Magnetosheath Plasma Compression: Role of Compression Speed and Alpha Particles

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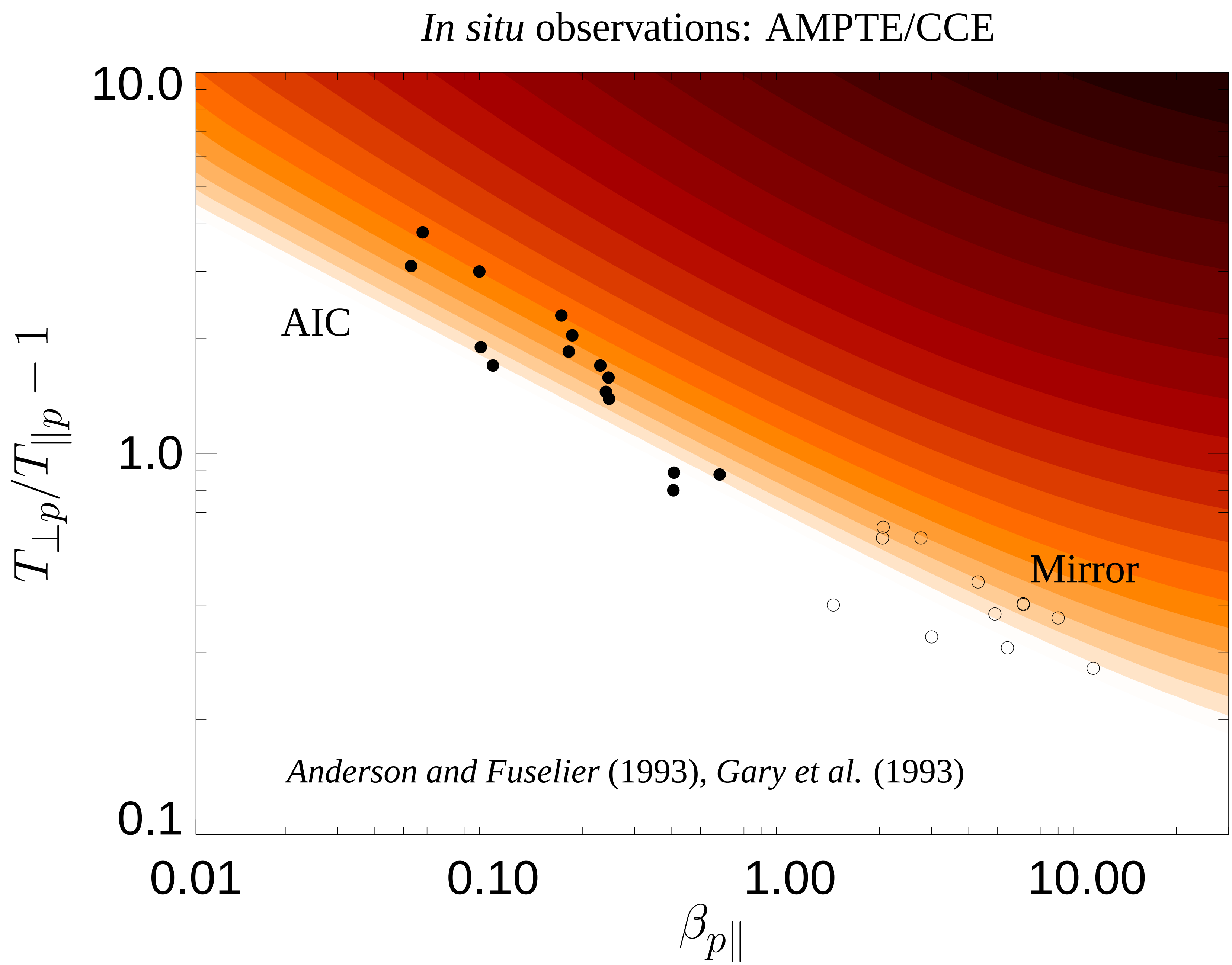
The **magnetosheath** flow around the magnetosphere leads to plasma *compression*, field line stretching, depletion, …

For quasi-perpendicular geometry low-frequency waves dominate the turbulence: Transverse Alvén ion cyclotron waves (AIC) in low-beta plasma and compressional mirror waves in high-beta plasma. Both the type of waves are observed near the marginal stability.

Suggestion: The plasma follows a marginal stability path in the ($\beta_{\|p}$, $T_{\perp p}/T_{\|p}$) space from the high $\beta_{\|p} \sim 2$, low anisotropy $T_{\perp p}/T_{\|p} \sim 1.4$ region, where mirror waves are most unstable to the opposite $\beta_{\|p} \sim 0.2$ and $T_{\perp p}/T_{\|p} \sim 3$ region where AIC waves are most unstable.

