Ben-Gurion University of the Negev

Computational Physics - Semester 2011A

Project Presentation

Accelerated ions at the Termination Shock

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- **The solar wind blows outward from the Sun and forms a bubble of solar material.**

- **Interaction of the solar wind with the local interstellar medium (ISM) results a termination shock (TS).**

- **The TS marks the transition where solar wind slows from supersonic to subsonic speed with respect to the surrounding ISM.**

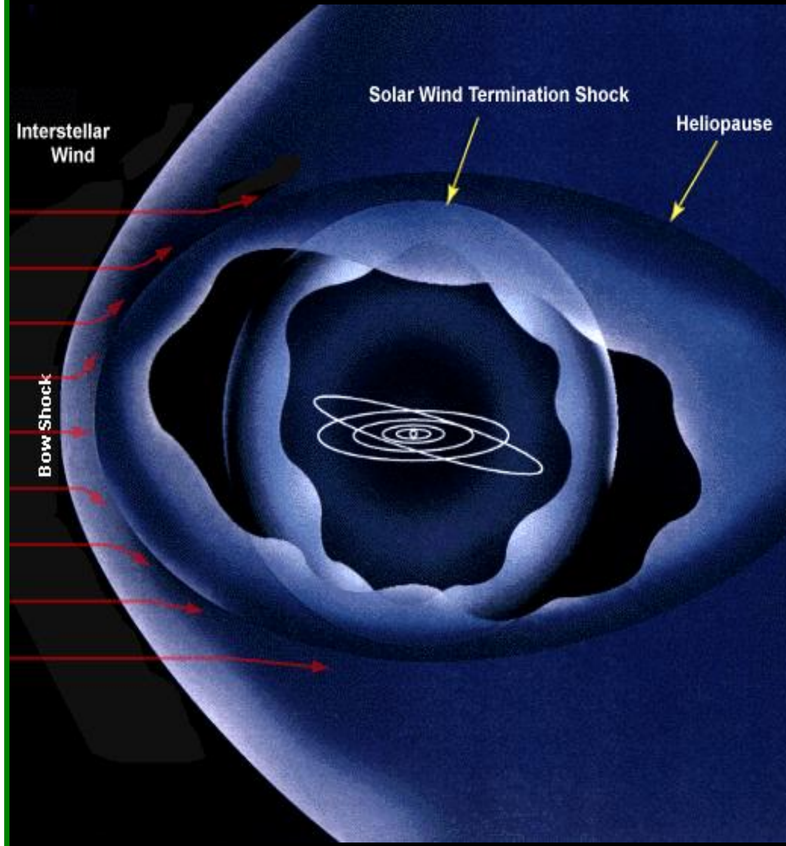


Diagram showing the regions of the heliosphere.

- **The TS is a weak, quasi-perpendicular shock with broad regions on both sides that are populated by high energy ions.**

- **It seems fluid energetic particles play an important role in the formation of the TS structure.**

