

The Injection Speed - Standard Focused Transport Theory

In focused transport theory – particles follow magnetic field lines- minimum requirement for shock acceleration to work – the particles must be able to swim upstream in order to have multiple shock encounters

From the spherically -symmetric focused transport equation using the method of characteristics one gets for the radial component of the particle speed in the traveling shock frame :

$$v_r^{sh} = U_1^{sh} + v'_1 \mu'_1 \cos\psi_1 > 0$$

where U_1^{sh} is the upstream solar wind speed in the shock frame, v'_1 is the particle speed in the upstream solar wind frame and ψ_1 is the magnetic field spiral angle upstream and μ'_1 is the cosine of the particle pitch angle.

$$\Rightarrow v'_1 \mu'_1 > -\frac{U_1^{sh}}{\cos\psi_1}$$

However, $U_1^{sh} = U_1 - V_{sh}$, and $\psi_1 = \theta_{BN}$ for a spherical shock, where V_{sh} is the shock speed, U_1 is the upstream solar wind speed in the observer frame, and θ_{BN} is the shock normal angle.

The minimum speed for injection is

$$\Rightarrow v'_{\min} = v_{\text{inj}} > \frac{V_{sh} - U_1}{\cos\theta_{BN}}$$

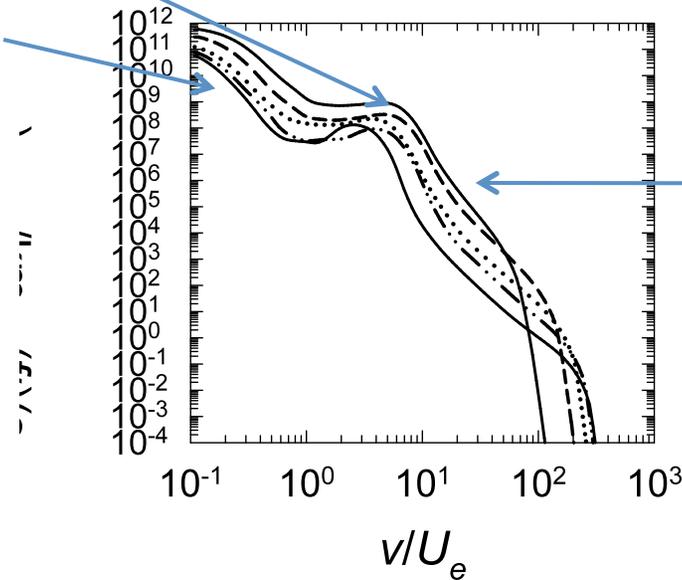
which is the de Hoffmann - Teller speed in the upstream solar wind frame for a traveling shock

Theoretical prediction for injection speed for strong shock moving at 2400 km/s at 0.1 AU

$$\begin{aligned}
 v_{inj} &= \frac{V_{sh} - U_1}{\cos \theta_{BN}} \\
 &= \frac{2400 \text{ km/s} - 400 \text{ km/s}}{\cos 0^\circ} \\
 &= 2000 \text{ km/s} \\
 \Rightarrow v_{inj} / U_e &= 2000 \text{ km/s} / 400 \text{ km/s} = 5
 \end{aligned}$$

$v_{inj}/U_e \sim 5$ (v/400 km/s) at 0.1 AU – model solution – agrees with theoretical Prediction

Kappa distribution



Shock acceleration