Electron pressure is less than $n_e k T_e$ in the solar wind

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We claim that in the solar wind beyond $5R_\odot$, electron pressure P_e is less than $n_e k T_e$. The reason is that though particles with random velocities beyond thermal velocity cannot collide, hence 'collisionless', particles below the thermal velocity can collide and exert pressure. We find $\alpha \equiv P_e/n_e k T_e$ = (density scale height/mean free path)$^{1/2}$ and the adiabatic relation of $T_e \propto n_e^{2\alpha/3}$, where $\alpha \approx 0.4$ near 1AU, and $\alpha \approx 1$ below $5R_\odot$. Similarly thermal conductivity for $\alpha < 1$ is shown to scale $\sim T_e^0$ instead of the classical $T_e^{5/2}$. Then thermal energy equation gives $T_e \propto$ (heliocentric distance)$^{-0.4}$ in rough accord with the observations. We find that observed large line widths of OVI and Ly$_\alpha$ in the polar coronal hole arise from large projected velocities of the solar wind, hence no need of very high 'perpendicular temperature'.

'Usual' Boltzmann equation always leads to $P_e = n_e k T_e$ by taking moment of $m_e \boldsymbol{v}$. In every textbook, the elementary length scale of e.g. dx in the collision term to be multiplied to the distribution function is adopted as much larger than the mean free paths, ensuring that mutual collisions of identical particles produce no momentum gain. All the other terms are however supposed not to include collisions within the same dx, which is a contradiction! By solving this, we show $P_e \le n_e k T_e$ if collisions are not entirely negligible.