SU(3) Weibel instabilities

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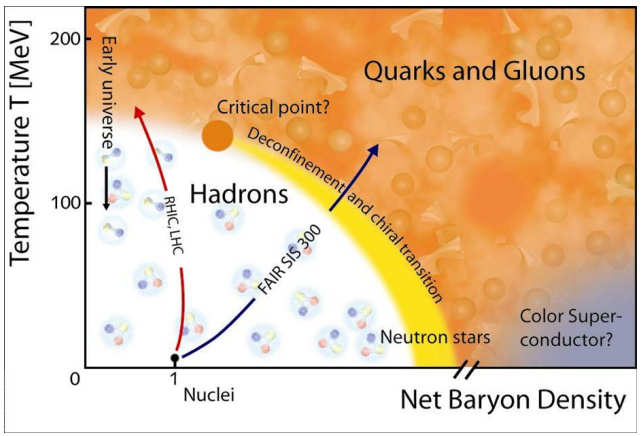
Motivation

Probing SU(3):

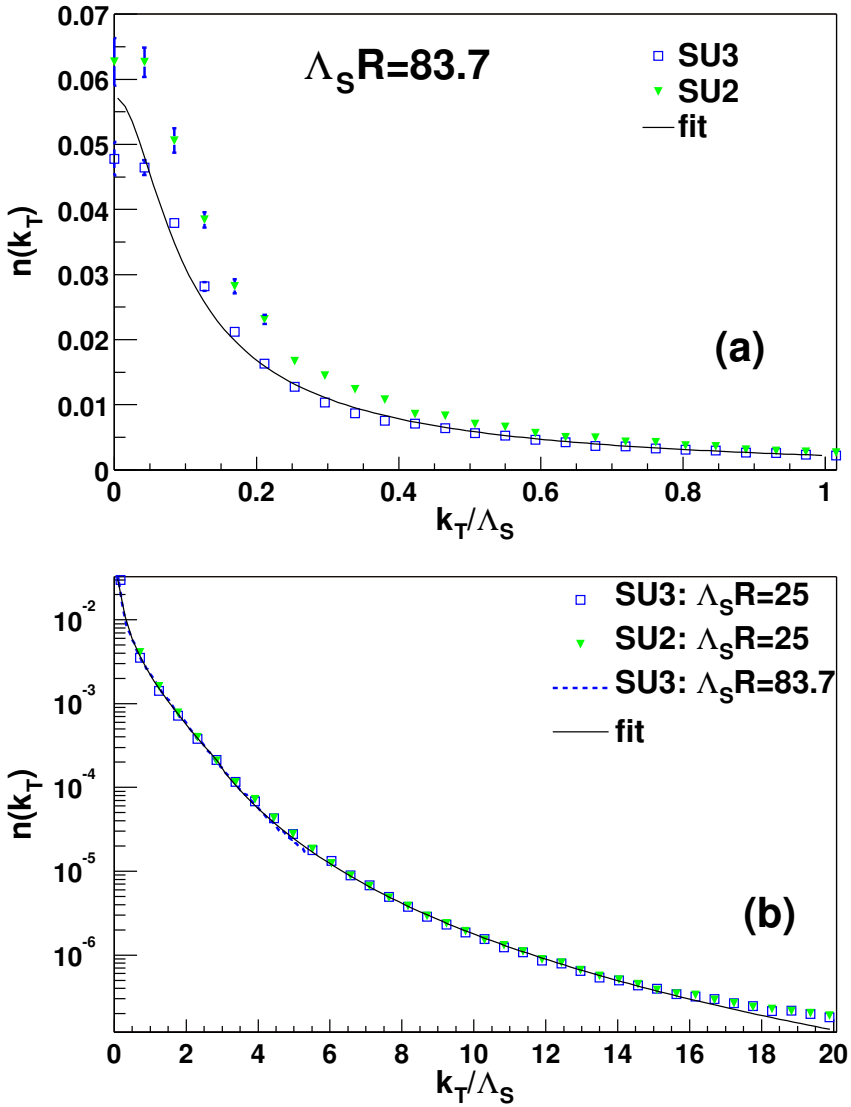
- richer symmetry structure
- QCD phase diagram
- computational challenge

Goals:

- Understanding of weakly coupled timescales
- Comparison to infinitely strongly coupled plasmas



Transverse thermalization



CGC setup at time scales Q_s^{-1} [Krasnitz, Nara, Venugopalan 2001]

