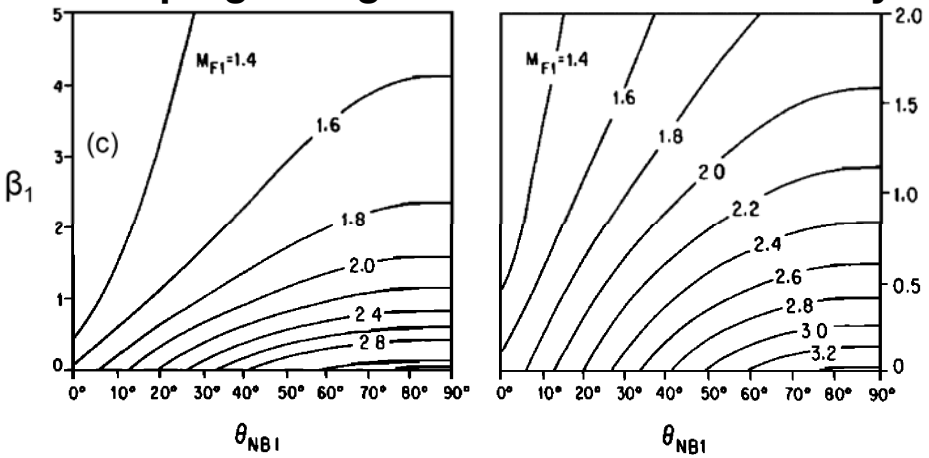
Escaping Energetic Ions and IS criticality



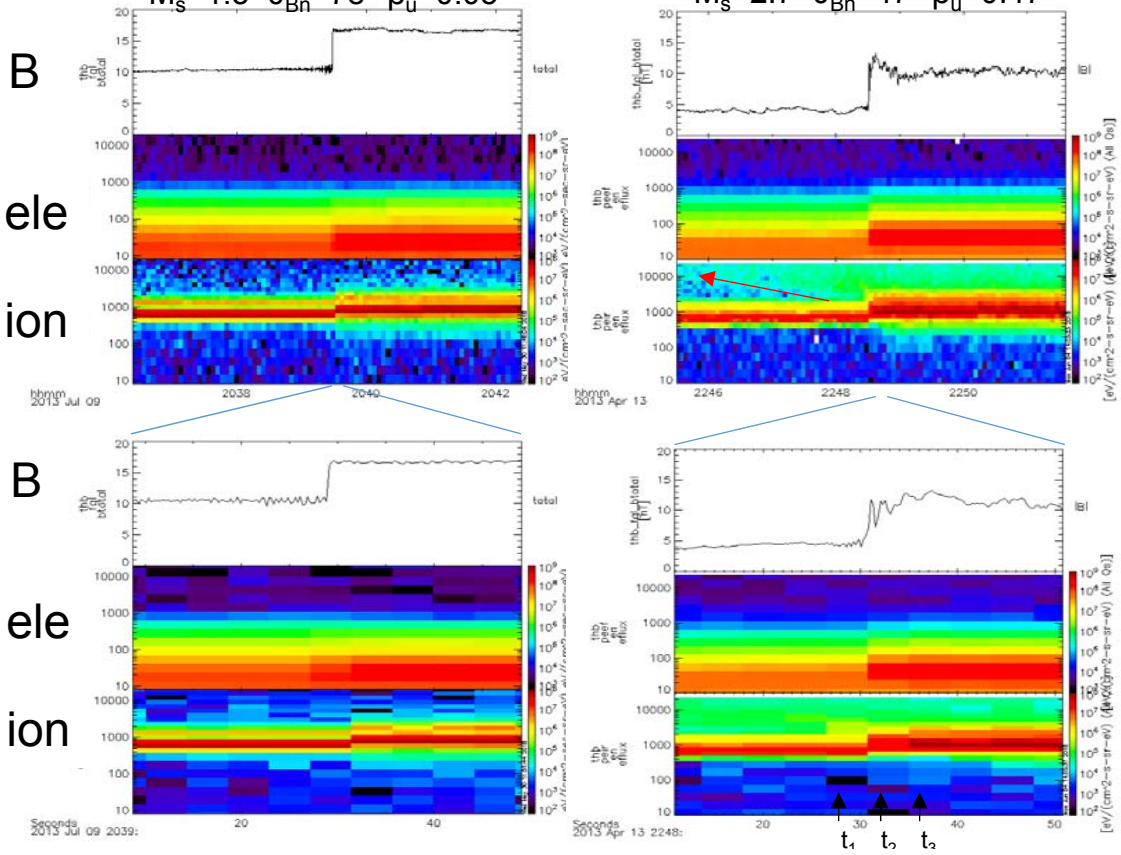
Critical Mach Number, Mc.

