

P1.1101 Pellet cloud expansion in hot plasmas

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See the full abstract here:

<http://ocs.ciemat.es/EPS2019ABS/pdf/P1.1101.pdf>

It has recently been demonstrated that the injection of cryogenic pellets into a magnetically confined plasma is accompanied by a considerable transfer of thermal energy from the electrons of the background plasma to the ions [1]. This is the result of the ambipolar expansion along the magnetic field line of the cold and dense plasma cloud left behind by the ablated pellet. During this expansion, the cloud is constantly heated by the hot background plasma. Ref. [1] suggested a self-similar solution for the system of hydrodynamic equations (continuity equation, momentum equation and power-balance equation), which describes such one-dimensional (along x) heated plasma expansion:

$$n(x,t) = n_0 \sqrt{3 m_i / 8 \pi \tau t^3} \exp(-3m_i x^2 / 8 \tau t^3),$$

$$u(x,t) = 3x/2t$$

$$T(t) = t,$$

where n is the plasma cloud density (assumed to be much greater than the background plasma density), u denotes the ion velocity, m_i the mass of the ions, and $\tau = 1/3n_0 \int Q dx$

the heating power (assumed to be uniform and constant in time). A notable feature of this solution is that the cloud electron temperature is half of what it would have been if the pellet cloud were stationary.

Therefore, half the heating power goes into the ion kinetic energy associated with the expansion of the cloud, significantly affecting the energy balance of the pellet-fuelled plasma.

In the present work, we compare predictions of this simplified analytical model with more complete numerical simulations in which the finite temperature for the cloud ions, cloud viscosity and heat conductivity are retained and the collisional transfer of momentum and energy from the background plasma are calculated kinetically. The applicability conditions for the analytical result are discussed. In addition, the effects of radiative energy losses from the pellet cloud are also investigated.

References

[1] Pavel Aleynikov, Boris N. Breizman, Per Helander and Yuriy Turkin, J. Plasma Phys. 85 (2019)

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