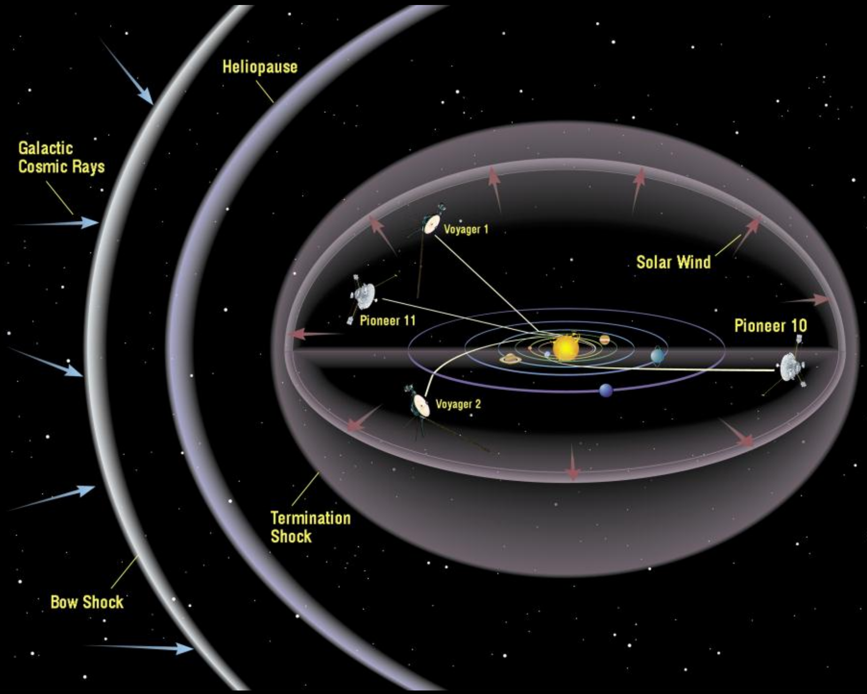


Diagram showing the trajectory of NASA spacecrafts exploring the heliosphere.

We introduce a non-self consistence model that describes the behavior of energetic particles as a function of the TS Parameters.

Motion equations:

$$m_i \dot{v}_x = \frac{e}{c} v_y B_z$$

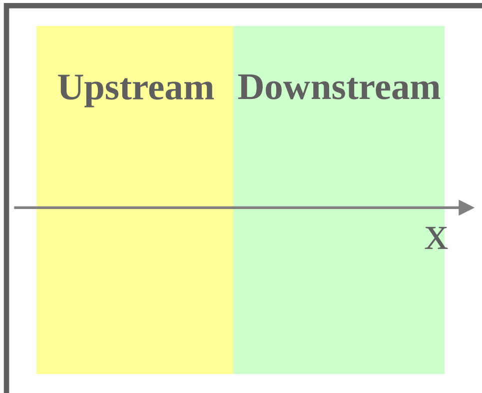
$$m_i \dot{v}_y = eE_y + \frac{e}{c}(v_z B_x - v_x B_z)$$

$$m_i \dot{v}_z = -\frac{e}{c} v_y B_x$$

Fields in the upstream and downstream region:

$$\mathbf{B}_{upstream} = B_{upstream}(\cos(\theta_{Bn}), 0, \sin(\theta_{Bn}))$$

$$\mathbf{B}_{downstream} = B_{upstream}(\cos(\theta_{Bn}), 0, R\sin(\theta_{Bn}))$$



- **The solution is of the form:**

$$u_x = V_x + SV_\perp \cos(\omega\tau + \alpha)$$

$$u_y = -SV_\perp \frac{\omega}{b_z} \sin(\omega\tau + \alpha)$$

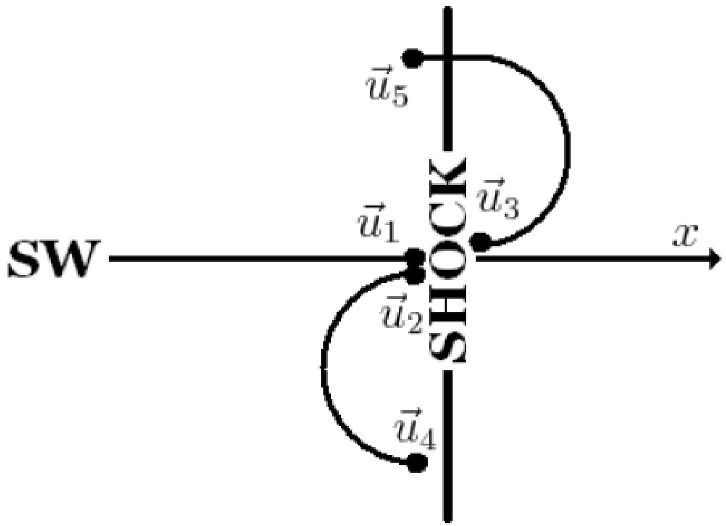
$$u_z = V_z - SV_\perp \frac{b_x}{b_z} \cos(\omega\tau + \alpha)$$

Where ω **,** α **,** S **,** V_x**,** V_z **,** $V_\perp$ **are function of the fields and the initial conditions of the particle.**

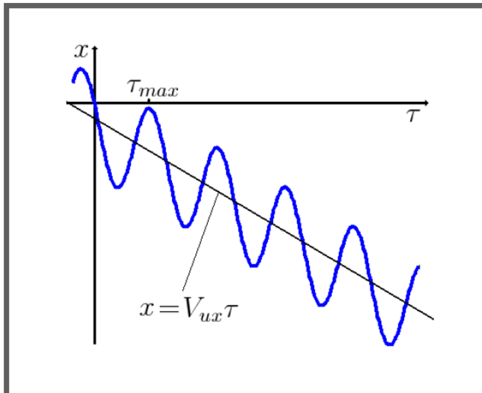
To calculate the trajectory we need to find when the particle crosses each time to another region and then switch to a complete new set of equation using suitable fields and initial conditions.