Mc(EK84) Edmiston and Kennel,1984 [EK84].
Mc(K87) Kennel, 1987 [K87]

A shock is supercritical if Ms/Mc=>1 or when there is a B overshoot

#20 7/9/2013 THB
M_s=1.5 θ_{Bn}=78° β_u=0.05

#16 4/13/2013 THB
M_s=2.7 θ_{Bn}=47° β_u=0.47

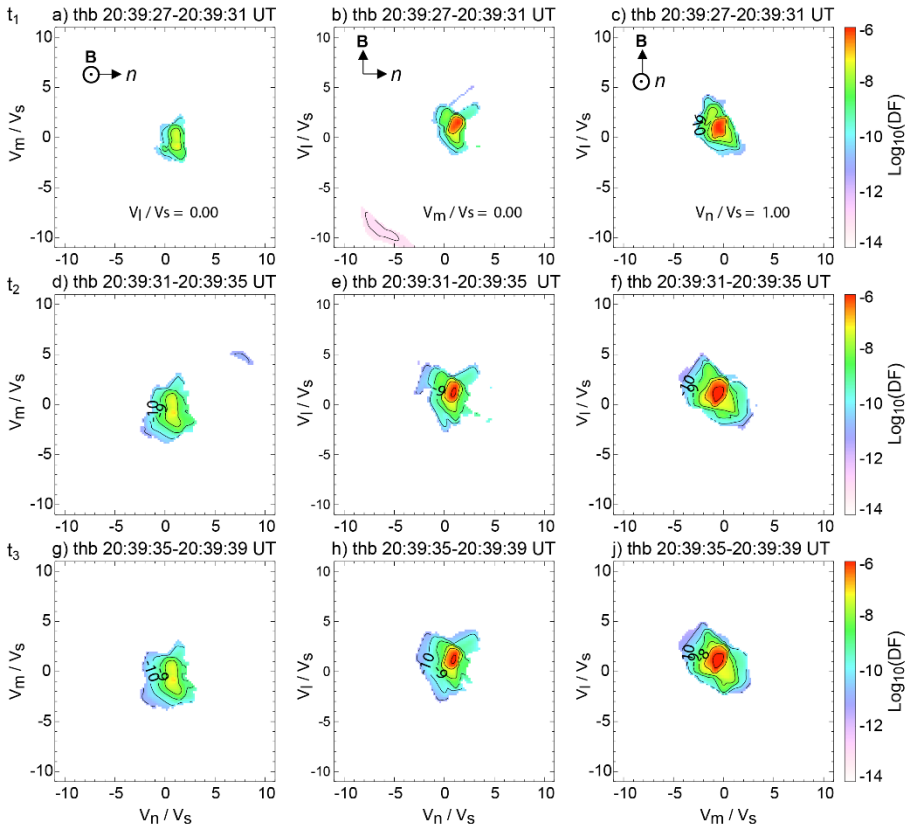


EIR for Energetic Ion Reflection (energy in ~4-25 keV)
CIR for Conventional Ion Reflection (energy in ~1-4 keV)