Scales of wQGP

Equilibrium:

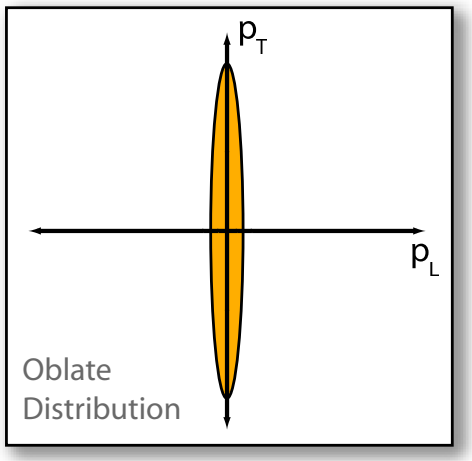
- T: energy of hard particles
- gT: thermal masses, Debye screening mass,
- $g^2 T$: magnetic confinement, color relaxation, rate for small angle scattering
- $g^4 T$: rate for large angle scattering, $\eta^{-1} T^4$

Scales of wQGP

Anisotropy:

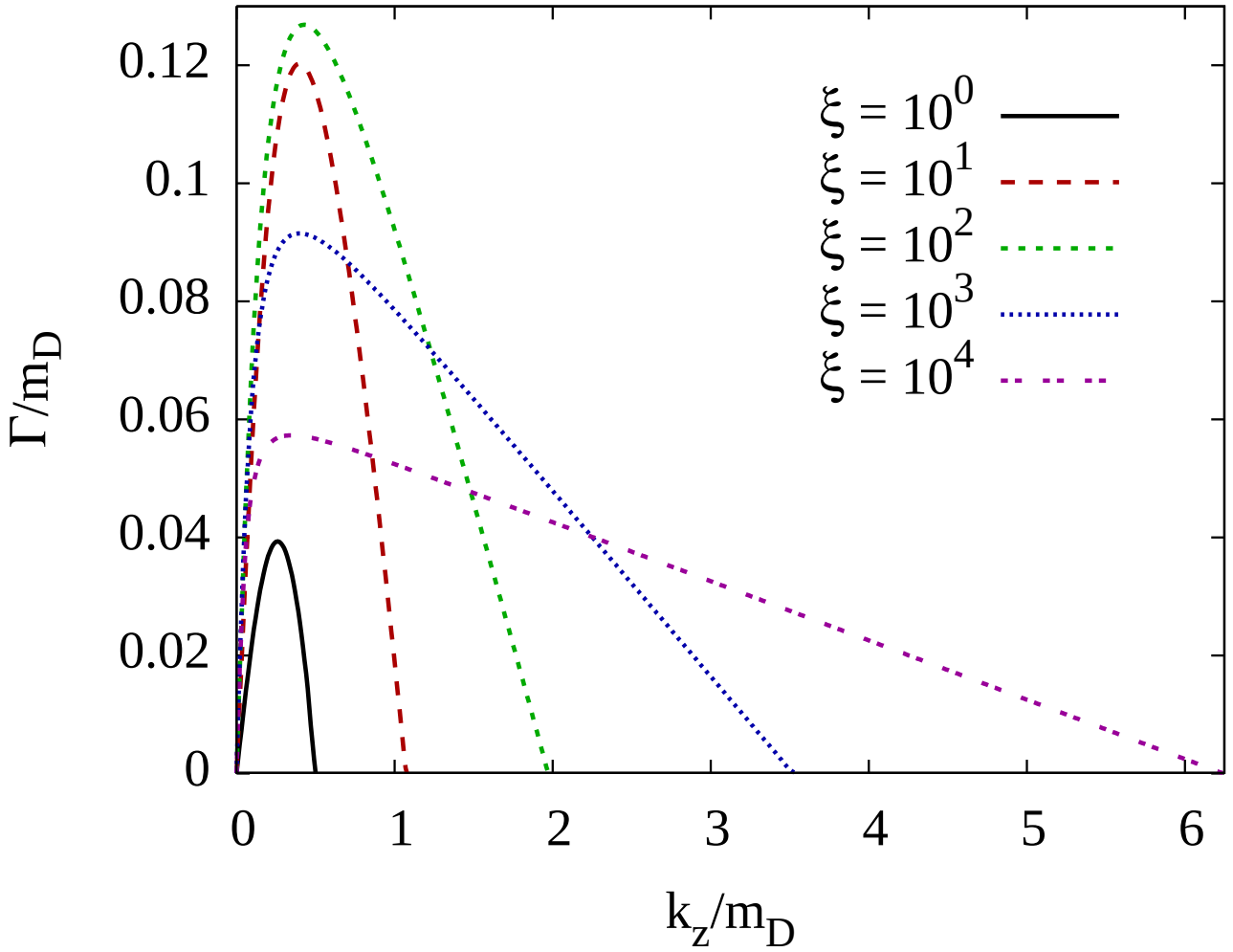
- T: energy of hard particles
- gT: thermal masses, Debye screening mass, plasma instabilities [Mrowczynski 1988, 1993, ..]
- $g^2 T$: magnetic confinement, color relaxation, rate for small angle scattering
- $g^4 T$: rate for large angle scattering, $\eta^{-1} T^4$

