WG IV Summary

Rishi Sharma

December 9, 2019

Co-organized with Asmita Mukherjee

List of talks

Plenary talks

- Plenary talk by Mauro Anselmino summarizing the theory and phenomenology of transverse momentum dependent parton distributions (TMDs) which are necessary to obtain the three dimensional structure of the proton
- Plenary talk by Peter Petreczky was an overview of the results from Lattice QCD relevant for the observations of heavy ion collisions at RHIC and the LHC, and the recent attempts to use Lattice QCD to calculate the full three dimensional structure of hadrons

List of talks

WG IV

Monday, December 2, 2019

Session 1 (Venue:)		
14.00-14.30	Talk 1 Mauro Anselmino	Topic: Single spin asymmetries
14.30-15.00	Talk 2: Mauro Anselmino	Topic : Single spin asymmetries (cntd.)
15.00-15.30	Discussion	
15.30-16.00	**Tea Break**	
Session 2 (Venue:)		
16.00-16.30	Talk 3: Rishi and Asmita	Topic: Introduction and planning of WG IV activities
16.30-17.00	Talk 4:	Topic:
17.00-17.30	Discussion	

Tuesday, December 3, 2019

Session 3 (Venue:)		
14.00-14.30	Talk 5: Sabyasachi Ghosh	Topic: Hall and normal components of electrical conductivity in presence of magnetic field
14.30-15.00	Talk 6: Sabyasachi Ghosh	Topic : Hall and normal components of electrical conductivity in presence of magnetic field
15.00-15.30	Discussion	
15.30-16.00	**Tea Break**	
Session 4 (Venue:)		
16.00-16.30	Talk 7: Saumen Datta	Topic: Quarkonia
16.30-17.00	Talk 8: Saumen Datta	Topic: Quarkonia
17.00-17.30	Discussion	

List of talks

Wednesday, December 4, 2019

Session 5 (Venue:)		
14.00-14.30	Talk 9:Subhashis Chattopadhyay	Topic: Experimental investigations of nuclear matter at extreme net-baryon density
14.30-15.00	Talk 10:Subhashis Chattopadhyay	Topic:Experimental investigations of nuclear matter at extreme net-baryon density
15.00-15.30	Discussion	
15.30-16.00	**Tea Break**	
Session 6 (Venue:)		
16.00-16.30	Talk 11: Ankita Budhraja	Topic:1 loop angularity distributions with recoil using SCET
16.30-17.00	Talk 12: Ankita Budhraja	Topic:1 loop angularity distributions with recoil using SCET
17.00-17.30	Discussion	

Thursday, December 5, 2019

Session 7 (Venue:)		
14.00-14.30	Talk 13a: Ashutosh Dash Talk 13b: Pulak Banerjee	Topic a: Flow correlations as a measure of phase transition: Results from a new hydrodynamic code. Topic b: Perturbative QCD
14.30-15.00	Talk 14a:Sandeep Chatterjee Talk 14b: Prasanna K Dhani	Topic a: Strange results on strange quarks Topic b: Perturbative QCD
15.00-15.30	Discussion	
15.30-16.00	**Tea Break**	
Session 8 (Venue:)		
16.00-16.30	Talk 15 a: Sourendu Gupta	Topic a: EFTs at finite temperature
16.30-17.00	Talk 16 b: Sourendu Gupta	Topic a: EFTs at finite temperature
17.00-17.30	Discussion	

List of talks

Friday, December 6, 2019

Session 9 (Venue:)		
14.00-14.30	Talk 17a: Rajarshi Ray	Topic a: Equilibrium properties of strong interactions
14.30-15.00	Talk 18a: Rajarshi Ray	Topic a: Equilibrium properties of strong interactions
15.00-15.30	Discussion	
15.30-16.00	**Tea Break**	
Session 10 (Venue:)		
16.00-16.30	Talk 19a:Deepak Kumar Talk 19b: Raj Kishore	Topic a: Chiral Susceptiblity in Quark Matter Topic b: Gluon TMDs in J/psi Production
16.30-17.00	Talk 19a: Saumia Pandiat Talk 20b: M C Kumar	Topic a: Z(3) metastable states in PNJL model Topic b: Resummation predictions for spin 2 production at LHC
17.00-17.30	Discussion	