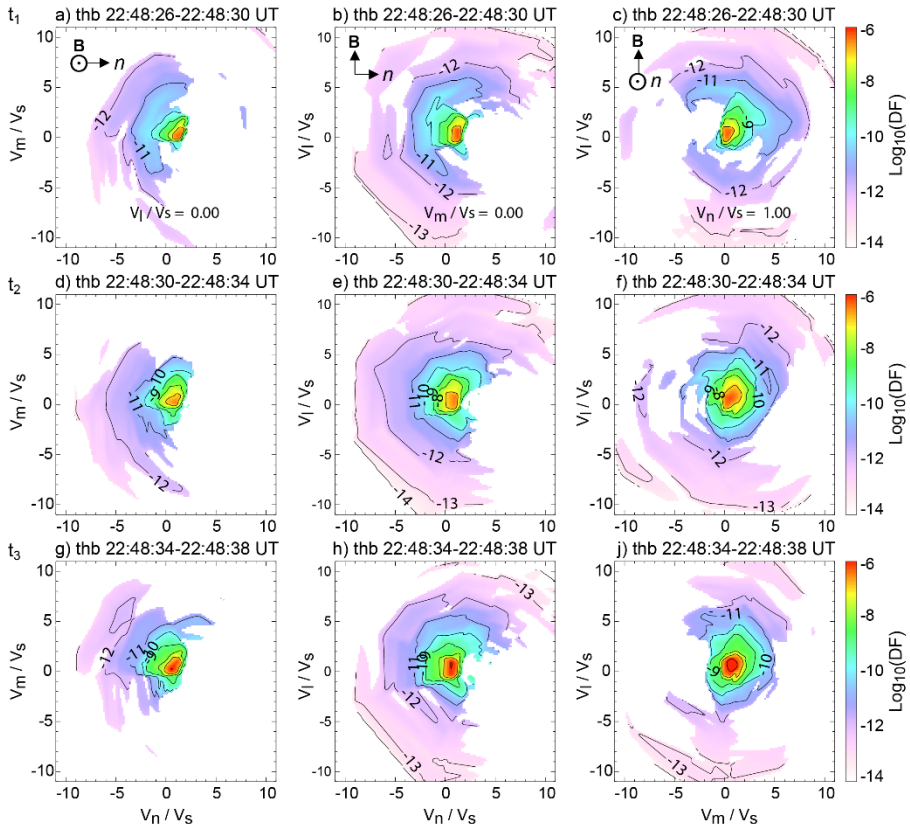
The time interval for top panels is six minutes. Bottom panels are zoomed-in to 40 sec around the shock time. Each panel has the same format, scale, same color bar.

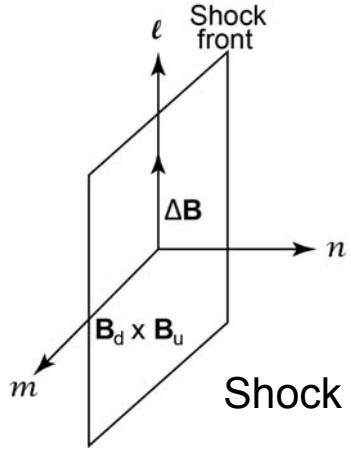
Overshoot is when the first perturbation amplitude at the shock ramp is larger than those followed in the downstream.