Weibel instabilities



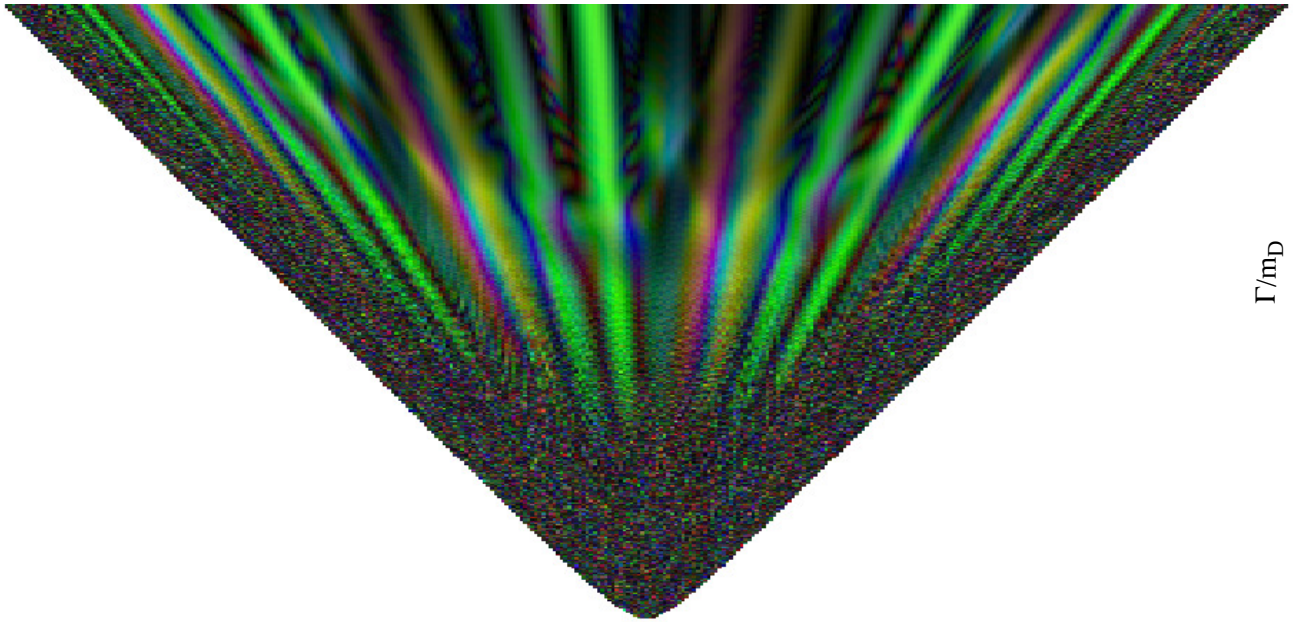
[Mrowczynski 1993; Strickland 2006]: Illustration of the mechanism of filamentation instabilities with Lorentz force.

