宇宙物理学Ⅰ Astrophysics Ⅰ

科目コード(Course Number) 20DASd0501
物理科学研究科 School of Physical Sciences　天文科学専攻 Department of Astronomical Science　共通基礎 Common Base
学年(Recommended Grade) 1年　2年　3年　4年　5年
2単位(credit)　前学期 1st semester

梶野　敏貴（KAJINO Toshitaka）

〔授業の概要 Outline〕

We will study a contemporary view of the modern astronomy of cosmic and galactic evolution on the firm basis of particle cosmology and theoretical nuclear astrophysics. Subjects include big-bang cosmology, space-time structure and phase transition, CMB anisotropies and cosmic structure formation, galaxy formation and evolution, stellar evolution and explosive nucleosynthesis, neutrino oscillation in supernovae, and the origin of the Solar system.

〔到達目標 Learning objectives〕

Our goal is to understand current basic knowledge of the cosmic evolution and origin of matter based on understanding elementary processes in various cosmological and astronomical phenomena.

〔成績評価方法 Grading policy〕

Evaluations will be made based upon the report publications, Q&A and positive action made by the students during the lectures.

〔授業計画 Lecture plan〕

Course Outline:

1. Goal and perspective
2. Basics of general relativity
3. Basics of elementary particle physics and nuclear physics
4. Basics of quantum statistical mechanics
5. Big-Bang cosmology
6. Cosmic phase transition, symmetry breaking, and particle creation
7. Big-Bang nucleosynthesis in the early universe
8. Cosmic microwave background radiation, formation of large scale structure, and cosmological parameters
9. Dark matter and dark energy
10. Extra-dimension and astronomical observation
11. Physics of supernova explosion, gamma ray bursts and nucleosynthesis
12. Dynamics and chemistry of Galactic evolution
13. Supernova neutrinos, oscillation, and explosive nucleosynthesis
14. Cosmic evolution and cosmochronology
15. Unification of elementary interactions and the universe

Method of Lecture:

Lectures will be basically based on writing on the blackboard and also involve slide presentations on topical subjects, with handouts provided.

Requirement:

We require that the students have already mastered electromagnetism, quantum mechanics, statistical mechanics, and relativity in the undergraduate course.

〔実施場所 Location〕

Lecture room, NAOJ Mitaka

〔使用言語 Language〕

English and/or Japanese

〔教科書・参考図書 Textbooks and references〕

References:

1.* Gravitation and Cosmology (John Wiley & Sons), Steven Weinberg
2.* The Early Universe (Addison Wesley), Edward W. Kolb and Michael S. Turner
3.* Cosmological Inflation and Large-Scale Structure (Cambridge), Andrew R. Liddle and David H. Lyth
4.* Supernovae and Nucleosynthesis (Princeton Univ. Press), David Arnett
5.* Cauldrons in the Cosmos (Univ. Chicago Press), Calus E. Rolfs and William S. Rodney
6.* Nucleosynthesis and Chemical Evolution of Galaxies (Cambridge), Bernard E. J. Pagel

Recommended Textbooks (Books with * are duplicate with those listed above.):

GALACTIC EVOLUTION

1. Principles of Physical Cosmology (Princeton University Press , 1st Edition - 1976), P. J. E. Peebles

You can learn almost all details on Galactic evolution from cosmological viewpoint. However, it is a little hard to read because chapter ordering is sometimes chaotic.

2.* Nucleosynthesis and Chemical Evolution of Galaxies (Cambridge University Press, 1st Edition - 1997), Bernard E. J. Pagel

Bernard is an observational astronomer, and the text is easy to read. You can study the basic knowledge on Galactic chemical evolution.

COSMOLOGY

3.* The Early Universe (Addison-Wesley, 1st Edition - 1990), Edward W. Kolb and Michael S. Turner

This is a good textbook on particle cosmology which is useful for practical use.

4.* Cosmological Inflation and Large Scale-Structure (Cambridge University Press, 1st Edition - 2000), Andrew R. Liddle and

David H. Lyth

You can learn modern cosmology including CMB and LSS.

5.* Gravitation and Cosmology (John Wiley & Sons, 1st Edition - 1972), Steven Weinberg

This is a masterpiece on cosmology.

NEUTRINO PHYSICS AND ASTROPHYSICS
6. Physics of Neutrinos and Applications to Astrophysics (Springer, 1st Edition - 2003), Masataka Fukugita and Ttsutomu Yanagida

This is a good textbook on particle physics and astrophysics by summarizing both theoretical and experimental studies of neutrinos. Chapter 8 is dedicated to neutrino oscillation.

7.* Supernovae and Nucleosynthesis (Princeton Univ. Press), David Arnett

This book describes the skeleton and the principles of supernova physics and astrophysics.

RELATIVISTIC COMPACT OBJECTS
8. Black Holes, White Dwarfs, and Neutron Stars (John Wiley & Sons, 1st Edition - 1983), Stuart L. Shapiro and Saul A. Teukolsky

This is a masterpiece on neutron stars and BHs.

GRAVITATIONAL WAVES
9. Gravitational Waves, Vol. 1: Theory and Experiments (Oxford University Press - 2008), Michele Maggiore

Chapters 3 & 4 discuss the essence of GW.

NUCLEAR ASTROPHYSICS
10.* Cauldrons in the Cosmos (The University of Chicago Press, 1st Edition - 1988), Claus E. Rolfs and William S. Rodney

This is a good introductory textbook on nuclear astrophysics. Claus is an experimental nuclear physicist, and the text is easy to read.

11. Nuclear Physics of Stars (Wiley-VCH, 1st Edition - 2007), Christian Illiadis

Christian also is an experimental nuclear physicist. Details on thermo-nuclear reaction rates are written in this textbook.

12. Principles of Stellar Evolution and Nucleosynthesis (The University of Chicago Press - 1968, 1983 ...), Donald D. Clayton

This is a classical book on nuclear astrophysics, and a bit old fashioned. Don however tried to give as many analytic solutions as possible of nucleosynthetic processes by making reasonable approximations.

〔授業を担当する教員 Lecturers〕
Toshitaka Kajino
〔関連URL Related URL〕
URL:http://th.nao.ac.jp/MEMBER/kajino/e/
〔上記URLの説明 Explanatory Note on above URL〕
This is the home page of Prof. Kajino's research group COSNAP - “COSmology and Nuclear AstroPhysics” in National Astronomical Observatory of Japan, The University of Tokyo, and
International Research Center for Big-Bang Cosmology and Element Genesis (IRCBBC), Beihang University. Visitors can learn the recent progress in this research field COSNAP which will be intruduced in the course of lectures.
〔備考・キーワード Others/Keyword〕
big-bang cosmology, space-time structure, phase transition, CMB anisotropies, cosmic structure formation, galaxy formation and evolution, stellar evolution, explosive nucleosynthesis, neutrino oscillation, supernovae