Ion distributions, #20, Subcritical shock, 7/9/2013, THB, Shock frame



Ion distributions, #16, Supercritical shock, 4/13/2013, THB, Shock frame





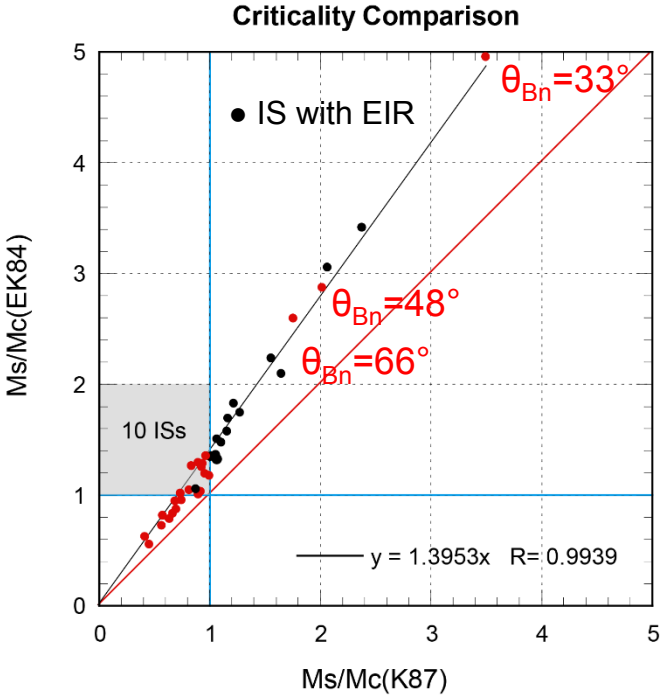
Shock frame

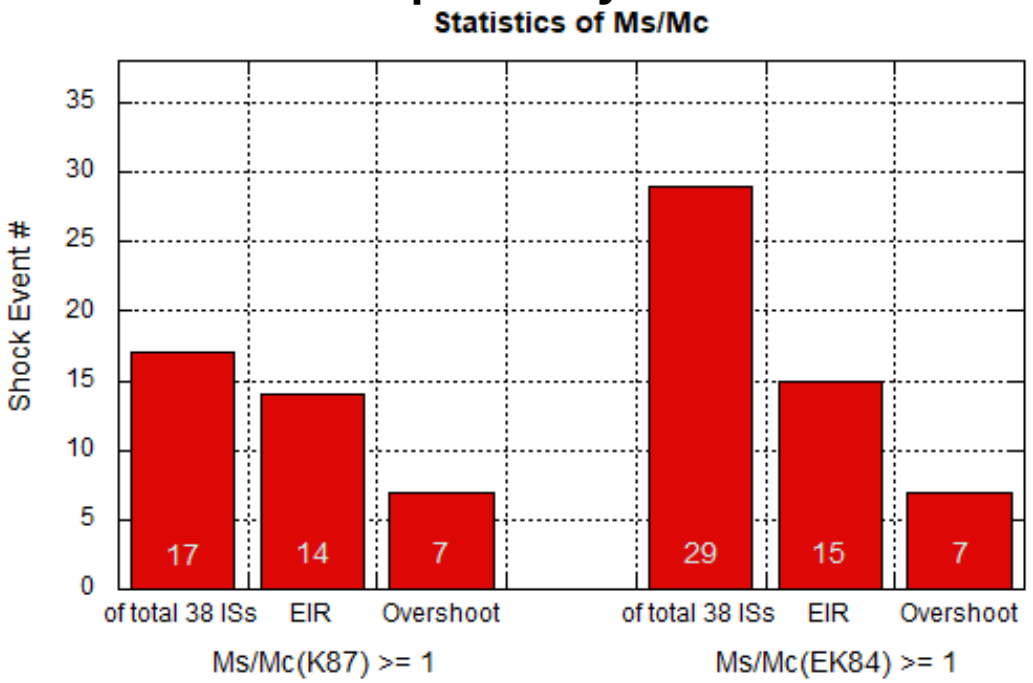
At t1 and t2, EIR ions are field-aligned and gyrating away from the ramp. At t3 they become more field-aligned.

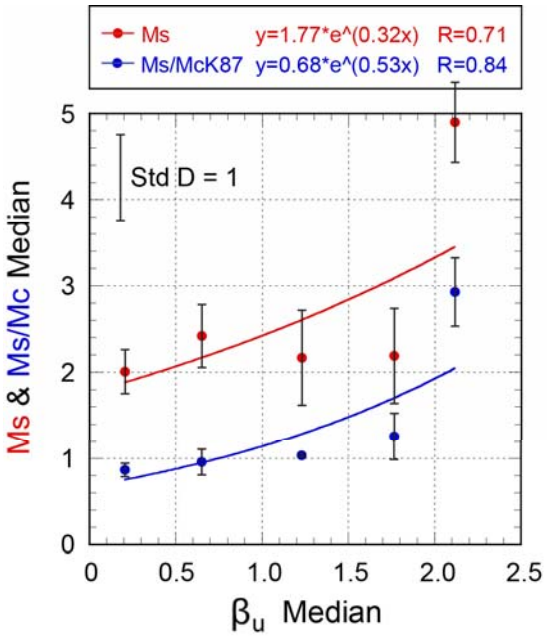
Ions could escape upstream if
$V_{i//} - V_{sw//} < -V_u/\mathrm{Cos}(\theta_{Bn})$

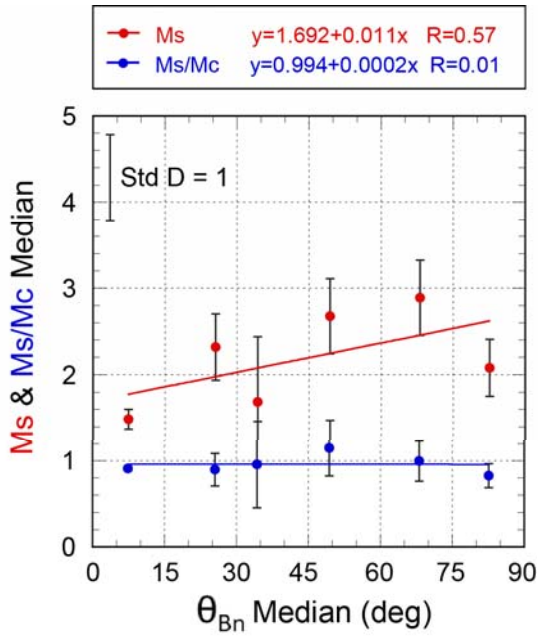
$V_{i//} - (210) < -453$ For this case, ions with $V_{i//} \approx <-250$ km/s will escape.