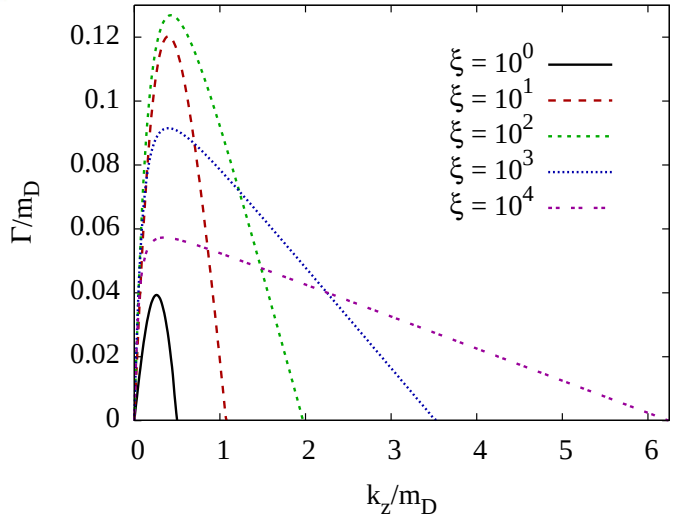
Unstable modes growth rate



[Romatschke, Strickland 2003] Unstable mode spectra of purely longitudinal modes: $N(\tau) \approx \exp(2m_D\sqrt{\tau\tau_{\mathrm{ISO}}})$.

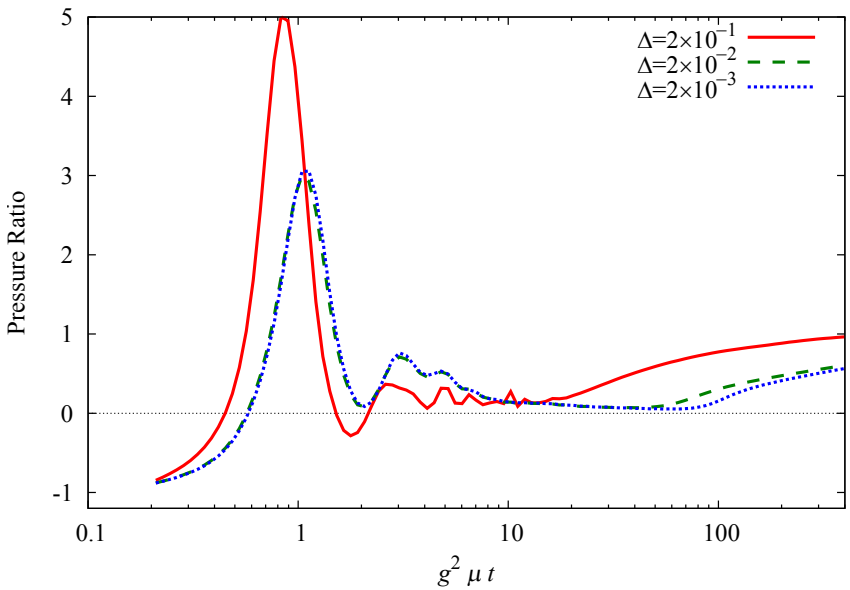
Filamentation instability



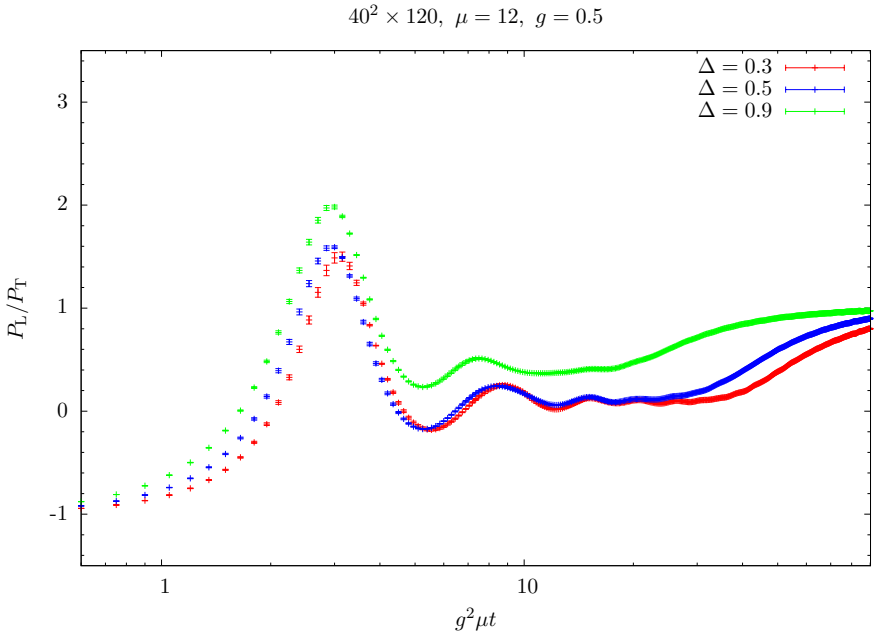


[2008 MA, Rebhan, Strickland.] Visualization of the 1D+3V space-time development of color correlations in a non-Abelian plasma instabilities in Bjorken expansion.

