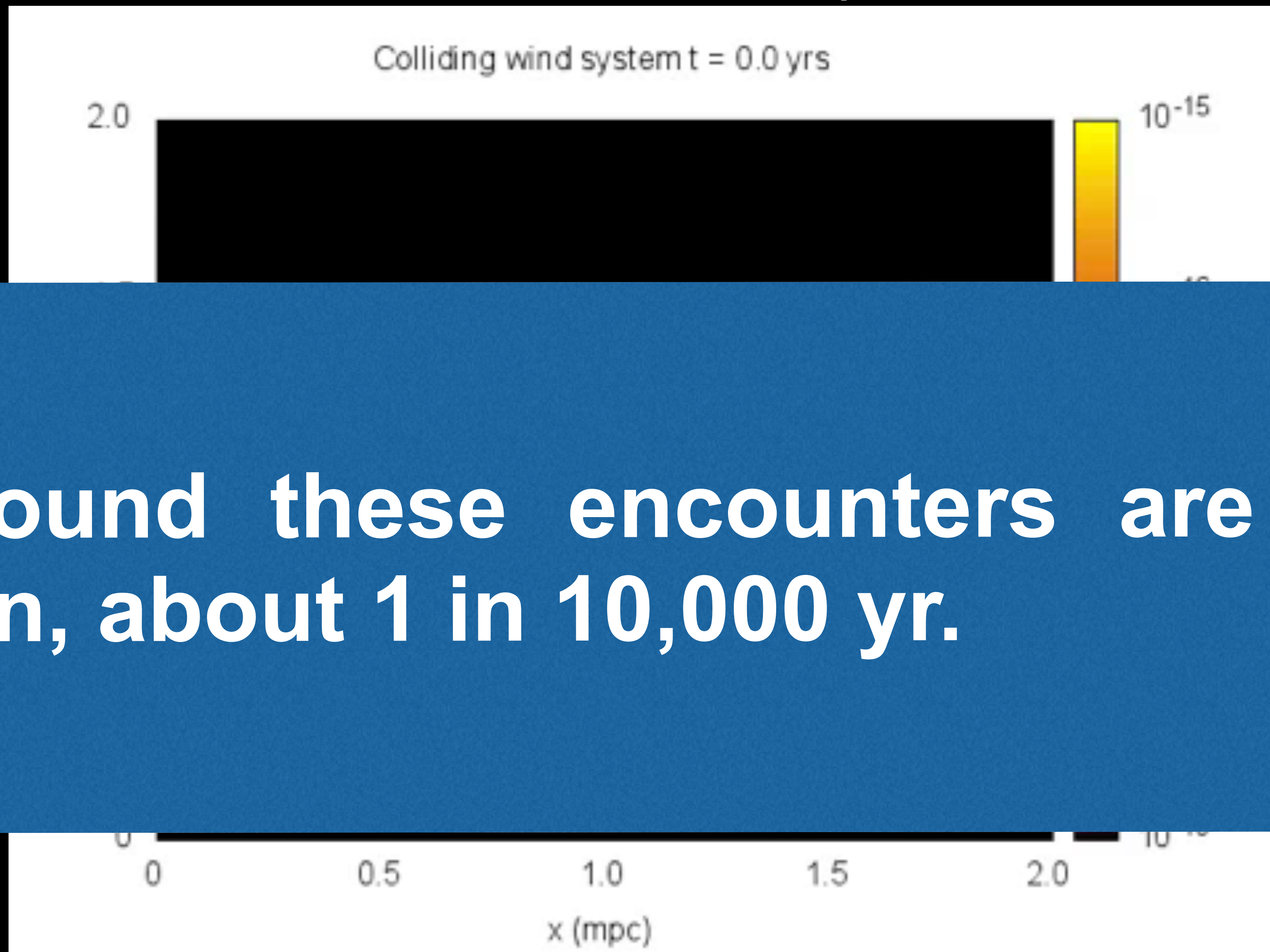

We found these encounters are not very common, about 1 in 10,000 yr.