Statistical results from 38 interplanetary shocks





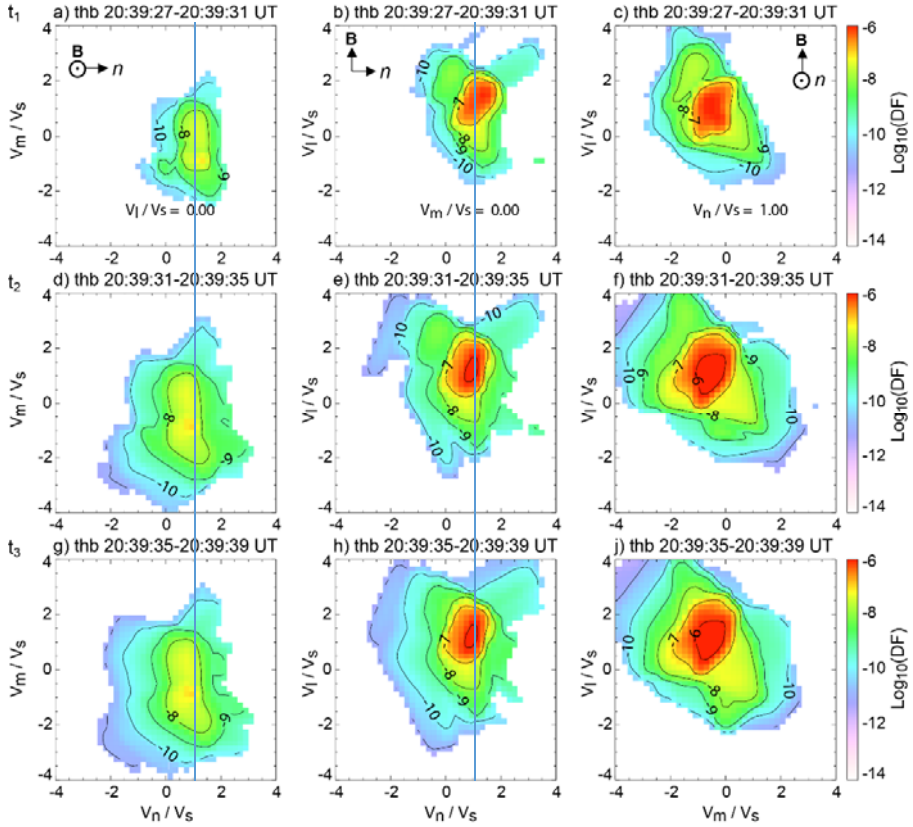




Conclusions

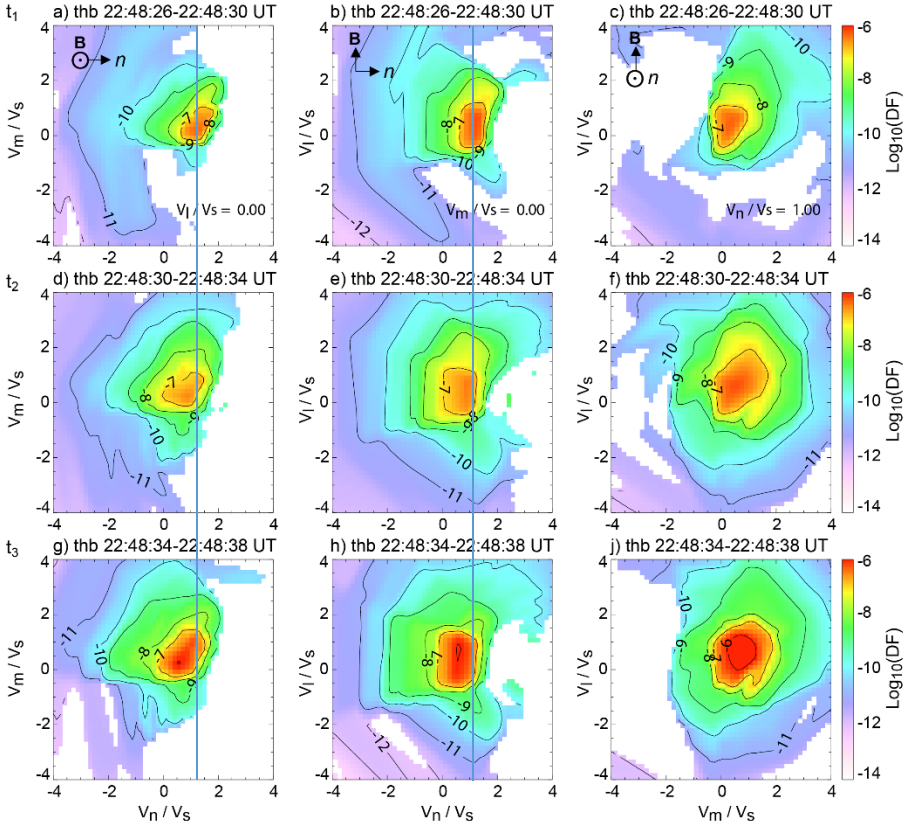
- The criticality/EIR is not correlated to θ_{Bn}.
- The ARTEMIS data showed EIRs are very consistent with the concept in K87, i.e., the ion “viscosity” plays a role in the supercritical-shock dissipation.
- More studies are needed to understand what is the ion viscosity at the kinetic-theory scale.