Saturday, December 7, 2019

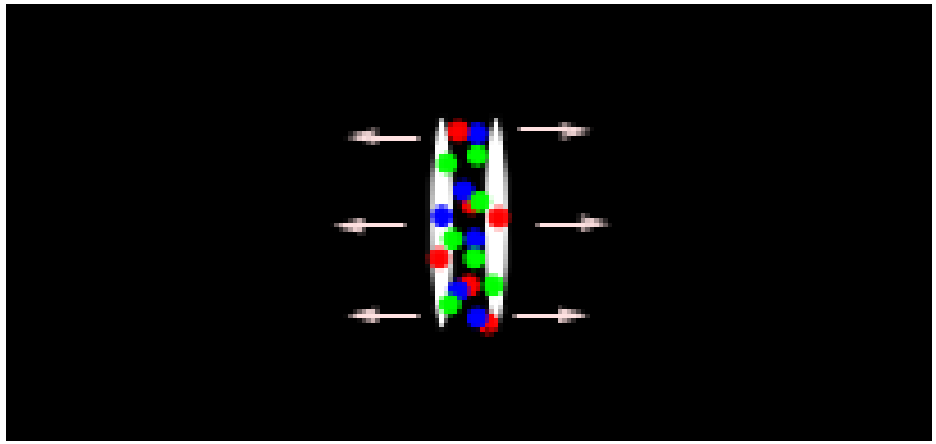
Session 11 (Venue:)		
09.00-09.30	Talk 21: Najmul Haque Talk 21 b: Mauro Anselmino	Topic a: Applications of thermal field theory in presence of magnetic field in HIC Topic b: Discussion on single spin asymmetries
09.30-10.00	Talk 22: Najmul Haque Talk 22 b: Mauro Anselmino	Topic: Applications of thermal field theory in presence of magnetic field in HIC Topic b: Discussion on single spin asymmetries
10.00-10.30	Discussion	
10.30-11.00	**Tea Break**	
Session 12 (Venue:)		
11.00-11.30	Talk 23 a:Balbeer Singh Talk 23 b:Chandan Mondal	Topic a: Heavy quark transport in a Polyakov loop Plasma Topic b: Hadron structure from light front hamiltonian
11.30-12.00	Talk 24 a:Saumen Datta Talk 24 b:Pulak Talukdar	Topic a: A discussion session on determining transport properties Topic b:2 photon exchange in low energy lepton proton scattering
12.00-12.30	Discussion	
12.30-14.00	**Lunch Break**	
Session 13 (Venue:)		
14.00-14.30	Talk 25 a: Shreyansh Dave Talk 25 b: Satvir Kaur	Topic a: Magnetohydrodynamics and effect on v2 Topic b:Structure of Kaons in light front quark model
14.30-15.00	Talk 26 a:Rajesh Kumar Talk 26 b: Udit Raha	Topic a: Effects of magnetic fields on heavy mesons Topic b:Discussion on EFT
15.00-15.30	Discussion	

