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HEATING OF A RECOMBINING PLASMA BY BULK VISCOSITY DISSIPATION OF SOUND WAVES

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When the gas dynamics equations are linearized the viscosity and the thermal conduction produce damping on the potential mode. The above dissipative effects have been invoked as one of the mechanisms of heat input in different astrophysical plasmas, particularly, in the interstellar medium. The bulk viscosity also introduces important qualitative as well as quantitative changes (due to its dispersive character) in the acoustic dissipation problem, in particular, introduces strong restrictions on the range of temperature where thermal equilibrium may exist as it will be shown in the case of the high velocity clouds (HVCs) at high galactic latitude.

THERMAL EQUILIBRIUM OF A PHOTOIONIZED GAS

Commonly the heat/loss function for a low density plasma at equilibrium temperatures in the range $30 < T < 10^6$ K can be written as

$$\rho\mathcal{L}(\rho,T,\xi) = \Lambda(\rho,T,\xi) - [\Gamma_{\rm o}(\rho,T,\xi) + \Gamma_w(\rho,T,\xi)]\,, \quad \text{erg cm}^{-3}\ \text{s}^{-1} \qquad (1)$$

where $\Lambda(\rho,T,\xi)$ is the cooling rate and $\Gamma_{\rm o}(\rho,T,\xi)$ is the heating input (different from wave dissipation, Corbelli & Ferrara 1995) per unit volume and time and $\Gamma_w(\rho,T,\xi)$ is the heat input by wave dissipation. So, at thermal equilibrium, $\mathcal{L}(\rho,T,\xi) = 0$, i.e.

$$\Lambda(\rho,T,\xi) = \Gamma_{\rm o}(\rho,T,\xi) + \gamma_d \frac{v_1^2}{2} k^2\,,$$
$$\gamma_d = \left[\left(\frac{4}{3}\eta + \zeta_R\right) + \frac{(\gamma-1)\,\kappa}{c_p}\right]\,, \qquad (2)$$

where c_p being the specific heat at constant pressure and η, ζ_R and κ the coefficients of dynamic and bulk viscosity and thermal conduction, respectively.

High velocity clouds at high galactic latitude

The hydrogen gas at large galactic latitude and in the halos of other galaxies $0.03 \lesssim Z \lesssim 0.3$ and $0.3 \lesssim E \lesssim 2$ keV (Maller & Bullock 2004; Ruszkowski et al. 2004; Collins et al. 2005), therefore, equilibrium states may exist for ϵk smaller than a thres-hold value $(\epsilon k)_{\rm thr}$ which depends on the exact values of Z, E and $N_0\rho$ (see Figure 1). For $\epsilon k > (\epsilon k)_{\rm thr}$ equilibrium states cannot exit. Therefore, the hydrogen gas into HVCs can be in thermochemical equilibrium as far as the HVCs have dimensions $l > l_{\rm thr}$ where $l_{\rm thr} = 3.24 \times 10^{-19}/(\epsilon k)_{\rm thr}$ pc for the above range of values of metallicity and mean photon energy. Strictly speaking this threshold value has to taken as a limiting value, for real situations one should expect thermochemical equilibrium for gas clouds with dimensions $l \gg l_{\rm thr}$.

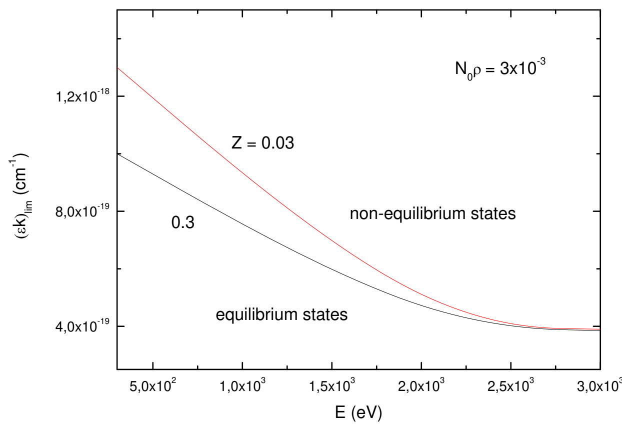

Fig. 1. The threshold value $(\epsilon k)_{\rm lim}$ (cm^{-1}) as a function of energy E (eV) for $N_0\rho = 3 \times 10^{-3}$ (cm^{-3}) and two values of Z (0.03 and 0.3).

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