Table 2.5 Main processes that cool the interstellar gas

Temperature	*Cooling process*	*Spectral region*
$>10^7$ K	Free–free	X-ray
$10^7 \text{ K} < T < 10^8$ K	Iron resonance lines	X-ray
$10^5 \text{ K} < T < 10^7$ K	Metal resonance lines	UV, soft X-ray
$8000 \text{ K} < T < 10^5$ K	C, N, O, Ne forbidden lines	IR, optical
Warm neutral gas: ~ 8000 K	Lyman-α, [OI]	1216 Å, 6300 Å
$100 \text{ K} < T < 1000$ K	[OI], [CII], H_2	Far IR: 63 μm, 158 μm
$T \sim 10-50$ K	CO rotational transitions	Millimeter-wave

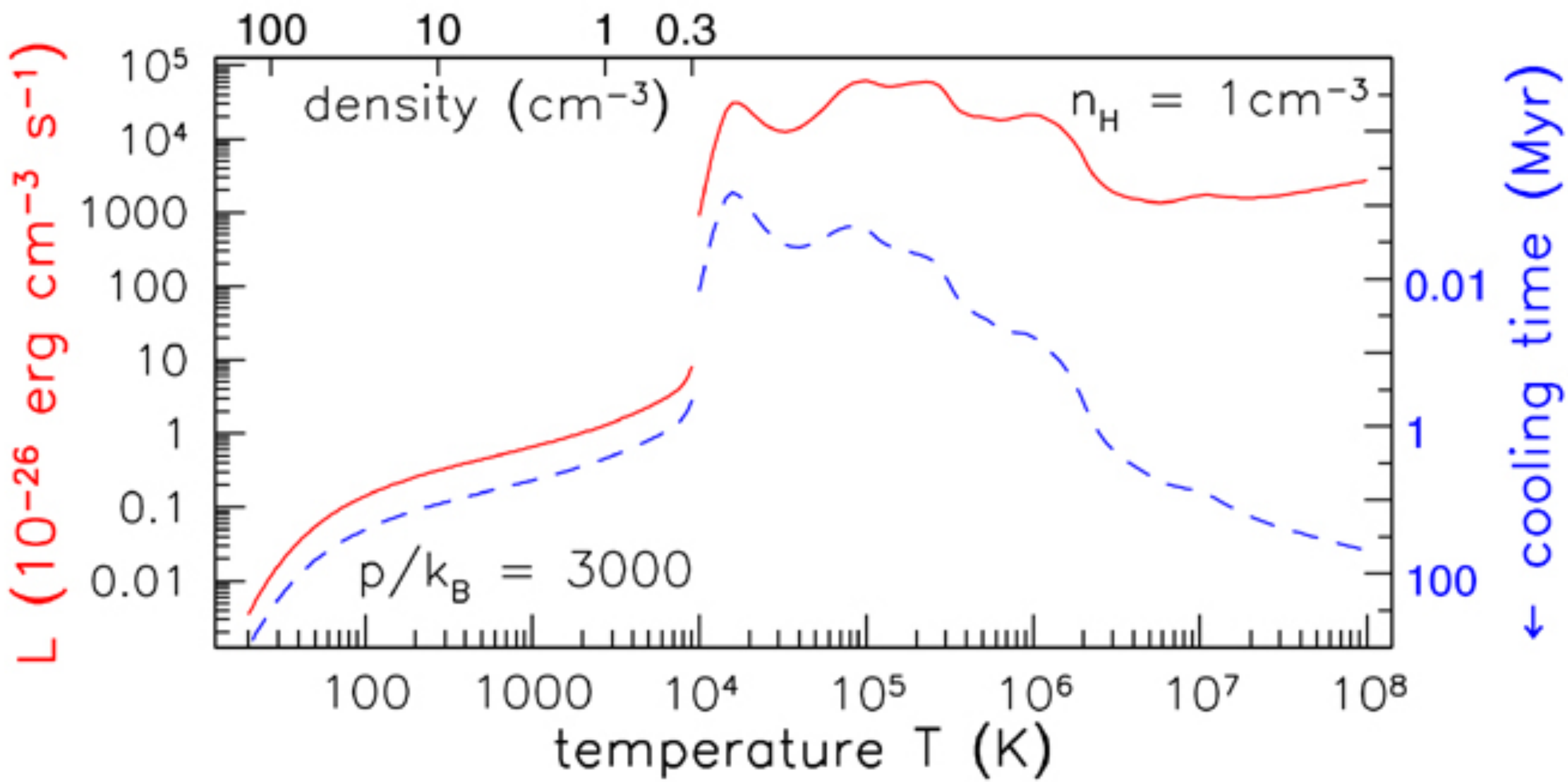


Fig 2.25 (Hensler, Wolfire) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

Fluid Dynamics

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{v}) = 0$$

Continuity equation

$$\frac{\partial \boldsymbol{v}}{\partial t} + \boldsymbol{v} \cdot \nabla \boldsymbol{v} = -\frac{\nabla P}{\rho}$$

Euler equation

$$P = P(\rho, S)$$

Equation of state

Small Perturbations

$$\frac{\partial \rho_1}{\partial t} + \rho_0 \nabla \cdot \boldsymbol{v}_1 = 0$$

Continuity equation

$$\frac{\partial \boldsymbol{v}_1}{\partial t} = -\frac{\nabla P_1}{\rho_0}$$

Euler equation

$$P_1 = \left.\frac{\partial P}{\partial \rho}\right|_{S,0} \rho_1 = c_s^2 \rho_1$$