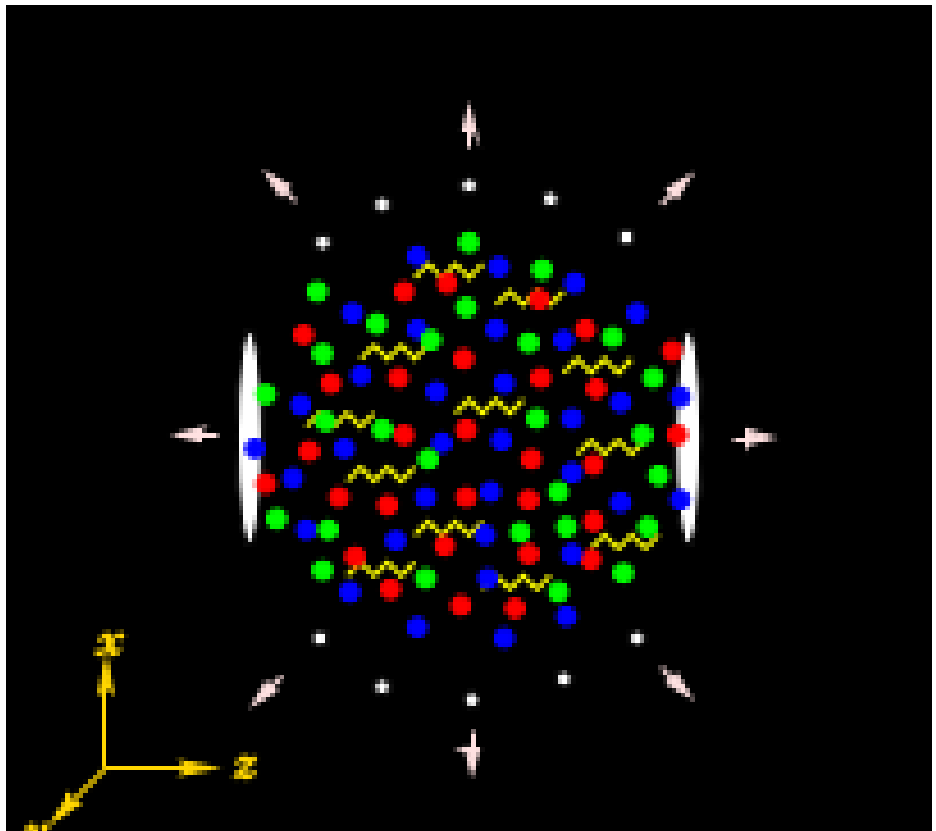
List of talks

Monday, December 9, 2019

Session 14 (Venue:)		
09.00-09.30	Talk 27: Plenary (Peter Petreczky)	Topic: TBA
09.30-10.00	Talk 28: Plenary (Peter Petreczky)	Topic: TBA
10.00-10.30	Discussion	
10.30-11.00	**Tea Break**	
Session 15 (Venue:)		
11.00-11.30	Talk 29: Sayantan Sharma Talk 29b : Chandan Mondal	Topic: Screening masses of mesons Topic : Discussion on light cone wavefunctions
11.30-12.00	Talk 30: Sayantan Sharma Talk 30b :Chandan Mondal	Topic: Screening masses of mesons Topic : Discussion on light cone wavefunctions
12.00-12.30	Discussion	
12.30-14.00	**Lunch Break**	
Session 16 (Venue:)		
14.00-14.30	Talk 31a: Peter Petreczky Talk 31b:	Topic a: Real time quantities from the lattice (Quarkonia) Topic b: Discussion
14.30-15.00	Talk 32a: Peter Petreczky Talk 32b:M C Kumar	Topic a: Real time quantities from the lattice (Diffusion) Topic:Discussion
15.00-15.30	Discussion	
15.30-16.00	Tea Break	
Session 17 (Venue:)		
16.00-16.30	Talk 33:	Topic: Informal discussions
16.30-17.00	Talk 34:	Topic: Informal discussions
17.00-17.30	Discussion	