Zoom-in Ion distributions, #20, Subcritical shock, 7/9/2013, THB, Shock frame

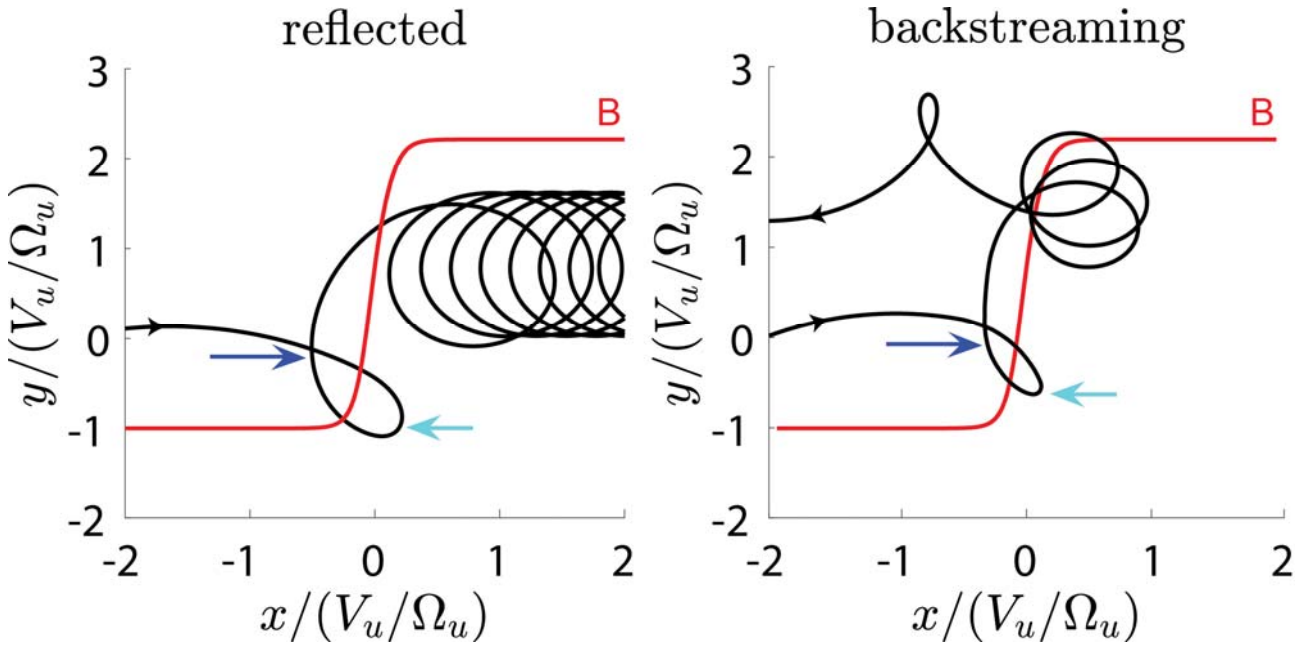


No foot and overshoot
The anisotropy is enhanced along *m* that is perpendicular to B.

Zoom-in Ion distributions, #16, Supercritical shock, 4/13/2013, THB, Shock frame



With EIR, CIR, and overshoot
The anisotropy is enhanced along *m* that is perpendicular to B.



Based on Gedalin et al. [2019], two possible ion trajectories: reflected (left) and multiply reflected and escaping (right). *x* and *y* are the ion convective gyroradius.
Within the ramp the dominant effect is from the cross-shock electric field. If an ion cannot overcome the cross-shock potential, it turns back.
Left panel shows for a reflected ion the second turning point is in the upstream region ahead of the ramp.
Right panel shows a possible trajectory of a back-streaming ion that has several turning points in the ramp vicinity and eventually escapes toward upstream.