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Conclusions

We developed a straight-forward diagnostic for clump formation through NTSI with (M_{dot}, V_{wind}, d) as input.

For stellar separations <2,000AU, clumps can be created in a very wide range of masses reaching 100 Earth masses.

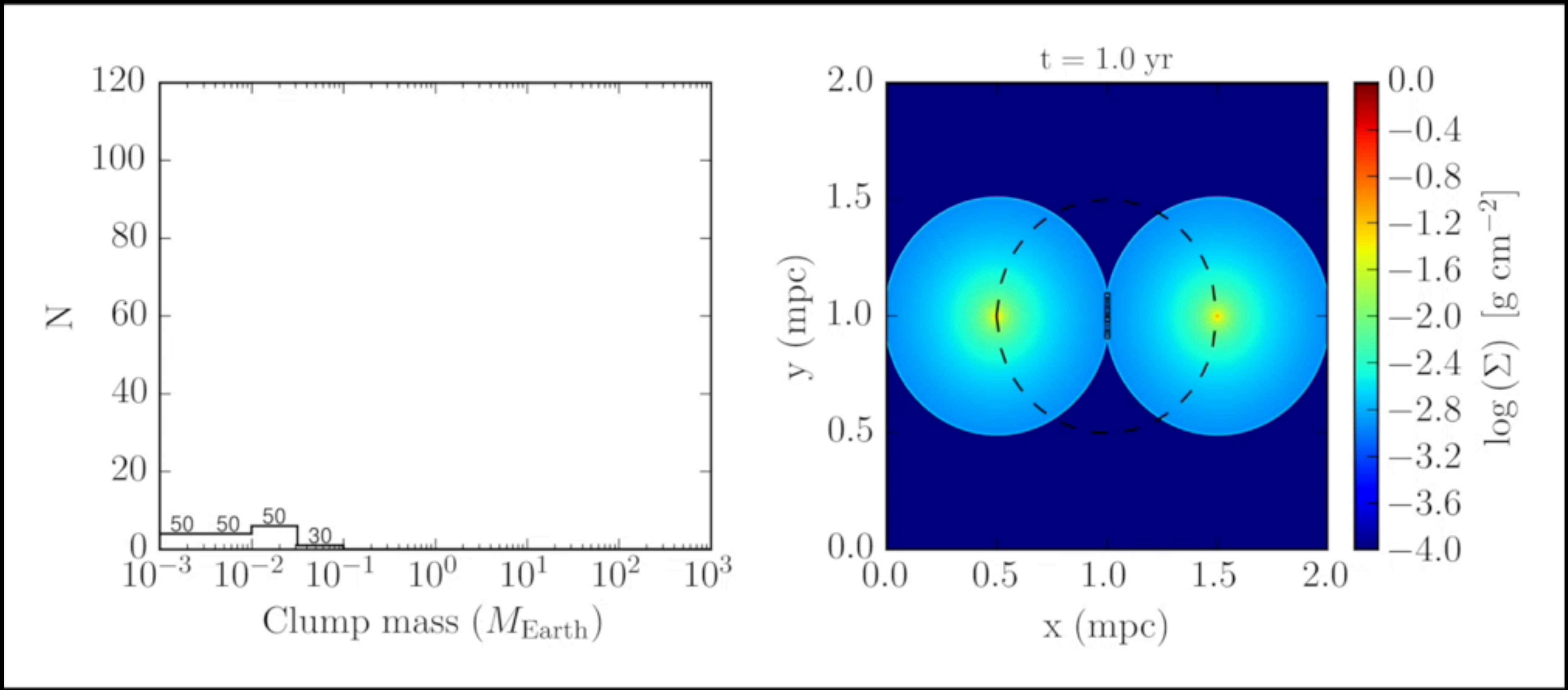
Symmetric colliding wind encounters are an unlikely source of clumps in the Galactic Centre.