Heavy Ion collisions



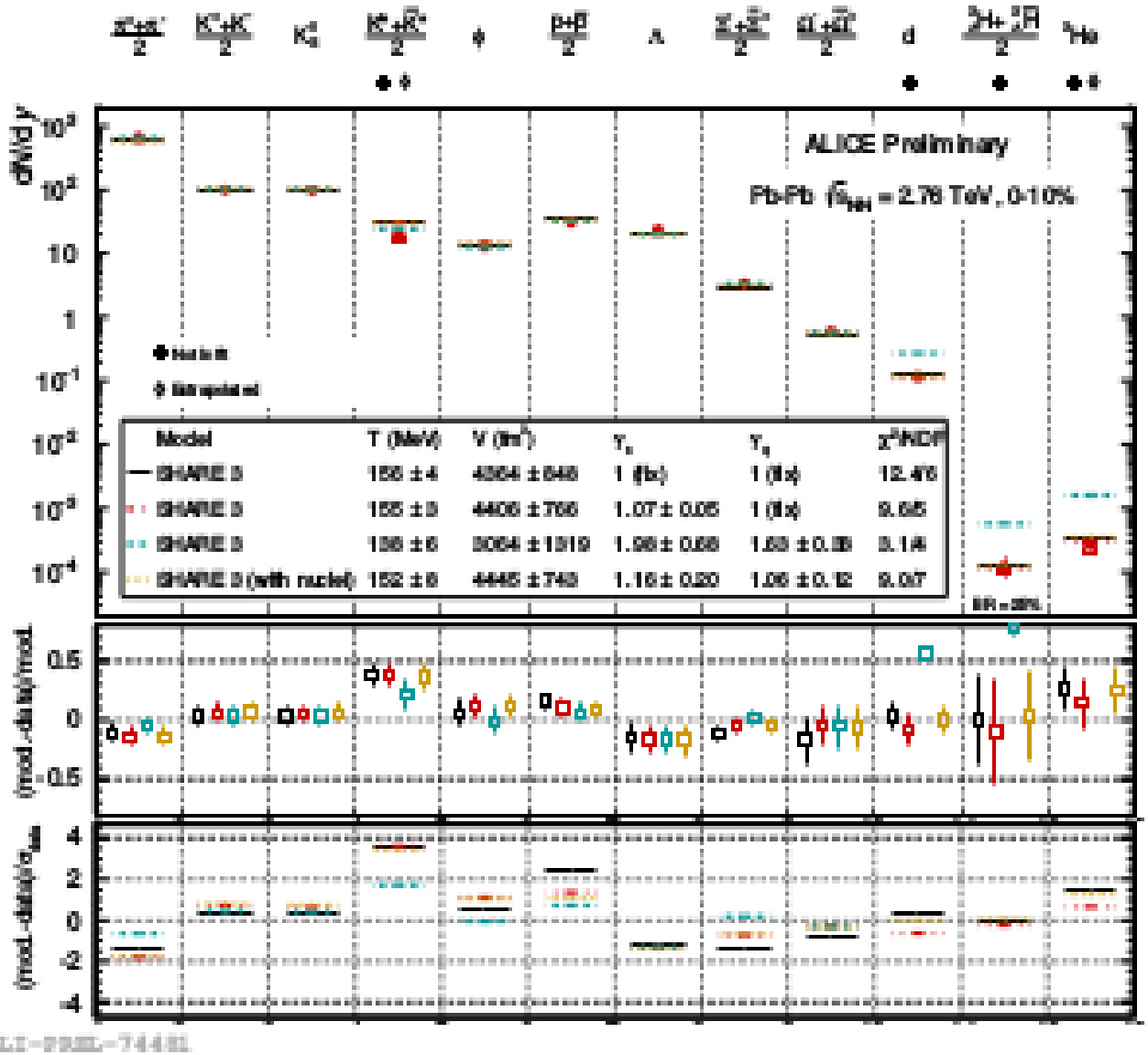


Themes

Hydrodynamics and freezeout

- Success of thermal freezeout suggests equilibration

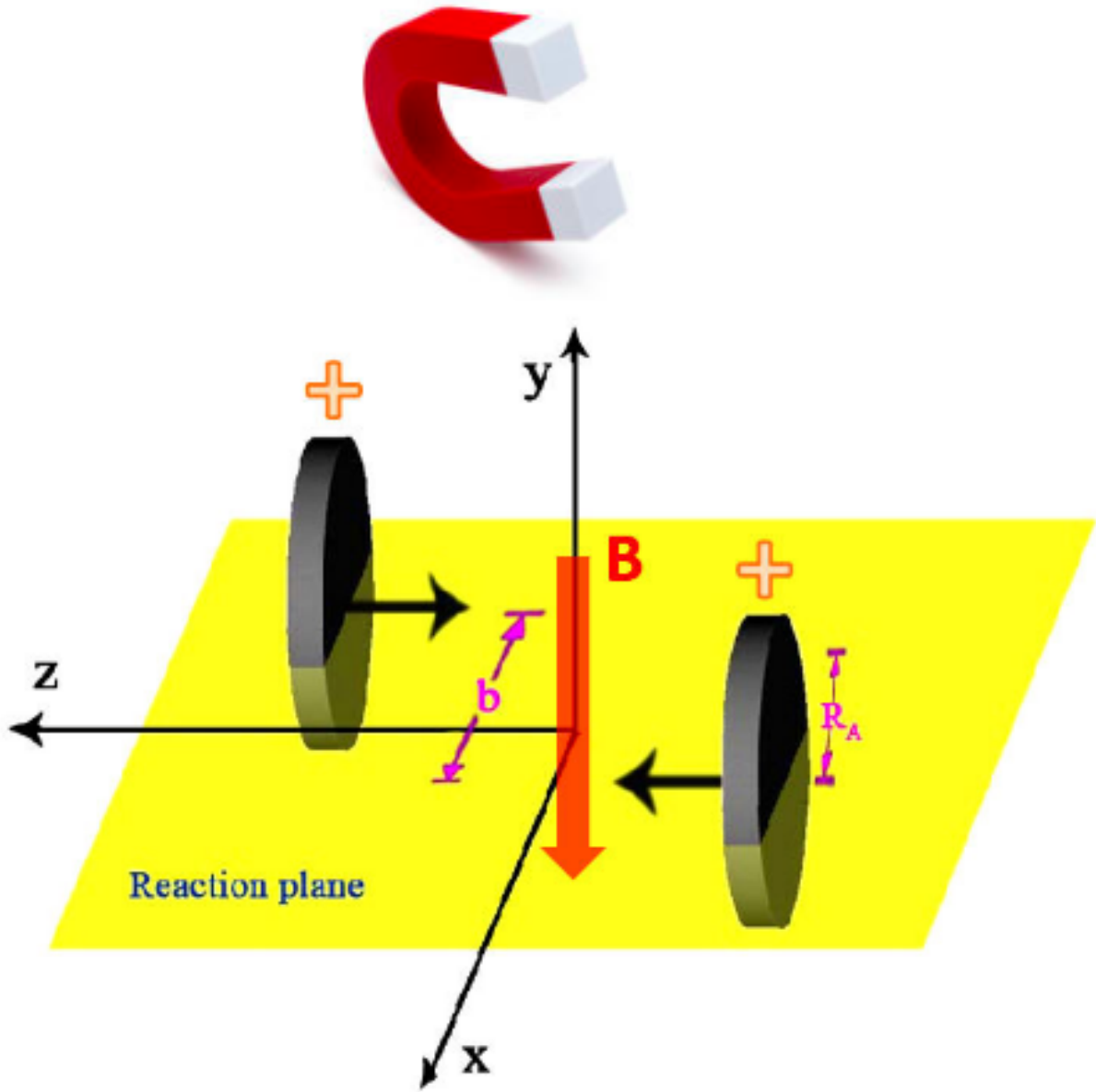
Hydrodynamics and freezeout



Hydrodynamics and freezeout

- Success of thermal freezeout suggests equilibration
- Talk by *Rajarshi Ray* on the subtleties on the extraction of the freezeout parameters. Leads the question of thermal equilibrium at freezeout
- Talk by *Sandeep Chatterjee* on "Strange results in strange freezeout": Is the strange quark in chemical equilibrium?
- Talk by *Ashutosh Dash* on the effect of a first order phase transition on the correlations of particle flows

Magnetohydrodynamics



Magnetodhydrodynamics

- B field created in heavy ion collisions
- Talk by *Sabyasachi Ghosh* on hall and normal conductivities in the presence of a magnetic field (B)
- Talk by *Shreyansh Dave* on ideal magnetohydrodynamics
- Talk by *Saumia Pandiat* on Z_3 bubbles during evolution
- Talk by *Najmul Haque* on the equation of state in B
- Talk by *Rajesh Kumar* on heavy mesons in B
- Talk by *Deepak Kumar* on chiral susceptibility in B

Transport and spectral functions

- Understanding the evolution of the QGP requires transport properties
- Talk by *Saumen Datta* on calculating the real part of the singlet potential of Quarkonia on the lattice and led a discussion
- Talk by *Peter Petreczky* on calculating Quarkonium spectral functions and transport properties on the lattice (in addition to equilibrium properties of the QGP)
- Talk by *Sourendu Gupta* on performing analytic continuations using EFT models
- Talk by *Sayantan Sharma* on screening masses and their connection with transport at high T
- Talk by *Balbeer Singh* on the calculation of the diffusion constant in the matrix model

Perspective

- Additionally, talk by Subhasish Chattopadhyay about CBM experiment and its capabilities