Equation of state

$$\frac{\partial^2 \rho_1}{\partial t^2} - c_s^2 \nabla^2 \rho_1 = 0$$

Wave equation

Wave equation

$$\frac{\partial^2 \rho_1}{\partial t^2} - c_s^2 \nabla^2 \rho_1 = 0$$

seek solution with $\rho_1 \propto e^{i\boldsymbol{k}\cdot\boldsymbol{x} - i\omega t}$

$$\Longrightarrow \quad \omega^2 = c_s^2 k^2$$

Fluid Dynamics with Gravity

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{v}) = 0$$ Continuity equation

$$\frac{\partial \boldsymbol{v}}{\partial t} + \boldsymbol{v} \cdot \nabla \boldsymbol{v} = -\frac{\nabla P}{\rho} - \nabla \phi$$ Euler equation

$$P = P(\rho, S)$$ Equation of state

$$\nabla^2 \phi = 4\pi G \rho$$ Poisson's equation

Small Perturbations

$$\frac{\partial \rho_1}{\partial t} + \rho_0 \nabla \cdot \boldsymbol{v}_1 = 0$$

Continuity equation

$$\frac{\partial \boldsymbol{v}_1}{\partial t} = -\frac{\nabla P_1}{\rho_0} - \nabla \phi_1$$

Euler equation

$$P_1 = \left.\frac{\partial P}{\partial \rho}\right|_{S,0} \rho_1 = c_s^2 \rho_1$$

Equation of state

$$\frac{\partial^2 \rho_1}{\partial t^2} - c_s^2 \nabla^2 \rho_1 = 4\pi G \rho_0 \rho_1$$

Wave equation?

Wave equation?