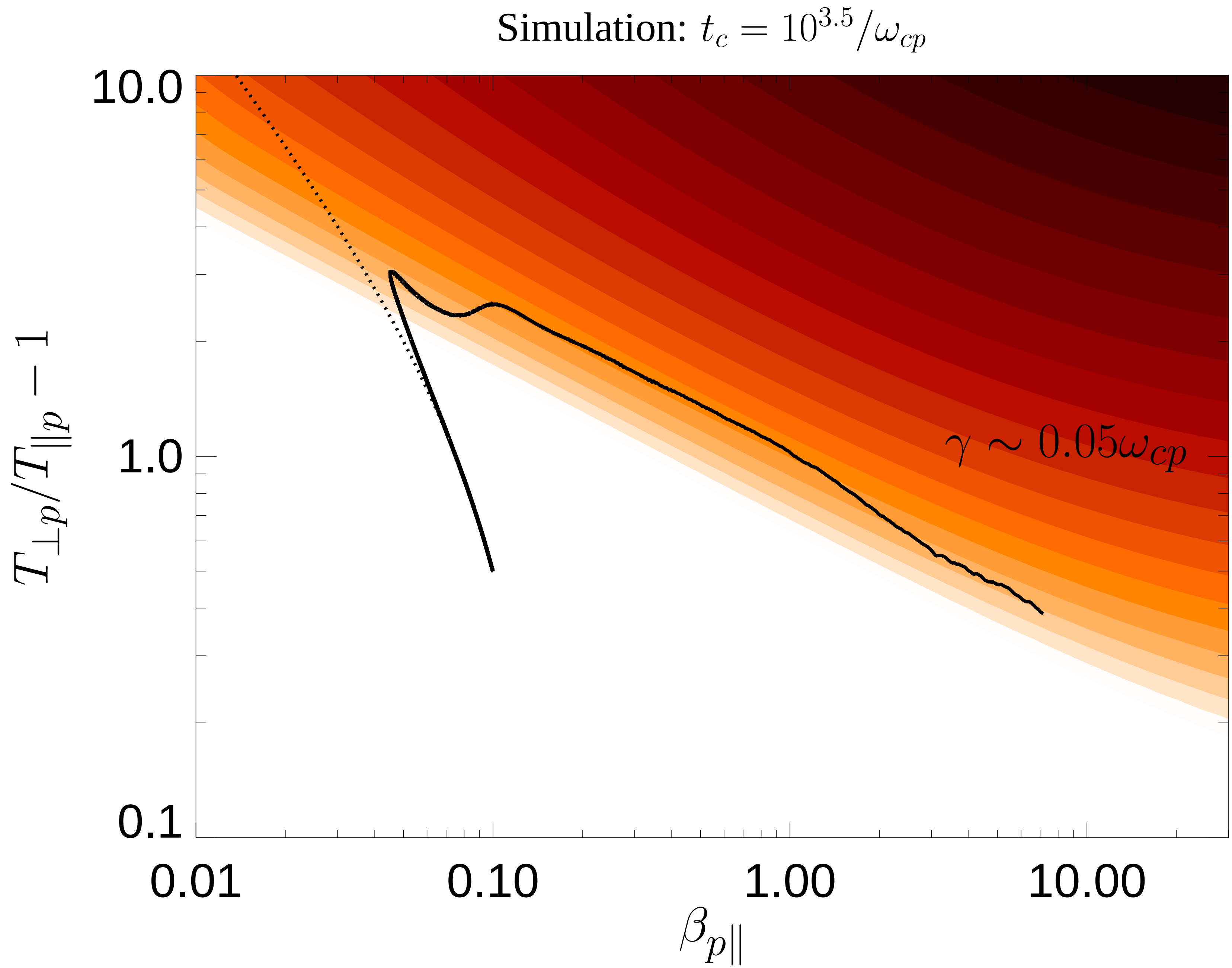


In situ observations: AMPTE/CCE
10.0
1.0
0.1
0.01
0.10
1.00
10.00
AIC
Mirror
Anderson and Fuselier (1993), *Gary et al.* (1993)
$T_{\perp p}/T_{\parallel p} - 1$
$\beta_{p\parallel}$