SU(2) versus SU(3)



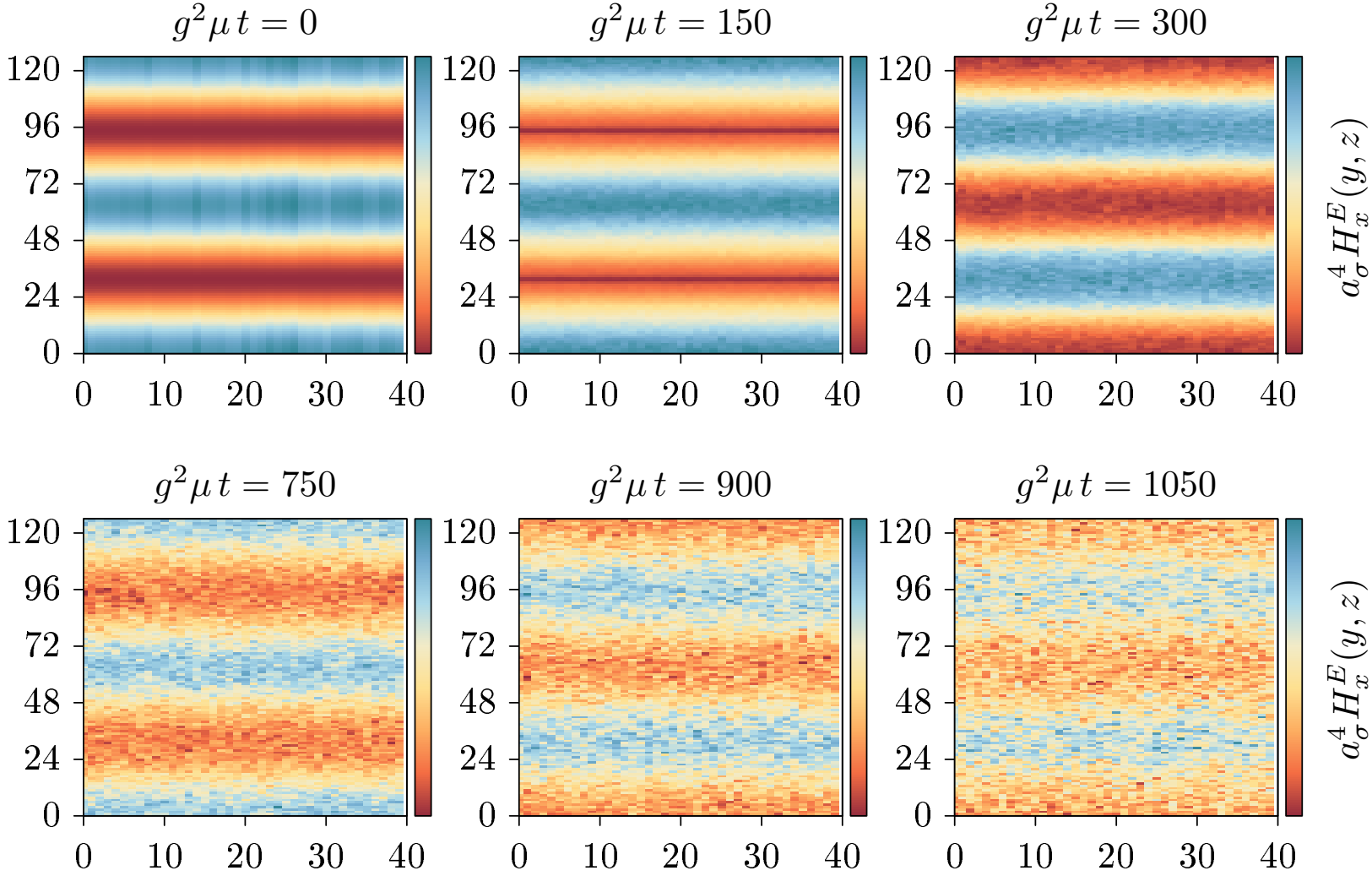
SU(2) [Fukushima 2013]



SU(3) [MA, Philipsen, Schäfer, Wagenbach, Zafeiropoulos 2015]

Isotropization takes some time in a non-expanding and symmetric box.