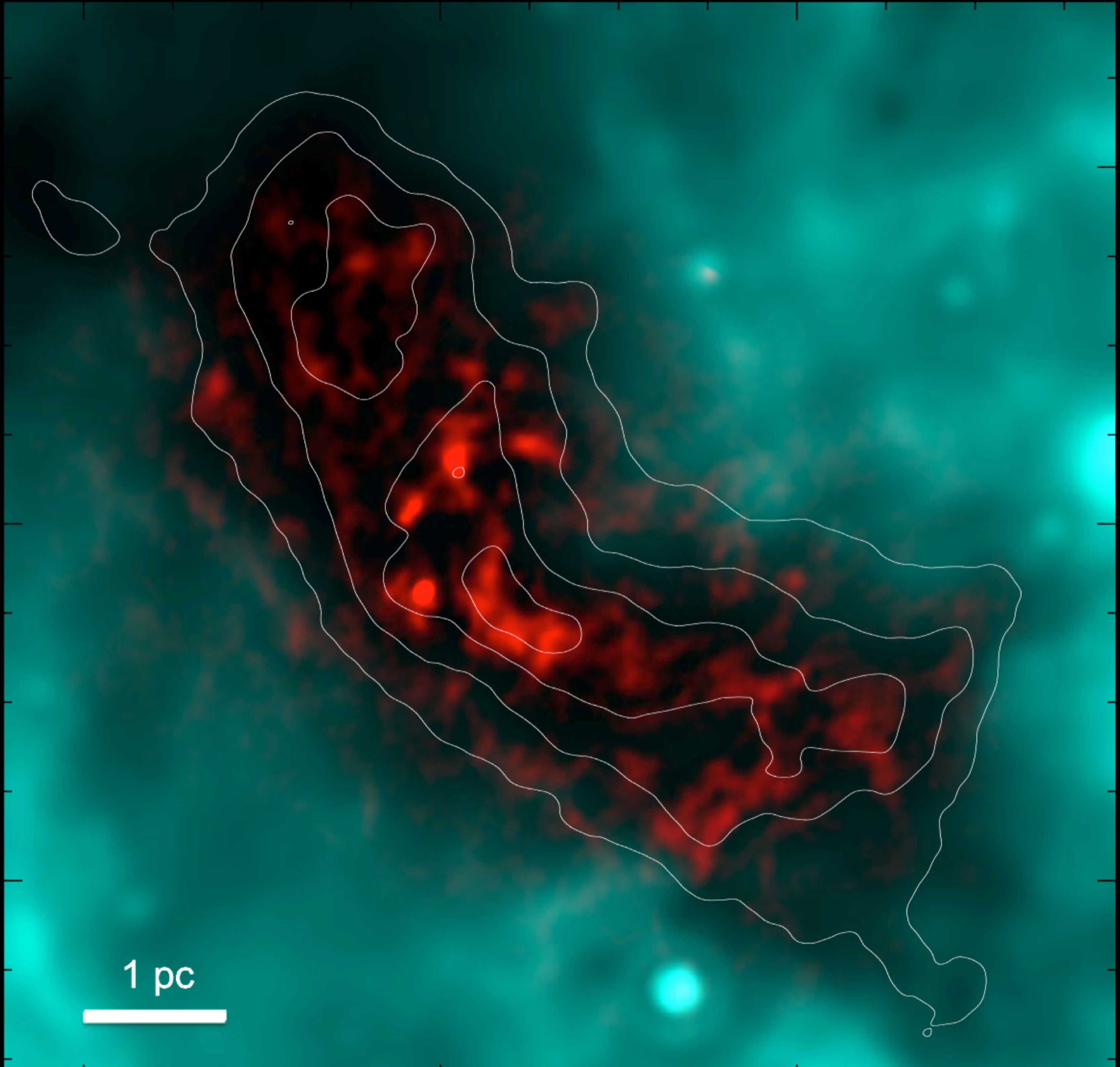
$$\frac{\partial^2 \rho_1}{\partial t^2} - c_s^2 \nabla^2 \rho_1 = 4\pi G \rho_0 \rho_1$$

seek solution with $\rho_1 \propto e^{i\boldsymbol{k}\cdot\boldsymbol{x} - i\omega t}$

$$\Longrightarrow \quad \omega^2 = c_s^2 k^2 - 4\pi G \rho_0$$

$$\Longrightarrow \quad \omega^2 < 0 \quad \text{for} \quad k^2 < \frac{4\pi G \rho_0}{c_s^2} \equiv k_J^2$$

$\longrightarrow$ Jeans instability


1 pc

M ~ 10^4 $M_\odot$
Δx = 0.12 pc

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