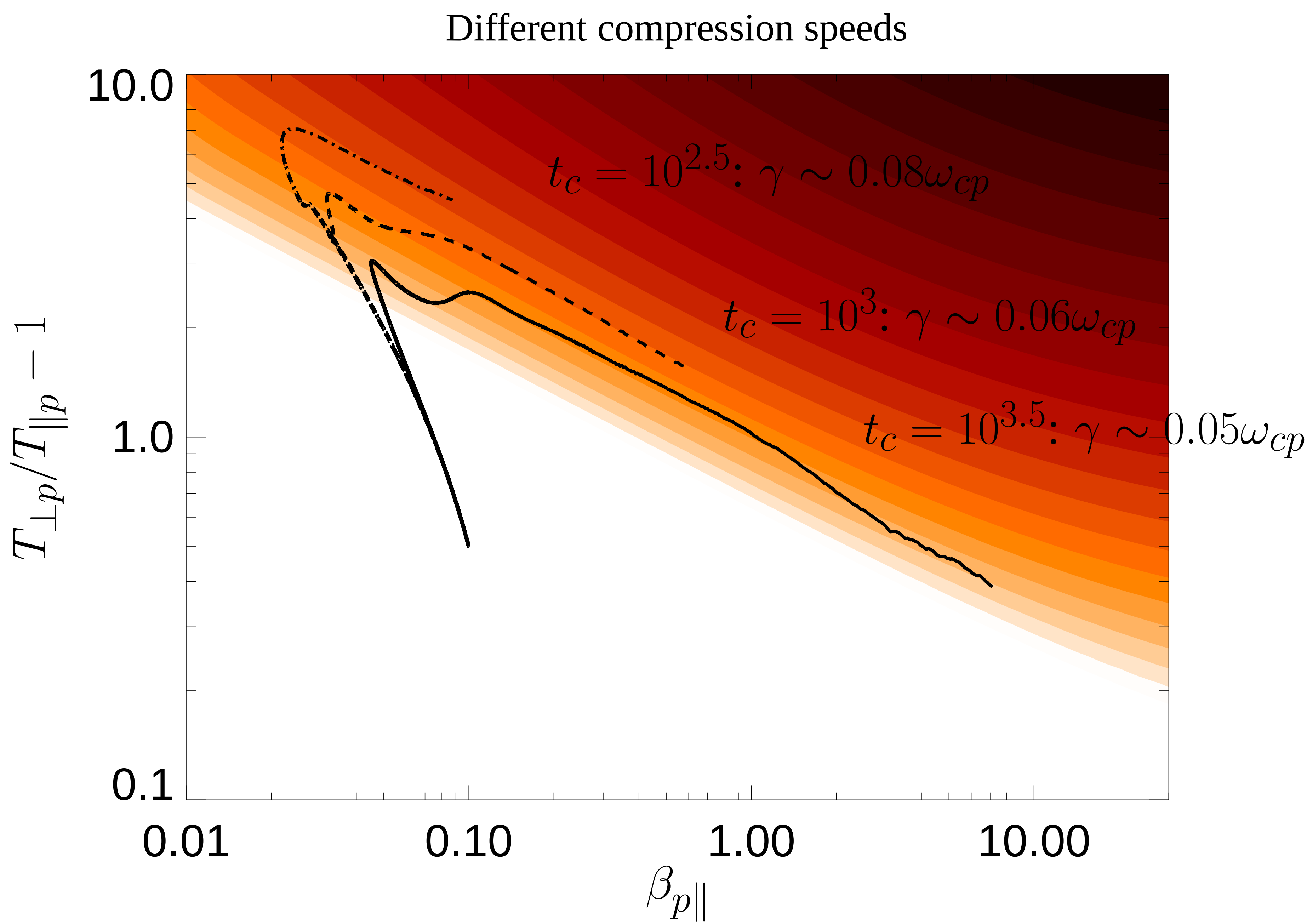
Theoretical prediction: *Gary et al*, 1994: Marginal stability condition for AIC:
$T_{\perp p}/T_{\| p} - 1 = a/\beta_{\| p}^{b}$, where $a \sim 1$, $b \sim 0.5$

Testing the hypothesis:
Hybrid Expanding box model (2D) where sizes $\propto 1 - t/t_c$ with the initial conditions $\beta_{\| p} = 0.1$, $A_p = 1.5$, and different t_c, and different abundance of alpha particles.