Close encounters (<2,000AU) of the known O/WR are not very common events, however some of them might be clump sources.

IRS 16SW is the most promising clump source and deserves future study (currently working on it).

Work in progress

Currently, we are running and analysing hydro AMR simulations.



Calculate a clump mass function for different systems, rate of ejecta to the ISM and the impact of orbital motion.

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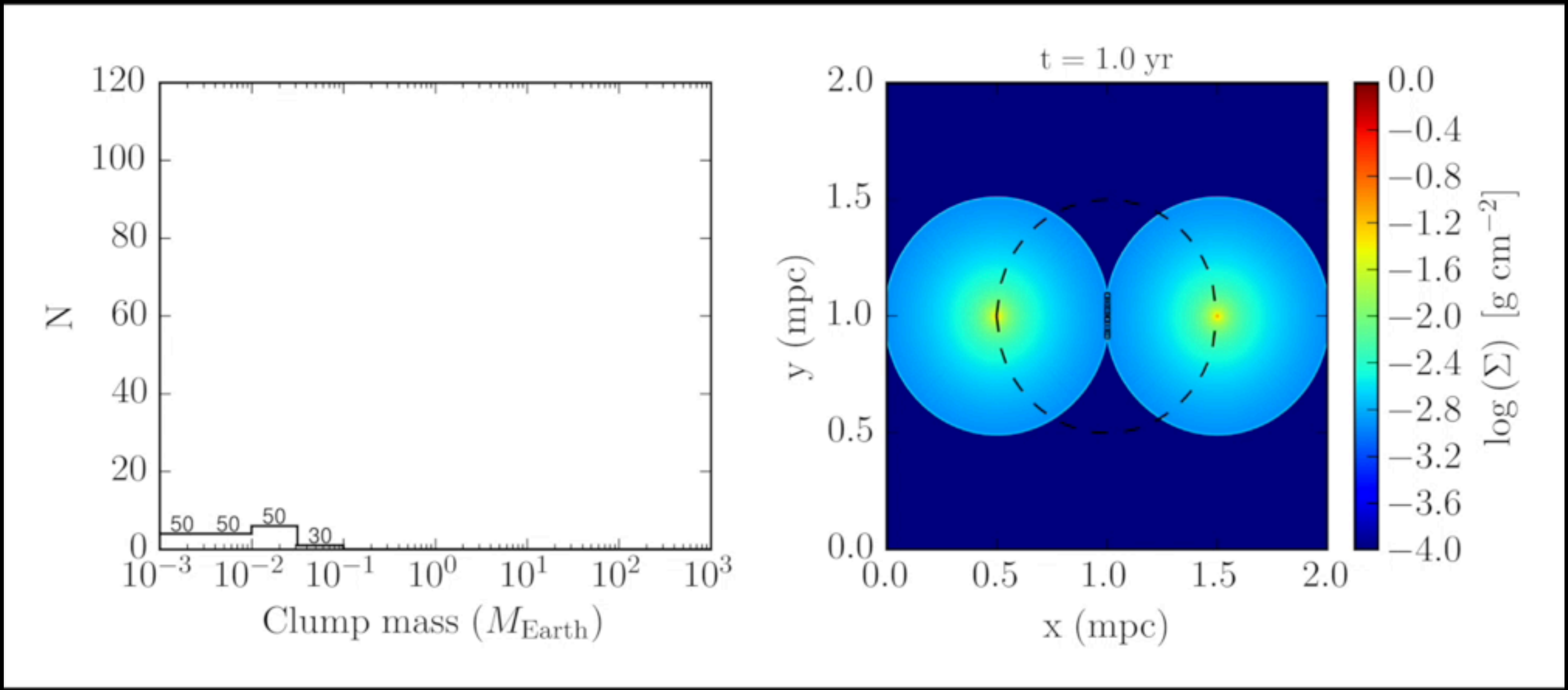

