A Galaxy Theorist's T-ρ Phase Guide

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The this "cheat-sheet plot" shows a helpful guide to the eye for the temperature-density phase diagram of gas in cosmological and galactic environments. Temperature and density are shown in units of Kelvin and $m_H cm^{-3}$, and a number of isocontours are displayed on top of a hexbin histogram showing the gas within the virial radius of a cosmological simulation of a Milky Way like galaxy. This guide is designed to be helpful to theorists and observers, but betrays a bit of my numerical bias.

The axes are twinned with the sound speed (equation 1) and the free-fall time (equation 2). Isocontours show a number of useful values for constant entropy (equation 3, shown with a black dotted curve), Jeans mass (equation 4, shown with a magenta solid curve), Jeans length (equation 5, shown with a solid gren curve), Courant time (equation 6, shown in a cyan dash-dotted line), and pressure (equation 7, shown in a grey dashed line). Also shown are lines of constant cooling time (in solid blue), and a handful of interesting densities (in dotted salmon). All curves assume a solar metallicity, and a mean molecular weight of $\mu = 1$.

The hexbin histogram is taken from g1536, one of the MUGS2 galaxies presented in Keller et al. (2015, 2016). The lines of constant cooling time are derived from the cooling rates first presented in Shen et al. (2010), now included as a standard feature in the GASOLINE2 code (Wadsley et al., 2017).

The data and code used to generate this figure, as well as the LaTeXsource for this document, can be found at `https://github.com/bwkeller/phase_guide`.

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$$c_s = \sqrt{\frac{\gamma k_B T}{\mu m_H}} \tag{1}$$

$$t_{ff} = \left(\frac{3\pi}{32 G \mu m_H n}\right)^{1/2} \tag{2}$$

$$K = k_B T n^{-2/3} \tag{3}$$

$$M_J = (\mu m_H)^{-2} \left(\frac{15 k_B}{4\pi G}\right)^{3/2} \left(\frac{T^3}{n}\right)^{1/2} \tag{4}$$

$$\lambda_J = (\mu m_H)^{-1} \left(\frac{15 k_B}{4\pi G}\right)^{1/2} \left(\frac{T}{n}\right)^{1/2} \tag{5}$$

$$t_{courant} \propto \frac{n^{-1/3}}{c_s} \tag{6}$$

$$P = k_B n T \tag{7}$$

References

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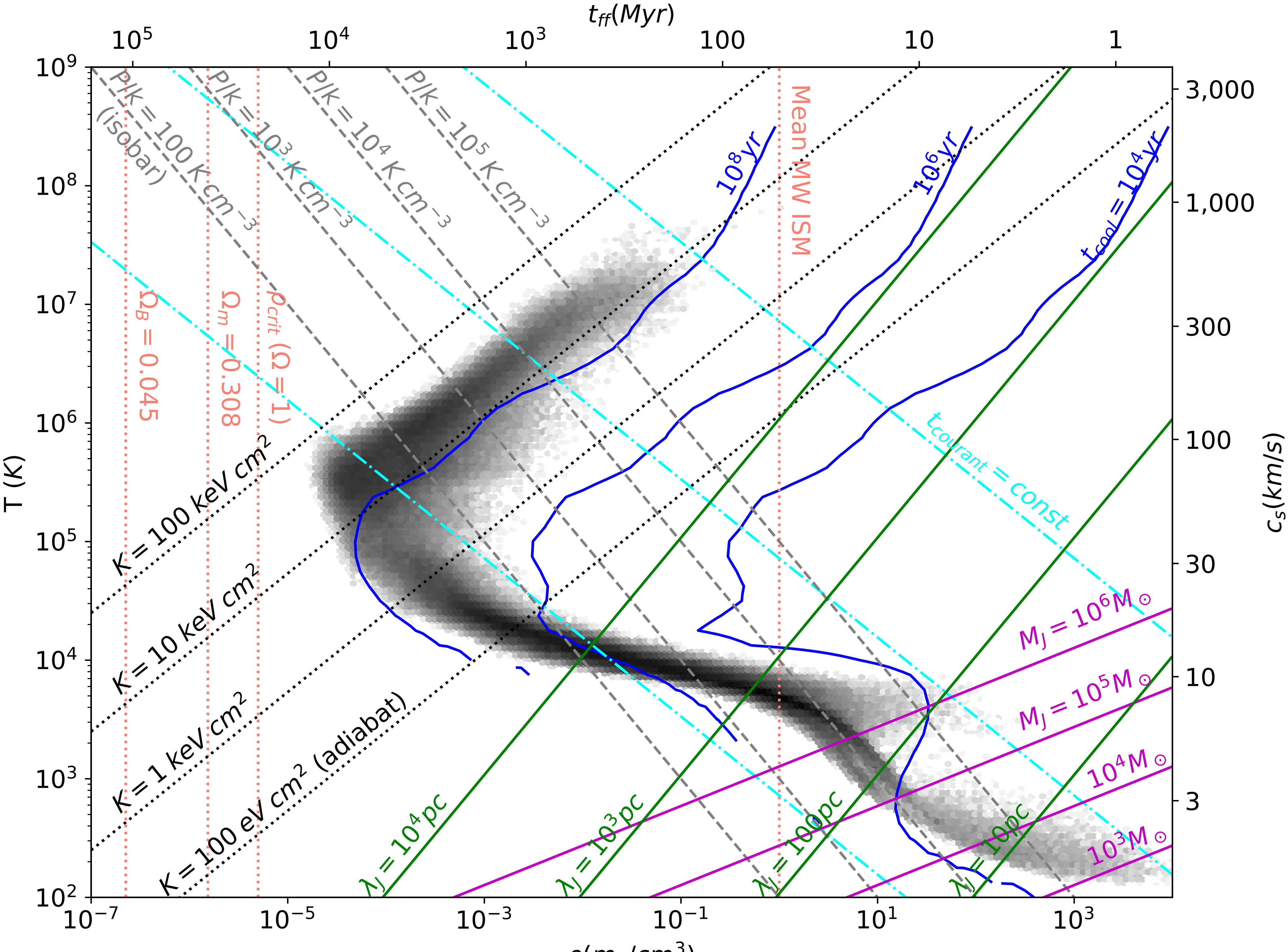

BW Keller's Reference Phase Diagram
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