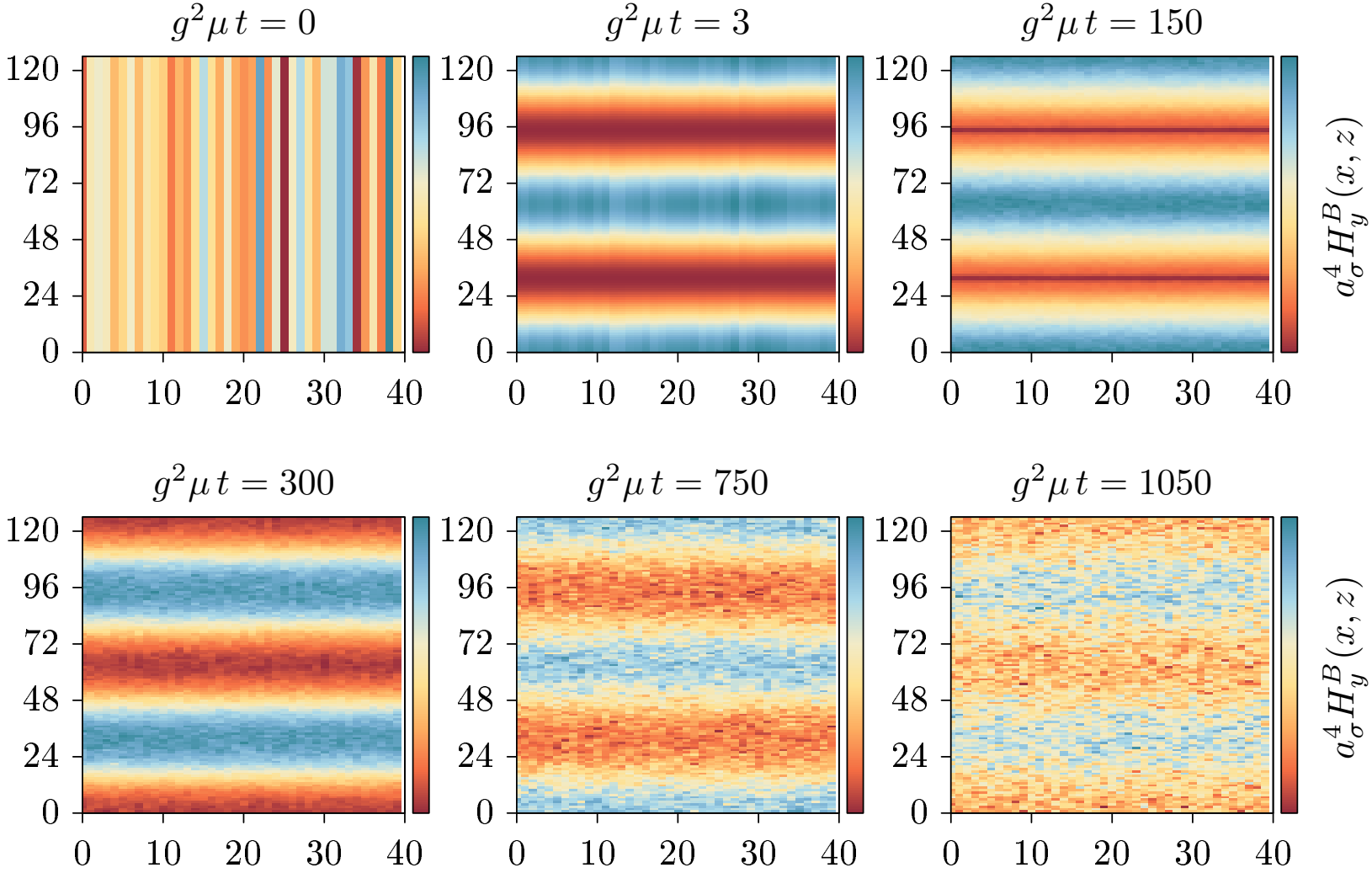
SU(3) Weibel instabilities



Local E energy density evolution in xz plane at different times

[MA, Philipsen, Schäfer, Wagenbach, Zafeiropoulos 2015]

SU(3) Weibel instabilities



Local B energy density evolution in yz plane at different times

[MA, Philipsen, Schäfer, Wagenbach, Zafeiropoulos 2015]

