

# **2016 Winter School on Cosmology and Particle Physics**

**Monday, 12 December 2016 - Friday, 23 December 2016**

**CTPU PTC**

## **Scientific Programme**

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:20px">Week  
1</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:16px">**Introduction to Hydrodynamics and Transport Coefficients**</span>

<span style="font-size:12px"><span style="font-size:14px">Sangyong Jeon (McGill University)</span></span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">Abstract:

Relativistic hydrodynamics is an extremely useful tool in relativistic heavy ion collisions as well as astrophysics. In this lecture, I will discuss relativistic hydrodynamics in some depth including the field theoretical calculation of transport coefficients (the shear and bulk viscosities, diffusion constants, ...).</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">The topics

1. Stress-energy tensor and energy-momentum conservation
2. Most general form of relativistic hydrodynamics
3. Concept of Local Equilibrium
4. Ideal fluid vs dissipative fluid
5. Understanding viscosities
6. Linear response theory of the stress-energy tensor and Kubo formulae
7. Quantum field theoretical calculation of transport coefficients</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">In addition, if time permits,

8. Connection to kinetic theory
9. Application to RHIC and the LHC heavy ion program

References:

[1] arXiv:1503.03931 [pdf, other]</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">Introduction to Hydrodynamics

Sangyong Jeon, Ulrich Heinz

Comments: Typos are corrected and some references are added. To be included in QGP 5 edited by Xin-Nian Wang

[2] arXiv:1301.5893 [pdf, other]

Hydrodynamic Modeling of Heavy-Ion Collisions

Charles Gale, Sangyong Jeon, Bjoern Schenke

Comments: 27 pages, 7 figures, invited review for a special issue of International Journal of Modern Physics A

Journal-ref: Int. J. of Mod. Phys. A, Vol. 28, 1340011 (2013)

[3] arXiv:1403.0962 [pdf, ps, other]

Transport Coefficients of Bulk Viscous Pressure in the 14-moment approximation

G. S. Denicol, S. Jeon, C. Gale

[4] arXiv:1202.4551 [pdf, ps, other]

Derivation of transient relativistic fluid dynamics from the Boltzmann equation

G.S. Denicol, H. Niemi, E. Molnar, D.H. Rischke

Comments: 27 pages

[5] arXiv:hep-ph/9512263 [pdf, ps, other]

From Quantum Field Theory to Hydrodynamics: Transport Coefficients and Effective Kinetic Theory

Sangyong Jeon, Laurence G. Yaffe (Univ. of Washington)

Comments: 27 pages, revtex format, 5 postscript figures included using epsf.sty

Journal-ref: Phys.Rev. D53 (1996) 5799-5809

[6] arXiv:hep-ph/9409250 [pdf, ps, other]

Hydrodynamic Transport Coefficients in Relativistic Scalar Field Theory

Sangyong Jeon

Comments: 116 pages. An error in printing the figures file is corrected. The bulk viscosity sections are corrected and entirely rewritten. 38 figures in post-script format. One style file is included

Journal-ref: Phys.Rev. D52 (1995) 3591-3642

[7] arXiv:hep-th/0201116 [pdf, ps, other]

Shear viscosity of hot scalar field theory in the real-time formalism

Enke Wang, Ulrich W. Heinz

Comments: Expanded introduction and conclusions. Several references and a footnote added. Fig.5 and its discussion in the text modified to avoid double counting. Signs in Eqs. (45) and (53) corrected

Journal-ref: Phys.Rev.D67:025022,2003</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:16px">Particle cosmology I </span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:14px">Kenji Kadota (CTPU)</span></span>

<span style="font-family:arial,helvetica,sans-serif">Topics

<span style="font-size:12px">1. Introduction to Standard Cosmology

2. The Early Universe Phenomenology

3. Dark Matter

References (classic books):

The Early Universe by E.W. Kolb and M.S. Turner, Addison-Wesley 1990

Modern Cosmology by Scott Dodelson, Academic Press 2003

Cosmological Physics by John Peacock, Cambridge University Press 1999

Particle physics models of inflation and the cosmological density

perturbation by David H. Lyth and Antonio Riotto

[<https://arxiv.org/abs/hep-ph/9807278>]

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:16px">Supersymmetry</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:14px"> Seungjoo Lee (Virginia Tech.) </span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">Topics</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">1: supersymmetry algebra

2: superfield and superspace

3: supersymmetric actions and selection rules

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:12px">References

``Supersymmetry and Supergravity'' by Wess and Bagger

Philip Argyres's lecture (<http://homepages.uc.edu/~argyrep/cu661-gr-SUSY/susy1996.pdf>)

Joseph Lykken's lecture (<https://arxiv.org/pdf/hep-th/9612114v1.pdf>)

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:20px">Week 2</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:16px">**Primordial Magnetogenesis - Problems, Recent Developments and Related Topics**</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:14px">Tomohiro Fujita (SLAC) </span></span>

Topics and references(arXiv.org number):

<span style="font-size:11px">Day 1: Introduction & observation of magnetic fields (Ref: 1006.3504)

Day 2: Kinetic coupling model (Ref: 0907.1030)

Day 3: Axial coupling model (Ref: 1503.05802)

Day 4: Magnetic Baryogenesis (Ref: 1602.02109)

Day 5: Magnetic field & Gravitational waves (Ref: 1608.04216)</span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:16px">**Particle cosmology II**</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:14px">Ewan Stewart (KAIST) </span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:16px">**Axion Cosmology**</span></span>

<span style="font-family:arial,helvetica,sans-serif"><span style="font-size:14px">Kiwoon Choi (CTPU)</span></span>

<span style="font-size:12px"><span style="font-family:arial,helvetica,sans-serif">Topics: </span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">1. Basics of the Strong CP Problem and Axion Solutions</span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">2. Axion Models and Low Energy Couplings</span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">3. Axion-like-Particles and Other Light States</span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">4. Axions in Cosmology</span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">References:</span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">Lecture note 1</span></span>

<span style="font-size:11px"><span style="font-family:arial,helvetica,sans-serif">Lecture note 2</span></span>