The x coordinate of the particle location:

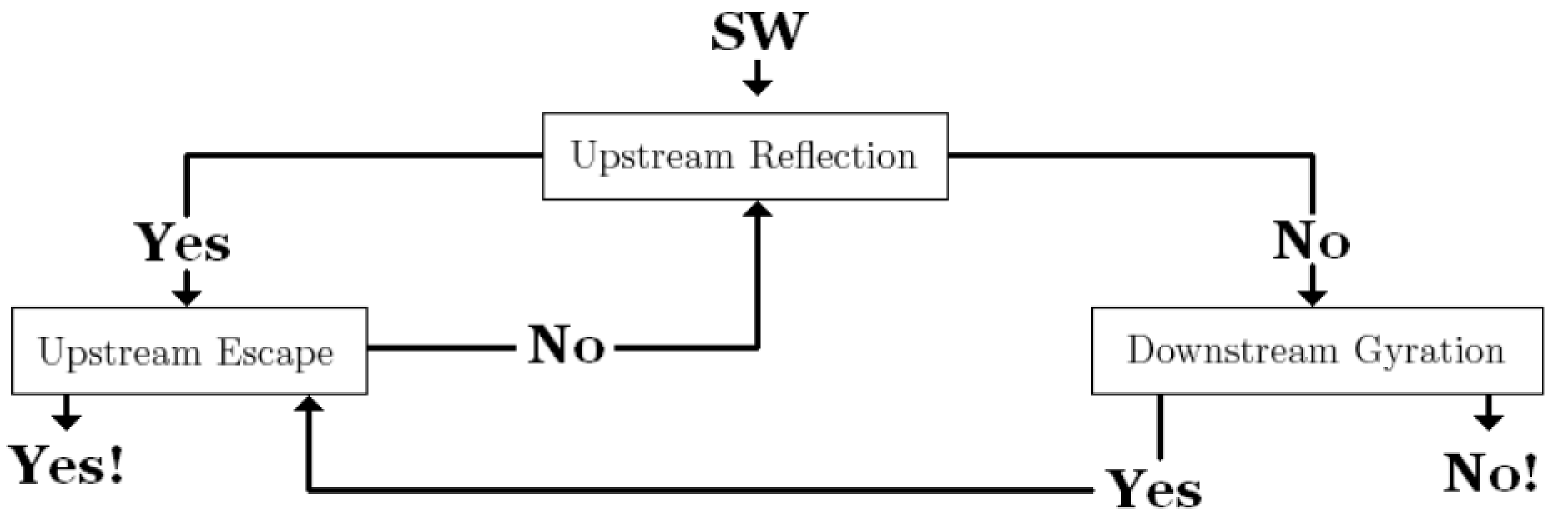
$$x_u(\tau) = u_{y2}\sin\theta + V_{ux}\tau + S_u V_{\perp}^{u}\sin(\tau - \alpha_u)$$



Schematics of ion trajectory in steps and corresponding velocities.



A Basic scheme of a program that calculates the particle trajectory:



Name	Conditions
Upstream Reflection (R)	$u_{x1}^2 < s$
Upstream Escape (E)	$V_{ux} < 0$ and $u_{y1}\sin(\theta) + V_{ux}(\alpha_u + 3\pi/2) - S_u V_\perp^u < 0$
Downstream Gyration (G)	$R u_{y0} \sin\theta/\omega^2 + V_{dx}(\alpha_d + 3\pi/2)/\omega - S_d V_\perp^d/\omega < 0$

- **The program needs to run on a wide spectrum of initial conditions matching data that was gathered by the spacecrafts. We can obtain results faster using Condor by letting trajectory calculations that match different initial conditions run simulationsly on a few computers.**