Fusion Plasma Theory I

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On behalf of Prof. Tak-Soo Hahm and Yong-Su Na

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Classroom: Rm 32-109 (Only for First and Last Day)

Time: 2-3:15pm on Monday and Wednesday

Instructor: Jong-Kyu Park (Rm 32-215, jpark@pppl.gov)

TA: YeoungSun Lee (Rm 30-103, leeys1996@snu.ac.kr)

Textbook:

GR - R. J. Goldston and P. H. Rutherford , "*Introduction to Plasma Physics*", IOP Publishing (1995)

Basic Reading:

- F. F. Chen, "*Introduction to Plasma Physics and Controlled Fusion*", 3rd Edition, Springer (2016)
- J. A. Bittencourt, "*Fundamentals of Plasma Physics*", 3rd Edition, Springer (2004)
- B. B. Kadomtsev, "*Tokamak Plasma: A Complex Physical System*", IOP Publishing (1992)

Advanced Reading:

- J. P. Freidberg, "*Ideal MagnetoHydroDynamics*", Updated Ver., Cambridge University Press (2014)
- W. D. D'haeseleer, W. N. G. Hitchon, J. D. Callen, J. L. Shohet, "*Flus Coordinates and Magnetic Field Structure: A Guide to a Fundamental Tool of Plasma Theory*", Springer-Verlag Berlin Heidelberg Prints (1991)
- R. B. White, "*The Theory of Toroidally Confined Plasmas*", Revised 2nd Edition, Imperial College Press (2006)
- R. D. Hazeltine and J. D. Meiss, "*Plasma Confinement*", Dover Publications (2003)
- K. Miyamoto, "*Plasma Physics for Nuclear Fusion*", Revised Edition, MIT Press (1989)
- J. Wesson, "*Tokamaks*", 3rd Edition, Oxford University Press (2004)

Syllabus:

I Introduction

1. Quasi-neutrality: Debye shielding [GR Ch. 1]
2. Sheath: Child-Langmuir and Bohm currents [GR Ch.1, Chen Ch. 7]

II Particle Motions in Plasmas under Electro-Magnetic Fields

3. Drifts in uniform fields: Gyromotion and $E \times B$ drift [GR Ch. 2]
4. Drifts in non-uniform fields: $\vec{\nabla} B$, Curv., Polarization drift [GR Ch. 3]
5. Adiabatic Invariant μ and Magnetic Mirror [GR Ch. 3]
6. Guiding-center Lagrangian: LittleJohn's Derivation [White Ch. 3]
7. Adiabatic Invariant J: Northrop's Proof [GR Ch. 4]

III Fluid Descriptions for Plasmas

8. Multi-Fluid Description: Moment and Closure [GR Ch. 6]
9. Fluid vs. Guiding-center Drifts [GR Ch. 7]
10. Single-Fluid Description: MHD [GR Ch. 8]
11. Reduced MHD Description: Four Fields

IV Plasma Equilibrium

12. MHD equilibrium: Pinches [GR Ch. 9]
13. Magnetic Field Line: KAM and stochasticity [White Ch. 1]
14. 3D equilibria: Curvilinear coordinates [White Ch. 1]
15. Tokamak equilibria: Grad-Shafranov Equation [White Ch. 2]

V Global Plasma Stability

16. Gravitational instability: Rayleigh and Taylor [GR Ch. 19]
17. Energy Principle: Berstein and Kulsrud [White Ch. 4]
18. Current-driven Kink instability: Suydam and Newcomb [White Ch. 4]

19. Pressure-driven Ballooning instability: Connor-Hastie [White Ch. 4]
20. Resistive tearing instability: Furth-Killeen-Rosentbluth [GR Ch. 20]
21. Non-linear tearing instability: Rutherford [White Ch. 5]

VI Neoclassical Plasma Transport (Time permitting)

22. Diffusion in Plasmas: Random walk process [GR Ch. 12]
23. Drift-kinetic description: Recursive Derivation [Hazeltine-Meiss CH. 4]
24. Collisional Transport: Pfirsch-Schlüter [Wesson Ch. 4]
25. Collisionless Transport: Banana and NTV [Wesson Ch. 4]