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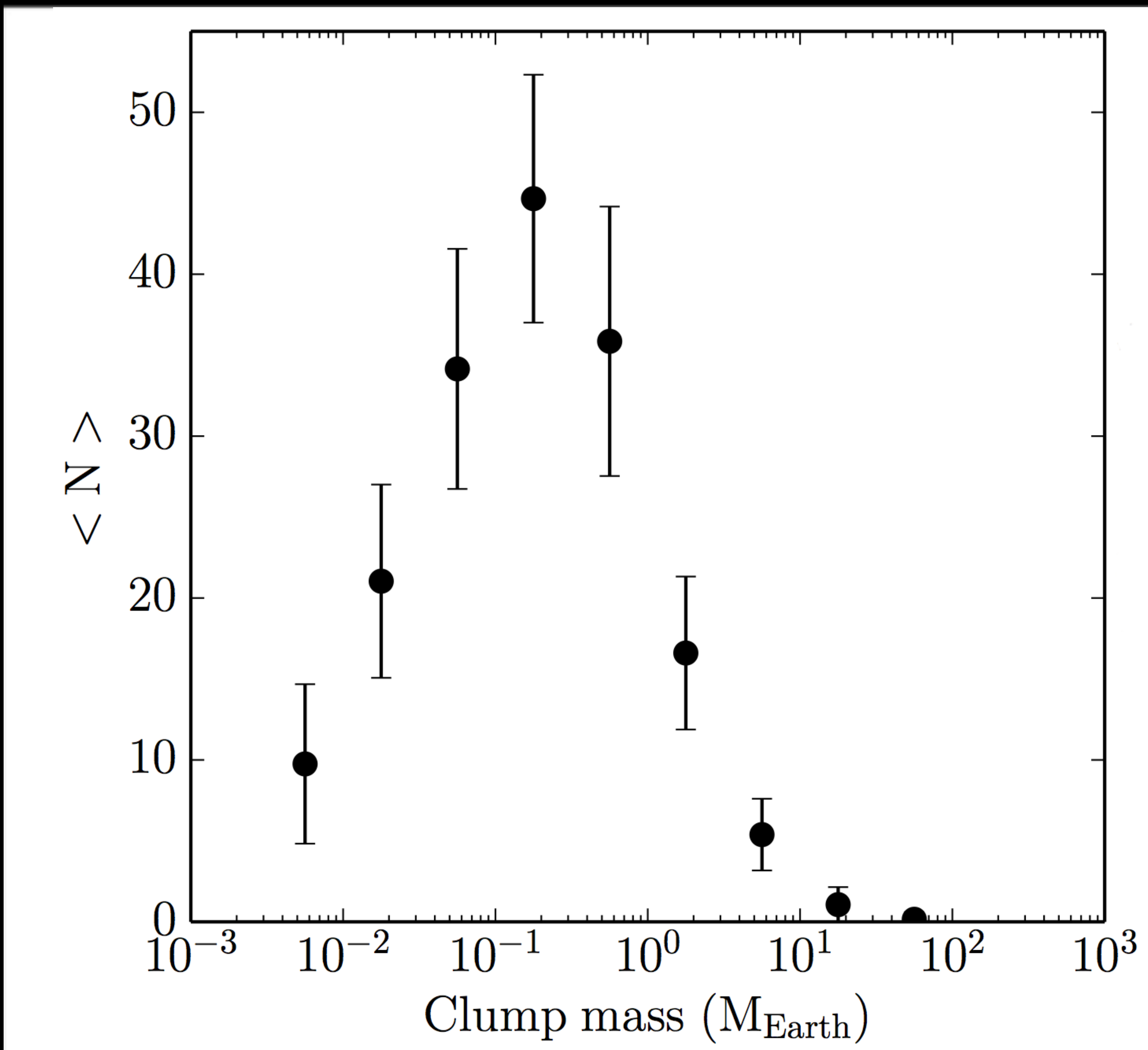

