

Nucleosynthesis

Titulaire

Stéphane GORIELY (Coordonnateur)

Mnémonique du cours

PHYS-F421

Crédits ECTS

5 crédits

Langue(s) d'enseignement

Anglais

Période du cours

Deuxième quadrimestre

Campus

Plaine et Autre campus

Contenu du cours

One of the major issues in modern astrophysics concerns the analysis and understanding of the present composition of the Universe and its various constituting objects. Nucleosynthesis models aim to explain the origin of the different nuclei observed in nature by identifying the possible processes able to synthesize them.

The composition of the various constituents of the Universe at the galactic and stellar scales has evolved since the Big Bang. Though the origin of most of the nuclides lighter than iron through the various hydrostatic and explosive burning stages in stars is now quite well understood, the synthesis of the heavy elements (i.e. heavier than iron) remains obscure in many respects. The major mechanisms called for to explain the production of the heavy nuclei are the slow neutron-capture process (or s-process) occurring during specific hydrostatic stellar burning phases, the rapid neutron-capture process (or r-process) believed to develop during the explosion of a star as a type II supernova or during the merging of two compact objects, and the photodisintegration process (or p-process) taking place in the high-temperature environment of type-Ia or type-II supernovae. The stellar nucleosynthesis requires a detailed knowledge not only of the astrophysical sites and physical conditions in which the processes take place, but also the nuclear structure and interaction properties for all the nuclei involved.

These lectures describe our present understanding of the stellar nucleosynthesis processes as well as the many experimental and theoretical efforts devoted to determine the related nuclear physics inputs of relevance. These include nuclear structure as well as decay and reaction properties of relevance in astrophysical environments. The specificity of such properties in a high-temperature astrophysical plasma will be emphasized.

The lectures also describe the particular links developed between nuclear physics and astrophysics.

Objectifs (et/ou acquis d'apprentissages spécifiques)

These lectures describe our present understanding of the various nucleosynthesis processes responsible to explain the origin of the elements in the Universe.

Pré-requis et co-requis

Connaissances et compétences pré-requis

Nuclear physics

Astrophysics: stellar structure and evolution

Méthodes d'enseignement et activités d'apprentissages

Lectures given as slides with ppt files available

Références, bibliographie et lectures recommandées

- › *Principles of Stellar Evolution and Nucleosynthesis*: D. Clayton (University of Chicago Press 1968, 1983)
- › *Supernovae and Nucleosynthesis*: D. Arnett (Princeton University Press, 1996)
- › *Nuclear physics of stars*: C. Iliadis (Wiley-VCH Verlag, 2007)
- › Astronuclear Physics: A tale of the atomic nuclei in the skies [http://164.15.254.82/pmwiki/pub/Lecture_Notes/PHYS-F-421/arnould3.pdf] :
M. Arnould, S. Goriely
Progress in Particle and Nuclear Physics (2020)
- › S-process nucleosynthesis: nuclear physics and the classical model [http://164.15.254.82/pmwiki/pub/Lecture_Notes/PHYS-F-421/kappeler.pdf] :
F. Kappeler, H. Beer, K Wisshak
Reports on Progress in Physics 52, 945 (1989)
- › The r-process of stellar nucleosynthesis: astrophysics and nuclear physics achievements and mysteries [http://164.15.254.82/pmwiki/pub/Lecture_Notes/PHYS-F-421/arnould1.pdf] :
M. Arnould, S. Goriely, K. Takahashi
Physics Reports 450, 97 (2007)
- › The p-process of stellar nucleosynthesis: astrophysics and nuclear physics status [http://164.15.254.82/pmwiki/pub/Lecture_Notes/PHYS-F-421/arnould2.pdf] :
M. Arnould, S. Goriely
Physics Reports 384, 1 (2003)

Autres renseignements

Lieu(x) d'enseignement

Plaine et Autre campus

Contact(s)

Stephane Goriely

Institut d'Astronomie et d'Astrophysique

Université Libre de Bruxelles

Campus de la Plaine - CP226

B-1050 Brussels, Belgium

Tel: +32 2 6502843

stephane.goriely@ulb.be

Méthode(s) d'évaluation

Examen oral

Examen oral

Question ouverte à développement long

Examen à livre ouvert et Examen avec préparation

Langue(s) d'évaluation principale(s)

Français et Anglais

Autre(s) langue(s) d'évaluation éventuelle(s)

Anglais

Programmes

Programmes proposant ce cours à la faculté des Sciences

MA-PHYS | **Master en sciences physiques** | finalité Approfondie/
bloc 1 et finalité Didactique/bloc 1