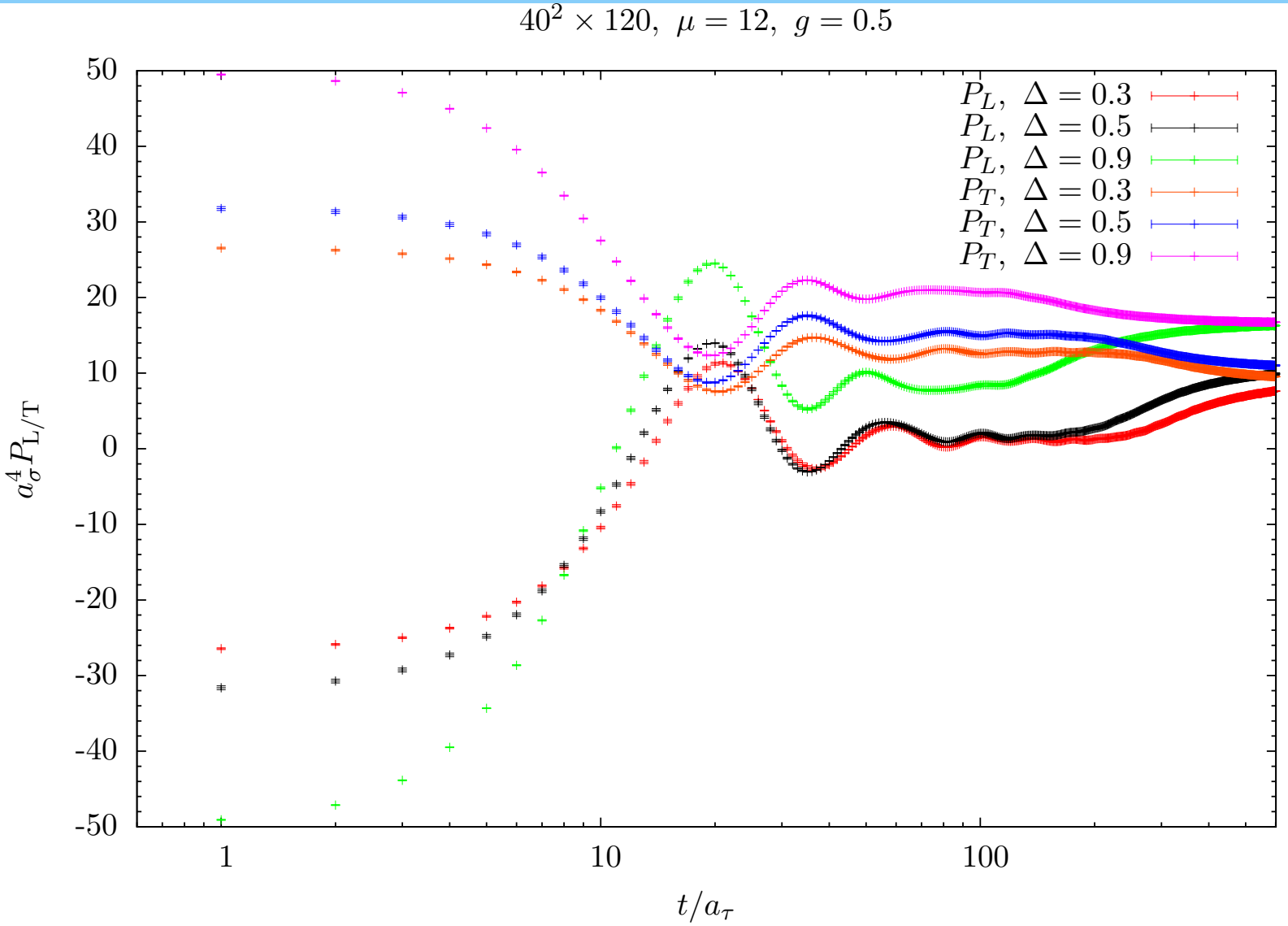
Conclusions

- In order to achieve an isotropisation time comparable with results from equivalent SU(2) simulations we had to increase for SU(3) the fuctuation seed from Δ:
  SU(3) gauge fields are about 25% slower compared to SU(2).

- We found evidence for the emergence of the chromo-Weibel instability displayed by the filaments in the local energy densities.

- We plan to investigate SU(3) and its magnetic Wilson loops in expanding comoving coordinates, plus check larger lattices.