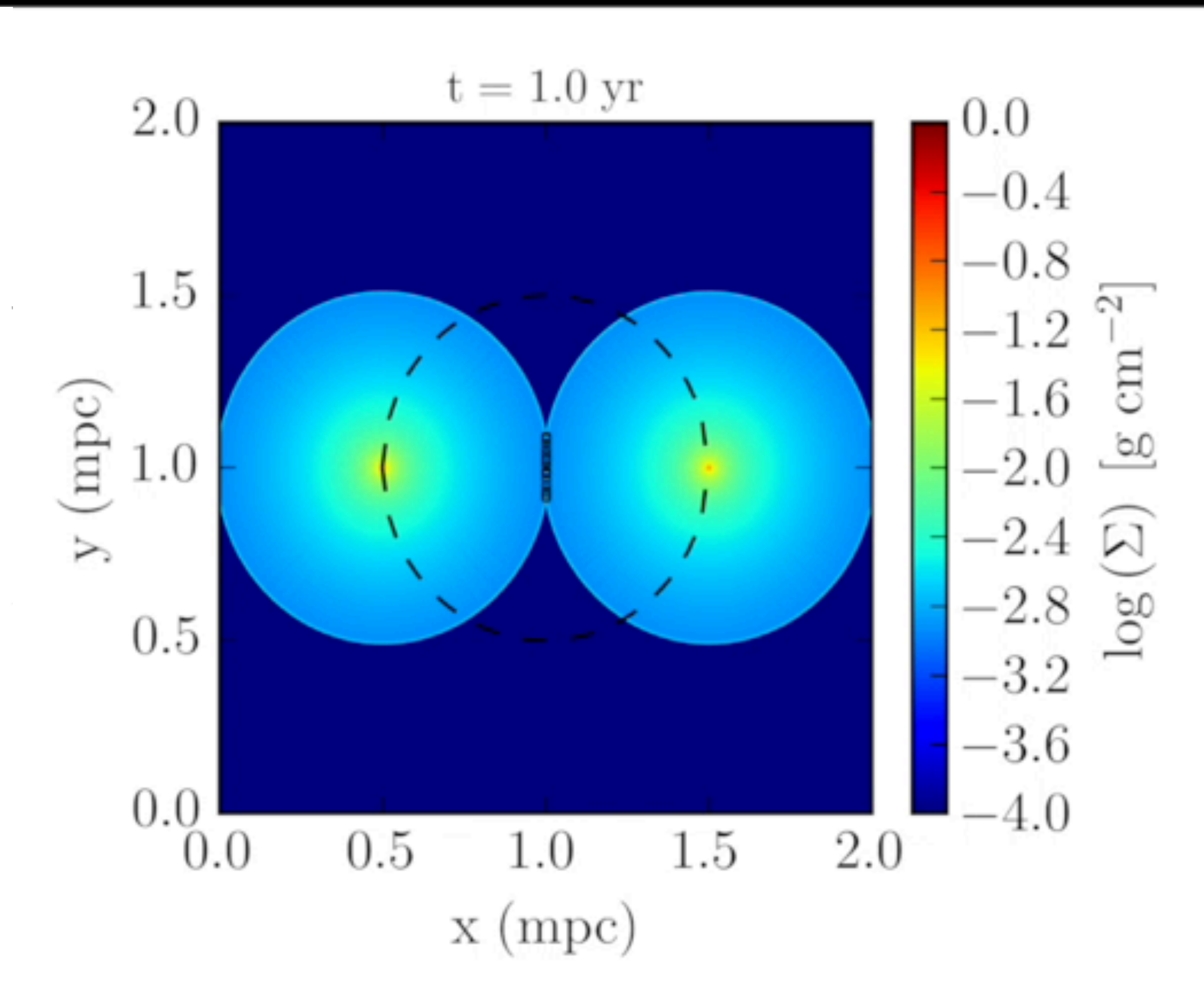

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Thanks for your attention!