Directions for the future

Transport coefficients and quarkonia I: Matrix model

- In his talk, *Balbeer Singh* described his calculation of the heavy quark diffusion constant using a Matrix model
- Gluonic degrees of freedom separated in a background field and (perturbative) fluctuating field
- Weak coupling calculations have been performed before by *Brambilla, Petreczky et. al.* but applicable at high T
- Motivated by capturing physics near the QCD crossover
- Since it has dynamical gluons, it can be used to calculate transport coefficients
- Can his calculation be extended for the calculation of Quarkonium suppression?
- Since the fluctuating gluons are perturbative, standard weak coupling techniques can be used
- Because of the background gauge field, the calculation will be modified but may capture some of the physics near crossover
- Discussions with Saumen Datta and Rishi Sharma (and Peter Petreczky)

Transport coefficients and quarkonia II: Open quantum systems

- Discussions with Saumen Datta, and Rishi Sharma
- Some discussions with Balbeer Singh
- The proper method to understand quarkonia is using the language of open quantum systems
- Lindblad equations for the density matrix evolution
- Has been analyzed in detail in perturbation theory by *Brambilla et. al* and *Akamatsu et. al.*
- Some work in non-perturbative Lindblad equations by *Brambilla et. al*
- Can one write a Lindblad equation whose terms can be calculated non-perturbatively on the lattice and then solve them?

Hydrodynamics and freezeout I

- Initiative by *Ashutosh Dash and Rajarshi Ray*
- Matter produced in heavy ion collision is said to be in chemical equilibrium since statistical models like HRG explain the hadronic yields
- Number/charge fluctuations, which are experimentally measured by in heavy-ion collisions, are promising observables to study the equilibrium properties of the fireball
- To keep matters simple one could model the hadrons as interacting hard spheres inside a box of fixed spatial dimension.
- Model: an ensemble of such system with each system having random initial configuration. Then one takes a small volume inside the fixed box and calculates the number fluctuation at each time step.
- It will be interesting to check if all the moments equilibrate simultaneously. How much does the relaxation time depend on the interaction and the evolution timescales.

Magnetohydrodynamics I

- Initiative by *Sabyasachi Ghosh*
- Title "Estimation of transport coefficients of quark gluon plasma at finite magnetic field from Lattice Quantum Chromodynamics"
- The "conductivity" and the diffusion constant are given by the spectral function of the current current correlator

$$\begin{aligned} \sigma &\sim \frac{1}{6}\frac{\rho(q^0,\vec{q})}{q^0} \\ D &\sim \frac{\sigma}{\chi_s} \end{aligned} \tag{1}$$

- Have been calculated in models and on the lattice (*Peter Petreczky, Saumen Datta*)
- How are they changed in the presence of B?

Magnetohydrodynamics I

- For the Boltzmann approximation in the relaxation time approximation,

$$\sigma \sim \frac{1}{\Gamma}\langle v^2 \rangle \chi_s$$
$$\sigma \sim \frac{1}{\Gamma}\langle v^2 \rangle \tag{2}$$

- For the normal components $\frac{1}{\Gamma} \rightarrow \frac{1}{\Gamma}\frac{1}{1+(\omega_B/\Gamma)^2}$
- For the hall components $\frac{1}{\Gamma} \rightarrow \frac{1}{\Gamma}\frac{\omega_B/\Gamma}{1+(\omega_B/\Gamma)^2}$
- Using χ computed on the lattice in the presence of B, and using an estimate for Γ, can we obtain transport coefficients in B?
- Assuming a quasiparticle picture captures the physics, the calculation can be modified to obtain σ and D in the presence of B

Magnetohydrodynamics II

- A talk on ideal magnetohydrodynamics by *Shreyansh Dave*
- The main result is that v_2 is highly affected by B
- The calculation was done in ideal magnetohydrodynamics (electrical conductivity is very "large")
- Electrical conductivity calculated on the lattice *Sourendu Gupta, Aarts et. al., H. T. Ding et. al.*
- Value of $\sigma/T \sim 0.2 - 0.7e^2(\sum_f q_f^2)$ *H. T. Ding et. al.*
- A question discussed in detail was how to extend it to finite electrical conductivity