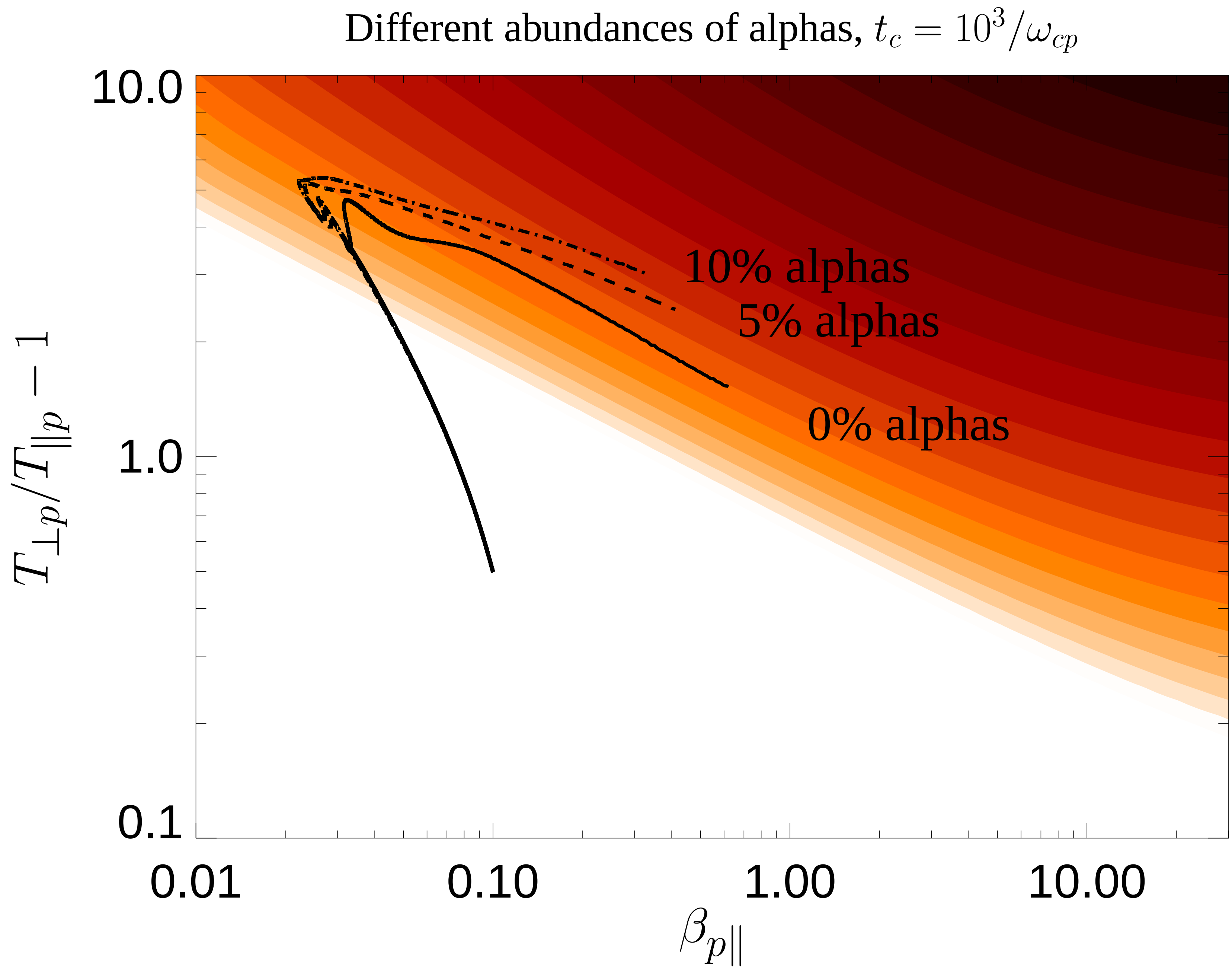
Simulation results:
After double adiabatic phase AIC waves appear and keep the system at marginal stability level in a low-beta plasma. In a high-beta plasma mirror waves become important.



Simulation: $t_c = 10^{3.5}/\omega_{cp}$
10.0
1.0
0.1
$T_{\perp p}/T_{\parallel p} - 1$
$\gamma \sim 0.05\omega_{cp}$
0.01
0.10
1.00
10.00
$\beta_{p\parallel}$



Different compression speeds
10.0
1.0
0.1
0.01
0.10
1.00
10.00
$T_{\perp p}/T_{\parallel p} - 1$
$\beta_{p\parallel}$
$t_c = 10^{2.5}$: $\gamma \sim 0.08\omega_{cp}$
$t_c = 10^{3}$: $\gamma \sim 0.06\omega_{cp}$
$t_c = 10^{3.5}$: $\gamma \sim 0.05\omega_{cp}$


Different abundances of alphas, $t_c = 10^3/\omega_{cp}$
10.0
1.0
0.1
0.01
0.10
1.00
10.00
$\beta_{p\parallel}$
$T_{\perp p}/T_{\parallel p} - 1$
10% alphas
5% alphas
0% alphas

Results

We have directly tested the *marginal stability path* evolution in the case of a slow compression.

This path depends on the compression speed:
$\gamma_{\mathrm{AIC}} \sim$ const. $\propto 1/t_c$

Alpha particles change the plasma properties: The growth rate of AIC decreases and therefore the *marginal stability path* is slightly modified.

These results are consistent with linear analysis, standard hybrid simulations and observations.