Backup



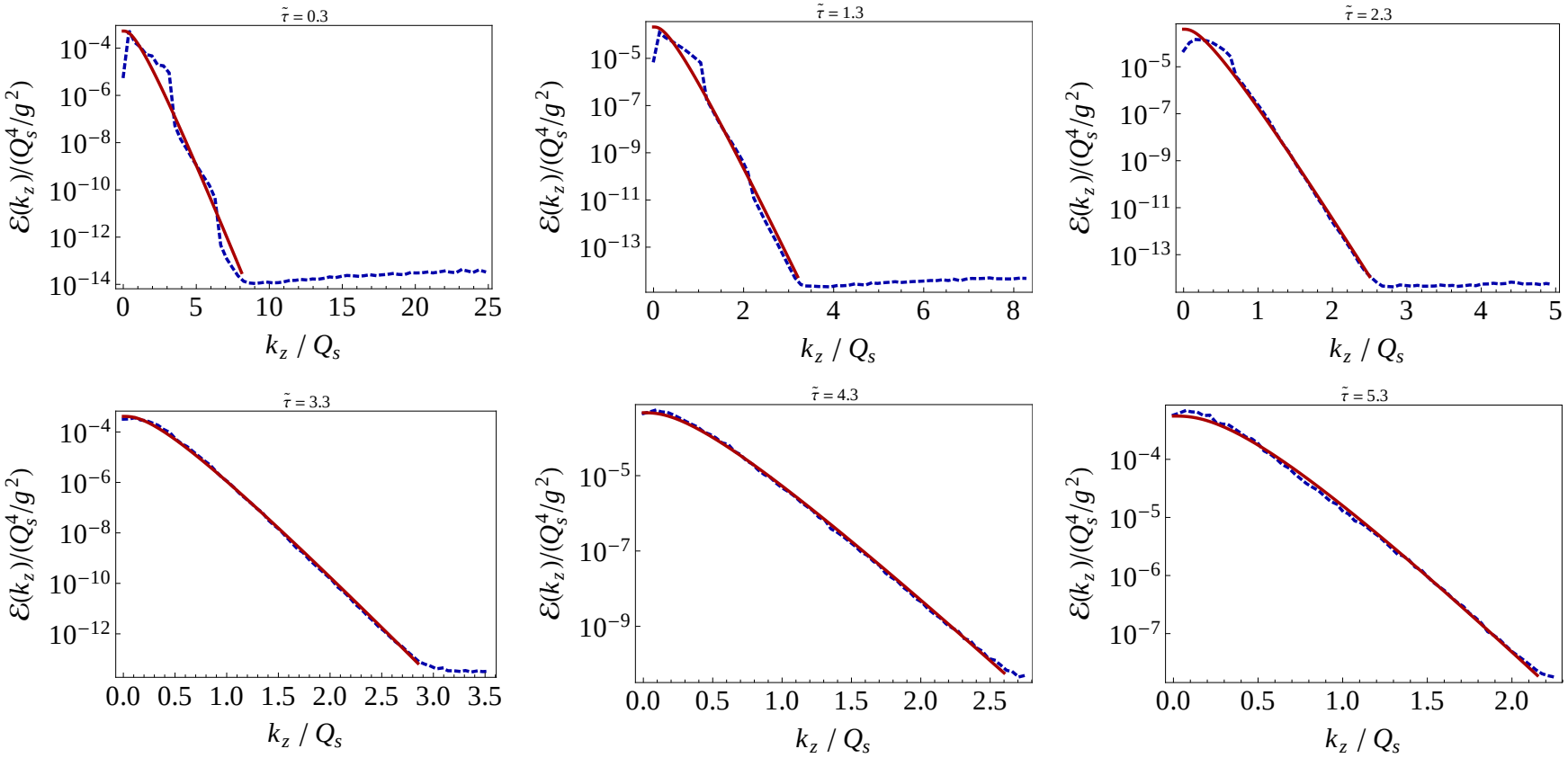
Pressure evolution for different initial color fluctuation seeds Δ

[MA, Philipsen, Schäfer, Wagenbach, Zafeiropoulos 2015]

Longitudinal thermalization

Massless Boltzmann distribution fits the longitudinal spectra:

$$\mathcal{E}_{\text{fit}}(k_z) = A\left(k_z^2 + 2|k_z|T + 2T^2\right)\exp\left(-|k_z|/T\right) \qquad (1)$$



Comparison of Vlasov simulation and fit function at six different $\tilde{\tau}$.
[MA, Rebhan Strickland 2012]